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Consumption of Added Sugars and Indicators of Cardiovascular Disease Risk among US Adolescents and Adults

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B.A., Luther College, 1983
M.P.H., University of Minnesota, 1993

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An abstract of
A dissertation submitted to the Faculty of the
James T. Laney School of Graduate Studies of Emory University
in partial fulfillment of the requirements for the degree of
Doctor of Philosophy

in

Graduate Division of Biological of Biomedical Science
Nutrition and Health Sciences

2010

Abstract

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By Jean A. Welsh

The consumption of sugars added to foods and beverages are major source of calories in the US diet. Animal studies have demonstrated that high consumption of sugars, particularly fructose, can induce cardiovascular disease (CVD) but their effect on human health is less clear. Previous studies have shown an association between high sugar consumption and increased insulin resistance, dyslipidemia (increased triglyceride levels and decreased high-density lipoprotein [HDL] levels), and obesity. Little is known about recent trends in the consumption of added sugars or about their effect on CVD risk when consumed at current levels.

To better understand role played by these added sugars (caloric sweeteners) in the development of CVD, we implemented a series of studies using national data to: 1) determine if the intake of added sugars at usual levels is associated with dyslipidemia among US adults, 2) to determine if the intake of added sugars among US adolescents, the highest consumers of added sugars, is associated with dyslipidemia, insulin resistance, obesity, or hypertension, and 3) to assess trends in the intake of added sugars to determine if consumption has continued to increase in recent years. In addition, we completed an extensive review of the published and unpublished literature to identify strategies that have been effective in reducing the consumption of sugar-sweetened beverages (SSBs), the largest source of added sugars in the US diet.

Through these studies, we found that intake of added sugars, at usual levels, is positively associated with dyslipidemia in US adults and adolescents. In addition, insulin resistance is higher among overweight adolescents with greater intake of added sugars. We also found that the trends in consumption of added sugars, which had increased substantially over recent decades, decreased progressively from 1999-2000 to 2007-08. Our review of previously literature indicates that little is in known about the most effective strategies for promoting a reduction in the consumption of sugar-sweetened beverages. Further research is needed to determine if reductions in the consumption in added sugars can decrease CVD risk, to determine the safe level of consumption of added sugars, and to identify the most effective public health strategies for further reducing this consumption.

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ACKNOWLEDGEMENTS

I would like to first thank my parents, William and Esther Welsh, who from my earliest years instilled in me a love of good food, an appreciation of the challenges faced by those who produce it, and a desire to learn more about how our dietary choices impact our health and our environment.

To my daughters Greta, Stella, Ellie, and Luciana, thank you all for your love, support, and patience. You've all grown so much over the past 4 years (2 months and 26 days). It is never easy having a parent in graduate school but you have had the added misfortune of having one that chose to study the health effects of sugars. You have all dealt well with my efforts to limit your experience of soft drinks and other sweets to one of an occasional treat rather than as a regular feature of your diets.

To Van, I am so grateful for you. While these years have been challenging, they have also been a lot of fun. Thanks for all you have done to help make this dream come true.

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1 INTRODUCTION

Sugars added to foods and beverages feature prominently in the US diet. Soft drinks, a major contributor to the intake of added sugars among all age groups, have become the single largest source of calories in the US diet.[1] While research dating back to the 1960s, has shown associations between the sugar consumption and indicators of cardiovascular disease (CVD), a review published by the Sugars Task Force of the Food and Drug Administration (FDA) in 1986 concluded that there was no firm evidence that sugar intake (sucrose) was an independent risk factor for heart disease.[2] Since then, the results of epidemiologic studies and short and long-term experimental studies have provided more evidence linking the intake of carbohydrates[3, 4] and sugars,[4-7](particularly fructose),[5, 8, 9] to an increased risk of CVD.

The National Health and Nutrition Examination Survey (NHANES) is a survey of non-institutionalized residents of the US. NHANES data, which has been collected continuously since 1999, allows for the cross-sectional examination of the association between diet and various health and health-related outcomes. NHANES is a tremendous resource because it provides a means to study the US diet, how it changes over time, and how diet might be playing a role in increasing or decreasing chronic disease risk. Unfortunately, though the NHANES database provides extensive information about the nutrient content of the foods consumed by Americans, it does not provide an estimate of the amount of added sugars in these foods. The lack of a single comprehensive, up-to-date nutrient database, which includes information on the quantity of added sugars in foods and beverages, has previously compromised research into the possible health effects of increased consumption.

The MyPyramid Equivalents Database (MPED), developed and maintained by the US Department of Agriculture since 1994-96, provides standard serving size information for the major food categories found on the USDA Food Guide Pyramid (grains, meat, dairy, fruits, vegetables, and beans) as well as for added sugars and excess fat. Combining MPED data with dietary data from NHANES provides a means to study added sugars, their consumption patterns and trends, and the health conditions that may be associated with this consumption. Since the 1986 report from the Sugars Task Force, extensive experimental research has been done to investigate the possibly causal role between increased consumption of added sugars and the development of cardiovascular disease but several questions remain. Therefore, the body of research for this dissertation was conceived and designed to use NHANES and MPED data to answer the following questions:

1) Is the consumption of added sugars at current levels associated with measures of dyslipidemia reflective of increased CVD risk among US adults?;
2) Is the consumption of added sugars at current levels associated with measures of CVD risk among US adolescents?; and
3) How have the trends in the intake level and major sources of added sugars in the US diet changed over the past decade?

In addition, an extensive review of the literature was performed to identify the most promising public health strategies for reducing the consumption of sugars-sweetened beverages (and added sugars).

This document will provide, in Chapter 2, a review of the literature on the consumption of added sugars, including how the term has been defined, how added sugars are measured, historical trends in intake, and a summary of the evidence of the association between consumption of added sugars and CVD and its risk factors. In Chapter 3, a summary description of the analytical methods used in doing this research is provided. Chapter 4 summarizes the analyses performed to determine if the consumption of added sugars at current levels in the US is associated with is measures of dyslipidemia among adults. Similarly, Chapter 5 is a summary of the analyses done to determine if the current added sugar consumption levels are associated with indicators of increased cardiovascular risk among US adolescents. Chapter 6 provides an overview of the study done to analyze recent trends in added sugars consumption by age, sex, and race/ethnicity. Here consumption trends and key sources in the US from 1999-2000 to 2007-2008, are presented by age, sex, and race/ethnic groups. Chapter 7 includes a document prepared for the Centers for Disease Control and Prevention (CDC) to provide guidance to state health departments and other partners working to reduce the consumption of sugar-sweetened beverages (SSBs), the largest source of added sugars in the US diet. In this document a series of strategies recommended by CDC for reducing SSB consumption are presented. The rational and a summary of the evidence to support each of the recommended strategies are also included as well as links to numerous program materials and other resources. The final chapter, Chapter 8, includes a summary of the finding of this body of research, as well as its strengths, limitations, and public health implications. Recommendations for further research on this topic are also provided.

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2 BACKGROUND

2.1 The Role of Dietary Sweeteners

Sweeteners have been used to improve the taste of foods and beverages for thousands of years. Honey and only very small amounts of high-priced refined sugar or "white gold" from cane, were available until the mid-1880s, so consumption was rare. At that time, with improved methods for extracting sugar from beets as well as cane, the price began to decline and consumption began to increase dramatically.[1] Added sugar was not a major component of the human diet until the advent of modern food processing. Since then, sucrose or table sugar from beats and cane and, more recently, high fructose corn syrup (HFCS) have become ubiquitous in the food supply.[2]

The primary role of carbohydrates, which includes sugars and starches, is to provide energy to cells in the body. Carbohydrates are consumed in foods as monosaccharides (single sugar molecule), disaccharides (2 sugar molecules), oligosaccharides (3-10 sugar molecules), and polysaccharides (more than 10 sugar molecules). Commonly consumed disaccharides include sucrose (glucose+fructose), lactose (glucose+galactose), and maltose (glucose+glucose). All forms of carbohydrates are digested, absorbed, and transported through the body as monosaccharides, including glucose (most common), as well as fructose and some galactose.[3] While all cells use carbohydrates for energy, brain and red blood cells are, under normal dietary conditions, depend specifically on glucose.

2.2 Definition of Added Sugars

Sugar, defined by its chemical structure, refers to a group of compounds composed of carbon, hydrogen, and oxygen. Currently consumed in approximately equal amounts, sucrose (produced, primarily, from beats and cane) and high-fructose corn syrup (HFCS) (a combination of fructose and glucose produced from corn starch) are the most commonly consumed sweeteners in the US diet.[4]

Several variations of the term "sugar" are used to refer to dietary sweeteners available. The term "sugar", as used by the Food and Drug Administration (FDA) in their oversight of food labeling and by the USDA in their dietary guidelines, indicates only sucrose[5] (Table 1). The plural form "sugars" refers to all monosaccharides and disaccharides. While chemically and physiologically there appears to be little difference between naturally occurring sugar and those added to foods, in 2000 the US Dietary Guidelines began to use the term "added sugars" to increase awareness of foods that provide energy but generally contribute few additional micronutrients or phytochemicals. "Added sugars" include all monosaccharides and disaccharides but also some oligosaccharides (chains of 3 to 10 simple sugars found in some syrups). The term is used by the USDA in their Food Guide Pyramid. "Caloric sweeteners" is another term used for added sugars. The term is used by the Economic Research Service of the USDA in reference to estimates of calorie containing sweeteners in use in the US food supply (Table 1). "Intrinsic sugars" and "extrinsic sugars" are used by the Department of Health in the United Kingdom to differentiate sugars inherent in foods from those added.[5]

Table 2-1. Definition of Terms Used to Describe Sugars Used in the Food Supply

Term	Includes	Use in the food supply
Sugar	Sucrose (table sugar) only	Use by FDA to indicate sucrose in the ingredient list on foods
Sugars	Monosaccharides and disaccharides (simple sugars)	Used by FDA on the food label to indicate the presence of all monosaccaharides and disaccharides in foods. This includes naturally occurring sugars as well as those added to foods and beverages. This includes sucrose, fruictose, maltose, lactose, honey, syrup, corn syrup, high-fructose corn syrup molasses, and fruit juice concentrate. Any longer chain compounds (oliogosccharides) present are not included as sugars.
Added Sugars	Monosaccharides, disaccharides, and some oligosaccharides (short chains of simple sugars)	Used by USDA in the Food Guide Pyramid to indicate sugars and syrups that are added to foods during processing or preparation (2005 Food Guide) May contain longer chain compounds (oliogosaccharides). Includes: white sugar, brown sugar, raw sugar, corn syrup, corn syrup solids, high-fructose corn syrup, malt syrup, maple syrup, pancake syrup, fructose sweetener, liquid fructose, honey, molasses, anhydrous dextrose, and crystal dextrose.
Caloric Sweeteners	Monosaccharides, disaccharides, and some oligosaccharides (short chains of simple sugars)	Used by the USDA Economic Research Service in their estimates of food use (food disappearance data) in the US. Includes sucrose (from refined cane and beet sugars), honey, dextrose, edible syrups, and corn sweeteners.
Instrinsic or Naturally Occurring Sugars	Sugars that are present within the cell wall of plants	Used by the United Kingdom Department of Health to help consumers differentiate sugars inherent in foords from those not naturally occurring
Extrinsic Sugars	Sugars typically added to foods	Used by the United Kingdom Department of Health to help consumers differentiate sugars inherent in foords from those not naturally occurring
Non-milk Exstrinsic Sugars	Sugars, other than milk sugars, typically added to foods	Used by the United Kingdom Department of Health to help consumers differentiate sugars inherent in foords from those not naturally occurring

2.3 Determining Content of Added Sugars in Foods and Beverages

As added sugars are chemically indistinguishable from those occurring naturally in foods, there is no analytical method available that can measure their quantity in foods and beverages. For its databases, USDA calculates the amount of added sugars using information on product food labels. The Ingredients List is used to identify the various sugars in a product, and the Nutrient Facts Panel is used to determine the total amount of sugar it contains.[6] The National Food Labeling Education Act of 1999 requires that all processed food and beverage items include this information on the label. The Food and Drug Administration (FDA) is charged with ensuring compliance with food labeling regulations.

2.4 Assessing Dietary Intake

Different methods have been used to monitor trends in the intake of added sugars (and other foods and nutrients) over the past several decades.[7] When evaluating trends, it is important to be aware of the strengths and limitations inherent in the various data collection methods used. Food availability, or disappearance data, is an estimate of usage by the population after existing inventory and losses are deducted from the total in the food supply. While it is known that disappearance data overestimate true intake they provide a useful means of monitoring trends. Using disappearance data from the Economic Research Service and Agricultural Research Service of the USDA we can see that the estimated per capita consumption of added sugars in the US was 113 g in 2000, representing an increase of 26% from 1990 when consumption was estimated at 90 g. Between 1960-69 and 1990-99, intake is estimated to have increased 39%.[7]

When nutrient databases with up-to-date information are available for calculating the nutrient content of foods consumed, dietary surveys provide an opportunity to obtain estimates that are more accurate than those obtained with disappearance data. In addition, an important advantage of dietary data is the ability to assess consumption by age, sex, race and other characteristics. A limitation of these data, though, is that they are based on self-reported intake, which tends to be an underestimate of true intake, particularly among some groups. For example, those who are overweight or obese have been shown to be more likely to underreport their intake.[8] Prior to the establishment of the first nutrient database with added sugars data by FDA in the late 1970s, all estimates of total and added sugars were obtained using disappearance data.[9]

Currently the database used to estimate nutrient intake in NHANES, the Food and Nutrient Database for Dietary Studies (FNDDS) based on the food composition data from the USDA National Nutrient Database for Standard Reference (Standard Reference),[10] does not include data on the content of added sugars for many foods and beverages. A separate USDA database, the MyPyramid Equivalents Database (developed to facilitate monitoring of compliance with US dietary guidelines) does include added sugars information but only for those foods consumed by respondents in previous NHANES surveys. As a result, data on the MPED database tends to be outdated by the time it is released. The most recent period for which MPED data is available is 2003-04. This has compromised timely research into the trends in the intake of dietary sugars and the associated health outcomes.

2.5 Dietary Recommendations regarding Intake of Added Sugars

National survey data from 1994-96 provide the most recent available estimates of the patterns and sources of added sugars intake. At that time consumption in the US averaged nearly 16% of total energy intake.[11] Consumption among adolescents, the highest consumers of added sugars, was over 20% of total energy. This represents a substantial increase from 1977-78, when added sugars contributed only 10.6% of the calories consumed among all Americans $\geq$2 y.[12] In 1994-96, soft drinks were the largest contributor of added sugars in the diet followed by candy, and sweetened grains.

While available intake estimates show that many US children and adults are consuming a large proportion of their daily calories as added sugars, guidance regarding the level of consumption that is safe has not yet been clearly defined. The World Health Organization (WHO) was the first organization to issue a recommendation regarding the intake of sugars. In 1989 WHO advised that consumption of "free sugars", which includes all added sugars, as well as those naturally present in honey, syrups and fruit juices, be limited to <10% of total energy, primarily as a means of preventing dental caries. In 2003, WHO affirmed this recommendation as a strategy for the prevention of obesity and chronic disease.[13] Two years later, in 2005, the Institute of Medicine of the National Academy of Science, in releasing their guidelines for the intake of macronutrients, cited a lack of evidence on which to base an upper limit for intake of added sugars but advised that consumption should not exceed 25% of total energy intake due to concerns about the displacement of other nutrients.[5] The US Dietary

Guidelines, which form the bases of US nutrition policy, have cautioned against excess intake of high added sugars, without specifying a safe upper limit, since 1980.[14]

The most recently released version, the 2005 Dietary Guidelines, advises that food and beverages that "moderate intake of added sugars" should be selected. Added sugars, as well as solid fats and alcohol, are included in the Dietary Guidelines as discretionary, or non-essential, calories to be consumed within the limits of total energy needs once nutrient requirements are met. The discretionary calories available to an individual are calculated as the difference between the total calories needed based on body size and level of physical activity and the number of calories consumed in meeting the daily nutrient requirements. Sample diets for a moderately active person provided in the MyPyramid Guide indicate that on average, 6 to 12% of total energy can be consumed as discretionary calories.[15]

In line with the guidance provided in the MyPyramid Guide, the American Heart Association (AHA) released recommendations in 2009 which encourage men and women to limit their daily intake of added sugars to less than 150 and 100 calories, respectively, an amount determined by taking one-half the average allowable discretionary calories.[16]

Based on the data from 1994-96 dietary survey, the level of added sugars consumed by many Americans exceeds currents guidelines.

2.6 Added Sugars and Cardiovascular Disease Risk

Cardiovascular disease is the leading cause of morbidity and mortality among US adults. And though CVD among children remains rare, an increase in risk factors, including dyslipidemia,[17] insulin resistance, and obesity at younger ages and their apparent tendency to track into adulthood[5-7] has been observed. Research dating back as far as the 1960s has shown an association between the consumption of sugars and alterations in blood lipid levels, however an FDA review done in 1986 determined that there was insufficient evidence of an association between the consumption of sugars and CVD or its risk factors.[12] Since then, additional evidence from studies using a variety of research designs, including randomized control trials and long term follow-up studies, have provided additional evidence to support the link between the consumption of added sugars and several indicators of increased cardiovascular disease risk.

A recent study using data from the longitudinal Nurse's Health Study II demonstrated that women had nearly two times the risk of developing type 2 diabetes if they consumed $\geq$1 sugar-sweetened soft drink daily compared with those who consumed <1 /month.[18] Data from the Nurse's Health Study II also showed that these higher consumers of sugar-sweetened soft drinks were also more likely to experience a later cardiac event.[19] A 2006 systematic review and meta-analysis of 33 studies, including short-term and long-term experimental studies, found that consumption of sugar-sweetened beverages was associated with an increase in total calorie consumption and body weight.[20]

2.7 Possible Biological Mechanisms

Several mechanisms have been proposed to explain the association between sugars and CVD risk. These mechanisms differ by the type of dietary sugar. In addition, some pathways involve consumption of calories in excess of energy needs and increased adiposity while others do not. Figure 1 below provides an illustration of the hypothesized relationships between dietary sugars and CVD.

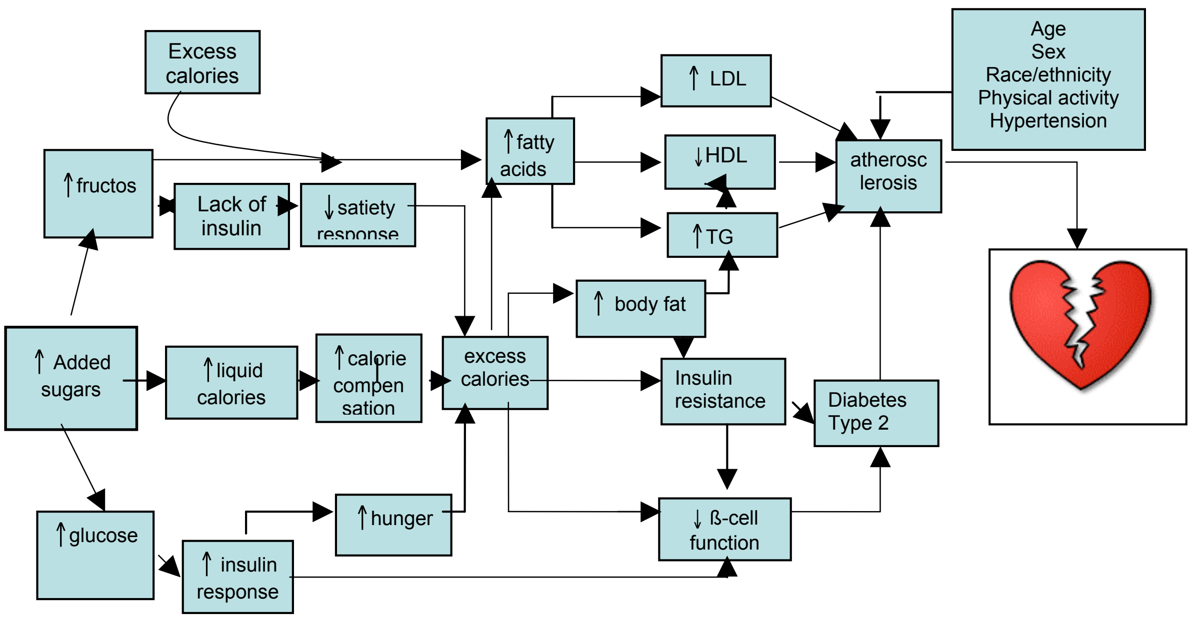

Figure 2-1. Illustration of the hypothesized mechanisms through which the consumption of added sugars may lead to heart disease.

The most commonly consumed added sugars, including sucrose or table sugar (from cane and beets) and high-fructose-corn-syrup (HFCS), are comprised of nearly equal amounts of glucose and fructose. Thus, the physiologic effects that have been observed with consumption could result from one or the other or, possibly, the combination of the two.

Researchers have hypothesized that glucose may have effects through the stimulation of insulin. Long-term consumption of diets high in foods with a high glycemic index, those that cause a rapid rise in glucose, and a corresponding spike in insulin levels, promotes hunger and excess energy intake and thereby could contribute to weight gain or inability to lose excess weight.[21, 22] In addition, it has been suggested that chronic high levels of insulin may have a direct effect on the development of ß-cell dysfunction and insulin resistance.[23]

In contrast, fructose has little effect on serum glucose concentrations and its consumption does not illicit an insulin response.[3] But controlled trials among adults have shown that high doses of fructose, particularly in the presence of excess energy intake, can alter blood lipid levels.[24] It is believed that this is the result of the way in which fructose is metabolized. Whereas glycolysis, which occurs in all cells, is a highly regulated process, fructose metabolism, which occurs primarily in the liver, bypasses the regulatory steps central to glucose metabolism. As a result, the metabolism of high doses of fructose favors the formation of new free fatty acids (de novo lipogenesis).[25] This increased lipogenesis results in increased hepatic triglyceride synthesis combined with increased secretion and/or decreased clearance of very-low-density lipoproteins (VLDL).[16] These VLDL particles with high triglyceride content will exchange triglycerides for cholesterol esters in high-density lipoproteins (HDL) and low-density lipoproteins (LDL) particles, thereby making the HDL particles dysfunctional at removing cholesterol and increasing the number of the small LDL particles known to increase the atherosclerosis associated with heart disease.[26]

In addition, as fructose does not elicit an insulin response, when it is consumed the satiety hormone leptin is not activated, nor is ghrelin, the hunger-promoting hormone suppressed. This has been hypothesized to lead to a dysregulation in energy balance, resulting in excess consumption and weight gain.[25]

One final possible mechanism that may help explain the association between added sugars and heart disease risk relates not to the type of sugars consumed but rather to the form. Much of added sugar is consumed in liquid form via soft drinks and other types of sugar-sweetened beverages. Research suggests that the compensation for calories consumed as liquids may be incomplete,[27] thereby leading to an excess in energy intake, weight gain and a related increase in cardiovascular disease risk.

2.8 Purpose of Research

Because recent short and long-term experimental studies are suggestive of a link between high intake of sugars and increased risk of CVD, [19, 25, 28, 29] but little is known about the effect of dietary sugar consumption at usual levels, a comprehensive dissertation research plan was developed to assess the consumption between added sugar consumption among US adults and adolescents and determine if this consumption was associated with indicators of cardiovascular disease. The specific research objectives included:

1) To determine if the consumption of added sugars at current levels associated with measures of dyslipidemia reflective of increased CVD risk among US adults
2) To determine if the consumption of added sugars at current levels associated with measures of CVD risk among US adolescents; and
3) To assess trends in the intake level and major sources of added sugars in the US diet over the past decade.
4) To identify public health strategies effective in reducing the consumption of sugar-sweetened beverages, the greatest contributor of added sugars.

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3 METHODS

3.1 Sample

Data for our study come from the continuous National Health and Nutrition Examination Survey (NHANES) 1999-2008. NHANES is a sequential series of cross-section surveys of the U.S. civilian, non-institutionalized population designed to obtain nationally representative estimates on diet and health indicators. A complex, multistage, probability sampling design was used to randomly select participants for NHANES. Oversampling of certain population subgroups was done to increase the reliability and precision of health status indicator estimates for these groups.[1] Study protocols for the NHANES 1999-2008 were approved by the institutional review board at the National Center for Health Statistics (NCHS).[2] Signed, informed consent was obtained from all participants

Given the unique diets of infants and young toddlers, those < 2 y were not included in our study. Our sample included all those ≥ 2 y who participated in the medical examination component of NHANES and provided a report of dietary intake deemed to be reliable.[3] A record was deemed reliable if it met the minimum criteria for the overall quality and completeness of the reported dietary information, which includes: 1) less than 25% foods with missing descriptive information (e.g., caffeinated or decaffeinated, preparation methods, or brand names); 2) less than 15% foods with missing amounts; and 3) at least one food for every meal reported. As the participants in NHANES are randomly selected and 92% to 93% of those selected completed the interview and provided a dietary report that was deemed reliable[3] any problems due to selection and participation bias can be expected to be minimal, making the results generalizable to the US population.

For our study examining trends in the consumption of added sugars, our sample included 42,446 children and adolescents ≥ 2 y. For our studies looking at the consumption of added sugars and indicators of cardiovascular disease risk our sample was reduced to those who, in addition to meeting the criteria above, also participated in the NHANES fasting laboratory component. The study among US adults included all those ≥19 y (n=8495). Excluded from this sample were: pregnant women, those reporting an unreliable or implausible dietary intake (<600 or > 4,000 kcal/day) (n= 403), those extreme triglyceride levels (>400 mg/dL) or extreme body-mass-index (BMI >65 kg/m^2), and those taking cholesterol-lowering medications. Because insulin resistance is known to alter lipid metabolism and those known to have diabetes are likely to change their dietary practices, those with diagnosed diabetes were also excluded from the sample. After these exclusions, the total sample for this study included 6113 adults (3088 women and 3025 men).

For the study among adolescents, all from the sample above who were age 12 to18 y were included. Excluded from the sample (in order of exclusion) were: those with unreliable[3] or implausible (<600 or >4,500 kcal/day) dietary data, those pregnant, those with extreme triglyceride levels (>300 mg/dL), those with previously diagnosed diabetes, and those with missing covariate data. After exclusions, the total sample for this study included 2,157 adolescents.

3.2 Exposure variable: Added Sugar Intake

In NHANES 1999-2000 and NHANES 2001-2002 one 24-hour dietary recall was used to assess dietary intake from all participants. In NHANES 2003-2004, 2005-06, 2007-2008 a second 24-hour recall was collected from all respondents. For consistency, only the first dietary recall was used to assess intake trends and to examine the association with CVD risk indicators among adults and adolescents. While data from a single 24-hour recall can provide an unbiased estimate of mean intake for a group, i.e. to assess trends in intake, they may not provide a valid estimate of usual dietary intake needed to assess associations with health outcomes.[4] The more variable the intake, the more days of recall are needed to obtain a valid measure. Though little information is available on the variability of added sugars intake, nutrients consumed daily, as added sugars are, will require fewer days of recall. As two days of dietary data were available on a subsample of respondents (those participating in NHANES 2003-2004) a sensitivity analysis was done to determine if the associations with health outcomes were consistent when the mean added sugars intake from two recalls was used.

Nutrient content of the foods consumed by the respondents was determined by NHANES using the Food and Nutrient Database for Dietary Studies, which utilizes food composition data from the United States Department of Agriculture (USDA) National Nutrient Database for Standard Reference.[5] Because the Standard Reference database does not include information on the added sugar content of many foods, we merged the individual food files from NHANES with MyPyramid Equivalents database

(MPED) for the matching years through 2003-2004.[6] The MPED provides MyPyramid food group serving equivalents for all food consumed in NHANES, including added sugars. As MyPyramid serving size equivalents have been released only for the foods reported in the NHANES through the 2003-2004 cycle, we used data from the last release to estimate the added sugar content of foods consumed by participants in NHANES 2005-2006 and 2007-2008. This enabled us to utilize the most recent NHANES dietary data in our study of dyslipidemia among adults and in our study of the trends in the consumption of added sugars over the past decade

To estimate missing added sugar content information, food codes for foods and beverages consumed in 2005-2006 and 2007-2008 were first matched with those on the 2003-2004 dataset. Items with exact food codes matches were assigned the 2003-3004 value of added sugars. Values for foods items without an exact match were imputed using food codes and food descriptions to identify similar foods on the MPED 2003-2004 dataset. For example, "SWEETPOTATO, CANNED IN SYRUP, W/ FAT ADDED" was reported in the 2005-2006 dietary recall, but did not have a corresponding MyPyramid Database equivalent. The added sugar content of this food was assigned the same value as "SWEETPOTATO, CANNED, NS (not specific) AS TO SYRUP." In these cases the default value for the similar food item was used. For processed foods having no similar comparison food on the 2003-2004 dataset, product nutrition label information available on food industry or food and dieting information websites, including: caloriecount.com and fatsecret.com were used. For mixed foods, on-line recipes were used to determine if they contained added sugars and, as necessary, to estimate quantity. Added sugar values were estimated for a total of 337 out of 4871 foods in NHANES 2005-2006 and 280 out of 5219 foods in 2007-2008.

Quantities of added sugar in the MPED are expressed in terms of teaspoons of table (granulated white) sugar (food code 91101010). One teaspoon of added sugar is defined as the quantity of sweetener that contains the same amount of total (nutrient) sugars (4.196 grams) provided by 1 teaspoon (4.2 grams) table sugar. To determine the amount of added sugars consumed in each food and beverage, we multiplied the total amount consumed in grams (as provided in the NHANES database) by the amount of added sugars in each of these foods (teaspoons/100 grams) (as provided in the MPED database). The results for each food consumed were summed to obtain the total added sugars intake in teaspoons and converted to grams by multiplying by 4.2 grams/teaspoon.[7] This result was multiplied by 4 kcal to obtain the total energy from added sugars. Finally, the total energy from added sugars (kcal) was divided by total energy intake (kcal/day) to obtain the percent of total energy from added sugars.

In the MPED added sugars are defined as white sugar, brown sugar, raw sugar, corn syrup, corn syrup solids, high fructose corn syrup, malt syrup, maple syrup, pancake syrup, fructose sweetener, liquid fructose, honey, molasses, anhydrous dextrose, crystal dextrose, and dextrin that are eaten separately or used as ingredients in processed or prepared foods. Total (nutrient) sugars were used to determine amounts of added sugars from caloric sweeteners. Added sugars do not include naturally occurring sugars. For example, they do not include the lactose in milk or the fructose in fruit.

USDA food codes[8] were used to group foods and beverages containing added sugars into the following food groups (sub-groups): sweets (sodas, candies/sugars, fruitades/sports drinks, pre-sweetened coffees and teas, alcohol-containing drinks, and energy drinks; grains (cakes/cookies, ready-to-eat [RTE] cereals, breads/muffins, other grains); dairy (dairy desserts, milk, yogurt, other dairy), fruits and vegetables, protein sources (combination of meat, eggs, beans) and fats/oils. All beverages including sodas, fruitades/sports drinks, coffees/teas, milks, and energy drinks were examined individually as well as combined together as sugar-sweetened beverages (SSBs). For items to which sugar was added at the point of consumption, the quantity of sugar consumed is included in the "candies/sugars" category rather as part of the food or beverage itself. A description of the food codes included in each of the food groups and food subgroups use in our study of the trend in consumption of added sugars is available in Appendix A.

3.3 Outcome variables: Indicators of CVD Risk

Biological indicators known to be associated with CVD[9-11] were measured in NHANES using standardized laboratory procedures that have been described elsewhere.[12] Measured lipids include those identified in the fasting serum or plasma: high-density lipoprotein cholesterol [HDL], total cholesterol [TC] and triglycerides. Measured indicators of glucose metabolism include fasting insulin and glucose. Anthropometric measures (height, weight, and waist circumference) and blood pressure were measured by trained interviewers using standardized equipment and protocols. Body-mass-index

(BMI) was calculated from measured weight and height as kg/m^2 and for children BMI was converted to age- and sex-standardized percentiles and z-scores based on the Centers for Disease Control and Prevention (CDC) 2000 growth charts.[13]

Low-density lipoprotein levels were calculated using the Friedewald formula: LDL-cholesterol = total cholesterol – HDL-cholesterol– triglycerides/5.[14] The homeostasis model assessment (HOMA-IR) is an estimate of insulin resistance derived from fasting glucose and insulin levels, with higher levels representing greater degrees of insulin resistance.[15] HOMA-IR was calculated using the formula developed by Mathews et. al: fasting insulin (pmol/L)*fasting glucose (mmol/L)/22.5.[16]

3.4 Statistic Analysis

Statistical Analysis Software (SAS), version 9.2 (SAS Institute, Cary, IN) was used for all analyses. Procedures that account for the complex sampling methods used in NHANES were applied. Sample weights that reflect the probability of selection, nonresponse, and post-stratification adjustments were calculated for each combination of survey cycles included in our studies.[17] These weights were used to ensure that results were representative of the U.S. population. Respondents were grouped according to their consumption of added sugars. For the adult study groupings incorporated the limits for added sugars specified in existing dietary guidelines as follows: <5% (referent group), 5-<10%, 10–<17.5%, 17.5-<25%, and ≥25% of total energy intake. For the adolescent study, to ensure sufficiently large sample sizes in each group, respondents were grouped into 6 approximately equally-sized groups by the % of their total energy intake from added sugars: 0 <10%, 10–<15%, 15-<20%, 20-<25%, 25-<30%, and ≥30%.

Percentages, means, and standard errors (SE) of key variables were calculated to describe the sample at each level of added sugars intake. Linear and logistic regression models were used to assess the relationship between intake of added sugars and our outcome measures while controlling for the effect of potentially confounding variables. As the distribution of triglycerides was skewed, the values in the linear regression models were log transformed and geometric means are presented. Estimate statements in the regression models were used to determine the adjusted mean of each of the measures of CVD risk for each level of added sugar intake.[18] Contrasts were used to specify linear tests among the levels of added sugars consumption and to compare each group of respondents to the referent group for each of the outcomes of interest.[18] Chi-square tests were used to test differences in categorical variables and Wald f-tests were used for continuous variables. All p-values were 2-sided. P-values <0.05 were considered significant.

Additional steps were taken to identify the macronutrients to be included as covariates in the regression models in the adolescent study than were used in the adult study. As the adult study included only lipid measures as outcomes, a decision was made *a priori* to control for intake of each of the specific types of dietary fats (saturated, MUFAs, and PUFAs) as well as carbohydrates (other than added sugars), in addition to total energy intake. Protein intake was excluded from these models. The results of these models can be interpreted at the effect of replacing protein in the diet with added sugars.[4]

Given the additional outcome measures assessed in the adolescent paper, were done to specify the most appropriate macronutrients to be included in each of the regression models. First we did bivariate analyses to assess the association between the intake of total fat and the intake of protein and each of our outcomes. As the energy-adjusted residuals for protein but not fat were found to be associated with measures of dysglycemia (fasting insulin, fasting glucose, and HOMA-IR), blood pressure, and adiposity (BMI and waist circumference) we included protein but not fat intake as a covariate in these models. The results obtained using these models can be interpreted as the effect of replacing fat in the diet (the macronutrient left out of the models) with added sugars.[4] In contrast, the energy adjusted residuals for the intake of PUFAs, MUFAs, and saturated fats, but not proteins were each found, in bivariate analyses, to be associated with blood lipid measures (HDL, LDL, TC, and triglycerides). Therefore, we included the intake of each of these fats but not protein in the models with lipid measures as the outcome.

Given the high correlation between BMI and waist circumference ($r=0.88$, $p<0.001$) and problems with multicollinearity (condition index >30 and variance decomposition proportion>0.5) in models in the adolescent study that included both variables, waist circumference was dropped from the regression models. No problems with multicollinearity were observed when all covariates were maintained in the models in the adult study.

As the postprandial lipoprotein[19] and insulin responses[20] have been shown to differ by body weight, race, and sex, we tested for the presence of effect modification between level of added sugars intake and each of these variables by including a multiplicative term for each in the models. For testing, body weight was dichotomized as not overweight (BMI percentile <85th for adolescents; BMI <25 for adults) and overweight (BMI percentile $\geq$85th for adolescents; BMI $\geq$25 for adults).[21] A p-value of <0.10 was considered significant.

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4 Caloric Sweetener Consumption and Dyslipidemia among US Adults

Welsh JA, Sharma A, Abramson JL, Vaccarino V, Gillespie C, Vos MB. Caloric sweetener consumption and dyslipidemia among US adults. *JAMA.* 2010 Apr 21;303(15):1490-1497.
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The findings of this paper are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention (CDC).

ABSTRACT

Context. Dietary carbohydrates have been associated with dyslipidemia, a lipid profile known to increase cardiovascular disease risk. Added sugars (caloric sweeteners used as ingredients in processed or prepared foods) are an increasing and potentially modifiable component in the US diet. No known studies have examined the association between the consumption of added sugars and lipid measures.

Objective. To assess the association between consumption of added sugars and blood lipids levels in US adults.

Design, Setting, and Participants. Cross-sectional study among US adults (n=6113) from the National Health and Nutrition Examination Survey (NHANES) 1999-2006. Respondents were grouped by intake of added sugars using limits specified in dietary recommendations, 0<5% (referent), 5-<10%, 10-<17.5%, 17.5-<25%, and ≥25% of total calories. Linear regression was used to estimate adjusted mean lipid levels. Logistic regression was used to determine adjusted odds ratios (AORs) of dyslipidemia. Interactions between added sugars and sex were evaluated.

Main Outcome Measures. Adjusted mean HDL, geometric mean TG, and mean LDL levels and AORs of dyslipidemia, including low HDL (<40mg/dL women; <50mg/dL men), high TG (≥150mg/dL), high TG:HDL (>3.8), or high LDL (≥130mg/dL). Results were weighted to be representative of the US population.

Results. A mean of 15.8% of consumed calories was from added sugars. Among those consuming 0-<5%, 5-<17.5%, 17.5-<25%, and ≥25% of calories as added sugars, adjusted mean HDLs were respectively, 58.7, 57.5, 53.7, 51.0, and 47.7 mg/dL (p-linear trend<0.001), geometric mean TGs were 105, 102, 111, 113, and 114 mg/dL (p-

linear trend<0.001) and LDLs, which were modified by sex, were 116, 115, 118, 121, and 123 mg/dL among women (p-trend=0.04). There were no significant trends in LDLs among men. Among higher consumers (≥10% added sugars) the odds of low HDL were 50%->300% greater compared to the referent (<5% added sugars).

Conclusion. There is a statistically significant correlation between dietary added sugars and blood lipid levels among US adults.

BACKGROUND

Increased carbohydrate consumption has been associated with lower high-density lipid protein cholesterol (HDL), higher triglyceride (TG) levels, and higher low-density lipoprotein cholesterol (LDL) levels,[1] a lipid profile associated with cardiovascular disease (CVD) risk.[2] In the US, total sugar consumption has increased substantially in recent decades, largely due to an increased intake of added sugars.[3] "Added sugars," defined as caloric sweeteners used as ingredients in processed or prepared foods,[4] are used by the food industry and consumers to increase the desirability of foods.[5] Dietary data from 1994-96 demonstrate that Americans $\geq$2 y consume nearly 16% of their daily energy as added sugars.[3] Today, the most commonly consumed added sugars are refined beet or cane sugar (sucrose) and high fructose corn syrup (HFCS).[6]

While chemically there appears to be little difference between naturally occurring sugars and those added to foods, in 2000 the US Dietary Guidelines began to use the term "added sugars" to help consumers identify foods that provide energy but few micronutrients or phytochemicals.[7] Consumption of foods high in added sugars has been associated with increased obesity,[8] diabetes,[9] dental caries,[10] and decreased diet quality.[11] Dietary guidelines for added sugars vary widely. The Institute of Medicine (IOM) suggests a limit of 25% of total energy,[12] the World Health Organization (WHO) advises <10% of total energy,[13] and recent recommendations from the American Heart Association (AHA) advise limiting added sugars to <100 calories daily for women and 150 calories for men (~5% of total energy).[14]

Though consumption of added sugars represents an important and potentially modifiable component of the diet, no known studies have examined the correlation between consumption of added sugars and lipid measures. The purpose of this study was to assess this association among US adults

SUBJECT AND METHODS

Subjects

Study subjects include US adults >18 years who participated in the National Health and Nutrition Examination Survey (NHANES) 1999-2006. NHANES is a continuous survey of the US civilian, noninstitutionalized population designed to obtain nationally representative estimates on diet and health indicators.[15] The sample for NHANES is selected using a complex, multistage sampling design. Study protocols for NHANES 1999-2006 were approved by the institutional review board at the National Center for Health Statistics (NCHS).[16] Signed, informed, consent was obtained from all participants.

A total of 8495 adults over the age of 18 provided fasting samples for NHANES 1999-2006. Excluded from this sample were: pregnant subjects (n= 495); subjects reporting an unreliable or implausible dietary intake (<600 or > 4,000 kcal/day) (n= 403); those with extreme triglyceride levels (>400 mg/dL) (n=206) or extreme body-mass-index (BMI >65 kg/m^2) (n=1); and those taking cholesterol-lowering medications (n=887). Because insulin resistance is known to alter lipid metabolism and those known to have diabetes are likely to change their dietary practices, those with diagnosed diabetes (n=390) were also excluded from the sample. After these exclusions, the total sample for this study included 6113 adults (3088 women and 3025 men).

Added Sugars and Other Dietary Intake

An interviewer-assisted 24-hour dietary recall (midnight to midnight of the previous day) was used to assess dietary intake from all respondents. As associations between nutrient intake assessed using one 24-hour recall and health outcomes can be attenuated due to the inability to account for day-to-day variations in intake,[17] we repeated our analysis among a subsample of respondents from whom 2 dietary recalls were collected (respondents participating in NHANES 2003-06).

Nutrient content of the foods consumed was determined by NHANES using the Food and Nutrient Database for Dietary Studies, which utilizes food composition data from the United States Department of Agriculture (USDA) National Nutrient Database for Standard Reference.[18] Because the Standard Reference database does not include information on the added sugar content of many foods, individual food files from NHANES were merged with the most recently released MyPyramid Equivalents Database files, those for 1999-2000, 2001-02, and 2003-04.[19] The MyPyramid Equivalents Database translates the amounts of foods eaten in the dietary intake component of the NHANES into the number of equivalents of the MyPyramid food groups using recommended serving sizes from the USDA Food Guide Pyramid. Added sugars are one of the 30 food groups and subgroups used in the Food Guide Pyramid. A description of the MyPyramid database[20] and the methods used to calculate the sugar content of foods can be found elsewhere.[21]

As MyPyramid serving size equivalents have been released only for the foods reported in the NHANES through the 2003-2004 cycle, we used the available data to estimate the added sugar content of foods consumed by participants in NHANES 2005-2006 in order to include the most recent NHANES data in our analysis. In the 2005-2006 NHANES cycle, foods represented by 5308 unique USDA food code and modification code combinations were reported by respondents. Added sugar content for 4971 of these foods was available on the MyPyramid Equivalents 2003-04 database, leaving 337 foods for which the added sugar content had to be estimated. The majority of these, 213 of the 337, were slightly modified forms of foods for which added sugar content was available on the My Pyramid database. To these foods, the added sugar content of the unmodified form was assigned. The added sugar values for the majority of the remaining foods were imputed using values obtained from similar foods. For example, "SWEETPOTATO, CANNED IN SYRUP, W/ FAT ADDED" was reported in the 2005-2006 dietary recall, but did not have a corresponding MyPyramid Database equivalent. The added sugar content of this food was assigned the same value as "SWEETPOTATO, CANNED, NS (not specific) AS TO SYRUP." This substitution method was used for 92 USDA food code and modification code combinations. The added sugar values for the remaining 32 items were calculated directly from nutrition label information available on food industry websites.

Lipid Measures

Dyslipidemia is commonly characterized by three lipid abnormalities: elevated TG, elevated small LDL particles, and reduced HDL.[2] We used the cut-offs for plasma lipids as established by the Adult Treatment Panel III (ATP III) guidelines published by the National Institutes of Health.[2] These include: low HDL (<40mg/dL women; <50mg/dL men), high LDL ($\geq$130mg/dL), or high TG ($\geq$150mg/dL). In addition, the ratio of TG to HDL was used as a measure of dyslipidemia because a ratio >3.8 has been shown to correlate well with the LDL phenotype (type B) that is associated with the small LDL particles most strongly linked with CVD risk.[22] Standardized laboratory procedures used to obtain serum or plasma HDL and TG measures have been described elsewhere.[23] The Friedewald formula:

[LDL-cholesterol] = [total cholesterol] – [HDL-cholesterol] – [triglycerides/5]

was used by NHANES to calculate LDL levels.[23]

Covariates

Intake of added sugars was examined in relation to known risk factors for cardiovascular disease.[24] Variables that have been demonstrated to be associated with intake of carbohydrates as well as lipid outcome measures were included in regression models to evaluate and, as necessary, control for possible confounding. These include measures obtained by NHANES staff using standardized protocols, including: body mass index (BMI) (calculated from measured weight and height [kg/m^2]); waist circumference (cm); and blood pressure (mmHg). Self-reported measures include: participant's age (y); sex; leisure time physical activity over the previous month (sum of the duration [minutes]*frequency*metabolic equivalent intensity level [MET score] for each activity); cigarette use (# cigarettes/day); alcohol consumption (#drinks/day); history of attempted weight loss previous year (y/n); weight change (pounds) (calculated as the difference between reported current weight and reported weight one year previous); and use of hypertension medication. As intake of added sugars[25] and blood lipid response to diet have[26] both been shown to vary by race/ethnicity, self-identified race/ethnicity[15] was included as a covariate.

Dietary covariates included the energy adjusted nutrient residuals for fiber, other carbohydrates (other than added sugars and fiber), saturated fatty acids (SFAs), polyunsaturated fatty acids (PUFAs), monounsaturated fatty acids (MUFAs), and cholesterol. These nutrient residuals were calculated using linear regression models with total calorie intake as the predictor and the absolute intake of each nutrient of interest (in grams) as the outcome.

DATA ANALYSIS

Statistical Analysis Software (SAS Institute, version 9.2) was used for all analysis. Procedures that account for the complex sampling methods used in NHANES were applied. Sample weights for the 6 years of data were calculated as follows: 1/2* wtsfa4yr (fasting sample weight for NHANES 1999-2002) plus 1/4* wtsfa2yr (fasting sample weight for NHANES 2003-04) plus 1/4 wtsaf2yr (fasting sample for NHANES 2005-06)[27] and used to ensure results were representative of the US population. Respondents were grouped according to their consumption of added sugars: <5% (referent group), 5-<10%, 10–<17.5%, 17.5-<25%, and ≥25% of total energy intake. These groupings incorporate the limits for added sugars specified in existing dietary guidelines. All of the p-values were 2-sided. P-values <0.05 were considered significant.

To determine the amount of added sugars consumed, we multiplied the total amount of each food consumed in grams (as provided in the NHANES database) by the amount of added sugars in each of these foods (teaspoons/100 grams) (as provided in the MyPyramid database). The results for all foods were summed to obtain the total intake of added sugars for each respondent in teaspoons. This was converted to grams by multiplying by 4.2 grams/teaspoon.[28] The result in grams was multiplied by 4 to obtain the total calories from added sugars. Finally, the result was divided by total energy intake (kcal/day) to obtain the percent of total energy from added sugars.

Weighted frequencies, means, and confidence intervals (CI) were calculated to describe the sample population by added sugar consumption level. The distribution of TG was skewed, therefore values were log transformed and geometric means are presented. As differences in the postprandial lipoprotein response have been shown between men and women,[29, 30] we first tested for the presence of an interaction ($p<1.0$) by including a multiplicative term between percent total energy from added sugars and sex in each of the linear regression models. Estimate statements in linear regression models, with intake of added sugars (categorized by consumption level) as the predictor, were used to determine the adjusted mean of each of the lipid measures with increased consumption of added sugars.

Logistic regression models were used to estimate the adjusted odds of dyslipidemia among those who consumed higher levels of added sugars compared to the referent (those consuming <5% energy from added sugars). The presence of a linear trend was tested by defining a linear contrast in each of the linear and logistic regression models.

A sensitivity analysis was done using dietary data from a second 24-hour recall collected from a 40% subsample of the respondents (those participating in NHANES 2003-04 and NHANES 2004-05) (n=2506). In this analysis, we used the mean intake of added sugars from the 2 dietary recalls (% total energy from added sugars) and controlled for the same dietary covariates (using the mean of the 2 dietary recalls for each) and other covariates as were specified in the primary analyses.

RESULTS

A description of the study sample by intake of added sugars is provided in Table 1. As added sugars increase, respondents are more likely to be younger, non-Hispanic black, and low-income. Intake of added sugars was correlated positively with the number of cigarettes smoked and negatively with being hypertensive. Self-reported weight change over the previous year tended to be greater among those consuming more added sugars: an average gain of 2.8 pounds among those with $\geq$ 25% total energy from added sugars compared with a loss of 0.3 pounds among those consuming <5% total energy from added sugars (p-linear trend<0.001). No significant trends were seen between consumption of added sugars and BMI or waist circumference.

Daily consumption of added sugars averaged 89.8 g (21.4 tsp), or 359 calories. This represents 15.8 % (95% confidence interval [CI] 15.3, 16.4) of total daily caloric intake (total energy) and 30.7% (95% CI: 29.7, 31.7) of total carbohydrate intake (not shown). Total energy and percent total energy from carbohydrates increased as the proportion of energy from added sugars increased from <5% total energy to ≥25% (p-trend<0.001 for both) (Table 1). Intake of added sugars was negatively correlated with percent total energy (% energy) from total, polyunsaturated, monounsaturated and saturated fats, protein, fiber, and cholesterol (p-linear trend<0.001 for all).

In the linear regression models we found no significant modification by sex for HDL (p=0.14), log transformed TG (p=0.89), or ratio of TG/HDL (p=0.93), but we did find that sex significantly modifies the correlation of added sugars and LDL levels (p=0.01). Adjusted mean HDL levels were lower among higher consumers of added sugars. Among those consuming 0-<5%, 5-<10%, 10-17.5%, 17.5-<25, and ≥25% energy from added sugars, HDL levels were 58.7 (95% CI: 57.4, 60.0), 57.5 (95% CI: 56.5, 58.4), 53.7 (95% CI: 53.0, 54.4), 51.0 (95% CI: 50.1, 51.9), and 47.7 (95% CI: 46.7, 48.8) mg/dL, respectively, p-linear trend<0.001 (Figure 1).

Among the consumption groups as defined above, geometric mean TG levels were 105 (95% CI: 100, 109), 102 (95% CI: 98, 106), 111 (95% CI: 108, 114), 113 (95% CI: 109, 117), and 114 (95% CI: 110, 118) mg/dL, respectively (p-linear trend<0.001) (Figure 2); TG/HDL ratios were 2.4 (95% CI: 2.2, 2.5), 2.3 (95% CI: 2.2, 2.4), 2.6 (95% CI: 2.5, 2.7), 2.8 (95% CI: 2.6, 2.9), 3.1 (95% CI: 2.9, 3.2), respectively, (p-trend<0.001) (not shown); and LDL levels among women were 116 (95% CI: 111, 120), 115 (95% CI: 110, 118), 118 (95% CI: 116, 120), 121 (95% CI:117, 124), and 123 (95% CI: 118, 128), respectively (Figure 3) (p-trend=0.04). There were no significant linear (p=0.17) or non-linear trends (p=0.39) between intake of added sugars and LDLs among men.

The odds of having a low HDL were greater with higher consumption of added sugars (Table 2). Compared to those consuming <5% energy from added sugars (referent), the adjusted odds ratios (AORs) among those consuming 5-<10%, 10-<17.5%, 17.5-25%, and ≥25% were 1.0 (95% CI: 0.8, 1.4), 1.5 (95% CI: 1.2-1.9), 1.9 (95% CI: 1.5, 2.6), and 3.1 (95% CI: 2.3-4.3), respectively (p-linear trend<0.001). The trends in AORs with higher intake of added sugars were also positive for TG (p=0.02) and for TG/HDL (p-linear trend<0.001) (see Table 2, Model II). AORs of high TG among the consumption groups as defined above were 0.8 (95% CI: 0.7, 1.1), 1.1 (95% CI: 0.9-1.4), 1.3 (95% CI: 1.0, 1.6), and 1.2 (95% CI: 0.9, 1.6), respectively, compared to the referent and AORs of high TG/HDL were 0.7 (95% CI: 0.5, 1.0), 1.1 (95% CI: 0.8, 1.4), 1.5 (95% CI: 1.1, 2.0), and 1.6 (95% CI:1.1, 2.3) mg/dL, respectively. There was no significant trend in AORs of high LDL with greater intake of added sugars.

The adjusted mean HDL, geometric mean TG, and mean TG/HDL ratio obtained when using the mean intake of added sugars from the subsample with 2 24-hour dietary recalls as the exposure were similar in magnitude (≤10%) and in trend to those obtained in the full sample using 1 24-hour recall (p-linear trend: HDL<0.001; log TG<0.02;

TG/HDL<0.001) (not shown). Among women in the subsample there was no longer a positive linear trend in LDL levels with greater added sugar intake (p=0.61).

DISCUSSION

The consumption of large amounts of added sugars, an important source of low-nutrient calories, is a relatively new phenomenon. It was not until the mid-19th century that these sweeteners became widely available and consumption began to increase dramatically.[31] Americans now consume a substantial proportion of their total energy as added sugars. The adults in our study consumed nearly 1/6 (15.8%) of their daily calories from added sugars. This represents a substantial increase from 1977-78, when added sugars contributed only 10.6% of the calories consumed by adults.[32]

Monitoring the trends in consumption and understanding the effect added sugars have on cardiovascular and other disease risk is critically important because added sugars are a potentially modifiable source of calories. While it has been known for some time that carbohydrates can increase the risk of CVD by altering lipid profiles, this knowledge has been difficult to translate effectively into improvement in dietary practices. This is likely due to lack of data identifying clear points for consumption limits and because carbohydrates and sugars are found in a wide variety of foods ranging from fruits, vegetables, and whole grains to soft drinks. Unlike most other carbohydrates, added sugars alone contribute no nutrients other than energy. Added sugars are food additives that can be recognized by consumers and have been proposed for specific labeling on food and beverage packaging. The results of our study demonstrate that increased added sugars are associated with lower HDL, higher TG, and higher TG:HDL ratios—important CVD risk factors, thus supporting as a public health priority efforts to reduce its consumption.

The mechanism through which the dysmetabolic effects of carbohydrates occur is not completely understood. Studies suggest that these effects could be mediated by fructose, a monosaccharide found in large quantities in nearly all added sugars. Fructose has been shown to increase de novo lipogenesis in the liver, hepatic triglyceride synthesis and secretion of very-low-density-lipoproteins. Fructose also appears to decrease the peripheral clearance of lipids.[14]

Our results support the importance of dietary guidelines that encourage consumers to limit their intake of added sugars. The 2005 US Dietary Guidelines do not provide a quantified intake guideline for added sugars, suggesting consumers "choose and prepare foods and beverages with little added sugars or caloric sweeteners". The new Food Guide Pyramid (the federal nutrition education tool designed to translate the Dietary Guidelines into kinds and amounts of food to eat each day) includes calories consumed as added sugars as part of "discretionary calories," those not required to meet nutrient needs. Most discretionary calorie allowances are very small (between 100 and 300 calories), especially for those who are not physically active—a level of added sugars substantially lower than that currently being consumed by adults in the US. New guidelines from the AHA encourage adults to limit added sugars more than any of the previously issued guidelines.[12-14] Women are advised to limit their added sugars to less than 100 calories daily and men to less than 150 calories (approximately 5% of total energy intake).

Recommendations to reduce CVD risk have long promoted a diet low in fat and cholesterol in order to lower serum total and LDL cholesterol.[33,34] Possibly as a result, the consumption of added fats and oils appears to have decreased and refined carbohydrate intake appears to have increased.[35] While the overall effect of these dietary trends is unclear, there is a need to review the dietary recommendations to see how they influence intake of added sugars and to develop further understanding of the role different carbohydrates and sugars play in increasing chronic disease risk.

Our study has several important strengths. First, we have used nationally representative data and, to our knowledge, this is the first study to assess the association between intake of added sugar and lipid measures among US adults. Second, we were able to control for several important confounding variables, including BMI, physical activity, total energy intake and other dietary components. Finally, the use of trained staff following standardized protocols to measure height and weight and collect laboratory and interview data increases the accuracy and validity of the data collected.

Our study is also subject to some limitations. A single 24-hour dietary recall was used to assess diet and may not represent the usual diet of respondents. Compared with food frequency questionnaires, 24-hour recalls provide greater detail on the types and amounts of food eaten but the inability to measure within-person variability can cause misclassification.[36] The similarity between the results in the subsample analysis using the mean of 2 dietary recalls and those obtained in the full sample with 1 dietary recall suggests that the effect of misclassification due to unmeasured variability was limited in our study. While underreporting of certain foods high in sugar, such as sodas and sweets, may occur more frequently among some groups, such as those overweight or obese,[37] who are also at increased risk of dyslipidemia, systematic misclassification of this type would be expected to bias our findings toward the null. In addition, studies that employ a cross-sectional study design such as ours are limited by the fact that exposures and outcomes are measured at the same time. As a result, our data can be used only to assess associations. They cannot be used to determine causality or even to assess directionality or temporality of the associations observed.

In conclusion, higher consumption of added sugars is associated with several important measures of dyslipidemia, an important risk factor for CVD among US adults. Though long-term trials to study the effect of reducing added sugars and other carbohydrates on lipid profiles are needed, our data supports dietary guidelines that target a reduction in the consumption of added sugar.

Author Contributions: J. Welsh had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: Welsh, Vos

Acquisition of data: Welsh

Analysis and interpretation of data: Welsh, Sharma, Abramson, Vaccarino, Vos, Gillespie

Drafting of the manuscript: Welsh, Vos

Critical revision of the manuscript for important intellectual content: Welsh, Vos, Sharma, Abramson, Vaccarino

Statistical analysis: Welsh, Abramson, Sharma, Gillespie

Administrative, technical, or material support: Vos

Financial Disclosures: None reported

Funding/Support: None

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Disclosures: Dr Vos is the author of a book about childhood obesity and receives royalties.

Acknowledgements: Dr. Vos is supported in part by a career award from the National Institutes of Diabetes and Digestive and Kidney Diseases (K23DK080953) and from the Children's Digestive Health and Nutrition Foundation

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Figure Legends

Figure 1. Multivariable-adjusted mean HDL levels (mg/dL) by level of added sugar intake (% total energy) among US adults, NHANES 1999-2006 (p-linear trend <0.001).

[a]Adjusted mean is significantly lower than the referent (<5% total energy), p<0.001.

Figure 2. Multivariable-adjusted geometric mean triglyceride levels (mg/dL) by level of added sugar intake (% total energy) among US adults, NHANES 1999-2006 (p-linear trend =0.02).

[a,b]Adjusted mean is significantly higher than the referent (<5% total energy), [a]p<0.01, [b]p<0.05.

Figure 3. Multivariable-adjusted mean LDL levels (mg/dL) by level of added sugar intake among US men and women, NHANES 1999-2006. Linear trend: p=0.047 for women; p=0.17 for men.

Table 4-1. Demographic and Dietary Characteristics of Adults (>18 y) in NHANES 1999-2004 by Percent Total Energy Intake from Added Sugars[a,b,c]

Characteristics	% Total Energy from Added Sugar														
	0 - <5% (n=893)			5 - <10% (n=1124)			10 - <17.5% (n=1751)			17.5 - <25% (n=1210)			≥25% (n=1135)		
Age, y, mean [SD], CI[d]	45.9	[18.1]	44.7, 47.1	45.7	[22.1]	44.0, 47.0	44.5	[20.3]	43.5, 45.5	42.6	[19.2]	41.5, 43.7	38.1	[16.4]	37.1, 39.1
Male, No. (%), CI	444	(48)	44, 53	551	(46)	42, 49	855	(46)	43, 49	628	(52)	49, 55	588	(47)	43, 50
Non-Hispanic white, No. (%), CI[f]	465	(71)	68, 78	619	(75)	72, 79	897	(73)	69, 77	555	(68)	64, 72	493	(70)	64, 75
Non-Hispanice black, No. (%), CI[d]	144	(8.2)	6, 10	174	(8.0)	6,11	316	(10)	8, 12	276	(14)	11, 17	313	(15)	11, 18
Hispanic, No. (%), CI	229	(11)	8, 15	289	(12)	9, 15	475	(13)	10, 16	355	(15)	12, 18	301	(13)	9, 16
Income (below poverty)[g], No. (%), CI[d]	194	(14)	11, 17	187	(18)	14, 21	415	(18)	16, 20	287	(18)	15, 20	318	(23)	20, 26
Physical activity[h], mean (se), CI[f]	5217	(423)	4370, 606	4984	(379)	4226, 574	5205	(351)	4503, 5908	5553	(494)	4564, 6541	3957	(323)	3309, 4605
Alcohol, drinks/d, mean (se), CI	2.3	(0.1)	2.0, 2.5	1.8	(0.1)	1.6, 2.0	1.8	(0.1)	1.7, 2.0	1.7	(0.1)	1.6, 1.9	2.0	(0.1)	1.8, 2.2
Smoking, cigarettes/d, mean (se), (	3.2	(0.3)	2.6, 4.0	2.5	(0.3)	1.9, 3.1	3.5	(0.4)	2.7, 4.3	3.7	(0.6)	2.8, 4.5	6.2	(0.9)	4.5, 8.0
Waist circumf., cm, mean (se), CI	95.5	(0.8)	93.8, 97.2	94.9	(0.7)	93.5, 96.7	94.0	(0.5)	92.9, 95.0	94.5	(0.6)	92.2, 94.4	95.0	(0.6)	93.9, 96.1
BMI, kg/m2, mean (se), CI	27.9	(0.3)	27.2, 28.5	27.8	(0.3)	27.2, 28.3	27.3	(0.2)	26.9, 27.7	27.7	(0.2)	27.3, 28.2	28.0	(0.2)	27.6, 28.5
Weight change, lbs, mean (se), CI[d]	-0.28	(0.7)	-1.6, 1.1	-0.2	(0.5)	-1.2, 0.8	+0.9	(0.4)	0.19, 1.7	+1.5	(0.5)	0.5, 2.4	+2.8	(0.6)	1.6, 4.0
Attempted weight loss, No. (%), CI	266	(37)	33, 41	353	(38)	35, 42	502	(37)	35, 40	346	(33)	29, 37	332	(35)	32, 39
Hypertensive[i], No. (%), CI[e]	200	(19)	15, 23	244	(21)	17, 24	319	(15)	13, 17	205	(14)	11, 16	174	(14)	11, 17
Total energy, kcal/d, mean (se)[d]	2038	(33)	1975, 210(	2172	(27)	2119, 2226	2235	(21)	2194, 2277	2315	(31)	2252, 2377	2312	(35)	2242, 2382
Carbohyd., %energy, mean (se),CI[d]	40.9	(0.8)	39.8, 42.0	45.5	(0.4)	44.7, 46.2	48.4	(0.3)	47.8, 49.0	52.3	(0.3)	51.6, 53.0	59.8	(3.2)	59.1, 60.4
Added sugar, g, mean (se), CI[d]	13.6	(0.4)	12.7, 14.5	41.4	(0.6)	40.1, 42.6	76.7	(0.7)	75.2, 78.2	122	(1.6)	118, 125	192	(3.3)	185, 199
Fiber, g, mean (se), CI[d]	16.2	(0.5)	15.2, 17.1	17.6	(0.4)	16.7, 18.4	16.1	(0.3)	15.5, 16.6	15.0	(0.1)	14.2, 15.9	12.0	(0.3)	11.4, 12.5
Protein, % energy, mean (se), CI[e]	18.1	(0.3)	17.6, 18.7	16.6	(0.2)	16.3, 17.0	15.5	(0.1)	15.3, 15.8	14.2	(0.1)	13.9, 14.5	11.8	(0.1)	11.6, 12.1
Fats, % energy, mean (se), CI[e]	35.6	(0.5)	34.5, 36.7	34.9	(0.4)	34.1, 35.7	34.3	(0.3)	33.8, 34.8	33.2	(0.3)	32.6, 33.7	28.9	(0.2)	28.4, 29.4
MUFAs, % energy, mean (se), CI[e]	13.3	(0.2)	12.8, 13.7	12.9	(0.2)	12.6, 13.3	12.7	(0.1)	12.4, 12.9	12.3	(0.1)	12.1, 12.5	10.8	(0.1)	10.6, 11.0
PUFAs, %energy, mean (se), CI[e]	7.8	(0.2)	7.4, 8.2	7.5	(0.1)	7.2, 7.8	7.2	(0.1)	6.9, 7.3	6.9	(0.1)	6.6, 7.2	5.8	(0.1)	5.7, 6.0
SFAs, % energy, mean (se), CI[e]	11.3	(0.2)	10.8, 11.7	11.3	(0.2)	10.9, 11.7	11.4	(0.1)	11.1, 11.7	11.0	(0.1)	10.7, 11.3	9.7	(0.1)	9.4, 9.9
Cholesterol intake, g, mean (se), CI[e]	312	(10)	291, 333	293	(9.2)	275, 312	308	(7.2)	293, 322	295	(6.7)	282, 309	238	(7.7)	222, 253

Abbreviations: y=year; NHANES=National Health and Nutrition Examination Survey; kcal=kilocalories; %=percent; SD=standard deviations; CI=95% confidence interval; se=standard error; No.=number; d=day; % energy= % total enery intake; MUFA=mono-unsaturated fatty acids; PUFA=poly-unsaturated fatty acids; SFA=saturated fatty acids

[a]n=4605; excluded: pregnant, implausible diet; diabetic (diagnosed or suspected with fasting blood sugar>120); TG>400; treatment for elevated cholesterol

[b]Results were weighted and adjusted to account for NHANES complex sampling methodology

[c]Analysis of Contrasts used to test trends, Chi-square tests for categorical variables and Wald F-tests for continuous variables.

[d,e,f]P-linear trend:[d]<0.001;[e]<0.01;[f]<0.05

[g]Income level was dichotomized based on the poverty:income ratio (ratio of annual family income to federal poverty line). Below poverty refers to persons at or below 130% of poverty.

[h]Physical activity defined as the sum of the: duration (minutes)*frequency*metabolic equivalent intensity level [MET score] for each activity

[i]Hypertension defined as systolic blood pressure≥130 and diastolic blood pressure ≥85 mmHg or taking hypertensive medication.

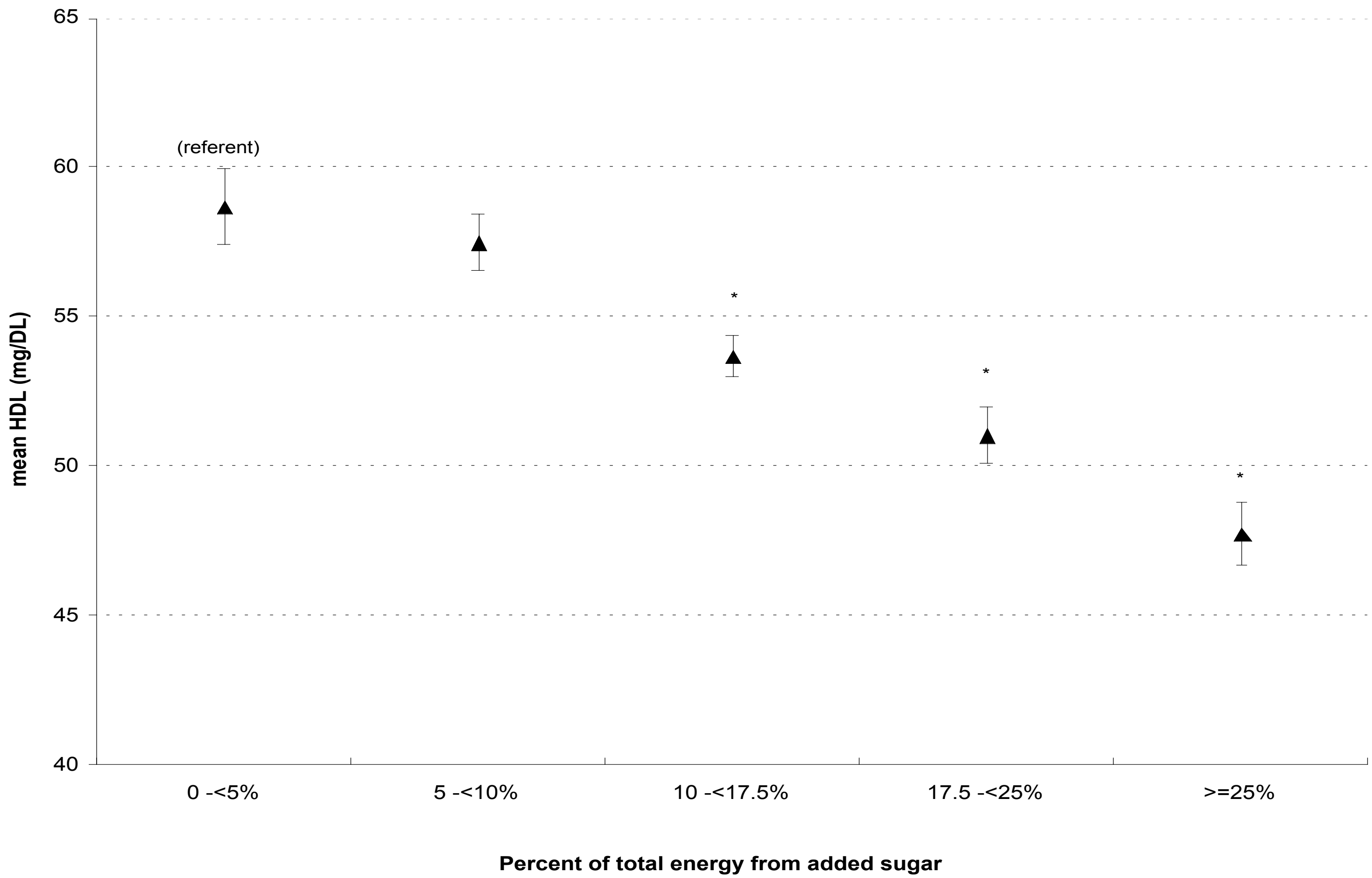

Figure 4-1. Multivariable-Adjusted Mean HDL-C Levels by Level of Added Sugar Intake Among US Adults, NHANES 1999-2006. (p-linear trend <0.001). [a]Adjusted mean is significantly lower than the referent (<5% total energy), p<0.001.

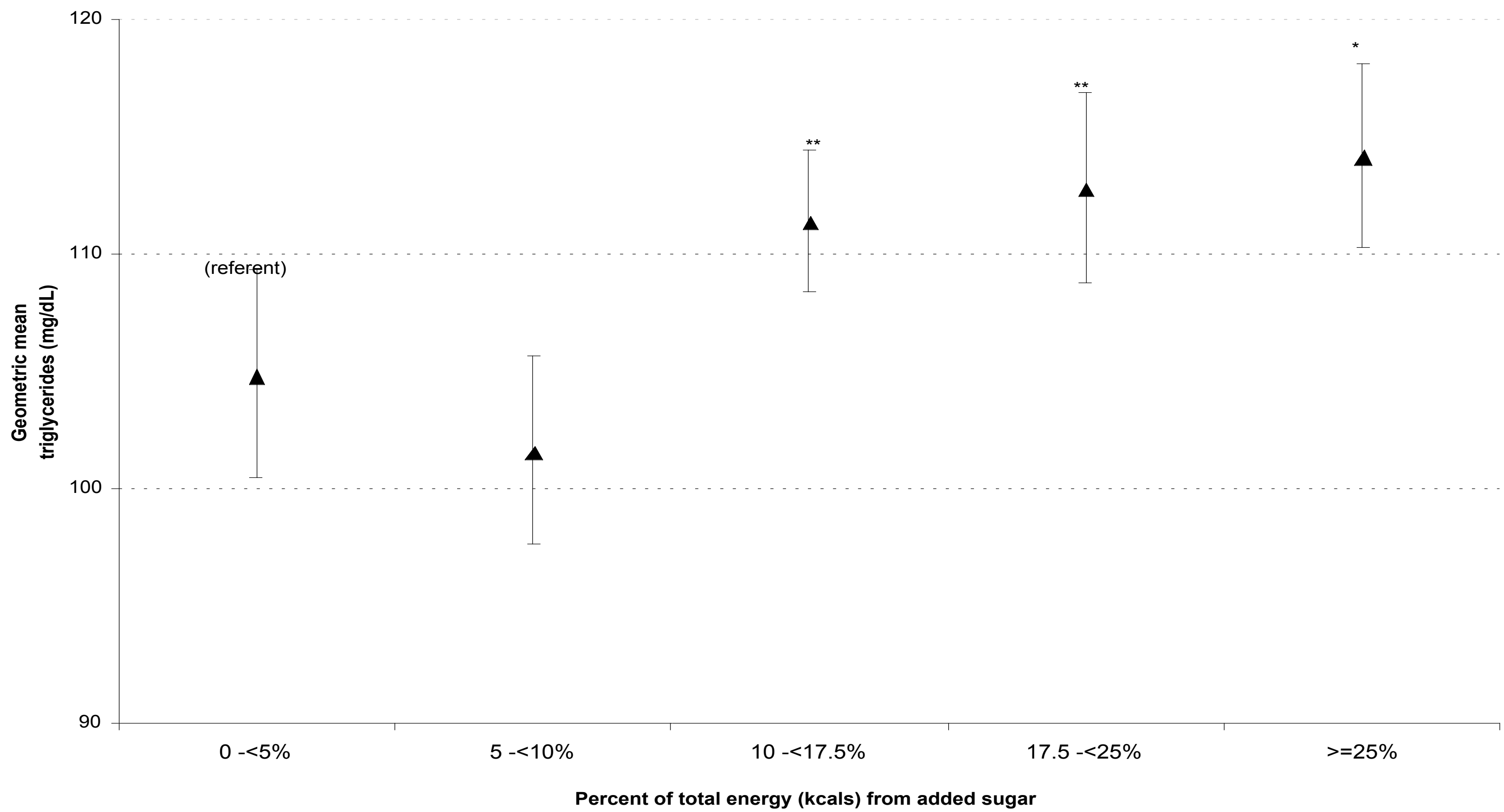

Figure 4-2 Multivariable-adjusted geometric mean triglyceride levels (mg/dL) by level of added sugar intake (% total energy) among US adults, NHANES 1999-2006 (p-linear trend =0.02).

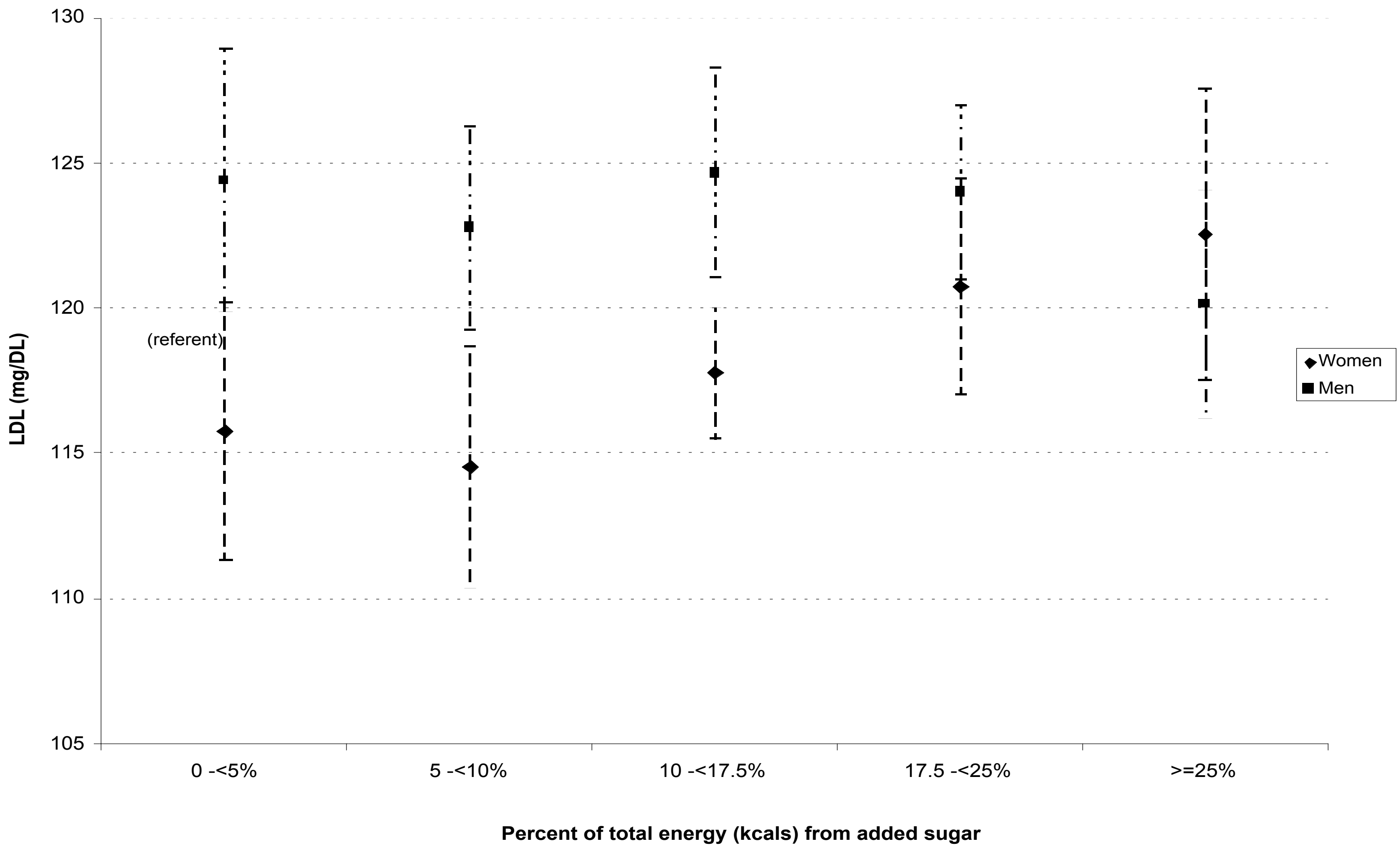

Figure 4-3. Multivariable-adjusted mean LDL levels (mg/dL) by level of added sugar intake among US men and women, NHANES 1999-2006. Linear trend: $p=0.047$ for women; $p=0.17$ for men.

Table 4-2. Adjusted Odds Ratios of Dyslipidemia Among US Adults Associated with Consumption of Added Sugars

		Low HDL (women<50 mg/dL; men<40 mg/dL) Fully Adjusted					**High LDL** (>130 mg/dL)				
			Model I[b,g]		Model II[c,g]			Model I[b]		Model II[d]	
% total energy from added sugar	n=	Prevalence (%)	AOR	(95% CI)	AOR	(95% CI)	Prevalence (%)	AOR	(95% CI)	AOR	(95% CI)
<5%	624	26.0		ref		ref	37.7		ref		ref
5-<10%	838	25.6	1.0	(0.7, 1.3)	1.0	(0.7, 1.4)	34.4	0.9	(0.7, 1.1)	0.9	(0.7, 1.1)
10-17.5%	1310	28.6	1.1	(0.9, 1.4)	1.3	(1.0, 1.7)	37.9	1.0	(0.8, 1.6)	1.0	(0.8, 1.4)
17.5-<25%	920	33.7	1.4	(1.1, 1.8)	1.9	(1.4, 2.6)	37.1	1.1	(0.8, 1.4)	1.1	(0.8, 1.5)
>=25%	913	46.3	2.3	1.8, 2.9)	3.0	(2.2, 4.2)	35.8	1.2	(0.9, 1.5)	1.1	(0.8, 1.5)
		High triglyceride (>150 mg/dL)					**High TG/HDL** (>3.8)				
			Model I[b,i]		Model II[e,i]			Model I[b,g]		Model II[f,g]	
% total energy from added sugar	n=	Prevalence (%)	AOR	(95% CI)	AOR	(95% CI)	Prevalence (%)	AOR	(95% CI)	AOR (95% CI)	
<5%	624	28.2		ref		ref	20.4		ref		ref
5-<10%	838	23.8	0.8	(0.6, 1.0)	0.8	(0.6, 1.1)	15.6	0.7	(0.5, 1.0)	0.7	(0.5, 1.0)
10-17.5%	1310	28.1	1.0	(0.8, 1.3)	1.1	(0.8, 1.4)	20.3	1.0	(0.7, 1.4)	1.1	(0.8, 1.6)
17.5-<25%	920	26.5	1.0	(0.8, 1.2)	1.1	(0.9, 1.5)	22.5	1.2	(0.9, 1.7)	1.5	(1.0, 2.0)
>=25%	913	28.4	1.2	(0.9, 1.6)	1.3	(0.9, 1.8)	25.1	1.5	(1.1, 2.1)	1.7	(1.2, 2.4)

[a] All results are weighted and adjusted to account for NHANES complex sampling methodology

[b] Model I adjusted for: age; race/ethnicity; sex

[c] HDL model II adjusted for: age; race/ethnicity; waist circumference; physical activity; total energy intake; nutrient residuals for intake of monounsaturated fats, cholesterol, and other carbohydrates (excluding fiber and added sugars); poverty; cigarette and alcohol use

[d] LDL model II adjusted for: age; race/ethnicity; poverty; BMI; waist circumference; total energy; nutrient residuals for intake of saturated, mono- and poly-unsaturated fatty acids; weight change; and cigarette smoking.

[e] Triglyceride model II adjusted for: age; sex, race/ethnicity; waist circumference; weight change, nutrient residuals for intake of PUFAs and other carbohydrates (excluding added sugar and fiber); hypertension, cigarette and alcohol use.

[f] TG/HDL model II adjusted for: sex, age; race/ethnicity; waist circumference, nutrient residuals for intake of fiber, other carbohydrates (excluding added sugar and fiber) and polyunsaturated fats;and physical activity

[g,h, i] Chi-square test for trend: [g] <0.001; [h] <0.01; [i] <0.05

SI conversions: To convert HDL-C and LDL-C to mmol/L multiply by 0.0259; to covert triglycerides to mmol/L, multiply by 0.0113

5 Consumption of Added Sugars and Indicators of Cardiovascular Disease Risk Among US Adolescents

Welsh JA, Sharma A, Argeseanu, Vos MB. Consumption of Added Sugars and Indicators of Cardiovascular Disease Risk Among US Adolescents. *Circulation* (in press).

Title: Consumption of Added Sugars and Indicators of Cardiovascular Disease Risk Among US Adolescents

First Author/Short title: Welsh/Added Sugars and Cardiovascular Disease

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The findings of this paper are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention (CDC).

Total word count: 5,939

Journal Subject Codes:

Cardiology/Etiology

[8] Epidemiology

[112] Lipids

[113] Obesity

[20] Other etiology

Diabetes

[190] Type 2 diabetes

[192] Glucose intolerance

ABSTRACT

Background. While increased carbohydrate and sugar consumption has been associated with higher cardiovascular disease risk among adults, little is known about the impact of high consumption of added sugars (caloric sweeteners) among US adolescents.

Methods and Results. Cross-sectional study of 2,157 US adolescents in the National Health and Nutrition Examination Survey (NHANES) 1999-2004. Dietary data from one 24-hour recall were merged with added sugar content data from the USDA MyPyramid Equivalents Databases. Measures of cardiovascular disease risk were estimated by added sugar consumption level (<10%, 10-<15%, 15-<20%, 20-<25%, 25-<30%, and ≥30% of total energy). Multivariable means were weighted to be representative of US adolescents and variances adjusted for the complex sampling methods. Daily consumption of added sugars averaged 21.4% of total energy. Added sugars intake was inversely correlated with mean high-density lipoprotein cholesterol (HDL) levels (mmol/L) which were 1.40 (95% confidence interval [CI]: 1.36, 1.44) among the lowest consumers and 1.28 (95% CI: 1.23, 1.33) among the highest (p-trend=0.001). Added sugars were positively correlated with low-density lipoproteins (LDL) (p-trend=0.01) and geometric mean triglycerides (p-trend=0.05). Among the lowest and highest consumers respectively, LDLs (mmol/L) were 2.24 (95% CI: 2.12, 2.37) and 2.44 (95% CI: 2.34, 2.53) and triglycerides (mmol/L) were 0.81 (95% CI: 0.74, 0.88) and 0.89 (95% CI: 0.83, 0.96). Among those overweight/obese ($\geq 85^{th}$ percentile body-mass-index [BMI]), added sugars were positively correlated with the homeostasis model assessment (HOMA-IR) (p-linear trend=0.004).

Conclusion. Consumption of added sugars among US adolescents is positively associated with multiple measures known to increase cardiovascular disease risk.

Key Words:

Sugars, cardiovascular disease risk factors, lipids, triglycerides, diabetes mellitus

BACKGROUND

Cardiovascular disease (CVD) is a leading cause of morbidity and mortality among U.S. adults. While atherosclerosis and CVD occur later in life, their risk factors, including lipid disorders[13], diabetes[39], and obesity are increasingly identified among adolescents and even children. Currently 32% of US children and adolescents aged 2 to 18 y are overweight or obese.[40] Though CVD among children is rare, an increase in risk factors at younger ages and their apparent tendency to track into adulthood highlights the need for early and effective prevention efforts.[41-43]

Lifestyle changes, including dietary change, have long been a central focus of efforts to reduce CVD risk. Since the 1950's Americans have been advised to reduce their consumption of fats and cholesterol, and replace them with complex carbohydrates.[44] It appears that, in part, Americans have followed this advice. But while food disappearance data suggests that fat consumption has decreased, it is refined rather than complex carbohydrates that have increased. While the overall health impact of this trend is unclear, several studies have shown a positive correlation between the consumption of carbohydrates – particularly some sugars - and the presence of CVD risk factors.[16, 18, 45] A recent longitudinal study among women demonstrated that the incidence of CVD was increased among higher consumers of sugar-sweetened beverages,[15] the largest contributor of added sugars in the U.S. diet.[8] Studies comparing the impact of different sugars have demonstrated that the monosaccharide fructose but not glucose, raises triglyceride levels and lowers HDL levels, suggesting that the metabolic impact may differ substantially by sugar type.[18, 46]

Added sugars are refined, calorie-containing sweeteners added to foods and beverages during processing or preparation. Consumption of these sugars has increased substantially in recent decades. Sugars used to sweeten soft drinks have become the largest single source of calories in the U.S. diet.[47] In 1994-1996, Americans over the age of 2 y obtained nearly 16% of their total energy from added sugars; adolescents, the highest consumers, obtained more than 20% of their energy from these sugars.[48] Today in the U.S., the most commonly consumed added sugars are refined beet or cane sugar (sucrose) and high fructose corn syrup (HFCS),[49] both of which contribute fructose and glucose, in approximately equal amounts, to the diet. Added sugars are estimated to contribute 74%-80% of the dietary fructose consumed.[50, 51]

Given the high consumption of added sugars among adolescents and the potential for long-term health risks associated with early diet, it is important to understand the impact of this dietary trend. The purpose of our study was to determine if there is an association between the consumption of added sugars and indicators of cardiovascular disease risk among U.S. adolescents and to determine if body weight modifies this association.

METHODS

Study Design and Subjects

Data for our study come from the National Health and Nutrition Examination Survey (NHANES). NHANES is a sequential series of cross-sectional surveys of the U.S. civilian, non-institutionalized population designed to obtain nationally representative estimates on diet and health indicators. A description of the complex sampling methodology is described elsewhere.[22] The study sample consists of adolescents ages 12 to18 y living in the US between 1999 and 2004 (n=2,485) who were randomly selected to provide a fasting blood sample for NHANES 1999-2000, NHANES 2001-02, or NHANES 2003-04. Excluded from the sample (in order of exclusion) were: those with unreliable[24] or implausible (<600 or >4,500 kcal/day) dietary data (n= 159), those pregnant (n= 33), those with extreme triglyceride levels (>300 mg/dL) (n=23), those with previously diagnosed diabetes (n=9), and those with missing covariate data (n=104). After exclusions, the total sample for this study included 2,157 adolescents. Study protocols for NHANES 1999-2004 were approved by the institutional review board at the National Center for Health Statistics (NCHS).[23] Signed, informed consent was obtained from all participants.

Added Sugars and Other Dietary Intake

In NHANES 1999-2000 and NHANES 2001-2002 one 24-hour dietary recall was used to assess dietary intake from all participants. In NHANES 2003-04 a second 24-hour recall was collected by phone from all respondents. For consistency we used only the first dietary recall to assess intake for all participants in the primary analysis. In addition, a sensitivity analysis was done using the mean added sugars intake for each of the respondents in NHANES 2003-04. Nutrient content of the foods consumed was determined by NHANES using the Food and Nutrient Database for Dietary Studies, which utilizes food composition data from the United States Department of Agriculture (USDA) National Nutrient Database for Standard Reference.[7] Because the Standard Reference database does not include information on the added sugar content of many foods, we merged the individual food files from NHANES with the most recently released MyPyramid Equivalents database (MPED) files, those for 1999-2000, 2001-02, and 2003-04.[25] The MPED database provides standard serving size information for the major food categories found on the USDA Food Guide Pyramid (grains, meat, dairy, fruits, vegetables, and beans) as well as for added sugars and excess fat. A description of the MPED database[52] and the methods used to calculate the sugar content of foods can be found elsewhere.[4]

To determine the amount of added sugars consumed in each food and beverage, we multiplied the total amount consumed in grams (as provided in the NHANES database) by the amount of added sugars in each of these foods (teaspoons/100 grams) (as provided in the MPED database). The results for each food consumed were summed to obtain the total added sugars intake in teaspoons and converted to grams by multiplying by 4.2 grams/teaspoon.[26] This result was multiplied by 4 kcal to obtain the total energy from added sugars. Finally, the total energy from added sugars (kcal) was divided by total energy intake (kcal/day) to obtain the percent of total energy from added sugars.

Indicators of Cardiovascular Disease Risk

Biological indicators known to be associated with CVD[13, 27, 28] were measured in NHANES using standardized laboratory procedures that have been described elsewhere.[29] Measured lipids include fasting serum or plasma: high-density lipoprotein cholesterol [HDL], total cholesterol [TC] and triglycerides. Measured indicators of glucose metabolism include fasting insulin and glucose. Anthropometric measures (height, weight, and waist circumference) and blood pressure were measured by trained interviewers using standardized equipment and protocols. Body-mass-index (BMI) was calculated from measured weight and height as kg/m^2 and BMI was converted to age- and sex-standardized percentiles and z-scores based on the Centers for Disease Control and Prevention (CDC) 2000 growth charts.[30]

Low-density lipoprotein levels were calculated using the Friedewald formula: LDL-cholesterol = total cholesterol – HDL-cholesterol– triglycerides/5.[31] The homeostasis model assessment (HOMA-IR) is an estimate of insulin resistance derived from fasting glucose and insulin levels, with higher levels representing greater degrees of insulin resistance.[32] HOMA-IR was calculated using the formula developed by Mathews et. al: fasting insulin (pmol/L)*fasting glucose (mmol/L)/22.5.[33]

Covariates

Variables previously shown to be associated with carbohydrate intake and with any of the CVD risk indicators specified above were included as covariates. These covariates include: measured waist circumference and BMI as well as self-reported demographic data (participant's age [y], sex, income, and race/ethnicity [% non-Hispanic white, non-Hispanic black, Hispanic, and other]). Given the small sample size, Mexican-American and other Hispanic were combined into a single category entitled "Hispanic" for analyses. As education, when compared to income and occupation, has been shown to be the only measure of SES significantly associated with measures of CVD risk[53] we included educational level of parent/guardian (greater than high-school [yes or no]) in our models.

Due to the high number of missing values (7.5% of sample), we elected to not include income as a second measure of SES. As a measure of physical activity, respondents were asked to provide a list all of the moderate or vigorous leisure activities done over the previous month and to provide the frequency and the usual duration of these activities. MET- (metabolic equivalent) minutes were then calculated as the sum of the following for each reported activity: duration in minutes*frequency* metabolic equivalent intensity level (MET score).

The values for dietary covariates were determined using data from one 24-hour dietary recall and included total energy intake and the total energy-adjusted nutrient residuals for: fiber; other carbohydrates (excluding added sugars and fiber); saturated fats (SFAs), poly-unsaturated fatty acids (PUFAs), and mono-unsaturated fatty acids (MUFAs); proteins; fiber; sodium, and cholesterol. These nutrient residuals were calculated, using linear regression models with total calorie intake as the predictor and the absolute intake of each nutrient of interest (in grams) as the outcome, in order to separate the nutrient effect from that of the calories consumed.[35]

Data analysis

Statistical Analysis Software (SAS), version 9.2 (SAS Institute, Cary, IN) was used for all analyses. Procedures that account for the complex sampling methods used in NHANES were applied. Sample weights for the 6 years of data that reflect the probability of selection, nonresponse, and post-stratification adjustments were calculated as follows: 2/3* wtsaf4yr (fasting sample weight for NHANES 1999-2002) and 1/3* wtsaf2yr (fasting sample weight for NHANES 2003-04)[22] and used to ensure that results were representative of the U.S. population. To ensure sufficiently large sample sizes in each group, respondents were grouped into 6 approximately equally-sized groups by the % of their total energy intake from added sugars: 0 <10%, 10–<15%, 15-<20%, 20-<25%, 25-<30%, and ≥30%. All of the p-values were 2-sided. A p-value<0.05 was considered statistically significant for main effects.

Percentages, means, and standard errors (SE) of key variables were calculated to describe the sample at each level of added sugars intake. Linear regression models were used to assess the relationship between intake of added sugars and our outcome measures while controlling for the effect of potentially confounding variables. As the distribution of triglycerides was skewed, the values in the linear regression models were log transformed and geometric means are presented. Estimate statements in the regression models were used to determine the adjusted mean of each of the measures of CVD risk for each level of added sugar intake.[34] Contrasts were used to specify linear tests among the levels of added sugars consumption and to compare each group of respondents to the referent group (<10% of total energy from added sugars) for each of the outcomes of interest.[34] Chi-square tests were used to test differences in categorical variables and Wald f-tests were used for continuous variables.

To identify the macronutrients to be included in our regression models, we first did bivariate analyses to assess the association between the intake of total fat and the intake of protein and each of our outcomes. The energy-adjusted residuals for protein but not fat were found to be associated with measures of dysglycemia (fasting insulin, fasting glucose, and HOMA-IR), blood pressure, and adiposity (BMI and waist circumference), therefore, we included protein but not fat intake as a covariate in these models. As we also controlled for total energy intake and intake of carbohydrates (other than added sugars), results obtained using these models can be interpreted as the effect of replacing fat in the diet (the macronutrient left out of the models) with added sugars.[35] In contrast, the energy adjusted residuals for the intake of PUFAs, MUFAs, and saturated fats, but not proteins were each found, in bivariate analyses, to be associated with blood lipid measures (HDL, LDL, TC, and triglycerides). Therefore, we included the intake of each of these dietary fats but not protein in the models with lipid measures as the outcome. The results of these models can be interpreted at the effect of replacing protein in the diet with added sugars.

Due to problems with multicollinearity in models that included both BMI and waist circumference, waist circumference was dropped from the regression models. As the postprandial lipoprotein[36] and insulin responses[37] have been shown to differ by body weight, race, and sex, we tested for the presence of effect modification between level of added sugars intake and each of these variables by including a multiplicative term for each in the models. Body weight was dichotomized as not overweight ($<85^{th}$ percentile BMI) (n=1340) and overweight ($\geq 85^{th}$ percentile BMI)[38] (n=817). A p-value of <0.10 was considered significant.

Sensitivity analysis was done to examine the association between intake of added sugars and HDL and HOMA-IR levels using the absolute intake of added sugar (in grams) as the exposure rather than the proportion of total energy from added sugars. To do this we grouped all respondents into 6 groups of equal size according to the grams of added sugars consumed. In addition, to determine if our results were consistent when data from 2 24-hour recalls were used, we repeated our analysis using a smaller (~30%) subsample of respondents from whom a second 24-hour dietary recall had been collected. In these analyses, the mean intake of added sugars (% total energy) and of other dietary covariates was used for each respondent together with the same non-dietary covariates as described for the models above.

RESULTS

A description of the study sample by level of added sugars is provided in Table 1. No significant differences were seen between level of added sugars consumed and demographic factors, including age, sex, race/ethnicity, poverty, or educational level. Similarly, no association was seen between the amount of added sugars consumed and physical activity or total energy intake.

Daily consumption of added sugars averaged 118.9 g (28.3 tsp or 476 calories) daily. This represents 21.4% (95% confidence interval [CI]: 20.5%, 22.2%) of total daily caloric intake (total energy) (not shown). There was no significant difference in consumption across race/ethnic groups. The increased trend in % total energy from carbohydrates with higher intake of added sugars was significant (p-linear trend<0.0001) as was the increased trend in the absolute intake of carbohydrates (p-linear trend<0.0001 (Table 1). Intake of added sugars was negatively correlated with both the % total energy and the absolute intake (g) of: total fats, SFAs, PUFAs, MUFAs, and protein (p-linear trend<0.0001 for all). Fiber, cholesterol, and sodium intakes were also negatively correlated with intake of added sugars (p-linear trend<0.0001, 0.0003, and <0.0001, respectively).

In fully adjusted linear regression models we found that neither body weight, race/ethnicity, nor sex modified the association between added sugar intake and lipid measures. Lipid levels were correlated with intake of added sugars (Table 2). HDL levels were lower among those who consumed more added sugars (p-linear trend=0.001). Among the highest consumers (≥30% total energy) HDLs were 1.28 mmol/L (95% CI: 1.23, 1.33) (49.5 mg/dL) compared to 1.40 mmol/L (95% CI: 1.36, 1.44) (54.0 mg/dL) among the lowest consumers (<10% total energy), a difference of 9% (p=0.001) (Figure 1). In contrast, LDL and geometric mean triglyceride levels were higher among those consuming higher levels of added sugars (p-linear trend=0.01 and 0.05, respectively) (Table 2). Among the highest compared to the lowest consumers, adjusted LDL levels were 2.44 mmol/L (95% CI: 2.34, 2.53) (94.3 mg/dL) and 2.24 mmol/L (95% CI: 2.12, 2.37) (86.7 mg/dL) and geometric mean triglyceride levels were 0.89 mmol/L (95% CI: 0.83, 0.96) (79.0 mg/dL) and 0.81 mmol/L (95% CI: 0.74, 0.88) (71.7 mg/dL), respectively. This represents a difference between lowest and highest consumers of 9% in LDL levels (p=0.08) and 10% in triglyceride levels (p=0.07). There was no significant trend in TC with higher intake of added sugars (p-linear trend=0.16).

As the effect of added sugars intake was shown to be modified by body weight (but not by race/ethnicity or sex) in models with HOMA-IR, insulin, glucose, systolic blood pressure and waist circumference as the outcomes (p-interaction =0.09 for glucose and ≤0.003 for all other outcomes) the analyses of these measures were stratified by weight status. We found that the intake of added sugars and HOMA-IR measures were positively correlated among overweight adolescents (p-linear trend =0.004) but not among those who were normal weight (p-linear trend=0.41) (Figure 2). Adjusted mean HOMA-IR among overweight adolescents with the highest consumption was 4.61 (95% CI: 4.08, 5.13) compared to 3.49 (95% CI: 3.02, 3.95) among the lowest consumers, a difference of 32% (Table 2). A similar difference was observed with fasting insulin levels. No significant association was observed between consumption of added sugars and fasting glucose. Similarly, there were no significant trends in systolic or diastolic blood pressure, waist circumference, or BMI (among either the overweight or not overweight) with increased intake of added sugars (Table 2).

We repeated the analyses of the associations between intake of added sugars and mean HDL and HOMA-IR levels with respondents divided into 6 equally-sized groups according to their absolute daily intake of added sugars (0-<49.5, 49.5-<79.6, 79.6-<106.7, 106.7-<137.1, 137.1-<180.4, and ≥180.4 g of added sugars) rather than by consumption relative to their total energy intake. The results were very similar to those obtained in the primary analysis. HDLs were 1.19 mmol/L (95% CI: 1.10, 1.28) among the highest consumers and 1.40 mmol/L (95% CI: 1.31, 1.49) among the lowest (p-linear trend=0.004). HOMA-IRs among those overweight were 4.85 (95% CI: 3.99, 5.72) among the highest consumers and 3.39 (95% CI: 2.84, 3.94) among the lowest (p-linear trend=0.02).

When the analysis was repeated using the mean intake obtained from the smaller subsample of respondents who provided 2 24-hour dietary recalls (those participating in NHANES 2003-04) (n=646) point estimates and trends for HDL and HOMA-IR were again similar to those obtained in the primary analyses. Among the highest vs. lowest added sugar consumers (% total energy): HDLs were 1.34 mmol/L (95% CI: 1.24, 1.44) and 1.43 mmol/L (95% CI: 1.34, 1.53) respectively (p-linear trend=0.009) and HOMA-IRs among the overweight/obese were 4.97 (95% CI: 3.19, 6.74) and 3.19 (95% CI: 2.43, 3.95), respectively (p-linear trend=0.05).

DISCUSSION

In 1986, the Sugars Task Force of the Food and Drug Administration (FDA) published a review of the research then available and concluded that there was no conclusive evidence of an association between sugar consumption and CVD or its risk factors.[9] Since then, the results of several new epidemiologic studies and short and long-term experimental studies have provided more evidence linking the intake of carbohydrates[21, 54] and sugars,[15, 18, 20, 21](particularly fructose),[18, 55, 56] and increased risk of CVD. And importantly, consumption of added sugars has risen substantially since the research reviewed in the Sugar Task Force report was done. The Task Force report estimated that consumption of added sugars among adolescents was 62 to 84 g in 1977-78. The results of our study indicate that by 1999-2004 consumption among this group had risen to 119 g, an increase of 42%-92%.

Our results demonstrate that intake of added sugars is positively associated with known cardiovascular risk factors when controlling for other characteristics. We found increased dyslipidemia (lower HDLs and higher LDLs and triglyceride levels) among adolescents, regardless of body size, and increased insulin resistance (higher fasting insulin and HOMA-IR measures) among those overweight or obese with higher intake of added sugars. Several mechanisms have been proposed to explain the dysmetabolic effects of carbohydrates and specifically sugars. These include 1) the insulin response to the metabolism of high glycemic index foods, such as processed sugars, that cause a rapid postprandial rise and fall in glucose levels, 2) the increased de novo lipogenesis that results when high levels of fructose are metabolized by the liver; and 3) increased hepatic triglyceride synthesis combined with increased secretion and/or decreased clearance of very-low-density lipoproteins.[12] Modification of the effect of added sugars on measures of glucose metabolism by weight status could be explained by the decreased insulin sensitivity known to result from increased adiposity.[37]

Clearly, added sugars play a significant role in the U.S. diet. They increase the desirability of foods by increasing sweetness. They also contribute substantially to energy intake without contributing other important nutrients to the diet.[57] Existing guidelines for limiting the consumption of added sugars vary widely. The Institute of Medicine (IOM) suggests a limit of 25% of total energy from added sugars in order to ensure adequate intake of important nutrients,[58] the World Health Organization (WHO) advises limiting added sugars to <10% total energy to prevent dental caries,[59] and recently released recommendations from the American Heart Association (AHA) advise that daily intake of added sugars should be limited to <100 calories daily for women and 150 calorie for men[12] (approximately 5% of total energy) as a strategy for preventing heart disease. The 2005 U.S. Dietary Guidelines for Americans encourage consumers to "choose and prepare foods and beverages with little added sugars or caloric sweeteners"[57] but do not specify an upper limit. While our results support the need for dietary guidelines that encourage lower intake of added sugars they also highlight the need for a comprehensive examination of the evidence on the effect of added sugars on cardiovascular and other chronic disease risk.

Our study has several important strengths. First, we have used nationally representative data and, to our knowledge, this is the first study to assess the association between added sugars and indicators of CVD risk among U.S. adolescents. Second, we were able to control for several important confounding variables, including BMI, SES, and physical activity. Also, as we had complete 24-hour dietary recall data on all participants, we were able to control for total energy intake, the intake of specific fats, and other dietary factors. Availability of a second 24-hour dietary recall in a subsample of respondents enabled us to do a sensitivity analysis using the mean of 2 days' intake of added sugars. Finally, the use of trained staff following standardized protocols to measure height and weight and collect laboratory and interview data increases the accuracy and validity of the data collected.

Our study is also subject to some limitations. Cross-sectional studies such as ours are limited by the fact that exposures and outcomes are measured at the same time. As a result, our data can be used only to assess associations. They cannot be used to assess the direction or temporarily of these associations or to determine causality. Also, as only a single 24 hour dietary recall was used to assess diet, the dietary intake data may not represent the usual diet of respondents. Our inability to account for with-in person day-to-day variability may have resulted in some misclassification of the intake of added sugars but we expect that this would be random.[60] In addition, when we evaluated those with 2 available 24 hour recalls, key findings remained consistent.

While underreporting of certain foods high in sugars, such as sodas and sweets, may occur more frequently among those who underreport total energy,[61] such as those overweight or obese[6] who are also at increased risk of diabetes and dyslipidemia, systematic misclassification of this type would be expected to bias our findings toward the null. In addition, as no information on the validity of the process used to estimate added sugar content data in the USDA MPED database is available, there could be some misclassification of our exposure variable. Similarly, as the instruments used to assess important covariates such as physical activity have not been validated in this population, residual confounding could also be present.

In conclusion, higher consumption of added sugars among U.S. adolescents is associated with several important CVD risk factors. Though long-term trials to study the effect of reducing the consumption of added sugars are needed, the results of this study suggest that future risk of CVD may be reduced by minimizing consumption of added sugars among adolescents.

Acknowledgements: We thank the participants and staff of the NHANES for their contribution to this study

Funding Sources: No specific funding was obtained for this study.   Dr. Vos is supported in part by a career award from the National Institutes of Diabetes and Digestive and Kidney Diseases (K23DK080953) and by the Children's Digestive Health and Nutrition Foundation.

Disclosures: Dr Vos is the author of "The No-Diet Solution for Kids" and receives royalties. Other co-authors report no conflicts of interest.

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Figure Legends.

Figure 1. Multivariable-adjusted mean high-density lipoprotein cholesterol (HDL) levels by intake of added sugars among US Adolescents. Participants grouped by percentage of total energy intake from added sugars; <10% comprises the referent group. P for linear trend=0.001 for HDL levels. Error bars indicate 95% confidence intervals. To convert HDL values to mg/dL, multiply by 39.

Figure 2. Intake of added sugars and adjusted mean homeostasis model assessment for insulin resistance (HOMA-IR) by weight status. Participants grouped by percentage of total energy intake from added sugars; <10% comprises the referent group. Among overweight/obese adolescents, p for linear trend=0.004; among normal weight adolescents, p for linear trend=0.41. Error bars indicate 95% confidence intervals.

Table 5-1. Description of US Adolescents by Intake of Added Sugars, NHANES 1999-2004

	% total energy from added sugars					
	0-<10% (n=300)	10-<15% (n=364)	15-<20% (n=425)	20-<25% (n=369)	25-<30% (n=303)	≥30% (n=396)
Age, y	14.8 (0.2)	14.8 (0.1)	15.1 (0.2)	14.9 (0.2)	15.2 (0.1)	14.9 (0.2)
Sex, male, %	53.1(3.4)	50.6 (3.6)	48.7 (3.4)	46.5 (3.9)	52.8 (3.5)	52.2 (2.7)
Race/ethnicity						
Non-Hispanic white, %	57.5 (4.1)	64.9 (3.7)	61.0 (2.9)	67.3 (3.6)	62.9 (3.9)	63.0 (2.9)
Non-Hispanic black, %	14.8 (2.7)	13.4 (2.0)	15.0 (1.8)	14.5 (2.1)	15.0 (2.3)	13.9 (1.8)
Hispanic, %	18.5 (2.0)	17.6 (2.5)	18.3 (2.7)	13.0 (2.1)	17.3 (2.8)	14.1 (2.2)
Other, %	10.5 (2.7)	4.1 (1.5)	4.1 (1.5)	5.2 (1.6)	4.8 (1.5)	9.0 (2.7)
Poverty-income ratio	2.46 (0.15)	2.82 (0.15)	2.72 (0.09	2.87 (0.11)	2.54 (0.13)	2.41 (0.14)
Education parent/guardian (< high school diploma)	49.0 (5.2)	44.8 (5.2)	44.7 (5.2)	45.1 (5.2)	48.2 (5.2)	55.3 (5.2)
Physical activity, MET min.	12268 (1520)	14154 (1156)	11514 (867)	13715 (1552)	13165 (1552)	10375 (723)
Energy intake, kcal/day	2070 (75)	2303 (58)	2344 (58)	2347 (49)	2299 (66)	2081 (62)
Carbohydrate intake						
-total, % total energy ‡	46.6 (0.01)	50.3 (0.01)	52.8 (0.01)	55.0 (0.01)	57.4 (0.01)	64.8 (0.01)
-total, g ‡	239 (8.2)	286 (6.6)	306 (8.6)	322 (7.2)	327 (9.3)	334 (10.7)
Added sugars,	31.0 (1.5)	73.2 (2.7)	103 (2.7)	132 (2.7)	158 (4.4)	200 (8.2)
Fiber intake, g	14.9 (0.6)	14.6 (0.4)	15.0 (0.6)	13.6 (0.5)	11.7 (0.5)	9.8 (0.4)
Protein intake						
-% energy	17.1 (0.4)	15.3 (0.3)	14.0 (0.2)	1.3 (0.3)	12.5 (0.3)	10.4 (0.2)
-total,	87.6 (3.6)	88.7 (2.4)	81.9 (2.3)	77.9 (2.4)	72.2 (2.9)	53.8 (1.8)
Fat intake						
-total, % total energy ‡	36.5 (0.7)	34.9 (0.6)	33.8 (0.5)	32.6 (0.6)	31.3 (0.4)	26.2 (0.4)
-total, g‡	85.5 (4.3)	89.9 (3.1)	89.3 (2.5)	85.1 (2.3)	81.1 (2.8)	61.8 (2.2)
MUFAs, % energy ‡	13.5 (0.3)	13.2 (0.3)	12.8 (0.2)	12.4 (0.2)	11.9 (0.2)	10.0 (0.2)
PUFAs, % energy ‡	7.1 (0.3)	7.0 (0.3)	6.7 (0.2)	6.4 (0.2)	6.1 (0.2)	5.1 (0.2)
SFAs, % energy ‡	13.0 (0.3)	12.0 (0.2)	11.6 (0.2)	11.3 (0.3)	10.9 (0.2)	9.1 (0.2)
Cholesterol intake, g §	264 (18)	289 (15)	250 (8)	251 (16)	251 (23)	171 (10)
Sodium intake, mg ‡	3638 (155)	3805 (111)	3616 (112)	3499 (114)	3237 (120)	2569 (87
Waist circumference, cm	78.0 (0.9)	80.7 (1.2)	77.0 (0.7)	80.3 (1.2)	79.8 (1.2)	80.6 (1.1)
BMI z-score	0.52 (0.07)	0.63 (0.09)	0.32 (0.06)	0.56 (0.08)	0.49 (0.09)	0.61 (0.08)
HOMA-IR §	2.54 (0.11)	2.69 (0.14)	2.46 (0.08)	3.01 (0.18)	2.89 (0.14)	2.92 (0.13)
Triglyceride, mmol/L ?	0.95 (0.04)	0.98 (0.04)	0.93 (0.01)	1.01 (0.01)	1.03 (0.01)	1.02 (0.01)
HDL, mmol/L ‡	1.38 (0.02)	1.31 (0.02)	1.31 (0.03)	1.29 (0.03)	1.23 (0.03)	1.27 (0.03)
LDL, mmol/L	2.33 (0.05)	2.30 (0.04)	2.37 (0.06)	2.50 (0.06)	2.38 (0.06)	2.39 (0.06)
Total cholesterol, mmol/L	4.14 (0.06)	4.06 (0.05)	4.11 (0.04)	4.25 (0.09)	4.08 (0.06)	4.13 (0.04)
Systolic BP, mmHg ?	107 (0.7)	109 (1.1)	108 (0.7)	108 (1.0)	110 (0.9)	108 (0.7)
Diastolic BP, mmHg ?	60.7 (0.9)	61.7 (0.7)	62.9 (0.7)	61.1 (0.8)	65.5 (0.7)	62.7 (0.7)

y=year; NHANES=National Health and Nutrition Examination Survey; kcal=kilocalories; %=percent; % energy= % total enery intake; physical activity=sum of MET (metabolic equivalent)*frequency*duration for all leisure time activities previous month; poverty-income ratio=ratio of annual family income to federal poverty level; education=highest level by parent/guardian;MUFAs=mono-unsaturated fatty acids; PUFAs=poly-unsaturated fatty acids;SFAs=saturated fatty acids; BMI=body-mass-index; HOMA-IR=home ostasis model assessment for insulin resistance; HDL=high density lipoproteins cholesterol; LDL=low-density lipoprotein cholesterol

*All results are adjusted to account for the complex sampling method used by NHANES and weighted to be representative of the U.S. population. Results are presented as means (SEs) unless specified as % (SEs).

† Analysis of contrasts in linear and logistic regression used to test trends using X2 for categorical variables and Wald F tests for continuous variables

‡p-linear trend<0.0001

§p-linear trend<0.001

? p-linear trend<0.05

Table 5-2. Intake of Added Sugars and Indicators of Cardiovascular Disease Risk, NHANES 1999-2004

	% total energy from added sugars												
	0 - <10% (referent)		10 - <15%		15 - <20%		20 - < 25%		25 - <30%		>30%		p-linear
Model 1* :	(n=300)		(n=364)		(n=425)		(n=369)		(n=303)		(n=396)		trend
Lipid measures (mmol/L)													
HDL cholesterol	1.40	(1.36 1.44)	1.35	(1.30 1.40)	1.31 §	(1.27 1.35)	1.32 ‡	(1.27 1.36)	1.24 #	(1.19 1.29)	1.28 §	(1.23 1.33)	0.001
LDL cholesterol	2.24	(2.12 2.37)	2.27	(2.16 2.37)	2.37 ‡	(2.31 2.44)	2.51 ‡	(2.35 2.66)	2.42	(2.29 2.55)	2.44	(2.34 2.53)	0.01
Total cholesterol	4.05	(3.92 4.19)	4.04	(3.94 4.15)	4.11	(4.02 4.19)	4.27	(4.11 4.43)	4.12	(3.99 4.25)	4.16	(4.05 4.27)	0.16
Triglycerides	0.81	(0.74 0.88)	0.83	(0.78 0.89)	0.84	(0.82 0.87)	0.87	(0.82 0.93)	0.90	(0.84 0.97)	0.89	(0.83 0.96)	0.05
Model 2 †:													
HOMA-IR													
not overweight	2.70	(2.06 3.33)	2.73	(2.11 3.36)	2.71 #	(2.09 3.34)	2.77	(2.12 3.41)	2.91	(2.23 3.58)	2.74	(2.11 3.37)	0.41
overweight	3.49	(3.02 3.95)	3.65	(3.15 4.16)	4.17 ‡	(3.86 4.47)	4.74 §	(4.07 5.41)	4.34 ‡	(3.81 4.86)	4.61 §	(4.08 5.13)	0.004
Insulin (fasting) (pmol/L)													
not overweight	78.5	(59.9 97.0)	80.1	(536.5 98.0)	78.5	(62.2 97.1)	80.9	(62.2 99.5)	84.6	(79.6 89.6)	80.7	(62.7 98.7)	0.33
overweight	108	(96.0 121)	112	(97.9 126)	127 ‡	(122.4 136)	140 ‡	(122 159)	130 ‡	(114.5 145)	139 §	(124 155)	0.006
Glucose (fasting) (pmol/L)													
not overweight	5.36	(5.18 5.55)	5.33	(5.14 5.52)	5.42	(5.17 5.63)	5.37	(5.17 5.57)	5.44	(5.24 5.65)	5.35	(5.12 5.57)	0.54
overweight	5.03	(4.91 5.15)	5.04	(4.95 5.14)	5.09	(5.04 5.15)	5.15	(5.04 5.26)	5.14	(5.06 5.22)	5.08	(4.99 5.18)	0.16
Systolic blood pressure (mmHg)													
not overweight	89.6	(83.4 95.9	90.9	84.8 97.0	90.8	84.6 97.0	90.6	83.4 97.8	93.1 §	86.9 99)	91.3	85.0 97.5	0.07
overweight	110.3	(107.7 113.0)	112.1	(109.8 114.4)	112.4	(110.2 114.7)	112.5	(110.1 115.0)	114.2 ‡	(111.8 116.5)	113.7	(111.4 115.9)	0.11
Waist circumference (cm)													
not overweight	47.2	(44.7 49.8)	48.5	(46.3 51)	48.5 #	(46.1 50.8)	48.2	(46.1 50)	47.9	(45.6 50)	48.7 ?	(46.5 51)	0.31
overweight	93.6	(92.3 94.8)	94.2	(92.8 95.6)	92.6	(91.5 93.8)	94.5	(93.2 95.9)	93.7	(92.4 95.0)	92.3	(90.7 93.8)	0.52
BMI (z-score)													
not overweight	0.32	(0.00 0.90)	0.41	(0.00 1.00)	0.30 #	(0.00 0.85)	0.28	(0.00 0.87)	0.21 ?	(0.00 0.76)	0.44	(0.00 0.96)	0.92
overweight	1.65	(1.54 1.76)	1.80	(1.67 1.92)	1.65 #	(1.57 1.74)	1.72	(1.6 1.85)	1.73	(1.61 1.84)	1.88 ?	(1.8 2.00)	0.07

NHANES=National Health and Nutrition Examination Survey; %=percent; HDL=high-density lipoprotein cholesterol; LDL=low-density lipoprotein cholesterol; HOMA-IR=homeostatis model assessment of insulin resistance; BMI=body-mass-index adjusted for age and sex. Data presented as means (95% confidence intervals)

*Model 1: Means adjusted for: sex; race; age, education, bmi (excluding model with BMI as outcome); physical activity; total energy intake; nutrient residuals for intake of: fats (mono-unsaturated fatty acids, poly- PUFAs, and saturated), cholesterol, fiber, sodium, and other carbohydrates (excluding added sugars and fiber). Geometric means for triglycerides are presented

†Model 2: Means adjusted for all covariates included in Model 1 except that all fats (PUFAs, MUFAs, SFAs) have been replaced with the energy-adjusted nutrient residuals for protein. Not overweight=BMI%ile<85th; Overweight=overweight or obese (BMI %ile >85th)

‡Mean values differ significantly from the referent: p<0.05

§Mean values differ significantly from the referent: p<0.01

? Mean values differ significantly from the referent: p<0.001.

#Mean values differ significantly from the referent: p<0.0001

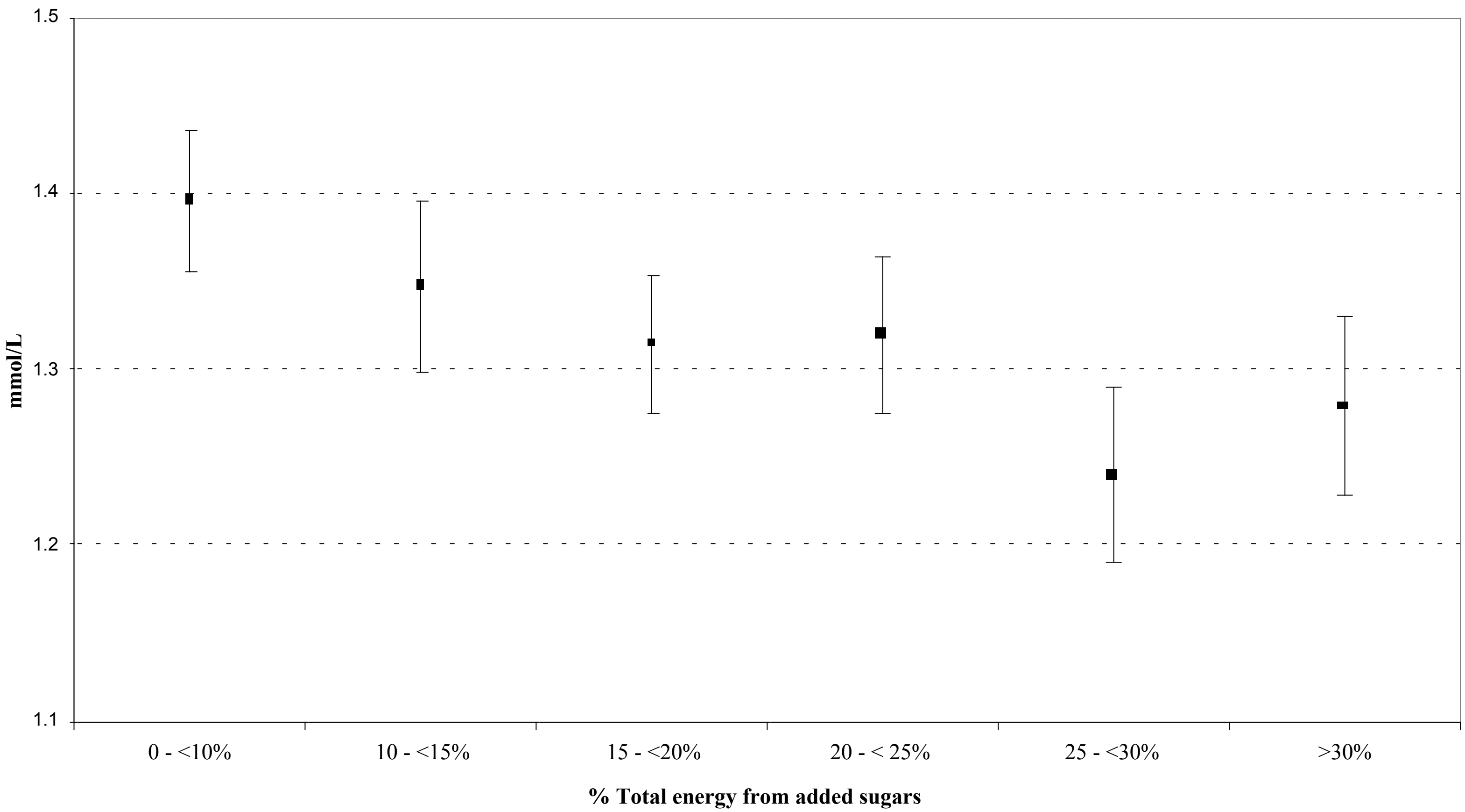

Figure 5-1. Multivariable-adjusted mean high-density lipoprotein cholesterol (HDL) levels by intake of added sugars among US Adolescents. Participants grouped by percentage of total energy intake from added sugars; <10% comprises the referent group.

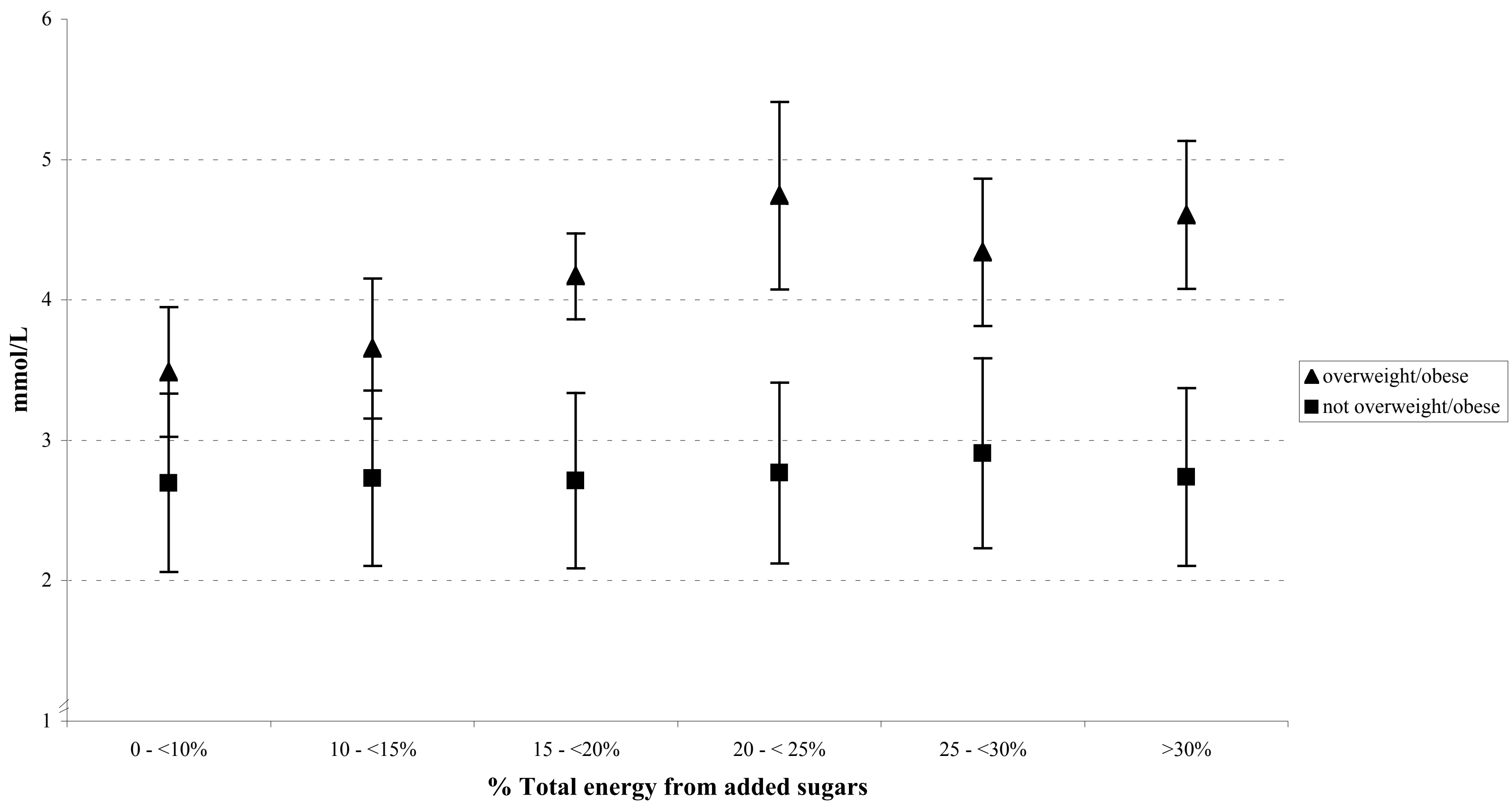

Figure 5-2. Intake of added sugars and adjusted mean homeostasis model assessment for insulin resistance (HOMA-IR) by weight status. Participants grouped by percentage of total energy intake from added sugars; <10% comprises the referent group.

6 Changing Trends in the Consumption of Added Sugars in the US

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ABSTRACT

Background The consumption of sugars added to foods and beverages rose substantially between the 1970s and the 1990s. High consumption of dietary sugars has been linked to decreased diet quality as well as obesity, heart disease, and diabetes. Recent recommendations from the American Heart Association (AHA) advise that men and women limit daily added sugars (caloric sweeteners) intake to 100 and 150 calories, respectively. Little is known about recent trends in the consumption of added sugars in the US.

Objective To assess recent trends in the intake and sources of added sugars in the US diet.

Design Cross-sectional study utilizing dietary data from the National Health and Nutrition Examination Survey 1999-2000 through 2007-08 and added sugars content data from the MyPyramid Equivalents Database. Intake of added sugars was compared over time across age, sex, and race/ethnicity groups.

Subjects/setting National sample of noninstitutionalized US residents ≥2 years (n=42,446).

Statistical analysis Mean intakes of added sugars (grams and % total energy intake) by food groups were estimated and weighted to obtain nationally representative estimates. Linear trends were tested using Wald f-tests.

Results Between 1999-2000 and 2007-08, mean intake of added sugars decreased from 100.3 g (320 calories; 18.0 % of total energy) to 76.1 g (320 calories; 14.5% of total energy). Two-thirds of the decrease in added sugars intake resulted from a reduction in soda consumption from 38.2 to 22.6 g daily (p-linear trend<0.001). Consumption decreased across all age, race/ethnic and income groups. Decreases in the proportion of total energy from added sugars among the highest consuming groups, adolescents, non-Hispanic blacks, and low-income were 21%, 16%, and 24% respectively. Energy drinks were the only source of added sugars to increase significantly over the study period (p-linear trend 0.003), though maximum mean intake reached just 0.14 g/day. There were no differences in consumption by sex after adjusting for total energy intake. Sodas, candies/sugars, cakes/cookies, and fruitades/sports drinks contributed 68% of the added sugars consumed in 2007-08.

Conclusions Consumption of added sugars in the US decreased between 1999-2000 and 2007-08, primarily due to a reduction in soda consumption. Despite this decrease, mean intake levels remain far above the AHA advised upper limit.

Changing Trends in the Consumption of Added Sugars in the US, 1999 to 2008

BACKGROUND

Added sugars, which are caloric sweeteners added in the processing or preparation of foods and beverages, have become a major source of calories in the US diet. Dietary data show that between 1977-78 and 1994-96, average daily consumption of added sugars by Americans >2 y increased from 235 to 318 calories, an increase of 35%.[1] At that time, regular soft drinks were the largest contributor of added sugars, and of calories, in the US diet.[2]

While chemically indistinguishable from naturally occurring sugars, the US Department of Agriculture (USDA) began to use the term "added sugars" in 2000 to help consumers identify foods with added energy but few additional micronutrients or phytochemicals[3]. Increased consumption of added sugars has been linked to an over-all decrease in diet quality,[4] an increase in body weight/obesity,[5] and the development of cardiovascular disease and its risk factors.[6, 7] Sucrose (tables sugar) and high fructose corn syrup (HFCS) are the two most commonly consumed forms of added sugar consumed in the US. Both sucrose and HFCS are comprised of nearly equal amounts of the simple sugars glucose and fructose.

Small experimental studies have shown that high intake of fructose intake can raise triglyceride levels and lower high-density lipoprotein ("good cholesterol") levels.[8] In addition, population-based data from the National Health and Nutrition Examination

Survey (NHANES) demonstrated a link between the consumption of added sugars and cardiovascular disease (CVD) risk factors, including dyslipidemia among adults[6] and adolescents[9] and measures of insulin resistance among overweight adolescents.[9] Similarly, prospective data from the Nurse's Health Study have demonstrated an association between high consumption of added sugars and increased incidence of diabetes[10] and cardiac events.[7]

Despite the prominence of added sugars in the US diet and their association with cardiovascular disease risk and obesity, little is known about recent trends and patterns of consumption. The last published description of added sugars in the diet utilized data collected in 1994-96.[11] The purpose of this study is to provide updated estimates of added sugar consumption levels among specific age, race, and gender groups and to analyze trends in the amount and sources of the added sugars consumed between 1999-2000 and 2007-2008.

METHODS

Sample

Data for our study come from the National Health and Nutrition Examination Survey (NHANES). NHANES is a sequential series of cross-sectional surveys of the U.S. civilian, non-institutionalized population designed to obtain nationally representative estimates on diet and health indicators. A description of the complex sampling methodology is described elsewhere.[12] The sample for the current study consists of noninstitutionalized individuals ≥2 y living in the US who were randomly selected to participate in the NHANES during one of the 2-year data collection cycle between 1999 and 2008 (n=45,641). Those who were selected to participate in NHANES but did not provide dietary information or whose dietary information was deemed unreliable[13] were excluded from analysis (n= 3,195) for a final sample of n=42,446. Study protocols for NHANES 1999-2008 were approved by the institutional review board at the National Center for Health Statistics (NCHS).[14] Signed, informed consent was obtained from all participants or their parent/guardian.

Added Sugars and Other Dietary Intake

One interviewer-assisted 24-hour dietary recall was used to assess dietary intake for all respondents. Proxy respondents were used for survey examinees who were <6 years of age, and children aged 6 to 11 years underwent assisted interviews.[15] Nutrient content of the foods consumed was determined by NHANES using the Food and Nutrient Database for Dietary Studies (FNDDS)[16] which utilizes food composition data from the United States Department of Agriculture (USDA) National Nutrient Database for Standard Reference.[17] Because the Standard Reference database does not maintain information on the added sugar content of many foods, we merged the individual food files from NHANES with the MyPyramid Equivalents database (MPED) files for the matching years.[18] The MyPyramid database provides standard serving size information for the major food categories found on the USDA Food Guide Pyramid (grains, meat, dairy, fruits, vegetables, and beans) as well as for added sugars and excess fat.

The term added sugars, as defined for use in the MPED, includes all sugars used as ingredients in processed or prepared foods. This includes sugars eaten separately or added to foods at the table. Examples include: white sugar, brown sugar, corn syrup, corn syrup solids, high fructose corn syrup, malt syrup, maple syrup, pancake syrup, fructose sweetener, liquid fructose, honey, molasses, anhydrous dextrose, crystal dextrose, and dextrin.[19] Added sugars do not include naturally occurring sugars such as lactose in milk or the fructose in fruit. Quantities of added sugar in the MPED are expressed in terms of teaspoons of table (granulated white) sugar (food code 91101010). One teaspoon of added sugar is defined as the quantity of sweetener that contains the same amount of sugars provided by 1 teaspoon of table sugar. Recipe information is used to determine the quantity of added sugars in mixed foods. A complete description of the MPED database[20] and the methods used to calculate the sugar content of foods can be found elsewhere.[21]

As MyPyramid serving size equivalents are available only for the foods reported consumed through the 2003-2004 NHANES cycle (MPED version 2.0), we used the data available for 2003-2004 to estimate the added sugar content of foods consumed by participants in the more recent NHANES surveys. The methods used have been described in detail elsewhere.[6] Briefly, food codes for food items consumed in 2005-2006 and 2007-2008 were matched with those on the 2003-2004 dataset. Items with exact food codes matches were assigned the 2003-3004 value of added sugars. Values for foods items without an exact match were imputed using food codes and food descriptions to identify similar foods on the MPED 2003-2004 dataset. For example,

"SWEETPOTATO, CANNED IN SYRUP, W/ FAT ADDED" was reported in the 2005-2006 dietary recall, but did not have a corresponding MyPyramid Database equivalent. The added sugar content of this food was assigned the same value as "SWEETPOTATO, CANNED, NS (not specific) AS TO SYRUP." In these cases the default value for the similar food item was used. For processed foods having no similar comparison food on the 2003-2004 dataset, product nutrition label information available on food industry or food and dieting information websites, including: caloriecount.com and fatsecret.com were used. For mixed foods, on-line recipes were used to determine if they contained added sugars and, as necessary, to estimate quantity. Added sugar values were estimated for a total of 337 out of 4871 foods in NHANES 2005-2006 and 280 out of 5219 foods in 2007-2008.

To determine the amount of added sugars consumed in each food and beverage, we multiplied the total amount consumed in grams (as provided in the NHANES database) by the amount of added sugars in each of these foods (teaspoons/100 grams) (as provided in the MPED database). The results for each food consumed were summed to obtain the total added sugars intake in teaspoons and converted to grams by multiplying by 4.2 grams/teaspoon.[22] This result was multiplied by 4 kcal to obtain the total energy from added sugars. To obtain the percent of total energy (% energy) from added sugars, total energy from added sugars (kcal) was divided by total energy intake (kcal/day), which was calculated as the sum of calories from all foods consumed.

USDA food codes[23] were used to group foods and beverages containing added sugars into the following food groups (sub-groups): sweets (sodas, candies/sugars, fruitades/sports drinks, pre-sweetened coffees and teas, alcohol-containing drinks, and energy drinks; grains (cakes/cookies, ready-to-eat [RTE] cereals, breads/muffins, other grains); dairy (dairy desserts, milk, yogurt, other dairy), fruits and vegetables, protein sources (combination of meat, eggs, beans) and fats/oils. All beverages including sodas, fruitades/sports drinks, coffees/teas, milks, and energy drinks were examined individually as well as combined together as sugar-sweetened beverages (SSBs). For items to which sugar was added at the point of consumption, the quantity of sugar consumed is included in the "candies/sugars" category rather as part of the food or beverage itself.

Demographic variables

Self-reported demographic information included: participant's age in years (grouped as 2-5, 6-12, 13-34, 35-54, ≥55 y), sex, education (of respondents for adults and of parent/guardian for children), and race/ethnicity (% non-Hispanic white, non-Hispanic black, Mexican-American, other Hispanic, and other).

Data analysis

Statistical Analysis Software (SAS), version 9.2 (SAS Institute, Cary, IN) was used for all analyses. Procedures that account for the complex sampling methods used in NHANES were applied. To ensure that results were representative of the U.S. population, sample weights that reflect the probability of selection, nonresponse, and post-stratification adjustments were calculated for each NHANES cycle as follows: 2/5* WTDR4YR (dietary assessment sample weight for NHANES 1999-2002) and 1/5*

WTDRD1 (dietary assessment sample weight for NHANES 2003-04, 2005-06, and 2007-08)[12] Wald f-tests were used to compare means and test trends in intake. All p-values were 2-sided. A p-value<0.05 was considered statistically significant.

A sensitivity analysis was done to determine if the mean added sugar intake for the subsample of respondents in NHANES 2005-2006 for whom no added sugar values had to be imputed (i.e. values for all foods consumed were available on the 2003-2004 MPED) (n=5,704) was the same as that obtained using all NHANES 2005-2006 respondents.

RESULTS

Consumption of added sugars among US residents $\geq$2 y decreased from 100.3 g (401 calories; 18.0 % of total energy in 1999-2000 to 76.1 g (304 calories; 14.5% of total energy) in 2007-08, a decline of 24% (Table 1). Two-thirds of the decrease in added sugars intake resulted from a reduction in soda consumption from 38.2 to 22.6 g daily (p-linear trend<0.001). Energy drinks were the only source of added sugars to increase over the study period (p-linear trend 0.003), though peak consumption was minimal (0.14 g/day in 2007-08).

In parallel to the decreasing trend in added sugars intake, total carbohydrates decreased from 51.7% to 50.5% of total energy intake (p linear trend<0.001) and the % of total energy intake from fats, proteins, and other carbohydrates (excluding added sugars) each increased slightly (p-linear trend=0.003, <0.001, and <0.001), respectively (Table 1).

Low-calorie beverage consumption also increased from 116 g to 152 g (p-trend=0.006) (not shown). Total energy intake declined 4% over the study period (p-linear trend=0.004).

The decreasing trend in added sugars consumption over the study period was observed across all age, race/ethnicity, and income groups. Total added sugars consumption declined 24%, from 22.6 to 17.2 g among those 13-17 y (Figure 1), the highest consumers of added sugars. Similar decreases in consumption were observed among children of other ages, 23% among those 2-5 y and 19% among those 6-12 y. Added sugars consumption decreased 21% among non-Hispanic blacks, the highest consuming race/ethnic group. The decline was similar among non-Hispanic whites, 20% (p-linear trend<0.001), Mexican-American, 20% (p-linear trend) and other Hispanics, 19% (p-linear trend<0.001) (Figure 2). Those in the lowest quartile of income were the highest consumers of total added sugars and those in the highest income quartile were the lowest consumers. Consumption among both income groups decreased by 16% over the study period (p-linear trend <0.001) (Figure 3).

Despite the decline in consumption, an average of 76.1 g of added sugars (304 calories) were consumed in 2007-2008. This represents 14.5% of the total energy intake and 30% of total carbohydrate intake. Absolute intake of added sugars was significantly higher among males than females in all age groups (p<0.009 for all) but there were no significant differences by sex when consumption level was adjusted for total energy intake (not shown).

Among all ages combined, sodas were the largest contributor of added sugars throughout the years studied (30% of total sugars consumed in 2007-2008), followed by candies/sugars, cakes/cookies, and fruitades/sports drinks (Table 1). Together these items contributed 68% of the added sugars consumed in 2007-2008. In 2007-2008, sodas were the leading contributor of added sugars for all aged groups except for the youngest children (2-5 y) (Table 2) and the oldest adults (≥55 y) (Table 3). Candies/sugars and fruitades/sports drinks were the leading source of added sugars for children 2-5 y (Table 2), despite a 40% reduction in sugar from these foods between 1999-2000 and 2007-2008 ($p<0.001$).

An analysis of the amount of added sugars consumed at specific eating occasions throughout the day showed that the largest portion of added sugars are consumed as part of a snack (35%-37%) followed by dinner/supper (22-23%), lunch (18%-19%), and breakfast (13%-15%) and desserts (5-7%). The proportion of added sugars consumed in the home remained constant throughout the study period at 58% to 59% of the total consumed (not shown).

When the mean added sugar intake was estimated after replacing the full 2005-06 sample with a 67% subsample that excluded those respondents who consumed at least one food or beverage item for which the value of added sugar had to be imputed, the results were similar to those obtained with the full sample. Total added sugar consumption among the subsample was 82.3 g or 15.2 % of daily energy intake. The decrease in consumption from 1999-2000 to 2005-06 remained significant ($p<0.001$).

DISCUSSION

The results of our analyses show that the consumption of added sugars in the US decreased significantly between 1999-2000 and 2007-2008. In their place, the intake of protein, fat, and other carbohydrates have risen slightly. These findings, combined with those obtained by Popkin and Nielsen have previously shown that national consumption rates increased from 59 g (13.1% total energy) in 1977-78 and 79.5 g (16.0% total energy) in 1994-96[1] to 98.6 g (17.9% total energy) in 1999-2000. Our results demonstrate that after 1999-2000 rates decreased progressively to a low of 76.1 g (14.5% total energy) in 2007-08 Together these data demonstrate that consumption of added sugars peaked in the early part of the decade and has declined steadily, among all age groups, sex, and income groups since then. These finding are supported by estimates from loss-adjusted food disappearance data which, though known to overestimate intake are a useful measure of trends. Disappearance data estimates show that intake of caloric sweeteners increased 6.5%, from 108 g in 1995 to a peak of 115 g in 2000, and then decreased by 6.3% between 2000 and 2003.[24, 25] This compares to a decrease of 10.6% in dietary intake between 1999-2000 and 2003-04 as measured in our study.

Though overall consumption of added sugars has decreased, the relative ranking of importance of the various sources of added sugars in the US diet did not change between 1999-2000 and 2005-06. Similar to Guthrie et al.[1] who examined sources of added sugars using data from 1994-96, we found that regular soft drinks were the largest source of added sugars, followed by candies/sugars, cakes/cookies, fruitades/sports drinks, and dairy desserts.

The US Dietary Guidelines provide evidence-based dietary recommendations to promote health and prevent disease. In the 2000 Dietary Guidelines, which were released at the beginning of this study period, Americans were advised to "choose beverages and foods to moderate intake of sugars" but no specific upper limit for the consumption of added sugars was given.[26] Sample diets from the Food Guide Pyramid, which translated the recommendations of the Dietary Guidelines for Americans into food group-based advice for a healthy diet, suggested a limit of 6-10% of total calorie intake, depending on energy needs. An updated version of the US Dietary Guidelines released in 2005 offered advice similar to that given in 2000.[27] Subsequently, in 2009, the American Heart Association specified a limit of 100 and 150 calories from added sugars for women and men, respectively, (approximately 5% of total energy intake) in order to help prevent heart disease. The results of our study highlight the fact that, despite the decrease in consumption since the end of the 1990s, intake of added sugars by most Americans far exceeds current recommendations.

While the driving force behind the reversal in the trends in added sugars consumption is unknown, it is undoubtedly multifactorial. The late 1990s and early 2000s were marked by increasing public interest and concern regarding the rising obesity prevalence in the US and it associated health risks, highlighted by the release of the Surgeon General's report on obesity in 2001.[28] Surveillance data suggest that the rise in the prevalence of obesity among children began to plateau after 1999-2000,[29] the same time period that our data shows the decline in consumption of added sugars began. This timing of these changes could support a causal role between high levels of added sugars intake and obesity, or it could simply be a reflection of broader lifestyle changes that resulted in improved diets and/or more physical activity.

Clearly, the decrease in added sugars has been driven by a reduction in soda consumption. While national efforts to promote a reduction in soft drinks were limited until the mid-2000s,[30] efforts such as those of the Center for Science in the Public Interest (CSPI) to raise awareness of the increasing trends in sugar-sweetened beverage consumption and the associated health effects in the late 1990s [31] may have helped to stimulate state and local efforts to promote a reduction in consumption. California was, in 2001, the first state to adopt legislation regulating access to beverage in the schools.[32] Subsequently, a 2005 review identified a total of 34 states with legislation or regulations restricting access to SSBs in schools.

The popularity of low carbohydrate diets in the late 1990s and early 2000s, which discouraged consumption of soft drinks and other sources of refined carbohydrates, may also have had an important influence on the trends in added sugars observed in our study. In addition, results of marketing research suggest that by 2002 consumers had begun to turn away from low-, no, and reduced fat products (in which fat tended to be replaced with sugars). This too may have contributed to the observed decrease.[33]

Our study has several important strengths. This includes the use of a large, national sample from which we are able to infer intake levels for the US children, adolescents and adults. The availability of data obtained using the same or similar methods spanning 10 years make valid comparisons and testing of trends possible. The availability of a full day's dietary intake data allowed us to examine trends in other nutrients in parallel to those in intake of added sugars.

Our study is also subject to some limitations. The quantity of added sugars in foods in the MPED database is calculated rather than measured. This could result in under- or overestimations of intake. Underreporting of foods high in sugar, such as soft drinks and sweets, may have occurred. While this would affect estimates of mean intake, it would not be expected to affect trends in consumption between the years of the study. Also, while data from a single 24-hour dietary recall may not represent the usual diet of respondents, they can be useful in assessing group means as was done in this study.

In conclusion, consumption of added sugars has decreased but continues to exceed, among all age groups, the limits advised in the USDA Food Guide Pyramids and by the American Heart Association. The biggest decrease was in soft drinks, which may reflect success of public health efforts to limit SSB consumption. Though the largest portion of added sugars is consumed as snacks, a substantial proportion is consumed at each meal. The reduced but continued high consumption of added sugars at all ages highlights the need to identify and build upon successful public health strategies to promote further reductions in consumption.

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Table 6-1. Trends in mean intake and sources of added sugars among US children and adults (≥2 y), NHANES 1999-2000

	1999-2000 n=8070		2001-02 n=9032		2003-04 n=8272		2005-06 n=8549		2007-08 n=8527	
Nutrient Intake	mean	SE	mean	SE	mean	SE	mean	SE	mean	SE
Added sugars, % energy ***	18.0	(0.6)	17.1	(0.4)	15.9	(0.4)	14.6	(0.2)	14.5	(0.4)
Added sugars, g ***	100.3	(3.5)	94.5	(1.7)	88.1	(1.7)	80.2	(2)	76.1	(2.4)
Sugared beverages, % energy ***	9.2	(0.5)	8.6	(0.3)	7.9	(0.4)	6.6	(0.2)	6.6	(0.4)
Calories (total), kcals **	2164	(16.3)	2177	(15.7)	2195	(16)	2158	(29)	2070	(24.5)
Fat, % energy **	32.6	(0.3)	33.1	(0.2)	33.4	(0.2)	33.5	(0.2)	33.4	(0.2)
Protein, % energy ***	14.8	(0.1)	14.7	(0.1)	14.9	(0.1)	15.4	(0.1)	15.3	(0.1)
Carbohydrates, % energy ***	51.7	(0.3)	51.6	(0.2)	50.6	(0.3)	49.8	(0.3)	50.5	(0.3)
Carbohydrates other than added sugars), % energy ***	33.7	(0.6)	34.5	(0.3)	34.7	(0.4)	35.3	(0.3)	35.9	(0.3)
Added Sugars by Food Source, g										
Sweets ***	67.8	(3.1)	63.0	(1.8)	57.1	(1.9)	49.4	(1.7)	47.2	(2.2)
-sodas, regular ***	38.2	(2.6)	34.4	(1.6)	31.5	(1.4)	24.3	(1.0)	22.6	(2.1)
-candies/sugars ***	15.9	(1.0)	14.0	(0.5)	12.0	(0.6)	11.8	(0.8)	12.0	(0.6)
-fruitades/sports drinks ***	10.2	(0.4)	10.8	(0.8)	9.4	(0.8)	9.1	(0.5)	7.4	(0.4)
-coffee/tea	3.2	(0.4)	3.2	(0.4)	3.4	(0.4)	3.4	(0.3)	3.9	(0.4)
-alcohol containing bevs	0.2	(0.1)	0.4	(0.1)	0.6	(0.1)	0.4	(0.1)	0.4	(0.0)
-energy drinks ***	0.0	(0.0)	0.1	(0.0)	0.1	(0.0)	0.1	(0.0)	0.1	(0.0)
Grains *	19.3	(0.7)	19.0	(0.4)	19.0	(0.6)	18.6	(0.5)	17.3	(0.5)
-cakes/cookies **	11.4	(0.6)	10.6	(0.4)	11.0	(0.5)	10.7	(0.4)	9.4	(0.4)
-RTE cereals **	3.7	(0.2)	3.8	(0.2)	3.4	(0.2)	3.2	(0.1)	3.0	(0.1)
-breads, muffins ***	2.8	(0.1)	3.2	(0.2)	3.2	(0.1)	3.2	(0.1)	3.1	(0.1)
-other grains ***	1.5	(0.1)	1.3	(0.1)	1.5	(0.1)	1.6	(0.1)	1.9	(0.1)
Dairy products *	8.2	(0.3)	8.8	(0.2)	8.0	(0.3)	8.5	(0.4)	7.6	(0.2)
-dairy desserts *	4.7	(0.2)	4.5	(0.2)	4.0	(0.2)	4.5	(0.2)	3.8	(0.2)
-sweetened milk	1.8	(0.1)	2.1	(0.1)	2.2	(0.1)	1.9	(0.2)	1.8	(0.2)
-yogurt	0.7	(0.1)	1.2	(0.1)	0.9	(0.1)	1.1	(0.1)	1.1	(0.1)
-other dairy	1.0	(0.8)	1.1	(0.1)	0.9	(0.1)	0.9	(0.1)	0.9	(0.1)
Fruits & veg ***	2.3	(0.1)	1.9	(0.1)	1.9	(0.2)	1.7	(0.1)	1.6	(0.1)
Protein sources	1.8	(0.1)	1.4	(0.0)	1.8	(0.1)	1.7	(0.1)	1.7	(0.1)
Oils **	0.8	(0.1)	0.6	(0.0)	0.6	(0.1)	0.5	(0.1)	0.6	(0.1)

% energy=percent of total calorie intake; % added sugars=percent of total intake of added sugars; NHANES=National Health and Nutrition Examination Survey; RTE=ready to eat; 1 g added sugars=4 calories; 1 tsp=4.2 g

Results are presented as mean % total energy intake (95% confidence interval) unless otherwise specified

Testing for linear trend: *P<0.05; **P<0.01; ***P<0.001

Table 6-2. Food Sources of Added Sugar in the Diets of US Children and Adolescents (2-18 y), 1999-2000 and 2007-2008

	2 to 5 y				6-12 y				13-17 y			
	1999-00		2007-08		1999-00		2007-08		1999-00		2007-08	
	n=665		n=832		n=962		n=1012		n=1708		n=886	
Nutrient	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Added sugars, % energy	17.3	(0.8)	13.2 ***	(0.4)	20.5	(0.8)	16.7 ***	(0.4)	22.6	(0.7)	17.2 ***	(0.7)
Added sugars, g	70.7	(4.6)	50.8 ***	(1.4)	105.6	(6.4)	82.4 **	(2.5)	128	(4.4)	88.8 ***	(3.5)
Sugared beverages	6.5	(0.6)	3.9 ***	(0.3)	9.3	(0.4)	6.1 ***	(0.3)	13	(0.8)	9.0 ***	(0.7)
Calories (total), kcals	1620	(35)	1526 *	(25)	2021	(59)	1928	(28)	2276	(41)	2095 **	(43)
Fat, % energy	31.6	(0.5)	32.4	(0.5)	32.9	(0.4)	33.0	(0.4)	32.5	(0.4)	32.6	(0.4)
Protein, % energy	13.4	(0.2)	14.1 *	(0.1)	13.2	(0.2)	13.7	(0.2)	13.6	(0.2)	14.6 **	(0.3)
Carbohydrates, %energy	56.7	(0.5)	54.9	(0.5)	55.0	(0.5)	54.5 *	(0.5)	54.8	(0.4)	53.7 *	(0.6)
Carbohydrates other than added sugars), % energy ***	39.4	(1.0)	41.7	(0.5)	34.4	(0.6)	38	(0.5)	32.3	(0.7)	36.6	(0.5)
Added Sugars by Food Source, g												
Sweets	41.5	(4.0)	23.6 ***	(1.3)	67.9	(5.5)	47.6 ***	(1.8)	92.3	(3.7)	58.4 ***	(3.6)
-sodas, regular	10.0	(1.1)	5.7 **	(0.8)	28.4	(1.8)	17.6 ***	(1.6)	54.1	(3.1)	29.6 ***	(3.2)
-candies,sugars	15.4	(2.3)	8.9 ***	(0.8)	21.9	(4.2)	17.0 ***	(2.1)	19.1	(2.3)	13.4 **	(1.5)
-fruitades, sports drinks	15.4	(1.8)	8.2 ***	(0.6)	15.8	(1.2)	10.5 ***	(0.7)	16.0	(1.5)	10.5 **	(0.8)
-coffee/tea	0.6	(0.2)	0.7	(0.2)	1.7	(0.8)	1.8	(0.5)	2.9	(0.6)	3.5	(0.7)
-alcohol containing drinks	0.0	(0.0)	0.0	(0.0)	0.0	(0.0)	0.0	(0.0)	0.0	(0.0)	0.0	(0.0)
-energy drinks	0.0	(0.0)	0.0	(0.0)	0.0	(0.0)	0.0	(0.0)	0.0	(0.0)	0.1	(0.1)
Grains, % added sugars	16.7	(1.0)	14.2 *	(0.7)	22.1	(1.4)	19.7	(1.2)	23.2	(1.4)	19.1 *	(0.9)
-cakes/cookies	8.1	(0.8)	6.9	(0.4)	9.5	(0.7)	9.5	(0.8)	12.3	(0.9)	9.0 *	(0.9)
-RTE cereals	5.0	(0.4)	3.6 *	(0.3)	7.5	(0.7)	5.0 **	(0.4)	6.2	(0.5)	5.0 *	(0.3)
-breads/muffins	1.8	(0.2)	1.6	(0.2)	3.2	(0.7)	3.2	(0.3)	2.8	(0.2)	2.4	(0.2)
-other grains	1.9	(0.3)	2.1	(0.2)	1.9	(0.3)	2.1	(0.2)	1.8	(0.2)	2.7 *	(0.3)
Dairy products	8.6	(1.2)	10.1	(0.7)	10.5	(1.0)	11.6	(0.5)	8.4	(0.5)	7.7	(1.1)
-dairy desserts	2.6	(0.3)	2.6	(0.3)	5.6	(0.7)	5.1	(0.6)	4.7	(0.4)	4.4	(1.0)
-sweetened milk	3.6	(0.9)	4.6	(0.7)	4.0	(0.6)	5.2	(0.5)	3.0	(0.5)	2.4	(0.5)
-yogurt	1.3	(0.3)	2.0	(0.3)	0.7	(0.2)	1.0	(0.2)	0.2	(0.1)	0.5	(0.1)
-other dairy	3.5	(0.4)	0.9 ***	(0.2)	0.2	(0.1)	0.3	(0.1)	0.5	(0.2)	0.4	(0.2)
Fruits & vegetables	2.7	(0.3)	1.9 ***	(0.4)	3.4	(0.5)	3.1 **	(0.3)	2.4	(0.4)	1.8	(0.2)
Meats/beans/eggs	1.1	(0.1)	0.8	(0.1)	1.2	(0.1)	1.3	(0.1)	1.5	(0.1)	1.6	(0.1)
Oils	0.2	(0.0)	0.1	(0.1)	0.4	(0.1)	0.2 *	(0.0)	0.5	(0.1)	0.3 *	(0.0)

% energy=percent of total calorie intake; % added sugars=percent of total intake of added sugars; NHANES=National Health and Nutrition Examination Survey; RTE=ready to eat; 1 g added sugars=4 calories; 1 tsp=4.2 g

Results are presented as mean % total energy intake (95% confidence interval) unless otherwise specified

Testing for linear trend: *P<0.05; **P<0.01; ***P<0.001

Table 6-3. Food Sources of Added Sugar in the Diets of US Adults (≥18 y), 1999-2000 and 2007-2008

	2 to 5 y				6-12 y				13-17 y			
	1999-00		2007-08		1999-00		2007-08		1999-00		2007-08	
	n=665		n=832		n=962		n=1012		n=1708		n=886	
Nutrient	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Added sugars, % energy	17.3	(0.8)	13.2 ***	(0.4)	20.5	(0.8)	16.7 ***	(0.4)	22.6	(0.7)	17.2 ***	(0.7)
Added sugars, g	70.7	(4.6)	50.8 ***	(1.4)	105.6	(6.4)	82.4 **	(2.5)	128	(4.4)	88.8 ***	(3.5)
Sugared beverages	6.5	(0.6)	3.9 ***	(0.3)	9.3	(0.4)	6.1 ***	(0.3)	13	(0.8)	9.0 ***	(0.7)
Calories (total), kcals	1620	(35)	1526 *	(25)	2021	(59)	1928	(28)	2276	(41)	2095 **	(43)
Fat, % energy	31.6	(0.5)	32.4	(0.5)	32.9	(0.4)	33.0	(0.4)	32.5	(0.4)	32.6	(0.4)
Protein, % energy	13.4	(0.2)	14.1 *	(0.1)	13.2	(0.2)	13.7	(0.2)	13.6	(0.2)	14.6 **	(0.3)
Carbohydrates, %energy	56.7	(0.5)	54.9	(0.5)	55.0	(0.5)	54.5 *	(0.5)	54.8	(0.4)	53.7 *	(0.6)
Carbohydrates other than added sugars), % energy ***	39.4	(1.0)	41.7	(0.5)	34.4	(0.6)	38	(0.5)	32.3	(0.7)	36.6	(0.5)
<u>Added Sugars by Food Source, g</u>												
Sweets	41.5	(4.0)	23.6 ***	(1.3)	67.9	(5.5)	47.6 ***	(1.8)	92.3	(3.7)	58.4 ***	(3.6)
-sodas, regular	10.0	(1.1)	5.7 **	(0.8)	28.4	(1.8)	17.6 ***	(1.6)	54.1	(3.1)	29.6 ***	(3.2)
-candies,sugars	15.4	(2.3)	8.9 ***	(0.8)	21.9	(4.2)	17.0 ***	(2.1)	19.1	(2.3)	13.4 **	(1.5)
-fruitades, sports drinks	15.4	(1.8)	8.2 ***	(0.6)	15.8	(1.2)	10.5 ***	(0.7)	16.0	(1.5)	10.5 **	(0.8)
-coffee/tea	0.6	(0.2)	0.7	(0.2)	1.7	(0.8)	1.8	(0.5)	2.9	(0.6)	3.5	(0.7)
-alcohol containing drinks	0.0	(0.0)	0.0	(0.0)	0.0	(0.0)	0.0	(0.0)	0.0	(0.0)	0.0	(0.0)
-energy drinks	0.0	(0.0)	0.0	(0.0)	0.0	(0.0)	0.0	(0.0)	0.0	(0.0)	0.1	(0.1)
Grains, % added sugars	16.7	(1.0)	14.2 *	(0.7)	22.1	(1.4)	19.7	(1.2)	23.2	(1.4)	19.1 *	(0.9)
-cakes/cookies	8.1	(0.8)	6.9	(0.4)	9.5	(0.7)	9.5	(0.8)	12.3	(0.9)	9.0 *	(0.9)
-RTE cereals	5.0	(0.4)	3.6 *	(0.3)	7.5	(0.7)	5.0 **	(0.4)	6.2	(0.5)	5.0 *	(0.3)
-breads/muffins	1.8	(0.2)	1.6	(0.2)	3.2	(0.7)	3.2	(0.3)	2.8	(0.2)	2.4	(0.2)
-other grains	1.9	(0.3)	2.1	(0.2)	1.9	(0.3)	2.1	(0.2)	1.8	(0.2)	2.7 *	(0.3)
Dairy products	8.6	(1.2)	10.1	(0.7)	10.5	(1.0)	11.6	(0.5)	8.4	(0.5)	7.7	(1.1)
-dairy desserts	2.6	(0.3)	2.6	(0.3)	5.6	(0.7)	5.1	(0.6)	4.7	(0.4)	4.4	(1.0)
-sweetened milk	3.6	(0.9)	4.6	(0.7)	4.0	(0.6)	5.2	(0.5)	3.0	(0.5)	2.4	(0.5)
-yogurt	1.3	(0.3)	2.0	(0.3)	0.7	(0.2)	1.0	(0.2)	0.2	(0.1)	0.5	(0.1)
-other dairy	3.5	(0.4)	0.9 ***	(0.2)	0.2	(0.1)	0.3	(0.1)	0.5	(0.2)	0.4	(0.2)
Fruits & vegetables	2.7	(0.3)	1.9 ***	(0.4)	3.4	(0.5)	3.1 **	(0.3)	2.4	(0.4)	1.8	(0.2)
Meats/beans/eggs	1.1	(0.1)	0.8	(0.1)	1.2	(0.1)	1.3	(0.1)	1.5	(0.1)	1.6	(0.1)
Oils	0.2	(0.0)	0.1	(0.1)	0.4	(0.1)	0.2 *	(0.0)	0.5	(0.1)	0.3 *	(0.0)

% energy=percent of total calorie intake; % added sugars=percent of total intake of added sugars; NHANES=National Health and Nutrition Examination Survey; RTE=ready to eat; 1 g added sugars=4 calories; 1 tsp=4.2 g

Results are presented as mean % total energy intake (95% confidence interval) unless otherwise specified

Testing for linear trend: *P<0.05; **P<0.01; ***P<0.001

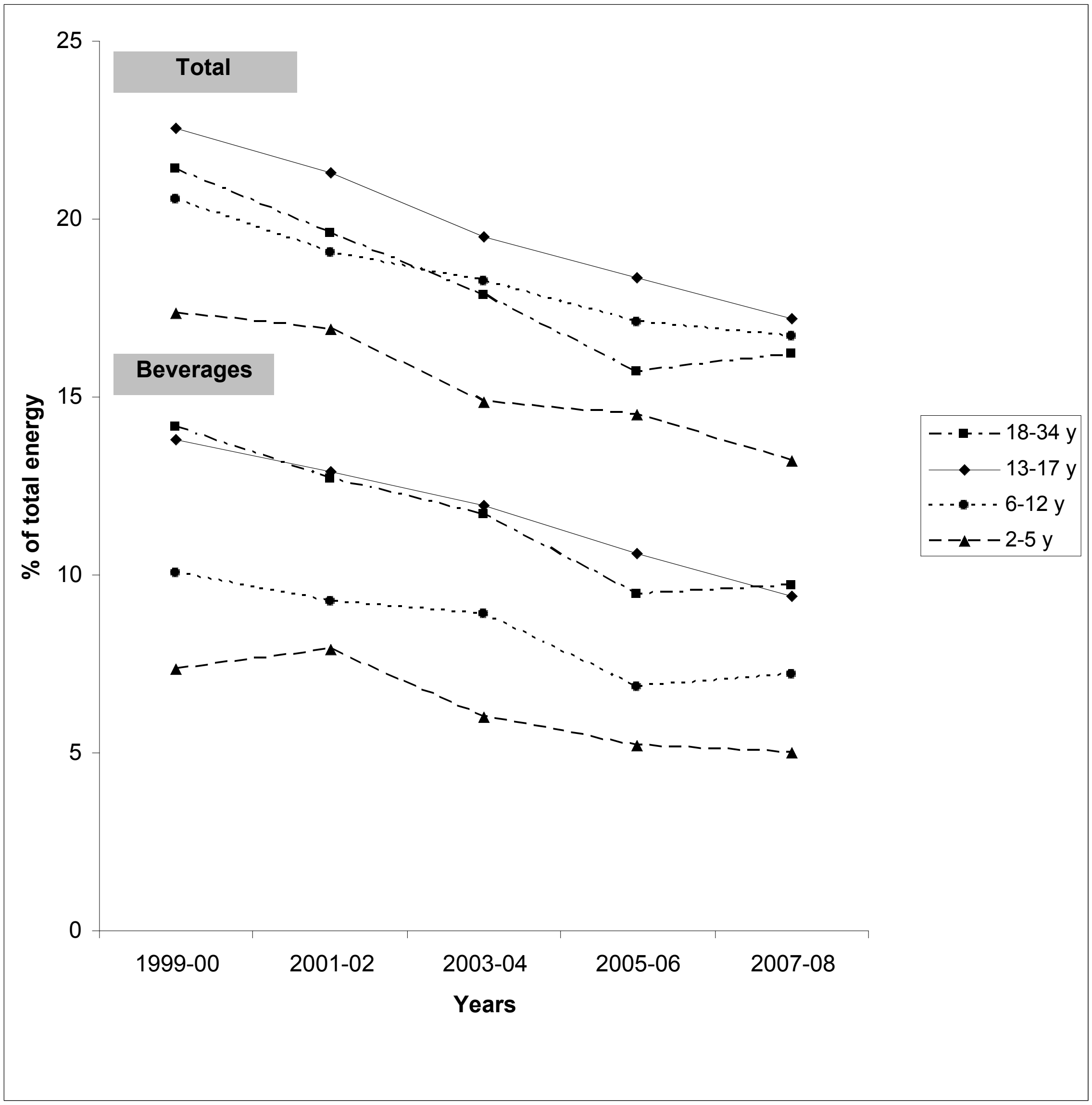

Figure 6-1. Trends in the proportion of total energy intake consumed as added sugars and as sugar-sweetened beverages by US children and young adults by age group, NHANES 1999-2008

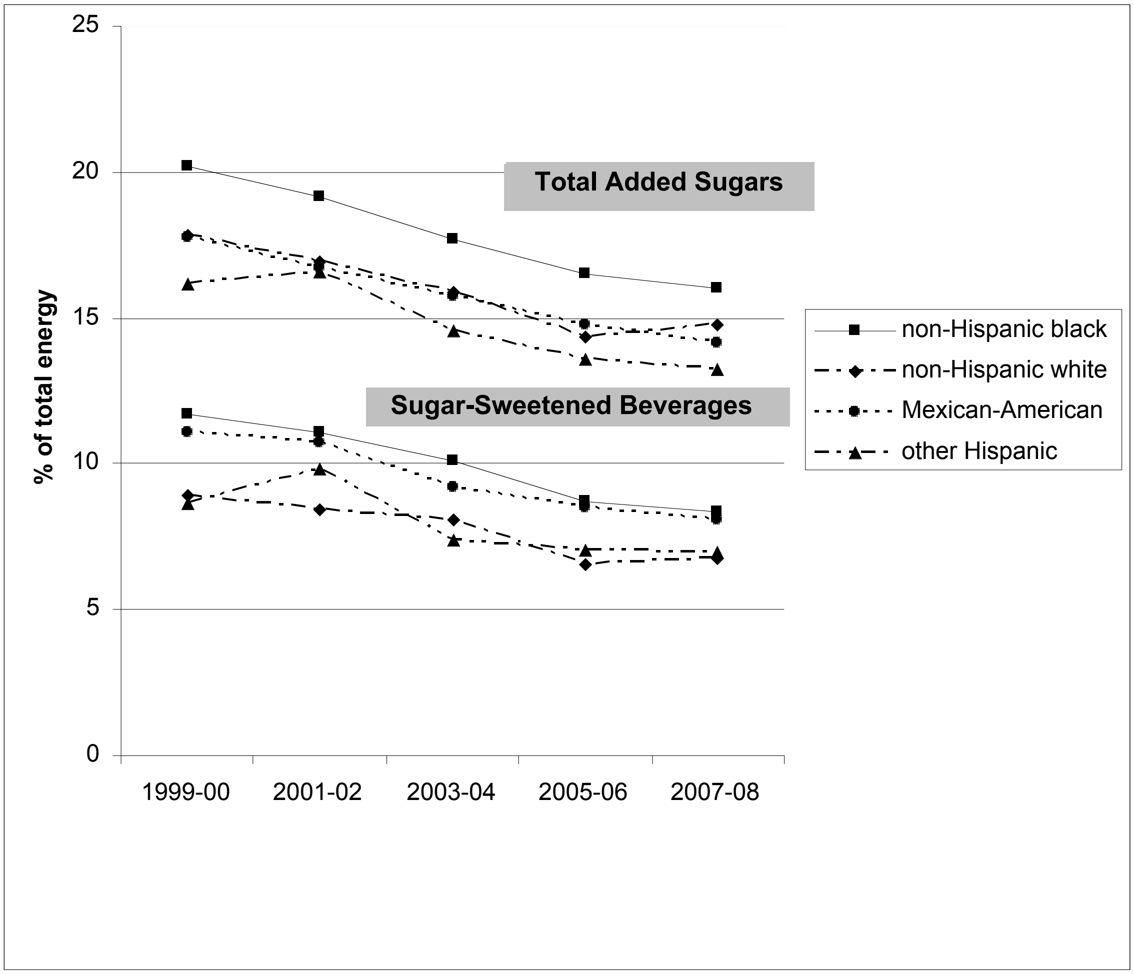

Figure 6-2. Trends in the proportion of total energy intake consumed as added sugars and as sugar-sweetened beverages by race/ethnic group, NHANES 1999-2000 to 2008-2008.

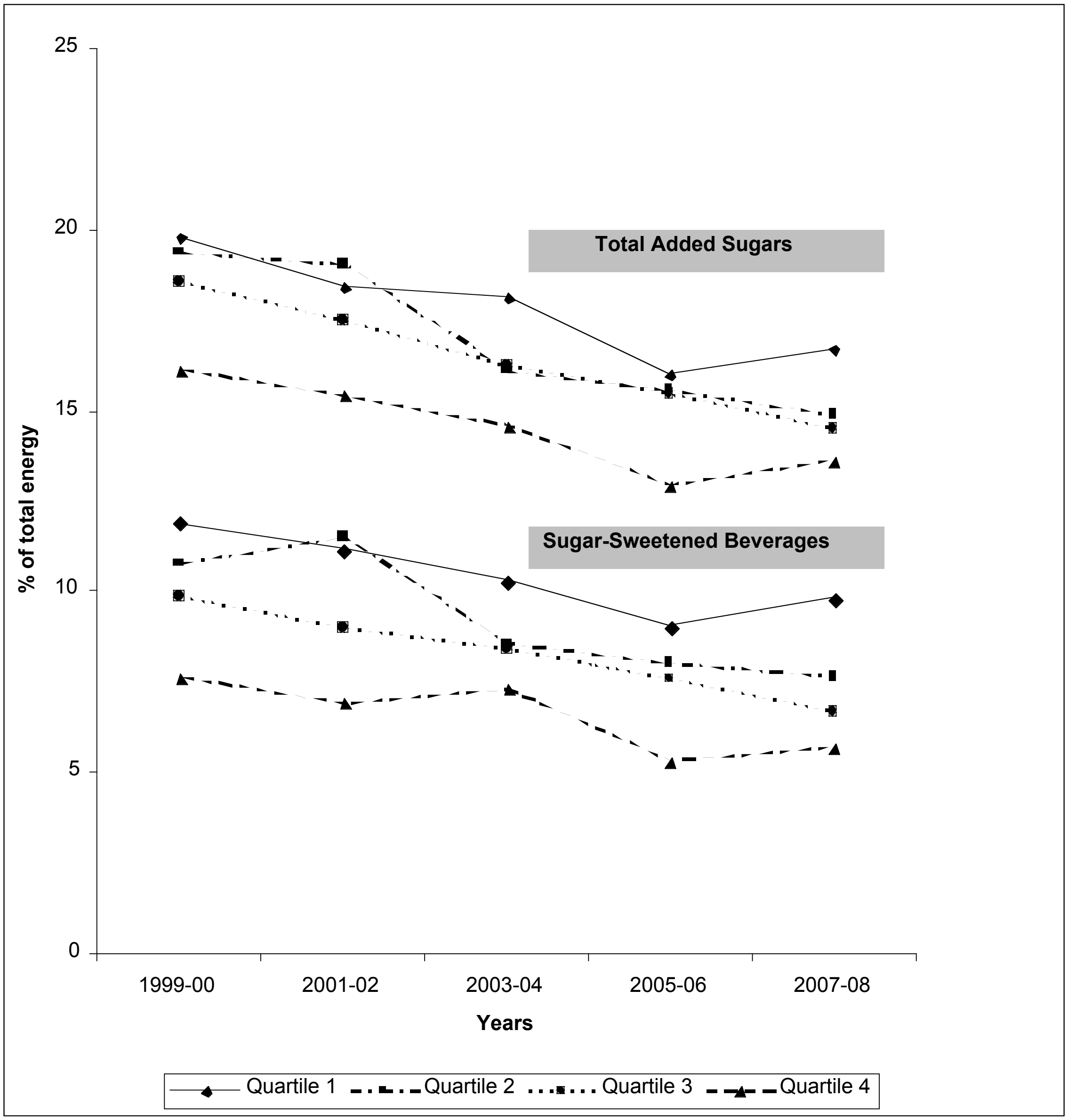

Figure 6-3. Trends in the proportion of total energy intake consumed as added sugars and as sugar-sweetened beverages by income quartile, NHANES 1999-2008

7 CDC Guide to Strategies for Reducing the Consumption of Sugar-Sweetened Beverages

Welsh J, Park S, Anderson S, and Sherry BL. The CDC Guide to Strategies for Reducing the Consumption of Sugar-Sweetened Beverages, March 2010. Available on-line at: www.cdc.gov/obesity

Introduction

In 2008-2009, the US Centers for Disease Control and Prevention developed a series of documents to serve as a resource to state departments of public health and others seeking to expand their efforts to reverse the increasing prevalence of obesity in the country. This document was developed as a resource for use those working to promote a reduction in the consumption of sugar-sweetened beverages as a means of reducing obesity.

This document was developed following a comprehensive review of the published and unpublished literature to identify program and policy interventions effective in reducing the consumption of sugar-sweetened beverages. In our review, only 13 papers from the peer-reviewed literature with the consumption of SSBs as an outcome were identified. All but one of these demonstrated a decreased, suggesting a possible bias toward the publication of positive findings. A summary of these studies and the key features of each can be found in Appendix B.

Given the limited available published evidence, the development of the strategies highlighted in this document was based, in large part, on unpublished evidence. This included program reports as well as expert opinion. The inclusion of a particular strategy in the CDC Guide to Reducing the Consumption of Sugar-Sweetened Beverages was dependent on the availability of evidence of its effectiveness and/or the existence of a strong rationale in support of it.

The CDC Guide to Strategies for Reducing the Consumption of Sugar-Sweetened Beverages

Table of Contents

Using This Guide

This document provides guidance for program managers, policy makers, and others seeking to identify strategies to reduce sugar-sweetened beverage (SSB) consumption. Several strategies outlined in this Guide, each of which includes;

Strategy: An environmental change or policy-related activity intended to prevent disease or promote health in a group of people, also referred to in the literature as "intervention." Criteria for inclusion of a strategy in the document are a rationale supporting the strategy and/or evidence that it has been effective.

Definition: Briefly describes the strategy.

Rationale: Explains why a particular type of strategy is important to reduce consumption of SSBs.

Evidence of effectiveness: Draws on peer-reviewed literature and current practice to summarize support for the strategy. .

Key considerations: Information that may be important to keep in mind during the planning, implementation, and/or evaluation phases of a recommended strategy.

Potential action steps: Identifies specific activities for each strategy for the priority settings for obesity prevention (communities, schools, worksites, and medical care settings).

Program examples: Examples of programs that employ the recommended strategies as a means of decreasing consumption of SSBs are presented. Program examples were selected from interventions described in publications, such as peer-reviewed journals or programmatic reports, identified through key informants and through internet searches...

*__Resources:__ Guides the reader to further materials and information that might be useful in implementing the recommended strategies.

References: A sequential list of all information sources.

*Note: Web site addresses of nonfederal organizations are provided solely as a service to readers. Provision of an address does not constitute an endorsement of this organization by CDC or the federal government. CDC is not responsible for the content of the individual organization Web pages.

I. Background

Sugar-sweetened beverages (SSBs) are the largest source of added sugar[1] and an important contributor of calories in the U.S. diet.[2] SSBs also tend to have few, if any, other nutrients. While the definitions used by researchers have varied,[3-5] we define SSBs to include soft drinks (soda or pop), fruit drinks, sports drinks, tea and coffee drinks, energy drinks, sweetened milk or milk alternatives, and any other beverages to which sugar, typically high fructose corn syrup or sucrose (table sugar), has been added (See Sugar Sweetened Beverages on this page). Although the presence of protein and other nutrients differentiates sweetened milk and alternative milk beverages from other SSBs, adding sugar to plain milk can substantially increase the calories per serving without increasing the overall nutrient value of the drink.

Sugar-Sweetened Beverages

Sugar-sweetened beverages are those that contain caloric sweeteners and include:
Soft drinks: Nonalcoholic, flavored, carbonated or non-carbonated beverages usually commercially prepared and sold in bottles or cans
Soda, pop, soda pop: Same as soft drink
Fruit drinks, punches, or ades: Sweetened beverages of diluted fruit juice
Sports drinks: Beverages designed to help athletes rehydrate, as well as replenish electrolytes, sugar, and other nutrients
Tea and coffee drinks: Teas and coffees to which caloric sweeteners have been added
Energy drinks: Most energy drinks are carbonated drinks that contain large amounts of caffeine, sugar and other ingredients, such as vitamins, amino acids, and herbal stimulants
Sweetened milks or milk alternatives: Beverages prepared by blending sweetened powder or syrup and milk*

[*]Though the body's response to added sugar in milk may differ from that of other SSBs because of the presence of protein and other nutrients, adding sugar to milk substantially increases the calories per serving.

In 1965, per capita consumption of SSBs (excluding sweetened milks) was 50 kcal/day (2.5% of total calories) among adults in the United States.[6] Currently, consumption is estimated at 224 kcal/day (11% of total calories) among youth[5] and 203 kcal/day (9% of total calories) among adults.[3] On a typical day, 80% of youth[5] and 63% of adults consume SSBs.[3]

The highest consumers of SSBs are adolescents aged 12 to 19 years (13% total calories), particularly males, non-Hispanic blacks and Mexican-Americans, those who are low-income, or obese (14% to 16% total calories).[5]

Several social and environmental factors have been linked to the purchase and consumption of SSBs. These factors include advertising and promotion;[7] increased portion sizes;[8] fast food consumption;[9] television watching;[10] permissive parenting practices;[11] parental SSB consumption;[12] and increased access to SSBs in the home and school.[5,13,14]

Several mechanisms have been proposed to explain the association between SSB consumption and obesity. First, individuals may fail to compensate for the added calories consumed as liquid and may result in excess intakes of sugar and calories.[15] Second, the rapid drop in blood sugar that follows the insulin response to consumption of foods high in sugar increases hunger and may thereby increase food consumption.[16] The third possible mechanism is the inability of fructose (a sugar found in commonly used sweeteners) to stimulate hormones that help regulate satiety.[17] Fourth, the inborn human desire for the sweet taste can override normal satiety signals.[14]

High consumption of SSBs has been associated with obesity. Many longitudinal studies have shown an association between SSBs and various measures of increased body fat.[18-26] Systematic reviews indicate that a greater consumption of SSBs is associated with small but significant weight gain and obesity.[15,27] In addition, the results of the recent PREMIER trial demonstrated that in reduction of SSB consumption among adults was significantly associated with weight loss. A decrease of 1 serving/day (12 ounces) was associated with a weight loss of 0.49 kg at 6 months and 0.65 kg at 18 months among adults.[28]

Several other health conditions have been associated with the consumption of SSBs. These include diabetes,[29,30] elevated triglycerides,[31,32] cardiovascular disease,[33] non-alcoholic fatty liver disease,[34] elevated uric acid levels,[35] gout,[36] and dental caries.[37] Furthermore, SSB consumption has been linked to nutritionally inadequate diets, possibly due to displacement of nutrient-rich foods, such as milk, with SSBs.[38-41]

II. Strategies for Reducing Sugar-Sweetened Beverage Consumption

Research indicates that consumption of SSBs is a modifiable behavior and that reducing consumption can result in a decrease in weight or body mass index (BMI),[28] a measure commonly used to assess excess body fat. Strategies to reduce SSB consumption have been identified for each of the priority settings for obesity prevention. These include communities (including homes), schools (including child care facilities), worksites, and medical care settings. The selection of each of these intervention strategies is based on a strong rationale supporting the strategy and, where available, evidence that the strategy has been effective. A review of the evidence included (1) an extensive search and review of the published literature identified through multiple searches of PubMed and (2) an extensive search and review of program reports identified through multiple internet searches and key informants.

Presented below are the strategies for reducing SSB consumption. Strategies that apply to all of the priority settings are listed first, followed by strategies that are setting-specific. For each strategy, the following are provided:

A. Definition
B. Rationale for the strategy
C. Summary of the available evidence of the strategy's effectiveness
D. Key considerations, such as barriers to implementation
E. Potential action steps
F. Program examples
G. Existing resources and tools for implementation

Strategies Applicable in All Priority Settings

Strategy 1: Ensure ready access to potable drinking water

A. Definition

To promote water consumption, potable drinking water should be easily accessible to children and adults in homes and public facilities, including parks, playgrounds, schools, public buildings, worksites, and clinics.

B. Rationale

Water is essential for life. Although our daily fluid intake requirements can be obtained from a variety of beverages and foods, potable drinking water is a calorie-free, thirst-quenching option.[42] In addition, fluoridated drinking water has another key function: it helps to prevent dental caries, the most prevalent chronic disease among children in the United States.[43]

In 2008, 8% of the U.S. population served by community water systems received drinking water that did not meet all applicable health-based drinking water standards.[44] Furthermore, in communities with potable drinking water, ready access outside of the home in schools, parks, public and commercial buildings is often limited because water fountains or coolers are not functioning.

Individuals without ready access to potable drinking water may consume more SSBs. For example, many rural areas in Alaska (northern and southwestern regions) lack ready access to potable drinking water. In these areas, over half (58%) of 2-year-olds drank two or more cups of SSBs (>13 teaspoons of added sugar) per day compared to 21%–26% of 2-year olds in all other regions of the state in 2006.[45] Rural Alaskan adults drink about three times as much soda per day as their urban counterparts.[46]

Over the past decade, bottled water sales have increased dramatically in the United States.[47] This increase has been influenced by the marketing and availability of a vast selection of new bottled water products and by consumer demand. The Institute of Medicine (IOM) Committee on Nutrition Standards for Foods in Schools examined evidence on increased consumption of bottled water products and their effects. The IOM recommended that carbonated, fortified, and flavored water should be excluded during the school day. This exclusion was based on evidence that these beverages are unnecessary for hydration and are associated with displacement of beverages that are more healthful than SSBs. In addition, the increasing number of products makes it difficult to identify the more healthful products among them.[48]

C. Evidence of Effectiveness

Three school-based interventions have been effectively increased water consumption among school-aged children.

A school-based environmental and educational intervention was conducted to promote water consumption among elementary school students in Germany. The intervention focused on the water needs of the body and the water circuit in nature. For the environmental intervention, water fountains were installed in schools, and plastic water bottles were given to each child. Outcome measures were evaluated at baseline and 1 year after intervention. The results indicated that the risk of overweight was significantly decreased by 31% in the intervention group compared to the control group. Furthermore, water consumption was 1.1 glasses/day (about 7.4 ounces) higher in the intervention group.[49]

A randomized, controlled trial was conducted to determine whether a multicomponent intervention aimed at discouraging SSB consumption could prevent excessive weight gain among 22 elementary schools in Brazil. Fourth graders in the intervention schools were given classroom-based education encouraging water consumption instead of SSBs throughout the school year. All students in the intervention classes were taught the benefits and importance of drinking water. In addition, a campaign promoting water consumption was conducted and water bottles with the campaign logo were distributed to the children and their teachers. After 7 months, children in the intervention schools drank significantly less carbonated beverages, about 2 ounces over the previous 24-hour recall, than those in the control schools. In addition, among overweight students at baseline, the intervention group had greater BMI reduction than the control group, but this difference was statistically significant among girls only. However, water intake was not measured.[50]

The Zuni High School Diabetes Prevention Program was a multicomponent intervention and conducted among American Indian high school students in the United States. Health education was provided to decrease SSB consumption and to increase knowledge of diabetes risk factors. Furthermore, this education was combined with environmental change to increase access to potable drinking water and physical activity. Outcome measures were evaluated at 0, 1.5, and 3 years. The results indicated that reducing access to SSBs could eliminate in-school SSB consumption among high school students. By the intervention's third year, the 400 students of Zuni High School consumed almost no sugared soft drinks at school, a decrease from 800 12-ounce cans/week/400 students (24 ounces/week/student). Soft drinks had been replaced by 150 gallons of water per week from the water coolers (24 ounces/week/student) and 260 12-ounce cans of diet soda (7.8 ounces/week/student). However, there were no significant differences in BMI over a 3 year-period.[51]

D. Key Considerations

- Increased bottled water sales have raised concerns regarding the lack of regulation, the lack of fluoridation, and the impact on the environment related to bottling and disposal practices.
- Because the taste and odor of drinking water is not included in federal and state requirements, challenges (e.g., costs) in providing palatable drinking water should be addressed.[52]

E. Potential Action Steps

All settings

- Complete a needs assessment to identify where access to potable drinking water is limited.
- Collaborate with oral health partners and others with a common interest to develop a workplan to promote the consumption of (fluoridated) drinking water.
- Advocate with public and private partners to improve the infrastructure to increase access to potable drinking water.
- Collaborate with state, local, and city government officials to establish, promote, and enforce policies to ensure ready access to potable drinking water.

Schools and child care facilities

- Promote legislation in your state to establish and promote policies to ensure children attending schools and child care facilities have ready access to potable drinking water throughout the day, including at meals.

F. Program Examples

School-based

Zuni High School Diabetes Prevention Program

A school-based multicomponent intervention was conducted to reduce SSB consumption as part of the Zuni Pueblo High School Diabetes Prevention Program. The intervention for American Indians included health education targeting decreased SSB consumption and increased knowledge regarding diabetes risk. The environmental change component included providing quality water for students in coolers in several school locations. Additionally, school officials gradually replaced sugar-sweetened soft drinks in the vending machines with diet soft drinks. Within 2 years, sugar-sweetened soft drinks in the schools were completely replaced by water and diet soft drinks.[51]

"Fresh Kids" Primary School Intervention

The aim of the Fresh Kids program was to evaluate the effectiveness of the Health Promoting Schools (HPS) framework. The framework was used to create a supportive school environment to increase water and fruit consumption and prevent obesity among students in 35 primary schools in Australia. The HPS objectives included: (1) establishing sustainable program partnerships between schools and local health and community agencies; (2) creating supportive school environments which promote water and fruit consumption during school day; and (3) enhancing student learning by linking the school curriculum with broader strategies to promote water and fruit consumption. Lunchbox audits were conducted to evaluate change in student dietary patterns. By the end of the first year, the increase in the proportion of children with filled water bottles ranged from 25% to 50% in these schools. The proportion of SSBs in lunchboxes decreased in all schools, by 11% to 38%.53

New York City's Nutritional Standards for Child Care
New York City Code requires that potable drinking water be made easily accessible to children attending child care throughout the day, including at meals. City code also prohibits providing beverages with added sweeteners, whether artificial or natural, to children enrolled in child care.[54]

G. Resources

All Settings

- **Wise up on Water**: Water UK. This document highlights the importance of adequate water intake for children. http://www.water.org.uk/home/water-for-health/resources/wise-up---children-web.pdf
- **Bottled Water, Learning the Facts and Taking Action**: Sierra Club. This document provides facts about bottled water and advocating for a reduction of bottled water use and an increased use of tap water. http://www.sierraclub.org/committees/cac/water/bottled_water/bottled_water.pdf
- **Fact Sheet on Questions About Bottled Water and Fluoride**: Centers for Disease Control and Prevention, Division of Oral Health, This fact sheet covers common questions about bottled water and fluoride. http://www.cdc.gov/fluoridation/fact_sheets/bottled_water.htm

Schools

- **Water Quality Funding Sources for Schools**: Environmental Protection Agency. This guide provides a list of over 60 national and state funding sources that schools may use to address water quality and other environmental health issues. http://www.epa.gov/-OGWDW/schools/pdfs/lead/funding_schools_fundingsources.pdf

Strategy 2: Limit access to sugar-sweetened beverages

A. Definition

SSBs are readily accessible in homes, schools, worksites, and communities. Limiting availability and accessibility of SSBs can decrease SSB consumption and increase the consumption of more healthful beverages.

B. Rationale

Currently, SSBs are readily accessible to children and adults throughout the day in their homes, schools, and worksites. Even very young children are being given SSBs by their parents and caregivers in home and child care settings. Almost 30% of 12- to 14-month-old children, 37% of 15- to 18-month-old children, and 44% of 19- to 24-month-old children consume fruit drinks and/or carbonated soft drinks at least once in a day.[55] On weekdays, children obtain 55% to 70% of the SSB calories they consume at home whereas, only 7% to 15% are consumed in schools.[5] Among young adults (age 20 to 44 years) about 50% of SSBs are consumed at home, and 20% are consumed at work.[3]

Several factors in the community and home environment influence beverage consumption patterns including accessibility of SSBs and parenting practices, although the impact of these influences may vary by sex. For example, adolescent boys with greater access to less healthful beverages at home are more likely to consume SSBs. However this access appears to be a poor predictor of soft drink consumption in girls.[11] Parenting behavior is also important; adolescent soda consumption has been associated with parental soda consumption.[56] The availability of fast food restaurants in communities may also play a role, as frequent use of fast food restaurants was associated with higher SSB consumption.[9]

School-aged children gain access to SSBs at school throughout the day through vending machines, school canteens, and at fundraising activities, school parties, and sporting events.[57] In the United States, 21% of elementary schools, 62% of middle schools, and 86% of high schools have a vending machine, a school store, a canteen, or a snack bar where students can purchase foods or beverages, often during their lunch periods.[57] While national school meal programs require that meals meet national nutrition standards, competitive foods (foods which are sold outside the United States Department of Agriculture (USDA) school meals programs) are not required to meet these standards.

Many schools have "pouring contracts" with their beverage suppliers, and profits from these contracts provide income to the school in proportion to beverage sales. Thus, encouragement to consume SSBs via school-based advertising and opportunities such as increased access to scholarship funds (from beverage suppliers) are greater in schools that have beverage contracts.[58,59] While concerns have been raised regarding the potential loss of income that would result from revising or eliminating pouring contracts, evidence suggests that these concerns may be unfounded. A review of school beverage contracts in Oregon Public School Districts in 2004 showed that vendor cash advances and non-cash payments to the school are minimal, ranging between $2 and $8 per student per year. This is in contrast to an expected vendor profit of $12 to $24 per student per year.[58]

Many state agencies and school districts impose restrictions on the sale of beverages and foods sold in schools. Twenty-three states (46%) and many school districts have policies for competitive foods that are more stringent than USDA regulations on the National School Lunch Program.[60] Another study reported that 19 (39%) of the 51 largest school districts in each state and the District of Columbia had competitive food policies beyond state or federal requirements in 2004–2005. Of those 19 school districts, 63% had policies that restrict soda in all schools, and 74% had policies that restrict sugar content of juice drinks.[61] Coinciding with this study, a recent report was released to assess availability of less healthful beverages and snack foods in middle and high schools as a part of the 2008 School Health Profiles Survey. The percentage of schools that restrict soda pop or sports drink sales to students varied widely. Among the 34 states included in this study, the 2008 data showed that the percentage of schools in which students could not purchase soda pop or sports drinks in schools ranged 26%–93% for soda pop and 23%–85% for sports drinks. Furthermore, the state median percentage of schools that restrict soda pop or sports drink sales to students was 63% for soda pop and 44% for sports drinks.[62]

A large proportion of children in the United States are enrolled in some form of child care facility. Based on the 2005 National Household Education Survey, 51% of U.S. children ages 0–2 years and 74% of children ages 3–6 years who were not in kindergarten were in some form of non-parental care. About 20% of children ages 0–2 years and 57% of children ages 3–6 years who were not in kindergarten were in center-based child care facilities.[63] However, a review of U.S. state regulations for child care facilities for all 50 states and the District of Columbia reported that only seven states (14%) have regulations which restrict SSBs in both child care centers and family child care homes. Furthermore, only four states (8%) have regulations which prohibit vending machines at the child care center, and two of these states also restrict vending machines at family child care homes.[64]

Vending machines were available in 79% (15 out of 19) of health care facilities (8 hospitals, 7 clinics, and 4 public health departments) located in six California communities that are participating an environmentally focused childhood obesity prevention program. The majority of beverages sold in vending machines were less healthy items. The most prevalent beverage was soda: 30% in hospital vending machines and 38% in clinic vending machines. Water (20%) comprised the highest percentage of all beverages offered for sale in health department vending machines. Across 19 health care facilities, 75% of beverages offered for sale in vending machines did not follow the California school nutrition standards.[65]

C. Evidence of Effectiveness

Students who participate in the National School Lunch Program, which restricts the sale of carbonated soft drinks in the same location where lunch is being served, consume significantly less added sugar than nonparticipants. Among participants, mean intake of added sugars contributed 17% of their daily caloric intakes, compared with 20% for nonparticipants.[66]

The Alliance for a Healthier Generation, a collaboration between the Clinton Foundation and the American Heart Association, developed School Beverage Guidelines[67] to promote the consumption of lower-calorie and nutritious beverages outside of school meals among students during the regular and extended school day. In voluntary agreement with the Alliance, the American Beverage Association and several beverage producers have adopted these guidelines as their school beverage policy. In doing so, the American Beverage Association and several beverage producers agreed to encourage their bottlers to adhere the School Beverage Guidelines. They also agreed to support an annual analysis to assess the implementation and impact of these guidelines. According to the 2007 independent evaluation of the program, nearly 80% of all school beverage contracts were in compliance with these guidelines, contributing to an almost 60% drop in beverage calories shipped to schools since 2004.[68] Furthermore, the reduction in the purchase of regular carbonated soft drinks was observed among high school students after the implementation of these guidelines. The average student purchased 12.5 ounces of regular carbonated soft drinks per week in schools (about one can of soda per school week) in 2004, but by the 2007–2008 school year, these soft drink purchases decreased by one-third to two-thirds of a can per student per week.[68]

D. Key Considerations

All settings

- Once policies are adopted, ensure that enforcement mechanisms are in place for these policies including those voluntarily adopted by the beverage industry.

Schools

- While schools provide an important opportunity to restrict SSB availability, educate, and model healthy behavior, reducing SSB consumption only at school may have little impact on overall SSB consumption, because the majority of SSBs are consumed at home.[5]
  Schools may be resistant to changes in their beverage policies until concerns regarding potential loss of revenue from the sale of SSBs are addressed. A growing body of evidence indicates that schools can have strong nutrition standards that restrict availability of SSB and maintain financial stability.

E. Potential Action Steps

All settings

- Use price adjustments to decrease the cost of more healthful beverage alternatives in relation to SSBs (See Potential Action Steps for Strategy 5).
- Establish a policy to require providing a greater proportion of healthier beverages relative to SSBs.

Schools

- Convene a meeting with school officials to jointly address the availability and sale of SSBs in schools and suggest they involve students in these discussions.
- Collaborate with state and school district officials to include in school wellness and nutrition policies a component that eliminates the sale of SSBs on school grounds, including sports venues, and as part of school-based activities such as fundraising efforts consistent with recommendations from IOM Nutrition Standards for Foods in Schools, Leading the Way Toward Healthier Youth.[48]
- Collaborate with state and school district officials to redefine or eliminate beverage "pouring contracts" in schools. As needed, build support for pouring contract changes by addressing concerns of school administrators, parents, and others regarding potential loss of revenue.

F. Program Examples

Community-based

City of New York

The city of New York is the first major city to set nutrition standards for all foods purchased and served. These guidelines apply to all meals or food supplies that are purchased, prepared or served in agency programs or other relevant settings. These standards are part of the city's effort to reduce obesity in school children who are the most frequent consumers of city food, and to reduce obesity and high blood pressure in adults and seniors who regularly consume publicly-purchased food. The new standards apply to snacks and meals served in places such as schools, senior centers, homeless shelters, child care centers, after school programs, correctional facilities, public hospitals, and parks. The standards require city agencies to serve only more healthful beverages such as skim or 1% milk (children aged 12 months to less than 2 years are allowed to drink whole milk).

These standards require ≤25 calories per 8 ounces for beverages other than 100% juice or milk.
Juice must be 100% fruit juice, and serving size is recommended not to exceed 6 ounces per serving for children in elementary school. For children ages 2–18 years flavored milk and flavored fluid milk substitutes are permitted but required to be ≤130 calories per serving. These standards include a recommendation that agencies continue to phase out flavored milk and flavored fluid milk substitutes over time.[69]

School-based

National School Lunch and School Breakfast Programs

The National School Lunch Program (NSLP) and the School Breakfast Program are federally supported programs that provide nutritionally balanced meals at low-cost or no-cost to students in nearly all public and many private schools throughout the United States. USDA regulations prohibit the sale of Foods of Minimal Nutritional Value, including carbonated soft drinks, at the same time and in the same location that national food program meals are being served. Evidence suggests that NSLP participants are 4 times as likely as nonparticipants to consume milk at lunch and to have adequate daily intakes of key nutrients.[70]

West Virginia Department of Education Standards for School Nutrition

Legislative rules were passed by the West Virginia State Department of Education in 2008 to establish comprehensive nutrition standards for beverages and foods sold, served or distributed during the school day. The rules specify that beverages available to students at all grade levels must contribute to students' nutrient requirements and should not add unnecessary calories, fat, or sodium. Specifically, allowable beverages are water, 100% fruit and/or vegetable juice, and non-fat or 1% low-fat milk (flavored or unflavored). All beverages must contain less than 200 calories and less than 35% of calories from sugar. Portion sizes of juice should be limited to 4 ounces for elementary students and no more than 8 ounces for middle and high schools students. Drinking water must be offered with meals. Furthermore, plain, unflavored drinking water must be available to students throughout the school day at no charge. Unacceptable beverages by these rules are soft drinks, coffee and coffee-based products, and other caffeinated products. In addition, the Board of Education policy also prohibits the use of beverages as a means of reward, restricts the use of beverages in fundraising, and sets limits on school advertising of beverages.[71]

The new policy is being phased in throughout West Virginia. Internal reports prepared by the West Virginia Department of Education indicate that the number of schools in compliance with these rules increased from 25 schools in 2007–08 to 46 schools in 2009–09. The impact of this new policy on school revenues has been minimal.[72]

Philadelphia School District Beverage Policy

A new beverage policy for the School District of Philadelphia, the fifth largest school district in the country, was developed to promote healthy eating and decrease childhood obesity and diet-related diseases. The new beverage policy eliminated sodas and implemented a policy for all vending and à la carte sales as of July 2004. Allowable beverages are 100% juice, water, with no additives except those normally added to tap water, and low-fat or non-fat milk (plain or flavored).[73]

G. Resources

Schools

- **IOM Nutrition Standards for Foods in Schools: Leading the Way to a Healthier Youth (2007)**: Funded by the Centers for Disease Control and Prevention and developed by the Institute of Medicine, this report sets nutrition standards for K-12 schools focused on competitive foods. http://www.iom.edu/CMS/3788/30181/42502.aspx
- **Nutrition Standards for Foods in Schools Fact Sheets** provides information for students, school staff, and parents to use to support strong nutrition standards consistent with the Institute of Medicine's recommendations.

http://www.cdc.gov/Healthyyouth/nutrition/standards.htm

- **Making it Happen! School Nutrition Success Stories**: U.S. Department of Agriculture and the Department of Health and Human Services' Centers for Disease Control and Prevention. This is a collection of approaches implemented by over 30 schools and school districts to improve the nutrition environment in schools. http://www.fns.usda.gov/tn/Resources/makingithappen.html
- **State Laws & Regulations Governing Beverage Sales in Schools**: The American Beverage Association & the Alliance for a Healthier Generation. It is a comprehensive list of state school beverage legislation. The list provides information on states with federal regulations only or state and federal regulations. The following is a direct link to this document: http://www.schoolbeverages.com/research--faqs/school-wellness-policies/download.aspx?id=59. The following is a link to the entire website: http://www.schoolbeverages.org/index.aspx
- **Action for Healthy Kids: Wellness Policy Toolkit**: Action for Healthy Kids. This toolkit provides a comprehensive step by step guide to developing a Local Wellness Policy within your school district. The toolkit also offers policy implementation strategies. http://www.actionforhealthykids.org/wellnesstool/index.php
- **Healthy Beverage Toolkit**: Food Trust. The toolkit provides school staff and administration, parents and the community with information about promoting healthy beverage consumption in schools to address childhood obesity. The toolkit highlights the importance of advocating for policies, engaging key partners, coalition building and other relevant topics. http://www.thefoodtrust.org/php/programs/school.food.beverage.reform.php
- **Best Practices for Healthy Eating: A Guide to Help Children Grow Up Healthy**: Nemours. This nutrition guide was prepared in collaboration with Delaware's Child and Adult Care Food Program as a guide for parents and health professionals on recommended eating habits throughout the life stages of infancy through adolescence. The guide is sectioned by age and food groups making it easy to find information. http://www.nemours.org/department/nhps/child-care/healthy-habit.html
- **School Beverage Guidelines Toolkit**: Alliance for a Healthier Generation. This toolkit provides guidelines for schools to assist them in revising their beverage policies in order to promote the consumption of more healthful beverage options among students. http://www.healthiergeneration.org/uploadedFiles/For_Schools/Helpful_Tools/Alliance%20School%20Beverage%20Toolkit.pdf

Strategy 3: Promote access to and consumption of more healthful alternatives to sugar-sweetened beverages

A. Definition

Beverages such as water, low-fat/non-fat milk, and 100% juice contribute to meeting daily nutrient needs. Although SSBs contain water, they tend to have high calories and few other nutrients, thus, may negatively impact dietary quality and contribute to excess energy intake.[3,20] This strategy aims to increase efforts by policymakers, community leaders and parents to provide access to and encourage consumption of more healthful beverages in place of SSBs. Efforts to promote the consumption of more healthful alternatives to SSBs include developing or adopting healthy beverage policies for various settings. These alternative beverages provide valuable nutrients, in addition to calories, including calcium, iron, folate, and vitamins A, etc.[74]

While there is no standard definition of a healthy beverage, the IOM School Nutrition Beverage Guidelines have established recommendations for school-age children. The IOM School Nutrition Beverage Guidelines are shown on this page.[48]

B. Rationale

Providing access to more healthful alternatives to SSBs may be important for reducing SSB consumption, because individuals without ready access to potable drinking water tended to drink more SSBs.[45] Furthermore, when availability of healthier beverages (e.g., milk) increases, their consumption increased and SSB consumption decreased.[75]

Marketing of foods and beverages influences children's preferences, purchase requests, and consumption.[76] In addition, beverage consumption patterns of parents appear to be an important influence on their children's consumption of soft drinks.[12] Youth whose parents regularly drink soft drinks are nearly three times more likely to consume soft drinks five or more times per week.[14] When parents avoid

Institute of Medicine (IOM) School Nutrition Beverage Guidelines

The IOM School Nutrition Committee developed recommendations for beverages sold outside of the national school meal programs.[48] Tier 1 beverages are those that provide important health benefits and do not exceed levels of nutrients and compounds that may be unhealthful for school-age children when consumed in excess. These include:

- Plain, potable water
- Low-fat/non-fat milk (or soy/lactose-free alternatives) in 8-ounce portions and, if flavored, with less than 22 g of total sugars per 8-ounce portion
- 100% fruit juice in 4-ounce portion for elementary and middle school and 8 ounces for high schools

Tier 2 beverages are for high school students and after school only. These provide additional options that help to limit caloric intake. These include:

- Non-caffeinated, non-fortified drinks that contain <5 calories per portion as packaged (with or without nonnutritive sweeteners, carbonation, or flavoring)

Other beverages:

- Sports drinks should be available only at the discretion of the coaches for students doing vigorous physical activity lasting an hour or more consuming soft drinks in the presence of children, children consume fewer soft drinks.[12]

C. Evidence of Effectiveness

Several individual/parent and school-based lifestyle interventions designed to improve dietary quality and/or access to more healthful alternatives have demonstrated a decrease in SSB consumption.

A diet and lifestyle change, multicomponent intervention targeting parents (the Hunter Illawarra Kids Challenge Using Parent Support study) improved the diets of their children by significantly decreasing total energy intake and SSB consumption. Overweight or obese children (5–9 years of age) and parents were randomly assigned to one of three groups, (1) a parent-centered family lifestyle and dietary modification program; (2) a child-centered physical activity skill development program; or (3) a combination of both programs. After 12 months, SSB consumption decreased among children participating in all of the programs. The mean SSB intake for all children significantly decreased from 5.0% of total energy intake to 2.9%.[77]

A family-based and culturally appropriate lifestyle, multicomponent intervention (the Memphis Girls Health Enrichment Multisite Study) effectively decreased SSB consumption among African American adolescent girls. The girls were randomly assigned to one of three groups, (1) an intervention group that provided weekly group sessions with the girls; (2) an intervention that included weekly group sessions with the girls' parents/caregivers; or (3) a comparison group. Content focused on knowledge and behavior change skills to promote healthy eating, including decreasing SSB consumption and increasing physical activity. The comparison group focused on self-esteem. The mean, baseline-adjusted, children's SSB intake at 12 weeks was significantly different by groups: 2.4 servings/day for those in the child-targeted group, 1.5 servings/day for those in the parent-targeted group, and 3.0 servings/day for those in the comparison group, suggesting that targeting parents/caregivers may provide the greatest impact.[78]

The effect of increasing availability of milk at home on weight status was examined among 98 children aged 8 to 10 years who regularly consumed SSBs in Chile. Children were randomly assigned to intervention and control groups. During the 16-week study, children in the intervention group were counseled to drink 3 servings of milk daily and to avoid consuming SSBs. Parents were asked to remove SSBs from the home. A supply of "flavored" milk (80 kcal/200 ml per serving; of note, skim milk has 69 kcal/200 ml[79]) was delivered to the homes of enrolled children weekly. Among children in the intervention group, milk consumption increased significantly by 453 g/day (16 ounces/day) and SSB consumption decreased by 711 g/day (25 ounces/day). For the control group, milk consumption did not change, and SSB consumption increased by 72 g/day (2.5 ounces/day). Changes in percentage body fat were not different between groups.[75]

In another randomized controlled trial, 103 U.S. adolescents aged 13 to 18 years who regularly consumed SSBs were assigned to intervention and control groups. Noncaloric beverages were delivered to the homes of adolescents in the intervention group for 25 weeks. The adolescents enrolled in the intervention group were discouraged from drinking SSBs through instructions given by phone or sent through the mail. In this study, daily consumption of SSBs decreased by 82% in the intervention group (-286 ml) while there was no change in the control group. Among adolescents with the highest BMIs (top one-third) at the beginning of the study, their increase in BMI by the end of the study was significantly less in the intervention compared to the control groups. Among those with lowest BMIs (bottom one-third), the change in BMI in the intervention group was less than the change in the control group but was not significant.[26]

Choice, Control, and Change (C3) was a formative evaluation of a middle school curriculum designed to foster healthful eating and physical activity. The C3 was conducted in 19 science classes within 5 U.S. middle schools using a pretest-posttest evaluation design without a control group. The C3 curriculum consisted of 24 lessons taught by science teachers most school days over a period of about 7 to 8 weeks. The evaluation demonstrated that science-based education could improve the diet of students over the study period, including a reduction in SSB intake. The weekly consumption of soft drinks significantly decreased from 4.5 days per week at baseline to 4.2 days per week at follow-up. The consumption of non-carbonated SSBs decreased from 4.8 days per week to 4.1 days per week.[80]

D. Key Considerations

All Settings

- Some of the more healthful alternative beverage choices, such as flavored milk (according to the IOM School Nutrition Beverage Guidelines[48], this could be low-fat/non-fat milk with less than 22 g of total sugars per 8-ounce portion) and 100% juice, contain a substantial number of calories per serving. Therefore, it is important to monitor the quantity and frequency of consumption of these beverages in relationship to dietary quality and individual calorie needs as described in the Dietary Guidelines for Americans.[81] The IOM School Nutrition Beverage Guidelines recommended that milk contain less than 22 g of total sugars per 8-ounce portion.[48] The American Academy of Pediatrics advises that daily consumption of 100% juice be limited to one 4–6 ounce serving daily for young children and to two 6-ounce servings for older children and adolescents.[82]
- While artificially sweetened beverages (e.g., diet soft drinks) have a sweet taste and fewer calories, the evidence regarding the effectiveness of artificial sweeteners as a weight management strategy is inconsistent.[83]

Schools

- As outline by the National Food Service Management Institute, efforts to promote more healthful beverages to students may be more effective when they:[84]
    - Identify and address the explicit rewards and barriers perceived by the target audience
    - Provide simple, strong, repetitive, consistent, and specific messages about the desired behavior

- Promote benefits in terms of taste instead of nutrition
- Be upbeat to engage and excite children and teenagers
- Convince children and teens that selecting nutritious foods is easy to do
- Present in a catchy and easily recalled format[84]

- Self-reports from schools working to improve the nutrient quality of beverages and foods sold to students indicate that increasing the availability of more healthful options does not reduce revenue from competitive foods. Of the 17 schools that reported income data for the report, *Making It Happen! School Nutrition Success*, 12 schools increased their revenue as a result of the changes made to increase the availability of healthful beverages and foods, and four schools reported no change.[85]

E. Potential Action Steps

All Settings
- Collaborate with state, local, and city government officials and community leaders to develop or adopt healthy beverage policies for different settings and monitor to ensure effective implementation. For example, healthy beverage policies could be the adoption of the IOM School Nutrition Beverage Guidelines[48]
- Work with relevant decision makers in each setting to develop a beverage purchasing policy to require beverages in container sizes that are age appropriate and suitable for each beverage type.
- Collaborate with relevant decision makers in each setting to develop and promote the adoption of healthy beverage policies for meetings, events, and other activities in their settings.
- Provide resources and training on how to select more healthful beverages for meetings and events to food service personnel and those who order catering for meetings and events.
- Provide information to the general public on potential benefit of healthful alternatives to SSBs.

Communities
- Collaborate with state, local, and city government officials and food service industry to include posting of beverage calorie information as a component of point of purchase and menu labeling initiatives.

Schools
- Collaborate with school district officials and child care officials to monitor the availability of more healthful alternatives to SSB in schools and child care facilities.
- Provide education regarding the potential health effects of SSBs to teachers, parents, and other influential adults and emphasize their role as models for healthy beverage consumption.
- Incorporate nutrition/healthy beverage training into existing teacher training curricula.
- Provide training, technical assistance and support to guide the development and maintenance of a healthy beverage environment in schools and child care facilities.

- Assess whether nutrition education is a part of the core curriculum for students and whether beverage consumption is a part of this curriculum.

F. Program Examples

Community-based

Santa Clara County Healthy Food and Beverage Policy

The county of Santa Clara, California passed legislation that requires that 50% of the beverages sold in county vending machines meet specific nutrition guidelines. Beverages that meet the nutrition guidelines include:

- Water
- 100% fruit juices, with no additives
- Non-fat, 1%, and 2% non-flavored milk
- Plant-derived milk (i.e. soy, rice, and others)
- Artificially-sweetened, calorie-reduced beverages that do not exceed 50 calories per 12-ounce container
- Other non-caloric beverages

The county also set nutrition standards for county sponsored meals and events.[86]

School-based

Aptos Middle School, San Francisco Unified School District

A pilot study was conducted in Aptos Middle School, San Francisco's most racially diverse middle school, to assess the effectiveness of changes to the school vending and à la carte food policies. As part of the study, all soft drinks were removed from the vending machines located in the physical education (PE) department and replaced with bottled water. Following the change, students bought more bottles of water than they used to buy of soft drinks when soft drinks were available. Because the larger water bottles sold for a higher price, vending machine revenues increased in the PE department. In addition, soft drinks were also removed from the à la carte line in the cafeteria and replaced with water, milk, and 100% juice (no more than 12 ounces per serving) and healthier food options were added to the menu. Since the changes, à la carte revenues have remained similar to sales before the changes. Net revenues have increased, however, because costs for the cafeteria to procure the more healthful items are lower. The Aptos cafeteria ended the 2002–2003 year with a surplus of $6,000.[85]

Work site-based

South Dakota Worksite Sodabriety Healthy Challenge
In May of 2008 Healthy South Dakota conducted the "Sodabriety Healthy Challenge," one of a series of online challenges targeting worksites.[87] The purpose was to get South Dakotans to drink more water and fewer sweetened beverages. Over 1,000 registered participants completed beverage consumption records online. Participants were primarily women between the ages of 20 and 59, and over half were state government workers. Results from an online questionnaire sent to participants after the challenge showed that over the month of the Sodabriety Challenge:

- 88% increased water intake
- 74% decreased sugar-sweetened beverage intake
- 77% maintained increased water intake since challenge ended (for one month)
- 78% increased knowledge of health effects of sweetened beverages[87]

G. Resources

Communities

- **Healthy Beverage Community Action Kit**: Indian Health Service (2006). This kit provides action plans to promote increased consumption of more healthful beverages. http://www.ihs.gov/MedicalPrograms/Nutrition/
- **Texas! Bringing Healthy Back Presents: Growing Community**: Texas Department of State Health Services. This video series is a communications initiative and tool created to educate and inspire communities into action against obesity. Watch "Positioned for Change: Decreasing Sugar-Sweetened Beverages" at the following site. http://www.dshs.state.tx.us/obesity/growingcommunity/default.shtm
- **Dietary Sugars Intake and Cardiovascular Health**: The American Heart Association (AHA) Nutrition Committee of the Council on Nutrition, Physical Activity, and Metabolism and the Council on Epidemiology and Prevention. An AHA scientific statement provides the association's recommendations on specific levels and limits on the added sugar consumption. http://americanheart.mediaroom.com/index.php?s=43&item=800

Schools/Child care

- **Nutrition Standards for Foods in Schools: Leading the Way toward Healthier Youth**: Institute of Medicine (2007). This report was funded by the Centers for Disease Control and Prevention and developed by the IOM. It sets nutrition standards for K–12 schools focused on competitive foods. http://www.iom.edu/CMS/3788/30181/42502.aspx
- **Making it Happen! School Nutrition Success Stories**: U.S. Department of Agriculture and the Department of Health and Human Services' Centers for Disease Control and Prevention. This document is a collection of approaches implemented by over 30 schools and school districts to improve the nutrition environment in schools. http://www.fns.usda.gov/tn/Resources/makingithappen.html
- **Marketing Nutrition in the Middle Grades: Adolescent Food Habits and Marketing Strategies That Work**: The National Food Service Management Institute

(2001). The school marketing report offers effective marketing strategies that apply to adolescents and middle grade students. The resource is intended for individuals and/or organizations who intend to implement a nutrition marketing campaign. www.cde.state.co.us/cdenutritran/download/pdf/Marketiiddlegrade.pdf

- **Nutrition and Physical Activity Self Assessment for Child Care (NAP SACC)**: This program aims to change the nutrition and physical activity environment of child care facilities with an assessment tool, implementation plan and policy information. The Website also provides information for parents, child care centers, health professionals, and policymakers. http://www.napsacc.org/

Worksites

- **Guidelines for Healthy Meetings**: New York Department of Health. The guidelines provide a list of suggestions for making work site meetings healthy. The guidelines give general information and specific recommendations for food options. http://www.health.state.ny.us/nysdoh/prevent/guidelines.htm
- **Meeting WellTM A Tool for Planning Healthy Meetings and Events**: The American Cancer Society. This tool is designed to help companies organize meetings and events with good health in mind. http://www.acsworkplacesolutions.com/meetingwell.asp

Strategy 4: Limit marketing of sugar-sweetened beverages and minimize marketing's impact on children

A. Definition

SSBs are extensively advertised and promoted to encourage their purchase. Efforts to reduce SSB consumption might include working to reduce the marketing of these beverages or to counter their marketing through media literacy training for children and other consumers.

B. Rationale

A report from the IOM concluded that beverage and food marketing influences children's preferences, their purchase requests, and consumption. The IOM also noted that beverage and food marketing is a likely contributor to the consumption of less healthful diets. In addition, consumption of a less healthful diet contributes to negative diet-related health outcomes.[76]

Consumer advertising and marketing is regulated almost exclusively at the federal level. However, there are no federal regulations regarding the advertising of SSBs. In 2006, the Federal Trade Commission and the Department of Health and Human Services issued a report urging the food marketing industry to take specific steps to change its marketing to children practices to help address childhood obesity.[88] Recently, the Council of the Better Business Bureau established guidelines on child-directed advertising of beverage and food products.[89] Since then, several beverage companies have agreed to voluntarily discontinue advertising SSBs directly to children under 12 and to instead promote products identified by the industry as those that contribute to more healthful dietary choices and healthy lifestyles.[89] However, no federal guidelines have been established for defining those more healthful lifestyle products or for monitoring compliance with these voluntary restrictions.

The nonalcoholic beverage industry is very competitive, so hundreds of new products are introduced each year. In 1999, this industry (excluding the dairy industry) spent more than $500 million on magazine and network television advertising.[90] Of food products, carbonated soft drinks have very high brand loyalty among teenagers. Because of this, many beverage and food marketers have increased their efforts to develop brand relationships with young consumers.[76]

The marketing of beverage and food products on the internet and through other digital media is increasing; however, television (TV) remains the leading media for targeting children and adolescents.[7] The amount of time spent watching TV has been associated with SSB intake.[91] Each 1-hour increment of TV viewing per day is associated with higher consumption of SSBs (0.06 servings/day), although this is unlikely nutritionally significant.[10]

The extent of soft drink advertising in schools is positively associated with existence of a pouring contract, subscription to Channel One (in-school television news network for teens nationwide), and receipt of incentives from soft drink bottlers based on sales. Soft drink advertising in schools is negatively associated with daily participation in the National School Lunch Program.[59] Another study reported that 19 (39%) of the 51 largest school districts in each state and D.C had competitive food policies beyond state or federal requirements in 2004–2005. Of those 19 school districts, only 5 (26%) had policies that addressed marketing to students.[61]

C. Evidence of Effectiveness

There is limited research on evaluating the impact of minimizing advertising of SSBs on their consumption. A study which followed children (6th and 7th grades) for 19 months showed that higher rates of TV viewing are associated with higher total calorie intake among adolescents in the United States. This association was mediated by increasing intake of foods that were commonly advertised on TV, including SSBs. This study indicates that many adolescents seem to eat foods which were advertised on TV.[92]

The IOM conducted a systematic evidence review to assess the influence of marketing on the diet of children and adolescents and released a report. In their report, the IOM concluded that TV beverage and food advertising targeted to children and adolescents that promotes high-calorie and low-nutrient products influences children to favor and demand high-calorie and low-nutrient beverages and foods. Furthermore, the IOM concluded that there is strong evidence that television advertising influences the short-term consumption of children aged 2–11 years, but insufficient evidence for adolescents aged 12–18 years. Additionally, there is moderate evidence that television advertising influences the typical dietary intake of younger children aged 2–5 years and weak evidence for children aged 6–11 years.[76]

A mathematical simulation model was constructed to estimate possible impacts of decreasing exposure to TV food advertising on the prevalence of obesity among U.S. children aged 6–12 years. The model estimated that decreasing exposure of TV food advertising to zero would reduce the mean BMI by 0.38 kg/m^2. Furthermore, it would reduce the prevalence of obesity from 17.8% to 15.2% for boys and from 15.9% to 13.5% for girls.[93]

D. Key Considerations

- Advertising and marketing messages are disseminated through a vast array of media (television, magazines, cell phones, and internet) and in many different venues such as grocery stores, shopping malls, and movie theaters.

E. Potential Action Steps

All Settings

- Collaborate with state and local policymakers to eliminate advertising of SSBs aimed at children.
- Collaborate with state and local policymakers to develop or adopt policies that limit advertising of SSBs in public service venues.
- Collaborate with food manufacturers, retailers, restaurants and others to adopt guidelines for responsible food marketing to children.

Schools

- Collaborate with school district officials to incorporate media literacy training into school and child care curricula.
- Collaborate with school district officials and community advocates to redefine beverage "pouring contracts" to eliminate advertising of SSBs to students.

F. Program Examples

School-based

State of Maine's School Advertising Policy
State law in Maine prohibits brand-specific advertising of foods or beverages in school buildings or on school grounds except for beverages and food that meet established nutrition standards. Maine is the only state known to have enacted legislation to limit advertising in the schools.[94]

San Francisco Unified School District Commercial Free School Act
The Commercial Free School Act restricts advertising of commercial products within San Francisco Unified School District (SFUSD). It also prohibits SFUSD from entering into an exclusive contract with a soft drink or snack food company, commits to making healthy drinks and healthy snacks available to students, and eliminates the purchase or use of curriculum materials that feature brand names.[95]

G. Resources

- **Marketing Food to Children and Adolescents, A Review of Industry Expenditures, Activities, and Self-Regulation**: Federal Trade Commission (2008). This report provides an overview of food and beverage industry efforts to market to children and adolescents
  http://www.ftc.gov/os/2008/07/P064504foodmktingreport.pdf
- **Food Marketing to Children and Youth: Threat or Opportunity?**: Institute of Medicine (2005). This report provides recommendations for different segments of society to guide the development of effective marketing and advertising strategies that promote more healthful foods, beverages, and meal options to children and youth.
  http://iom.edu/CMS/3788/21939/31330.aspx

- **Guidelines for Responsible Food Marketing to Children**: The Center for Science for the Public Interest (CSPI) (2005). The guidelines provide the criteria for marketing food to children in a way that does not compromise their health. CSPI suggests that anyone who advertises to children (all industries) as well as parents and schools should utilize the tool. http://www.cspinet.org/marketingguidelines.pdf

Schools

- **Captive Kids: Selling Obesity at Schools**: California Project LEAN. This toolkit was developed as an action guide for those working to reduce the marketing of less healthful foods and beverages in schools. This guide provides information on policy development as well as, talking points, fact sheets and other resources to improve the school nutrition environment. http://www.californiaprojectlean.org/Assets/1019/files/CK2007.pdf

Strategy 5: Decrease the relative cost of more healthful beverage alternatives through differential pricing of sugar-sweetened beverages

A. Definition

This strategy increases the price of SSBs relative to other more healthful beverages through pricing adjustments, subsidies, taxation, or other differential pricing strategies.

B. Rationale

Price has been shown to be a key determinant of food choices.[96] There are number of strategies proposed to reduce SSB consumption, including pricing adjustments, subsides, and/or taxation. Reducing prices of more healthful beverages or increasing prices of SSBs may be effective strategies for reducing consumption of SSBs. Pricing strategies could encourage positive behaviors and discourage negative behaviors. A combination of pricing strategies that include a mix of subsidies and taxes may be the most effective way to accomplish this.[97]

Increased taxation has been associated with decreased consumption of alcoholic beverages[98] and tobacco products.[99] The effectiveness of tobacco taxation initiatives on consumption led to the development of a national Healthy People 2010 Objective to increase the combined federal and average state tax on cigarettes from $0.63 to $2.00.[100] As for SSBs research suggests that current mean tax of 5.2% is not large enough to impact consumption.[101]

Pricing adjustments and/or taxation on SSBs have the potential to (1) discourage their consumption (2) equalize the costs of healthier and less healthier foods (3) encourage the production of healthier foods and (4) generate revenue that could be dedicated to obesity prevention.[74, 97-100, 102,103] It was estimated that a national tax of 1 cent per ounce on SSBs would generate $14.9 billion in the first year alone.[101]

C. Evidence of Effectiveness

Evidence suggests that pricing adjustments on SSBs may impact obesity prevalence. Researchers examined associations between having soft drink or snack food taxes between 1991 and 1998 and relative increases in obesity prevalence over the same time period among states. The obesity prevalence was based on the BRFSS data among 43 states. The results showed that states without a soft drink or snack food tax had a four times higher relative increase in obesity (defined as BMI ≥75th percentile in the relative increase) prevalence than states with a tax. Furthermore, states that had repealed a soft drink or snack food tax had >13 times higher relative increase in obesity prevalence than states with a tax.[104] One study of states' taxation rates from 1990 to 2006 found that BMI decreased modestly as a result of soft drink taxation.[105] A review article suggested that youth, low-income populations, and those who are overweight, are more likely to experience a decrease in weight as a result of nontrivial pricing strategies.[106]

Based on the National Food Stamp Program Survey in the United States, it was estimated that a 10% increase in the price of soft drinks would lead to an 8% reduction in consumption among low-income households. A 10% reduction in milk price was estimated to increase the consumption of reduced-fat milk by 14%.[41]

The impact of price interventions on soft drink consumption may vary substantially depending on baseline consumption status. A study conducted in Norway showed that individuals who drink greater amounts of SSBs are more sensitive to price increases and less likely to drink SSBs as prices increase. In this study, increasing the price of soft drinks by 11% was estimated to decrease consumption by nearly 7% in the lowest consumers and 17% among highest consumers. Increasing the price by 27% was associated with a drop in consumption of 17% in the lowest use group, 44% in the highest use group, with an overall 24% reduction in consumption across the population. This larger increase would reduce consumption of sugar-sweetened sodas by 2 liters per year for the moderate consumers and by 74 liters per year for those in the top 5% in level of consumption.[107]

Reducing prices of more healthful foods has been shown to increase their sales. For example, a study of restaurant purchases reported that a 25% price reduction for salads was associated with a doubling in sales.[108] Another study examined effects of pricing and promotion strategies on purchases of low-fat snacks from vending machines. Price reductions of 10%, 25%, and 50% on low-fat snacks were associated with significant increases in low-fat snack sales; percentages of low-fat snack sales increased by 9%, 39%, and 93%, respectively.[109]

D. Key Considerations

- Several states that passed SSB tax legislation subsequently revoked it because of difficulties with implementation and pressure from interest groups.[102]
- Small taxes, with the clear purpose of benefiting specific groups, such as children, are more likely to gain public support,[97] but less likely to influence consumption or lead to meaningful decreases in BMI.[105]
- Taxing beverage ingredients for production (excise tax) or beverage advertising may be more effective than taxing the end-point consumer (sales tax).[97]
- Pricing initiatives to affect consumption should consider all SSBs rather than limiting to soft drinks.

E. Potential Action Steps

All Settings

- Build a coalition to advocate for and support the use of pricing adjustments to influence SSB consumption.
- Develop guidelines for voluntary implementation of price adjustments in vending machines and other venues to encourage healthy beverage consumption.

Communities

- Sponsor a meeting with key decision makers to discuss the options for beverage pricing adjustments.

F. Program Examples

School-based

Seattle Public Schools Policy on the Distribution and Sales of Competitive Foods
The Seattle Public Schools Policy on Competitive Foods requires that, for an equal-sized serving, all beverages, except milk, be priced higher than the price for bottled water. In addition, vendor contracts for sales of competitive foods shall not include incentives for increasing students' consumption of foods or drinks.[110]

Primary medical care-based

The University of Virginia Health System's "Snack Smart" Healthy Vending Program
The University of Virginia Health System's Healthy Vending Program uses colored stickers and a pricing incentive to encourage healthy beverage consumption. Red stickers are used to indicate beverages (and foods) that are the least healthy, including regular sodas, tea, and lemonade. A 5-cent surcharge is added to the cost of these items. Yellow stickers indicate beverages that can be consumed "once in a while". These include fruit drinks (<100% juice) and sports drinks. Green stickers are used to indicate the healthiest choices, including water, 100% juice, and diet beverages. Funds raised from red labeled items are used to support the University of Virginia's Children Fitness Clinic.

After the first year of implementation, a program demonstrated that overall sales increased by 8%. Sales of red labeled items decreased by 5%, yellow items increased by 31%, and green labeled items increased by 1.5%. The 5-cent tax raised $6,700 for the University of Virginia's Children Fitness Clinic.[111]

G. Resources

- **Rudd Report, Soft Drink Taxes: Opportunities for Public Policy**: Rudd Center for Food Policy and Obesity (2009). This report a policy brief for policymakers and citizens interested in the benefits of soft drink taxes, research on taxing soft drinks and policy recommendations. http://www.yaleruddcenter.org/resources/upload/docs/what/reports/RuddReportSoftDrinkTaxFall2009.pdf
- **Texas! Bringing Healthy Back Presents: Growing Community**: Texas Department of State Health Services. This video series is a communications initiative and tool created to educate and inspire communities into action against obesity. Watch "Positioned for Change: Decreasing Sugar-Sweetened Beverages" at the following site. http://www.dshs.state.tx.us/obesity/growingcommunity/default.shtm

Strategies Applicable to Medical care Settings

Strategy 6: Include screening and counseling about sugar-sweetened beverage consumption as part of routine medical care

A. Definition

Screening and advice from primary care providers regarding SSB consumption practices and associated risks done as part of routine medical and dental care visits.

B. Rationale

Primary health care visits provide a unique opportunity for creating awareness and motivating change in regard to the consumption of SSBs, because primary care providers have direct contact with about 76% of U.S. children and youth under 18 years in 2004.[112] The U.S. Preventive Services Task Force recommended that clinicians screen children and adolescents aged 6–18 years for obesity. Clinicians can either offer or refer children and adolescents to comprehensive, intensive counseling and behavioral interventions to improve weight status.[113] Furthermore, the Expert Committee on the Assessment, Preventions, and Treatment of Child and Adolescent Overweight and Obesity recommended that a qualitative assessment of dietary patterns of all pediatric patients be conducted at each well child visit at a minimum for preventive guidance. According to the Committee, this assessment should include identifying excessive consumption of sweetened beverages.[114]

The National Committee for Quality Assurance has added two new measures related to obesity to the 2009 Healthcare Effectiveness and Data Information Set (HEDIS). The HEDIS is the most commonly used quality performance measurement set in medical care. The new measures will assess physician performance for BMI measurements among adults and children and track physician counseling for nutrition and physical activity among children.[115]

SSB consumption also has been linked to increased risk of dental caries[37] and dental care providers, including general and pediatric dentists, can be important primary care partners in the effort to reduce SSB consumption. The American Academy of Pediatric Dentistry recommends that all children should see dental professionals in their first year of life and at least every 6 months thereafter, depending on their risk status.[116] Furthermore, the American Academy of Pediatric Dentistry encourages (1) dentists and medical care providers to educate their patients to increase public awareness of the negative effects of frequent SSB consumption (carbonated and noncarbonated) on infant, child, and adolescent nutrition, oral health, and general health including obesity and (2) school officials and parent groups to think about the importance of maintaining healthy choices in school vending machines and promote beverages with high nutritional value; bottled water and other more healthful alternatives should be available in vending machines instead of soft drinks.[117]

C. Evidence of Effectiveness

The Keep ME Healthy (or the 5-2-1-0) Program was developed by the Maine Youth Overweight Collaborative (MYOC) to support obesity prevention efforts in the clinical setting (see *Program Examples* below). The MYOC evaluated use of this framework among primary care practices. The study results demonstrated that the percentage of parents/caregivers reporting that a doctor, nurse, or other office staff spoke with them about sugar-sweetened drinks increased by 30% to 50% among those using the framework. About 90% of parents/caregivers of obese patients reported that someone in the primary care practice had talked with them about sugar-sweetened drinks and 40% reported that a beverage goal was set to change behavior.[118]

D. Key Considerations

- In general, time available for physicians to do nutrition screening and counseling is limited.[119]
- Availability of insurance reimbursement for preventive nutrition counseling may be limited.[120]

E. Potential Action Steps

- Support the implementation of the recommendation from the Expert Committee on Assessment, Preventions, and Treatment of Child and Adolescent Overweight to ensure screening and counseling for high SSB consumption as part of all well child visits.
- Develop and promote the use of decision prompts/tools to facilitate assessment and guidance in regard to SSB consumption by primary care providers.
- Support efforts to ensure reimbursement for practitioner time spent providing nutrition counseling.

F. Program Examples

Keep ME Healthy
The *Maine Youth Overweight Collaborative* (MYOC), together with the Maine chapter of the American Academy of Pediatrics, developed a framework based on four key messages to guide obesity prevention in the clinical setting. This framework for their "Keep ME Healthy" Program, also referred to as the "5-2-1-0" Program, consists of encouraging five (5) or more servings of fruits and vegetables on most days; limiting screen time to two (2) hours or less daily; participating in at least one (1) hour or more of physical activity daily, and; avoiding (0) sugar-sweetened beverages, limiting fruit juice to one-half cup or less per day and encouraging water and 3–4 servings of non-fat milk daily. An evaluation of the program demonstrated that patients attending clinics that adopted the 5-2-1-0 framework were more likely to speak with their medical care providers about their beverage consumption practices and these patients were more likely to set goals related to their SSB consumption.[118]

As a result of the success of the Keep ME Healthy Program, the American Academy of Pediatrics has developed a new Pediatric Obesity and Nutrition Resource Package that includes a flip chart adapted from the Keep ME Healthy Program that can be used by medical care providers as a decision-support tool. In addition, the Nemours Health and Prevention Services has adapted the Keep ME Healthy (5-2-1-0) framework to formulate their "5-2-1-Almost None" strategy to promote their healthy lifestyle theme.[121]

Alliance for a Healthier Generation Healthcare Initiative

The Alliance Healthcare Initiative is a collaborative effort with national medical associations, leading insurers and employers to offer comprehensive health benefits to children and families for the prevention, assessment, and treatment of childhood obesity. Through this program, doctors are reimbursed for bringing children back for follow-up visits and for working with them on the adoption of healthy behaviors. Registered dietitians are also reimbursed for providing in depth nutrition counseling over multiple visits to those children who are referred by their doctors. By working together, doctors and registered dietitians help children and their families adopt more healthful eating habits to improve their health and weight. Participating companies have access to materials and resources developed by the Alliance to inform parents about childhood obesity prevention and treatment.[122] To date, the effectiveness of this initiative has not been evaluated.

G. Resources

- **Barlow SE and the Expert Committee. Expert committee recommendations regarding the prevention, assessment, and treatment of child and adolescent overweight and obesity: Summary Report.** *Pediatrics*. 2007;120 (Suppl 4): S164-192. This report advises pediatric physicians on assessing dietary behaviors including sugar-sweetened beverage consumption and promoting healthy dietary behaviors. http://pediatrics.aappublications.org/cgi/reprint/120/Supplement_4/S164
- **Pediatric Obesity and Nutrition Resource Package**: American Academy of Pediatrics. This package includes pediatric obesity prevention, intervention, and treatment strategies for primary care, the pediatric obesity clinical decision support chart, and parent's guide to childhood obesity. https://www.nfaap.org/netforum/eweb/DynamicPage.aspx?webcode=aapbks_productdetail&key=72d080ff-2b54-48c6-afba-8609a35109f5
- **The Alliance for a Healthier Generation Healthcare Initiative**: This initiative was developed to address childhood obesity by focusing on prevention and assessment by primary caregivers. http://www.healthiergeneration.org/healthcareprofessionals.aspx?id=294

Strategy 7: Expand the knowledge and skills of medical care providers to conduct nutrition screening and counseling regarding sugar-sweetened beverage consumption

A. Definition

Increase the knowledge and skills of medical care providers in offering or referring patients to comprehensive, intensive counseling and behavioral interventions to improve weight status and their SSB consumption practices through core training and continuing education.

B. Rationale

Evidence suggests that clinicians have a wide range of training and experience in nutrition counseling. However, some medical care practitioners report low confidence in their ability to provide nutrition and lifestyle counseling.[123,124] A study demonstrated that one of the most common areas of self-perceived low proficiency among U.S. pediatricians, pediatric nurse, and registered dietitians was counseling-related skills needed to manage childhood obesity effectively.[123]

Although there is increased concern on childhood obesity and diet-related diseases, nutrition education continues to be lacking in medical training programs. A study conducted in the United States reported that among 61 internal medicine interns, 62% reported receiving nutrition education in undergraduate, graduate, or medical schools. About 31% of medical schools offered a nutrition elective, but only 3% of interns took the nutrition course. Furthermore, when their knowledge was tested in the study regarding nutrition assessment, endocrine disease, cardiovascular disease, gastrointestinal disease, renal disease, and pulmonary disease, the overall correct score was 66%. When test scores were broken down by topic areas, mean nutrition knowledge at 62% was below the average score. About 77% of interns agreed that nutrition assessment should be incorporated into routine primary care visits, and almost all interns (94%) agreed that it is their job to provide nutrition counseling. However, 86% agreed that most physicians are not trained to provide nutrition counseling to their patients.[124]

There is need to increase physician counseling about diet and physical activity. One option is for medical schools to provide nutrition education to improve counseling skills of medical students as a part of their curricula.[125] This information should include the childhood obesity Expert Committee recommendation to limit consumption of SSBs as one of seven target behaviors for which consistent evidence shows an association between the recommended behavior and either obesity risk or energy balance.[114]

The American Heart Association, in their guide for practitioners regarding dietary recommendations for children and adolescents, highlights the importance of reducing the intake of SSBs to minimize cardiovascular disease risks.[126] In addition, the American Academy of Pediatrics Committee on School Health has issued a policy statement intended to inform pediatricians and other health care providers about nutritional concerns regarding soft drink consumption in schools.[127]

In addition to nutrition knowledge, medical care providers need to build skills in effective counseling techniques. Motivational interviewing is a commonly used counseling technique. It is a directive, client-centered counseling style that facilitates behavior change.[128] It has been used by public health professionals, dietitians, and other health professionals to address various chronic disease behaviors including childhood obesity.[129]

C. Evidence of Effectiveness

A study was conducted to evaluate an impact of an innovative preventive medicine and nutrition course on medical students' confidence regarding diet and exercise counseling in the Harvard Medical School. A 28-hour preventive medicine and nutrition course was given to the second-year medical school students. Survey data were collected before and after the course from 134 students and 118 students, respectively. This study reported that an innovative preventive medicine and nutrition course significantly improved medical students' confidence in diet and exercise counseling. This improvement on nutritional counseling for patients among medical students may influence their practice patterns.[125]

An intervention study was conducted to examine the impact of nutrition education provided by a physician nutrition specialist on physicians' nutrition knowledge, nutritional counseling practice, and patients' reports of nutritional counseling. For 6 months, a physician nutrition specialist provided family physicians (7 faculty members and 9 residents) with individualized recommendations for nutrition-related issues that should be discussed with their patients. These recommendations were given in detachable notes placed in the charts of patients or by discussion with the physicians. Additionally, the physician nutrition specialist gave a lecture on nutrition-related disease and recommendations for healthy diets to family physicians during family practice inpatient rounds. Nutrition knowledge of physicians and patients were collected before and after intervention. This study reported that the nutrition intervention significantly increased nutrition knowledge scores from 73% to 76% for physicians and from 46% to 50% for their patients. Furthermore, the frequency that physicians asked their patients about nutrition and diet increased significantly from 26% to 40%.[130,131]

The Maine Youth Overweight Collaborative (MYOC) intervention was used as the prevention program to identify whether a pediatric primary care-based intervention can improve physician practice and patient and family behaviors for childhood obesity. The intervention sites participating MYOC received packages of tools for clinical decision support and counseling and self-management support for families and patients. During 18 months of MYOC implementation, significant changes occurred in clinical practice to identify, prevent, and treat childhood obesity and family management of risk behaviors for childhood obesity. Clinicians in the intervention sites increased the frequency in assessment of BMI and BMI percentiles for age and sex, use of the 5-2-1-0 behavior screening tool, and weight classification. Furthermore, clinicians in the intervention sites reported improvements in knowledge, attitudes, self-efficacy, and practice.[132]

D. Key Considerations

- There are many competing interests for material to be covered in the core training curriculum and in continuing education for medical care providers.

E. Potential Action Steps

- Collaborate with professional national and state health practitioner associations to provide continuing education for primary care providers to enhance their dietary assessment and counseling skills regarding SSB consumption.
- Collaborate with schools of medicine, nursing, dentistry, and other allied health professions to incorporate training on nutrition and effective counseling techniques as a part of core curricula.

F. Program Examples

Sugar-sweetened beverage training for dental students
An intervention study was conducted to increase knowledge related to oral and systemic health effects of soda consumption among dental students in the United States. An educational brochure was distributed to the first-year dental students during a lecture. This lecture focused on the effects of soda consumption on oral and systemic health. After a combination of written (brochure) and oral (lecture) education, the first-year dental students significantly improved both their knowledge and behavioral intent related to soda consumption. This accumulated knowledge among dental students can be incorporated into their dental caries risk assessment conducted with their patients.[133]

G. Resources

- **Educating Physicians on Controversies & Challenges in Health, Motivating Patients to Change Behavior:** The American Medical Association. Continuing medical education (CME) course on the use of motivational interviewing is available. http://www.ama-assn.org/ama/pub/physician-resources/public-health/general-resources-health-care-professionals/educating-physicians-controversies-challenges-health.shtml
- **CounterDetails: Pediatric Obesity Management, July 2008**: Pennsylvania Department of Health and Pennsylvania Medical Society. This newsletter issue is based on the Expert Committee Report and offers continuing education credits through the PMS website. CMEs available until Dec. 31, 2010. Pennsylvania Department of Health:
  http://www.dsf.health.state.pa.us/health/cwp/browse.asp?a=174&bc=0&c=38832
  Pennsylvania Medical Society:
  http://www.pamedsoc.org/MainMenuCategories/CME/CME-Activities/CounterDetails/Pediatricobesity.aspx

- **5210 Pediatric Obesity Clinical Decision Support Chart:** Adapted from the keep ME healthy flip chart developed by the Maine Center for Public Health and the Maine Chapter of the American Academy of Pediatrics. www.aap.org/bookstore

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8 DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

Discussion

The results of our studies demonstrate that the intake of added sugars is positively associated with known cardiovascular risk factors. We found increased dyslipidemia (lower HDLs and higher LDLs and triglyceride levels) among both adults and adolescents, regardless of weight status (overweight vs. not) with increased added sugar consumption. We also found increased insulin resistance (higher fasting insulin and HOMA-IR measures) among overweight or obese adolescents who consumed more added sugars. These findings persisted even after controlling for BMI, suggesting that these associations are not mediated by adiposity. These studies were the first known population-based studies to show an association between usual levels of added sugar consumption and indicators of cardiovascular disease risk, first among adults and then among adolescents.

Our analysis of trends the trends and sources of added sugars over the past decade is the first to show the decreasing trend in consumption. In this study we were able to show that consumption decreased significantly between 1999 and 2008, among all age, race/ethnic, and income groups. Combing our findings with those of previous studies it appears as though consumption of added sugars peaked in the late 1990s/early 2000s and declined progressively since.

While the results of our trends study demonstrate that consumption has decreased, the proportion of total calories consumed as added sugars remains high, far exceeding the latest dietary recommendations. Our examination of the cardiovascular risks highlighted important health consequences that may result from consuming added sugars at the high levels currently being consumed, but little is known about the safe level of intake, particularly for children whose exposure may continue for many years. Dietary guidance regarding added sugar from authoritative agencies is limited and variable. In 2005, the Institute of Medicine, the body charged with developing the Daily Recommended Intake levels for Americans, declined to make a recommendation regarding added sugars consumption and chronic disease risk, citing a lack of evidence. This conclusion was reached, despite the fact that two years earlier the World Health Organization reviewed the available evidence and determined that added as well as naturally occurring sugars should be limited to less than 10% of total energy in order to prevent obesity and chronic disease. Since then the American Heart Association, in the most recently released recommendation, advised adults to consume less than approximately 5% of total energy in order to prevent heart disease but provided no guidance for children. Given the range in current recommendations, it is important that the existing evidence be reviewed and a clear guideline for consumption be established for children as well as adults, that can be used by clinicians, policy makers public health nutritionists, and parents who are concerned about the immediate and potential long-term health consequences of high consumption of added sugars but do not know how much is too much.

In the process of developing the *CDC Guide to Reducing Sugar-Sweetened Beverage Consumption* we completed a comprehensive review of the published and unpublished literature to identify programs that had been implemented, at least in part, with a goal of reducing consumption of sugar-sweetened beverages. Toward this end we also interviewed subject experts and other key informants. Through this process we identified a variety of program and policy initiatives but few of them had been evaluated. As a result, we were able to learn little about which strategies are most effective in promoting a reduction in the consumption of added sugars, or even which factors may have contributed to the decline in added sugar consumption over the past decade. In order to enhance the effectiveness of future public health efforts to reduce the consumption of added sugars, current programs need to include an effective evaluation component, and the results, whether positive or negative, need to be readily accessible for those who desire to implement a similar program.

Our series of studies have several important strengths. First, we have used nationally representative data and, to our knowledge, this is the first study to assess the association between added sugars and indicators of CVD risk among U.S. adolescents. Second, we were able to control for several important confounding variables, including BMI, SES, and physical activity. Also, the availability of 24-hour dietary recall data on total food and beverage intakes allowed us to control for total energy intake, the intake of carbohydrates other than added sugars, and other components of the diet. The availability of a second 24-hour dietary recall in a subsample of respondents further enabled us to do a sensitivity analysis using the mean of 2 days' intake of added sugars. Finally, the use of trained staff following standardized protocols to measure height and weight and collect laboratory and interview data increases the accuracy and validity of the data collected.

Our studies are also subject to some limitations. Cross-sectional studies such as ours are limited by the fact that exposures and outcomes are measured at the same time. As a result, our data can be used only to assess associations. They cannot be used to assess the direction or temporarily of these associations or to determine causality. Also, as only a single 24 hour dietary recall was used to assess diet, the dietary intake data may not represent the usual diet of respondents. Our inability to account for with-in person day-to-day variability may have resulted in some misclassification of the intake of added sugars but we expect that this would be random.[1] The fact that key findings were unchanged when the analyses were repeated using the mean of 2 available 24 hour recalls (participants in NHANES 2003-04) suggests that the day-to-day variation may be minimal. As self-reports of diet have been shown to underestimate consumption, true intake levels of added sugars may be higher than we've reported.[2] While the imputation of added sugar content for several foods consumed in 2005-2006 and 2007-2008 could have resulted in invalid estimates of intake for those years, the results of our sensitivity analysis indicate otherwise. When our analysis to estimate the mean intake of added sugars among all respondents in NHANES 2005-2006 was repeated among a subsample which excluded all respondents who consumed $\geq$ 1 food item with imputed added sugar values, the results were very similar, indicating that the imputation did not bias our results.

While underreporting of certain foods high in sugars, such as sodas and sweets, may occur more frequently among those who underreport total energy,[3] such as those overweight or obese[4] who are also at increased risk of diabetes and dyslipidemia, systematic misclassification of this type would be expected to bias the associations between intake and health outcomes towards the null. In addition, as no information on the validity of the process used to estimate added sugar content data in the USDA MPED database is available, there could be some misclassification of our exposure variable. Similarly, as the instruments used to assess important covariates such as physical activity have not been validated in this population, residual confounding could also be present.

Conclusion

In conclusion, higher consumption of added sugars among U.S. adults and adolescents is associated with several important CVD risk factors. Though consumption appears to be decreasing, intake by many Americans exceeds the most recent American Heart Association recommendation. Though long-term trials to study the effect of reducing the consumption of added sugars are needed, the results of this study suggest that risk (current and future) of CVD may be reduced by minimizing consumption of added sugars among adults and adolescents. Given the concerns for long-term health associated with added sugars, it is critical that clear and consistent dietary guidance, which specifies the most appropriate upper limit for children as well as adults, be made available.

Recommendations

A review of all available evidence should be done and clear, quantified guidance from a responsible agency (IOM and/or USDA) should be given regarding the safe upper limit for the intake of added sugars. Special attention should be given to a review of the evidence on which the WHO added sugar recommendation was based.

Answers to the following research questions would provide information important to understanding of the relationship between the consumption of added sugars and cardiovascular disease and to guiding the development of dietary policies regarding the consumption of added sugars:

1. Does reducing the consumption of added sugars improve measures of cardiovascular disease risk (triglycerides, LDL, HDL, insulin resistance) among habitually high added sugar consumers?
2. Do trends in cardiovascular risk indicators in the US population parallel the reductions in added sugar intake over the past decade?
3. Does the impact of sugar containing beverages on measures of cardiovascular disease risk vary by the type of beverage consumed, those with added sugars (soft drinks) or those with naturally occurring sugars (fruit juices)?
4. What components of an intervention strategy are most important to the success of a program or policy designed to reduce the consumption of added sugars?

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Appendix A. Food Code Grouping for Foods with Added Sugars

Food Group	Codes Included		
Dairy	10000000	-	<20000000
Other dairy	10000000	-	11400000
Yogurt	11400000	-	11500000
Milk	11500000	-	11600000
Other dairy	11600000	-	13000000
Desserts	13000000	-	14000000
Other dairy	14000000	-	20000000
		-	
Meat	20000000	-	30000000
		-	
Eggs	30000000	-	40000000
		-	
Beans	40000000	-	50000000
		-	
Grains	50000000	-	60000000
Other grains	50000000	-	51000000
Breads	51000000	-	53000000
Cakes/Cookies	53000000	-	54000000
Other grains	54000000	-	57000000
RTE cereals	57000000	-	58000000
Other grains	58000000	-	60000000
		-	
Fruit	60000000	-	70000000
Fruit juice	61201230	-	61201620
	61201630	-	61204000
	61210730	-	61210820
	61213230	-	61216620
	61222230	-	61222600
	61225230	-	61225600
	64116030	-	64116040
	64116150	-	64120010
	64122030	-	64123000
	64124030	-	64124060
	64132030		64132500
Fruit (not juice)	60000000	-	70000000
(if not juice, coded as fruit			
Vegetables	70000000	-	80000000
		-	
Oils/Dressings	80000000	-	90000000
		-	
Sweets	90000000	-	100000000
Beverages	92000000	-	94000000
		-	
Other sweets	90000000	-	91000000
Sugars/syrups	91000000	-	91700000
Candy/gum	91700000	-	92000000
Coffee/tea	92000000	-	92400000

Food Group	Codes Included		
Sodas	92400000	-	92500000
Fruitades	92500000	-	92600000
Energy	92650000		
Other bevs	92600000	-	92650000
Alcohol containing	93000000	-	94000000
Low-calorie bev	92400100	-	92410110
	92410210	-	92410310
	92410320	-	92410330
	92410350	-	92410360
	92410370	-	92410390
	92410400	-	92410410
	92410420	-	92410510
	92410520	-	92410550
	92410560	-	92410610
	92750000	-	93000000
	92410620	-	92410710
	92410720	-	92410810
	92410820	-	92411510
	92411610	-	92416010
	92520410	-	92530210
	92541040	-	92541100
	92541120	-	92542000
	92550050	-	92560000
	92582000	-	92582100
	92741000	-	92751000

Low calories beverages (total beverage grams)		
92400100	-	92410110
92410210	-	92410310
92410320	-	92410330
92410350	-	92410360
92410370	-	92410390
92410400	-	92410410
92410420	-	92410510
92410520	-	92410550
92410560	-	92410610
92410620	-	92410710
92410720		92410810
92410820		92411510
92411610		92416010
92520410		92530210
92541040		92541100
92541120		92542000
92550050		92560000
92582000		92582100
92741000		92751000

Appendix B. Summary of Intervention Studies with Sugar-Sweetened Beverage Consumption as the Outcome

	Methodology							Intervention													Outcome			
								Environmental change					Education											
	Author	Study Design	Intervention description	Target group	Duration	Theor frame	Intake Assess	Dec SSBs	Inc other bevs	Inc water	Promote altern	Bev. contracts	caloric balance	Dec. SSB	health risks	Alternatives	Advertising	Self-efficacy	Parents	Peers	Nut Knowl	SSB availability	SSB consump	Change in consumption
Middle & Secondary Schools																								
1	Sichieri, 2008	C-RCT	Education to discourage SSBs, replace with water	9-12yo urban Brazil; n=47 classes in 22 schools; 1140 students	7 m		24HRs x 2; bev FFQ				y			y		y						D	D	SSB dec 56 ml/day
2	Singh, 200 & Paw, 2008	C-RCT	Dutch Do-it; use Intervention Mapping	11 classroom lessons of biology & PE classes & an environmental component.	1 y						y			y								D		SSB dec 222 ml/day
3	Contento, 2007	Formative evaluation	Inquiry-based science education curriculum; 24 sessions. Choice, Control, and Change. Used	n=5 middleschools, 19 science class, 278 students,	7-8 w	Ext. theory of planned beh.	EatWalk survey (validated)						y		y			y				D		SSB freq, portion size both decrease
4	James, 2004 (f-up study done ?2007)	C-RCT	Single component, focused school-based nut.educ; 4 1-hr sessions, one school yea. Discourage consumption of SSBs. Replace SSBs w/diet drinks	n=644; 6 junior high schools; 7-11 yo;England			3-day drink diary at base & f-up							y	y	y				y		D	D	at f-up mean difference interv & control 0.7 serving SSB/day
5	Ritenbaugh, 2003	multiple cross-sectional	Educational component targeting decreased consumption of sugared beverages, knowledge of diabetes risk factors, and a youth-oriented fitness center	Zuni high schools	4 y		24 HR	y	y	y	y			y		y			y	y	D	D		SSB consumption to 0 (Dec among all by 4.8 oz/day).
	Primary Care																							
6	Cummings-2008	pre & post	Parents and kids given lilifestyle intevention (Kidpower), including dietician advice re calories and SSBs. The initial dietary phase of the intervention involved a baseline visit and 3 subsequent visits ~ 4 to 6 weeks.	n=45 kids < 18 y, BMI >=95th%ile	12 w		24 HR				y		y	y		y					D			Prev of those consume < 600 ml/day inc from 14-35%
	Community-based																							
7	Albala, 2008	RCT	Home-based delivery of flavored milk. Instructed to drink 3 milk and no SSBs	n=98 8-10 yo overweight or obese SSB consumers. Chile	16 w		FFQx 2		y					y		y				y		D		SSB dec 711 g/day
8	Baranowski, 2003	RCT	GEMS. Goal to prevent obesity via incrase fruit, juice, veg, &water through ducation	AA girls	4 w camp; 8 w internet	Soc. Cog Theory	24-HR x 2			y						y		y		y		D[2]	NC	SSB dec 20%

	Author	Study Design	Intervention description	Target group	Duration	Theor frame	Intake Assess	Environmental change					Education											
								Dec SSBs	Inc other bevs	Inc water	Promote altern	Bev. contracts	caloric balance	Dec. SSB	health risks	Alternatives	Advertising	Self-efficacy	Parents	Peers	Nut Knowl	SSB availability	SSB consump	Change in consumption
	Community-based																							
9	Ebbeling	RCT	Home delivery of noncaloric beverages to displace SSBS and decrease consumption. Subjects instructed not to by or drink SSBs	n=103; 13-18 yr olds who regularly consume SSBs	25 wks				y		y					y	y			y		D	D	?82% interv; NC controls
10	Klohe-Lehman-2007	pre-post	Weight loss program for low-income overwt or obese mothers. 8 week intervention Diet, PA, beh modif.	n=91 low-income overweight or obes moms w/ child 1-3y	24 w																	D		kids SSB dec o.8 to 0.4 serve/day
11	Burrows, et al., 2008	RCT	HIKCUPS study; 3 interevention arms(1) a parent-centered family lifestyle and dietary modification program called PRAISE; 2) a child-centered physical activity skill development program called SHARK or 3) both.	n=165, Australian. Overweight/obese children aged 5–9 years and their parents	6 m	Health Belief Model	FFQx 3							y								D	D	SSBs dec all 3 arms -2.1 % total energy (assessed at 12 m
12	Beech, 2003	RCT	2 arms: Intervention girls only or girls & parents focused on nutrition & PA. Control self-esteem only.	AA girls 8-10y w/parent; girls >=25th %ile BMI	12 wks	Social Cognitive Theory							y	y		y		y				D		SSB mean dec 1.6 serv/day greater in both inervention groups; decrease by 100% in parent group (2.96 vs 1.52 adjust mean at f-up)
13	Story, 2003	RCT	girls after-school program with Parents Nights	AA; 8-10 yr										y					y			NC	NC	No significant change in SSB consumpt

24 HR=24 hour dietary recall; yr=year; y=yes; D=decreased; I=increased; NC=no change;NM=not measured; LFLS=low fat, low sugar