Consistency Between Increasing Trends in Added-Sugar Intake and Body Mass Index Among Adults: The Minnesota Heart Survey, 1980–1982 to 2007–2009

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Objectives. We described 27-year secular trends in added-sugar intake and body mass index (BMI) among Americans aged 25 to 74 years.

Methods. The Minnesota Heart Survey (1980–1982 to 2007–2009) is a surveillance study of cardiovascular risk factors among residents of the Minneapolis–St Paul area. We used generalized linear mixed regressions to describe trends in added-sugar intake and BMI by gender and age groups and intake trends by weight status.

Results. BMI increased concurrently with added-sugar intake in both genders and all age and weight groups. Percentage of energy intake from added sugar increased by 54% in women between 1980 to 1982 and 2000 to 2002, but declined somewhat in 2007 to 2009; men followed the same pattern (all $P < .001$). Added-sugar intake was lower among women than men and higher among younger than older adults. BMI in women paralleled added-sugar intake, but men's BMI increased through 2009. Percentage of energy intake from added sugar was similar among weight groups.

Conclusions. Limiting added-sugar intake should be part of energy balance strategies in response to the obesity epidemic. (*Am J Public Health.* 2013;103:501–507. doi:10.2105/AJPH.2011.300562)

The increasing prevalence of overweight and obesity over several decades has contributed significantly to the burden of cardiovascular disease (CVD).[1,2] According to 2005 to 2006 National Health and Nutrition Examination Survey (NHANES) data, 33.4% of men and 36.5% of women in the United States were obese, representing a 55.3% increase among men and an 83.4% increase among women since NHANES I (1971–1975).[3] Energy imbalance—excessive energy intake and a sedentary lifestyle—is considered to be the primary cause of the obesity epidemic. Although dietary fat consumption (as a percentage of energy) decreased between 1971 to 1975 and 2005 to 2006, total energy intake among the US population increased substantially and is mostly attributed to dietary carbohydrates.[3] As reported in a cross-sectional analysis of NHANES 1999 to 2006 data, approximately 16% of calories consumed came from added sugar in the general US adult population,[4] an increase of approximately 49% from intake reported in 1977 to 1978.[5]

By contrast to natural occurring sugars from fruits and vegetables, added sugars, defined as caloric sweeteners, used by the food industry and consumers during food processing or preparation or added at the table, have potential adverse health effects.[6] Sugar-sweetened beverages, such as soda and fruit drinks, are the primary source of added sugars in the US diet.[7] Strong evidence exists that greater intake of sugar-sweetened beverages is associated with higher adiposity in children; moderate evidence has been presented for the same effect in adults.[7] Potential explanations for these associations include the effect of lower satiety for liquid calories[8] and the addictive effect of added sugars on total calorie consumption and macronutrient metabolism.[9] Significant associations were also found among US adults between dietary added sugars and other CVD risk factors, such as dyslipidemia[4] and high blood pressure.[10]

According to US Department of Agriculture's (USDA) food availability data, sugars and sweeteners available for consumption increased by 19% from 1970 to 2005,[6,11] despite a slight decline after 2000.[12,13] However, limited temporal trend data of added-sugar intake are available, especially in relation to body mass index (BMI). Most studies focus primarily on sugar-sweetened beverages rather than other sources of added sugars.[12] Although almost half of the added sugar in American diets comes from sugar-sweetened beverages, desserts (e.g., grain-based desserts) and candy contribute about 24.3%.[7] One analysis of national data from 1965 through 2004 described temporal trends of added sugar and high-fructose corn syrup (an important and commonly used caloric sweetener) intake.[12]

We examined the secular trends of added sugar intake and BMI over 27 years (1980–1982 through 2007–2009) in data collected in the Minnesota Heart Survey (MHS), an ongoing surveillance study of trends in CVD risk factors among a large population living in the Minneapolis–St Paul metropolitan area.

METHODS

The study design of MHS is described elsewhere.[14] Briefly, MHS is a population-based surveillance study of trends in CVD risk factors conducted in 1980 to 1982, 1985 to 1987, 1990 to 1992, 1995 to 1997, 2000 to 2002, and 2007 to 2009. The study population included independent probability samples of noninstitutionalized adults in a defined geographic area: the 7-county metropolitan area of Minneapolis–St Paul. In each survey, samples were selected with a 2-stage cluster design. In the first stage, 40 clusters (1980–1992), 44 clusters (1995–2002), and 47 clusters (2007–2009) were randomly selected from 704 clusters. In the second stage, about 5% of households were randomly selected from each cluster to generate a sample size of about 5000 adults. Adults aged 25 to 74 years were eligible to participate in 1980 through 1987; thereafter, the eligibility extended to adults aged 25 to 84 years. Study participants were asked to complete a home interview and a clinic visit. Response rates for all participants examined in MHS surveys were 69.1% (1980–1982; n = 4083), 68.1% (1985–1987; n = 5734), 68.4% (1990–1992; n = 6304), 64.8% (1995–1997; n = 6284), 64.0% (2000–2002; n = 4159), and 64.3% (2007–2009; n = 4894).

Home interviews ascertained demographic characteristics and health behaviors. Clinic visits collected more detailed information about medical history, diet, and physical activity habits. Trained staff measured height in stocking feet on a firm floor, with a rigid ruler attached to a wall and a wooden triangle. They measured weight with a balance beam scale, with participants wearing lightweight clothing and no shoes. BMI was defined as weight in kilograms divided by the square of height in meters.

Dietary Intake Assessment

In each survey, trained and certified interviewers administered a multiple-pass 24-hour dietary recall among a systematic 50% sample (i.e., every other participant who attended a clinic visit). In 2000 to 2002, all study participants were asked to complete a 24-hour dietary recall interview during their clinic visit. Because a computer was necessary to collect 24-hour dietary recall information during the 1995 to 1997 survey, dietary data were not collected from participants whose measurements were obtained at home rather than in a clinic (approximately 25% of the sample).[15] A comparability study in which approximately 100 participants completed both a computerized and manual (paper and pencil) recall showed that differences in total caloric intake (3.2 kcal) and percentage of calories from fat (1.1%) between the computerized and manual methods were not significant ($P > .05$).[16] The participants with dietary data were comparable to those without dietary data in age, gender, BMI, and education level, but were slightly more likely to be nonsmoking and White.

Researchers first obtained a list of all foods and beverages consumed and reviewed it with participants for completeness and accuracy. They then collected and reviewed detailed information about each food and beverage, such as consumption amount and additions to foods. Three-dimensional food models aided in estimating portion size; in the 2007 to 2009 data collection, larger food models facilitated portion size estimation. Researchers calculated nutrient intakes according to the Food and Nutrient Database developed at the Nutrition Coordinating Center at the University of Minnesota. The database has been continuously updated for changes in foods available in the marketplace and nutrient composition.[17]

Added sugars were defined as sugars and syrups used by the food industry and consumers during food processing or preparation, including white sugar (sucrose), brown sugar, powdered sugar, honey, molasses, pancake syrup, corn syrup, high-fructose corn syrup, invert sugar, invert syrup, malt extract, malt syrup, fructose, glucose (dextrose), galactose, and lactose; added-sugar values for other foods in the database were determined according to the product formulations or home-prepared recipes.[18]

Statistical Analyses

We conducted all analyses with SAS version 9.2 (SAS Inc, Cary, NC). We included all adults aged 25 to 74 years who satisfactorily completed a dietary recall and did not have missing data. We excluded respondents with missing BMI: 7 in 1980 to 1982 (n = 1655), 4 in 1985 to 1987 (n = 2270), 5 in 1990 to 1992 (n = 2483), 15 in 1995–1997 (n = 1835), 15 in 2000 to 2002 (n = 2762), and 8 in 2007 to 2009 (n = 1503). Tables 1 and 2 show sample size by gender.

We used generalized linear mixed models to estimate gender-specific 27-year trends of BMI and intakes of total energy, macronutrients, and added sugars, adjusted for age (continuous) and total energy intake as appropriate. We also conducted analyses by 15-year age groups (25–39 years, 40–54 years, and 55–74 years) and by weight status (normal weight, BMI < 25 kg/m^2; overweight, BMI = 25–< 30 kg/m^2; and obese, BMI ≥ 30 kg/m^2). We also tested the interactions between study year and age or weight groups in relation to added-sugar intake or BMI among both men and women. We included a random-effects term of neighborhood cluster in the statistical models to account for the independent design effects of neighborhood cluster. We considered results statistically significant with a P value of less than .05.

RESULTS

Mean total energy and macronutrient intake among MHS adults aged 25 to 74 years are shown in Tables 1 and 2. The age-adjusted total energy intake (kcal) significantly increased over time among MHS women ($P_{trend} < .001$) but not men ($P_{trend} = .35$). Consistently in both women and men, the age-adjusted intake of total fat (% kcal) decreased across survey years; total carbohydrate intake (% kcal) increased (all $P_{trend} < .001$).

TABLE 1—Age-Adjusted Total Energy and Macronutrient Intake Among Women: Minnesota Heart Survey, 1980–1982 to 2007–2009

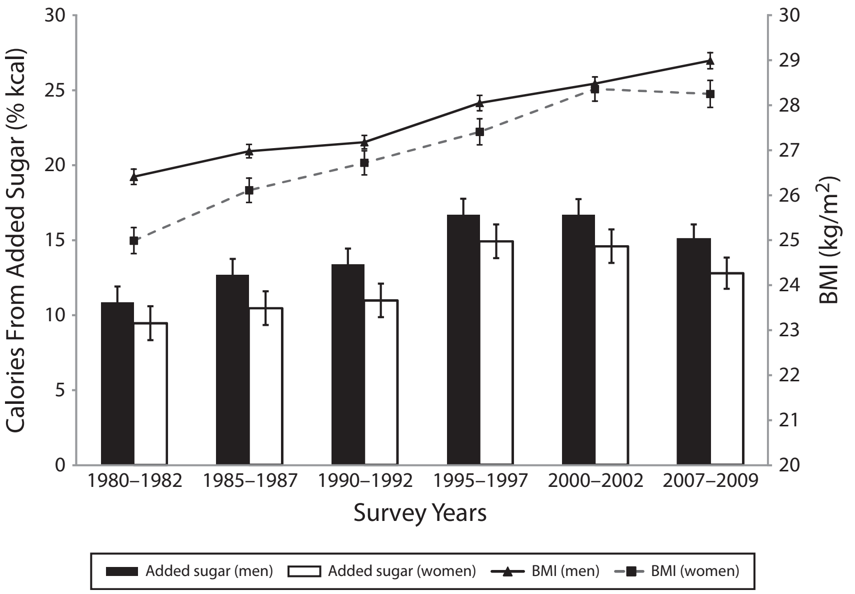
Dietary Intake	1980–1982 (n = 859), Mean (SD)	1985–1987 (n = 1173), Mean (SD)	1990–1992 (n = 1342), Mean (SD)	1995–1997 (n = 973), Mean (SD)	2000–2002 (n = 1483), Mean (SD)	2007–2009 (n = 806), Mean (SD)	P_{trend}
Total energy, kcal	1596 (83)	1592 (83)	1600 (82)	1774 (83)	1731 (82)	1753 (77)	< .001
Fat, % kcal	38.1 (1.2)	35.8 (1.2)	33.7 (1.1)	30.1 (1.2)	31.7 (1.1)	32.8 (1.1)	< .001
Protein, % kcal	17.1 (0.6)	17.3 (0.6)	17.1 (0.6)	16.7 (0.6)	17.1 (0.6)	17.8 (0.6)	.08
Carbohydrate, % kcal	44.3 (1.4)	46.7 (1.3)	49.8 (1.3)	53.3 (1.4)	51.5 (1.3)	49.6 (1.2)	< .001
Alcohol, % kcal	1.81 (0.67)	1.72 (0.66)	0.98 (0.66)	1.49 (0.66)	1.36 (0.66)	1.79 (0.61)	.68

TABLE 2—Age-Adjusted Total Energy and Macronutrient Intake Among Men: Minnesota Heart Survey, 1980–1982 to 2007–2009

Dietary Intake	1980–1982 (n = 796), Mean (SD)	1985–1987 (n = 1097), Mean (SD)	1990–1992 (n = 1141), Mean (SD)	1995–1997 (n = 862), Mean (SD)	2000–2002 (n = 1279), Mean (SD)	2007–2009 (n = 697), Mean (SD)	P_{trend}
Total energy, kcal	2608 (113)	2635 (112)	2626 (112)	2652 (113)	2599 (111)	2569 (101)	.35
Fat, % kcal	38.9 (1.1)	37.7 (1.1)	35.1 (1.1)	30.9 (1.1)	32.6 (1.0)	33.6 (1.0)	< .001
Protein, % kcal	15.9 (0.6)	15.7 (0.6)	15.6 (0.6)	15.7 (0.6)	15.9 (0.6)	16.5 (0.5)	.03
Carbohydrate, % kcal	43.2 (1.3)	45.4 (1.3)	48.5 (1.3)	52.7 (1.3)	50.7 (1.3)	49.4 (1.2)	< .001
Alcohol, % kcal	3.10 (0.75)	2.46 (0.74)	2.11 (0.74)	1.97 (0.74)	2.13 (0.73)	2.05 (0.67)	.001

Age-adjusted added-sugar intake (% kcal) increased concurrently with level of BMI in both men and women over 27 survey years (all $P_{trend} < .001$; Figure 1). Women consumed less added sugar (grams) than did men in each survey (all $P_{diff} < .001$; data not shown), although the proportion of calories from added sugar was similar between genders. Men consumed approximately 10.9% of energy from added sugar in 1980 to 1982 and 15.1% in the last survey (2007–2009), representing a 38.5% increase across survey years. Among women, added-sugar intake changed significantly, from 9.5% of total energy in 1980 to 1982 to 12.8% in 2007 to 2009. However, added-sugar intake declined for both men and women between surveys 2000 to 2002 and 2007 to 2009 (both $P_{diff} < .001$). We observed no significant interaction by gender for sugar intake across survey years. BMI in women paralleled their added-sugar intake, decreasing in the last survey, whereas BMI in men continued to increase after 2000 to 2002 ($P_{interaction} < .001$ between survey year and gender in relation to BMI).

As shown in Figures 2 (women) and 3 (men), BMI and percentage of calories from added-sugar intake for all gender-specific 15-year age groups followed a similar upward trend across the 6 surveys (all $P_{trend} < .001$), except for a decline in added-sugar intake in the last survey. However, older adults (55–74 years) generally consumed fewer calories from added sugar than did young adults (25–39 years) across surveys, except in the last survey (all $P_{diff} < .01$ from 1980–1982 to 2000–2002; $P_{diff} = .07$ for men and $P_{diff} = .09$ for women at survey 2007–2009). The slopes for added-sugar intake by age group were similar, despite different levels of intake ($P_{interaction} > .05$ for both men and women). For adiposity, young adult women (25–39 years) had the greatest increase in BMI over 27 years among the 15-year age groups ($P_{interaction} = .02$). BMI increased at the same rate among men for all age groups ($P_{interaction} = .25$). In all weight groups among women, total energy intake and percentage of calories from added sugars increased significantly over time (all, $P_{trend} < .001$; Table 3); men in all 3 weight groups followed a similar pattern, except for total energy intake, which remained stable across surveys (all $P_{trend} < .001$; Table 4). However, within each survey, for both genders, intake of total calories and added sugar was generally similar among normal-weight, overweight, and obese adults.

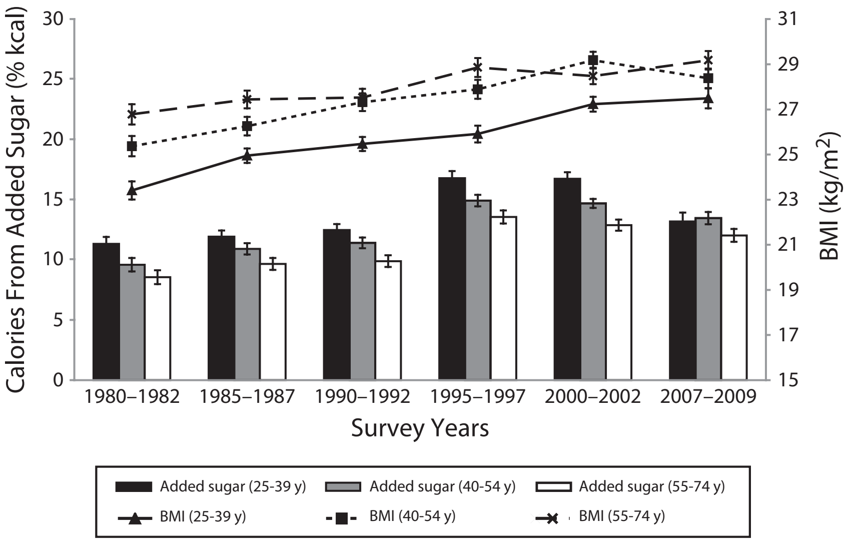


Note. BMI = body mass index. All *P* for trend < .001.

FIGURE 1—Trends in added-sugar intake and body mass index increased significantly across survey years among men and women: Minnesota Heart Survey, 1980–1982 to 2007–2009.

DISCUSSION

Among noninstitutionalized adults aged 25 to 74 years living in the 7-county metropolitan area of Minneapolis–St Paul, trends in added-sugar intake over 27 years increased concurrently with BMI in both genders and in gender-specific 15-year age groups and weight status groups. Our results are consistent with findings from national surveys, including the National Food Consumption Surveys (1965 and 1977), Continuing Survey of Food Intake

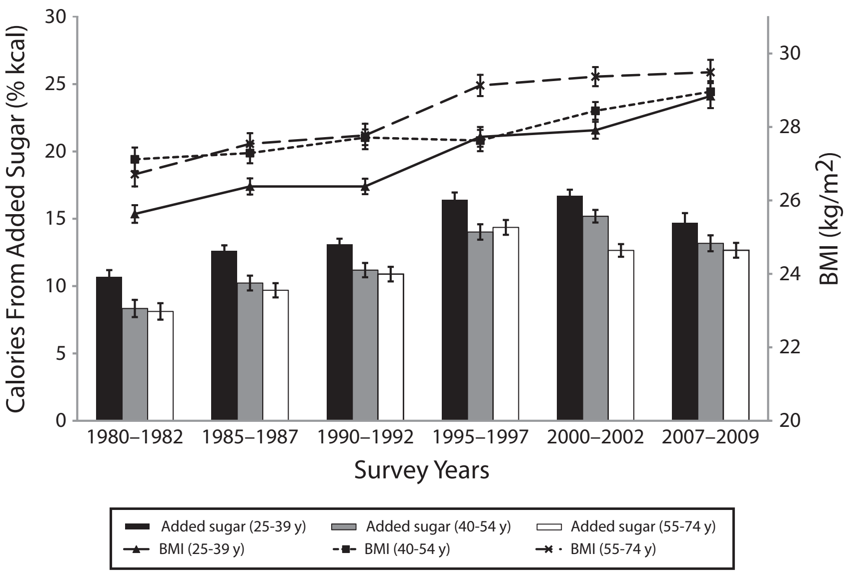


Note. BMI = body mass index. For BMI and % kcal from added sugar, all *P* for trend < .001.

FIGURE 2—Trends in added-sugar intake and BMI by 15-year age groups increased significantly across survey years among women: Minnesota Heart Survey, 1980–1982 to 2007–2009.

by Individuals (1989–1991), and NHANES (1999–2000, 2001–2002, and 2003–2004).[12] Among the general US population aged 2 years and older, calories consumed from added sugar were reported to be 15.4% in 1965, 13.1% in 1977, 13.6% in 1989 to 1991, 18.3% in 1999 to 2000, 17.0% in 2001 to 2002, and 16.8% in 2003 to 2004.[12] The decline in added-sugar intake after 2000 to 2002 observed in MHS and NHANES was consistent with a decrease in the per capita availability of caloric sweeteners from foods and beverages reported in US Department of Agriculture food supply data.[11,13] Although added-sugar intake declined after 2000 to 2002, it remained high among the US population, including adult Minnesota residents. The *2010 Dietary Guidelines for Americans* recommends that the consumption of added sugar, together with solid fats, should be limited to no more than about 5% to 15% of total calories for most individuals.[7] MHS men and women consumed 15.1% and 12.8%, respectively, of their total energy from added sugar in 2007 to 2009. According to an analysis of NHANES 2001 to 2004 data, the majority of Americans aged 19 years or older (~67% of men and ~78% of women) consumed more added sugars than recommended by the dietary guidelines.[19]

The excess consumption of added sugars, especially via consumption of sugar-sweetened beverages, has raised numerous health concerns. Research has focused on associations of added-sugar intake with not only obesity but also other CVD risk factors, such as hypertension, diabetes, and dyslipidemia.[6,20] Glycemic index or load and displacement of milk have been proposed as potential explanations for a link between sweetened beverages and increased body weight. The leading explanation for how sweetened beverage intake might cause weight gain is excess caloric intake and weaker satiety effect.[7,21] The primary concern is that obesity is promoted by consumption of excess calories, especially contributed by sugar-sweetened beverages, which have few or no nutrients.[7] However, limited evidence links sugar-sweetened beverages to higher energy intake in adults.[7] Although strong evidence supports the positive association between sugar-sweetened beverages and adiposity in children, the related evidence among adults is only moderate.[7] To date, most studies that examined the health effects of added sugars ignored food sources other than sugar-sweetened beverages or focused only on high-fructose corn syrup.[12]



Note. BMI = body mass index. For BMI and % kcal from added sugar, all *P* for trend < .001.

FIGURE 3—Trends in added-sugar intake and BMI by 15-year age groups increased significantly among men: Minnesota Heart Survey, 1980–1982 to 2007–2009.

TABLE 3—Age-Adjusted Total Energy, Added Sugar, and Other Carbohydrate Intake by Weight Groups Among Women: Minnesota Heart Survey, 1980–1982 to 2007–2009

Dietary Intake	1980–1982 (n = 859), Mean (SD)	1985–1987 (n = 1173), Mean (SD)	1990–1992 (n = 1342), Mean (SD)	1995–1997 (n = 973), Mean (SD)	2000–2002 (n = 1483), Mean (SD)	2007–2009 (n = 806), Mean (SD)	P_{trend}
Total energy, kcal							
Normal weight	1597 (126)	1587 (125)	1600 (125)	1768 (127)	1651 (126)	1683 (118)	.007
Overweight	1578 (123)	1628 (120)	1682 (120)	1756 (121)	1807 (119)	1822 (110)	< .001
Obese	1505 (138)	1517 (131)	1597 (130)	1808 (130)	1752 (128)	1748 (119)	< .001
$P_{diff\ between\ groups}$	.02	.03	.003	.04	.32	.82	
Added sugar, % kcal							
Normal weight	10.7 (1.6)	11.3 (1.6)	11.5 (1.6)	15.8 (1.6)	14.8 (1.6)	14.5 (1.5)	< .001
Overweight	9.6 (1.8)	11.6 (1.8)	11.7 (1.8)	16.0 (1.8)	16.0 (1.8)	12.5 (1.6)	< .001
Obese	8.7 (2.0)	9.1 (1.9)	10.6 (1.8)	13.6 (1.8)	13.6 (1.8)	11.8 (1.7)	< .001
$P_{diff\ between\ groups}$	.24	.57	.03	.63	.02	.06	
Other carbohydrates, % kcal							
Normal weight	33.1 (1.9)	34.2 (1.9)	37.5 (1.9)	36.3 (1.9)	35.9 (1.9)	35.7 (1.8)	< .001
Overweight	38.8 (2.0)	41.0 (2.0)	42.8 (2.0)	43.0 (2.0)	40.4 (2.0)	40.7 (1.8)	.2
Obese	32.3 (2.1)	33.9 (2.0)	36.2 (2.0)	36.5 (2.0)	34.8 (2.0)	34.3 (1.8)	.05
$P_{diff\ between\ groups}$	.19	.09	.01	.27	.001	.09	

Note. Normal weight defined as body mass index (BMI; defined as weight in kilograms divided by the square of height in meters) < 25 kg/m^2; overweight, BMI = 25–< 30 kg/m^2; and obese, BMI ≥ 30 kg/m^2.

Our results from MHS adults provide a timely description of the temporal trend of total added-sugar intake. As was pointed out in a report from the Added Sugars Conference in 2010, various types of added sugars do not differ in their physical properties or effects on human metabolism.[20] The concurrent increase of added-sugar intake and BMI in both men and women and in all 15-year age groups over

TABLE 4—Age-Adjusted Total Energy, Added Sugar, and Other Carbohydrate Intake by Weight Groups Among Men: Minnesota Heart Survey, 1980–1982 to 2007–2009

Dietary Intake	1980–1982 (n = 796), Mean (SD)	1985–1987 (n = 1097), Mean (SD)	1990–1992 (n = 1141), Mean (SD)	1995–1997 (n = 862), Mean (SD)	2000–2002 (n = 1279), Mean (SD)	2007–2009 (n = 697), Mean (SD)	P_{trend}
Total energy, kcal							
Normal weight	2580 (207)	2462 (205)	2482 (205)	2641 (213)	2417 (206)	2460 (185)	.35
Overweight	2535 (153)	2619 (151)	2593 (151)	2549 (153)	2537 (151)	2547 (138)	.59
Obese	2491 (197)	2678 (187)	2660 (184)	2716 (182)	2697 (179)	2574 (162)	.42
$P_{diff\ between\ groups}$	.01	.71	.97	.07	.32	.76	
Added sugar, % kcal							
Normal weight	14.1 (1.9)	16.2 (1.9)	17.2 (1.9)	19.9 (1.9)	20.2 (1.9)	18.6 (1.7)	< .001
Overweight	10.3 (1.4)	12.2 (1.4)	13.1 (1.4)	16.0 (1.4)	16.3 (1.4)	14.7 (1.3)	< .001
Obese	8.4 (1.9)	9.6 (1.8)	10.0 (1.8)	14.6 (1.8)	14.1 (1.7)	12.4 (1.6)	< .001
$P_{diff\ between\ groups}$	.72	.27	.04	.69	.63	.57	
Other carbohydrates, % kcal							
Normal weight	28.8 (2.2)	30.1 (2.2)	31.3 (2.2)	32.9 (2.3)	31.5 (2.2)	32.3 (2.0)	.001
Overweight	34.9 (1.6)	34.9 (1.6)	37.3 (1.6)	38.8 (1.6)	36.5 (1.6)	36.2 (1.5)	.007
Obese	30.1 (2.0)	31.0 (1.9)	34.6 (1.9)	34.3 (1.8)	32.3 (1.8)	33.3 (1.6)	.003
$P_{diff\ between\ groups}$	.05	.03	.97	.06	.003	.14	

Note. Normal weight defined as body mass index (BMI; defined as weight in kilograms divided by the square of height in meters) < 25 kg/m^2; overweight, BMI = 25–< 30 kg/m^2; and obese, BMI ≥ 30 kg/m^2.

27 survey years of the MHS data is noteworthy because the calories from added sugar are close to or exceed the maximum calorie limit recommended by the 2010 dietary guidelines.[22] Even though added-sugar intake increased across survey years in all weight groups among both men and women, total energy intake and percentage of calories consumed from added sugars generally did not differ among normal-weight, overweight, and obese adults. This finding of similar total energy intake between weight groups in MHS was consistent with recent findings from NHANES 1971 to 2006.[3] Validation studies that used double-labeled water as a marker for total energy expenditure demonstrated that overweight and obese individuals underreport dietary intake, including total energy intake.[23–26] Furthermore, Poppitt et al. observed underreporting of foods such as grain-based desserts (cakes, cookies, pies, donuts) and macronutrients such as total carbohydrates and added sugars, but not fat or protein.[27] Therefore, it is likely that overweight and obese adults in MHS and NHANES underreported total energy intake, including foods rich in added sugar.

Among Minnesotans, we found greater intakes of added sugar in younger than older adults, and men tended to consume more added sugars than did women, although their percentage of kilocalories from added sugar was similar. BMI increased the most over time in young adults. Another report had similar findings for NHANES 2001 to 2004.[19] In that national study, Krebs-Smith et al. reported that the proportion of men whose added-sugar intake exceeded the maximum discretionary energy allowances were, by age group, about 80% (19–30 years), 71% (31–50 years), 55% (51–70 years), and 45% (≥ 71 years).[19] Women in the same age groups followed the same pattern.[19] Findings from both MHS and NHANES suggest that public health efforts to lower added-sugar intake should be targeted to specific age groups.

Several methodological issues must be considered in interpreting our findings. Generalizability of results may be limited because participants were adult, predominantly White men and women residing in a midwestern metropolitan area. However, our results were generally consistent with trends reported from national surveys.[4,5,12] Dietary intake in MHS was assessed by one 24-hour recall, which may not reflect usual dietary intake. It is also not possible to establish a causal link between added-sugar intake and BMI in an ecological study. To examine the differential in participant characteristics between those who were and were not selected to complete a dietary recall, we conducted a sensitivity analysis to compare added-sugar intake (% kcal) by smoking status (smokers vs nonsmokers) and race (Whites vs non-Whites). However, the added-sugar intake across surveys did not significantly differ by smoking status or race among either gender (all $p_{interaction} > .05$).

Despite a decline after 2002, added-sugar intake among adult Minnesotans increased concurrently with BMI over 27 years and remained high. More studies that provide strong scientific evidence—that is, prospective studies and randomized clinical trials—are warranted to determine whether added-sugar intake is related to or promotes weight gain and other CVD risk factors. Research should also explore the underlying mechanisms, such as weight gain attributable to additional calories as opposed to added sugars per se.[7] ■

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Contributors

L. M. Steffen, H. Wang, and R. V. Luepker originated and designed the research. L. M. Steffen, H. Wang, L. Harnack, and R. V. Luepker conducted the research. H. Wang and X. Zhou analyzed the data. L. M. Steffen, H. Wang, and L. Harnack wrote the article. L. M. Steffen and R. V. Luepker had primary responsibility for final content. All authors contributed to data interpretation and approved the final version of the article.

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Human Participant Protection

The University of Minnesota institutional review board approved the study, and informed consent was collected from all participants.

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