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Declining consumption of added sugars and sugar-sweetened beverages in Australia: a challenge for obesity prevention[1,2]

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ABSTRACT

Background: Reduced intakes of added sugars and sugar-sweetened beverages (SSBs) have been the main focus of efforts to stall obesity. Although obesity has risen steeply in Australia, some evidence suggests that added-sugars and SSB intakes have declined over the same time frame.

Objective: We investigated recent trends in the availability of sugars and sweeteners and changes in intakes of total sugars, added sugars, and SSBs in Australia by using multiple, independent data sources.

Design: The study was designed to compare relevant data published by the Food and Agriculture Organization of the United Nations [FAO Statistics Division Database (FAOSTAT)], the Australian government, academia, and the food industry.

Results: With the use of the FAOSTAT food balance sheets for Australia, the per capita availability of added or refined sugars and sweeteners was shown to have fallen 16% from 152 g/d in 1980 to 127 g/d in 2011 (P-trend = 0.001). In national dietary surveys in 1995 and 2011–2012, added-sugars intake declined markedly in adult men (from 72 to 59 g/d; −18%) but not in women (44–42 g/d; NS). As a proportion of total energy, added-sugars intake fell 10% in adult men but nonsignificantly in adult women. Between 1995 and 2011–2012, the proportion of energy from SSBs (including 100% juice) declined 10% in adult men and 20% in women. More marked changes were observed in children aged 2–18 y. Data from national grocery sales indicated that per capita added-sugars intakes derived from carbonated soft drinks fell 26% between 1997 and 2011 (from 23 to 17 g/d) with similar trends for noncarbonated beverages.

Conclusions: In Australia, 4 independent data sets confirmed shorter- and longer-term declines in the availability and intake of added sugars, including those contributed by SSBs. The findings challenge the widespread belief that energy from added sugars or sugars in solution are uniquely linked to the prevalence of obesity. *Am J Clin Nutr* doi: 10.3945/ajcn.116.145318.

Keywords: added sugars, Australia, food availability, obesity, sugar-sweetened beverages

INTRODUCTION

Between 1980 and 2013, the combined worldwide age-standardized prevalence of overweight and obesity rose 28% in adults and 47% in children (1). Attempts to explain the rise have focused on increases in energy intake, changes in diet composition, decreasing levels of physical activity, changes in the gut microbiome, and maternal weight (2–5). In many countries, particularly in the United States, the sharp increase in the prevalence of obesity has coincided with a temporal increase in the consumption of added sugars and sugar-sweetened beverages (SSBs)[5] (6, 7). This observation has precipitated numerous observational studies and randomized controlled trials of the effect of added sugars or SSB consumption on body weight and cardiovascular disease risk factors (6, 8, 9). Most health authorities have agreed that added sugars, and SSBs in particular, have played a dominant causative role (10). Therefore, it is reasonable to assume that a reduction of added sugars or SSB intake would lower the prevalences of obesity and chronic disease that are related to excess body fat as has been modeled by several groups (11, 12). The labeling of added sugars and taxes on SSBs have been recommended as part of the efforts to reduce intake (13, 14).

Australian trends are relevant for several reasons. As shown by a global analysis, Australia and New Zealand experienced the single-largest absolute increase in adult obesity since 1980 (from 16% to 29%) and the single largest increase in adult female obesity (1). More than 68% of Australian men and 56% of women are overweight or obese, which is the second-largest sex gap in overweight and obesity globally. Obesity rates for women aged ≥20 y have reached 30%, which is more than quadruple the obesity rates in girls (7%). For Australian boys, obesity prevalence climbed 4-fold from 7% in childhood to 28% in adulthood.

However, a previous analysis of food balance sheets of the FAO Statistics Division Database (FAOSTAT) indicated that, within the same time frame, Australia experienced a decline in

[1] The authors reported no funding received for this study.

[2] Supplemental Figure 1 is available from the "Online Supporting Material" link in the online posting of the article and from the same link in the online table of contents at http://ajcn.nutrition.org.

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[5] Abbreviations used: ABS, Australian Bureau of Statistics; CSIRO, Commonwealth Scientific and Industrial Research Organization; FAOSTAT, FAO Statistics Division Database; RSE, relative SE; SSB, sugar-sweetened beverage.

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the availability of refined sugars and sweeteners (15). Grocery sales have also indicated a fall in the market share of SSBs and a rise in intensely sweetened (diet) soft drinks (16). This inverse relation between trends in the prevalence of overweight and obesity and changes in the consumption of added sugars has been termed the Australian Paradox (15, 17). The rising prevalence of obesity in the face of apparently falling intake of added sugars challenges the widespread belief that energy from sugars is uniquely linked to changes in the incidence of obesity. Since its publication in 2011, new sources of information, including national dietary surveys, have become available. In the current study, we provide novel data on changes in the availability of added and refined sugars and in recorded intakes of total sugars, added sugars, SSB, carbonated soft drinks, juices, confectionery, and alcohol consumption in Australian adults and children between the 2 most recent national dietary surveys in 1995 and 2011–2012.

METHODS

Data sources

We systematically searched scientific databases [MEDLINE (https://www.nlm.nih.gov), Cinahl (https://www.ebscohost.com/nursing/products/cinahl-databases/cinahl-complete), Embase (https://www.elsevier.com/solutions/embase-biomedical-research), and Cochrane (http://www.cochranelibrary.com)] for articles published between 2009 and July 2016 to update our previous analysis (15). The same keywords (sugars, sucrose, dietary carbohydrate, consumption, intake, sugar-sweetened beverages, sweeteners, and refined sugar) and prespecified inclusion and exclusion criteria were used. Australia was included as a search term and the terms blood glucose and blood sugar were excluded. Only national-level (not state-level) consumption data that were representative of the general population were included. Prespecified outcomes were estimates of intake of total sugars, added or refined sugars, and sugars in SSBs in absolute amounts, percentages of energy, and percentages of total sugars. In addition to the peer-reviewed literature, we included publications and data that have been issued by the government, academia, and industry. The websites of the WHO, FAO of the UN, Australian Bureau of Statistics (ABS), Australian Food and Grocery Council, Australian Retailers Association, Commonwealth Scientific and Industrial Research Organization (CSIRO), and the Australian Government were searched for relevant information.

Definitions

In the current context, the term total sugars was used to refer to the monosaccharides and disaccharides that are present in foods both naturally occurring and those that are added during processing or food preparation, but the term excludes oligosaccharides (degree of polymerization: 3–9). Total sugars included glucose, fructose, galactose, sucrose, maltose, and lactose. The term added sugars was used to refer to sugars that have been added during food processing or food preparation. SSBs were defined as drinks that contained added sugar, which included cordials; carbonated soft drinks; flavored mineral waters; energy, sports, and electrolyte drinks; fortified waters; and fruit and vegetable drinks (water-based beverages that contained some fruit and vegetable juice in addition to added sugars). The definition of SSBs excluded 100% fruit and vegetable juices. The definition of SSBs included drinks that were mixtures of both nutritive and nonnutritive sweeteners with lower total sugar contents. Nonnutritively (intensely) sweetened or diet beverages were defined as carbonated or still, plain or mineral waters and beverages that were sweetened with nonnutritive sweeteners and were not combined with nutritive sweeteners.

Availability of sugars and sweeteners

Food balance sheets are compiled every year by the FAO mainly with country-level data on the production and trade of food commodities (18). The FAO Methods and Standards have used these data and the available information on waste coefficients, stock changes, and types of utilization (feed, food, processing, and other) to prepare a supply and utilization account for each commodity in units of weight. The food component of the commodity account, which was derived as a balancing item, was used to refer to the total amount of the commodity that was available for human consumption during the year, including of processed products that were derived from the food commodity, and was expressed as primary commodity equivalents. The FAOSTAT definition of sugars and sweeteners included sugar cane (raw and centrifugal), sugar beet (raw and centrifugal), refined sugar, confectionery sugar, flavored sugar, pure fructose and syrups, maltose, glucose and dextrose, isoglucose, lactose, maple sugar and syrups, and molasses. The FAOSTAT food balance sheets took into account imports and sugars in processed foods but may not have accounted for sugars that disappeared in food fermentation.

Apparent consumption of refined sugars

Until 1998–1999, the consumption of refined sugars in Australia was published as part of the apparent consumption of foodstuffs series that was collected by the Australian government through its statistical organization the ABS (19). Refined sugars was defined as sucrose in the form of refined or raw sugars or liquified sugars that were manufactured for human consumption and represented the main form of added sugars consumed in Australia. Excluded from this definition of the apparent consumption of sugars were other sweeteners such as honey, glucose, fructose, dextrose, and syrups such as golden syrup and treacle. The term apparent consumption was used because it assumed that all of the foodstuffs available were consumed. The data were derived from source collections including the agricultural census, agricultural commodity survey, the manufacturing survey of inventories and production, merchandise imports, merchandise exports, and livestock products. For merchandise exports and imports, the scope of the collection concurred with that recommended by the UN Statistical Division and covered all moveable goods (with some identified exceptions) that subtracted from or added to Australia's stock of material resources as a result of their movement out of or into Australia (19).

National dietary survey data: consumption of total sugars, added sugars, and SSBs

Unlike the NHANES in the United States, Australia does not undertake the regular monitoring of food and nutrient intakes.

The 2 most recent national dietary surveys that were undertaken by the ABS in 1995 and 2011–2012 were included in the current analysis. In the 1995 National Nutrition Survey (20), ~14,000 people who were aged ≥2 y and were from all states and territories participated in the survey with a 61% response rate. The survey used the 3-pass method and 1 face-to-face 24-h dietary recall with a pen-and-paper interview by trained nutritionists who sought detailed information on all foods and beverages that were consumed during the day before the interview (from midnight until midnight). Each food and beverage was described in sufficient detail to allow its nutrient composition to be determined. The 1995 National Nutrition Survey Nutrient Composition Database was prepared specifically for the survey. Data for children and youths (2–18 y old) and adults (19–70 y old) were analyzed separately.

The 2011–2013 Australian Health Survey was the largest and most-comprehensive health survey to be conducted in Australia (21). The survey collected a range of information about health-related issues including health status, risk factors, health-service usage, and medication use. In 2011–2012, the survey incorporated the National Nutrition and Physical Activity Survey, which included detailed food intake information (21). In total, ~12,000 adults and children aged ≥2 y were interviewed face-to-face (77% response rate) with the use of the 5-pass method that was developed by the USDA and the Agricultural Research Service (22). One 24-h dietary recall was used to generate nutrient-intake data with the use of the AUSNUT 2011–2013 food-composition database.

Estimation of added-sugars intake

Added-sugars intake was generated in the 2011–2012 data set with the use of the AUSNUT 2013 food-composition database that was developed specifically for this purpose (21). Added sugars were calculated for each food and beverage item on the basis of the definition for added sugars in clause 1 of standard 2.8.1 of the Australia New Zealand Food Standards Code (23). By this definition, sugars were defined as follows: *1*) hexose monosaccharides and disaccharides including dextrose, fructose, sucrose, and lactose; *2*) starch hydrolysate; *3*) glucose syrups, maltodextrin, and similar products; *4*) products derived from a sugar refinery including brown sugar and molasses; *5*) icing sugar; *6*) invert sugar; or *7*) fruit-sugar syrup derived from any source but not including malt, malt extracts, sorbitol, mannitol, glycerol, xylitol, polydextrose, isomalt, maltitol, maltitol syrup, or lactitol. Maltodextrins were not reported as part of total sugars in the 2011–2012 survey and were excluded in this analysis. Honey, 100% juice, and juice concentrates were not included in the code and, therefore, were not considered added sugars in this definition.

Because the ABS did not undertake an analysis of added sugars for the 1995 survey, we used data that were generated by Cobiac et al. (24) at the CSIRO. In their analysis, added sugars and the energy contributions of added sugars were determined by apportioning total sugars between added and natural sugars. The added-sugars content of each food was defined as the quantity of sugars that was added as sweetening agents during the manufacturing, cooking, or preparation of the food (such as granular sugar, syrups, and honey but not fruit or 100% fruit juice). Added sugars were defined similarly in both data sets with the exception that honey was considered an added sugar in 1995 but not in 2011–2012. Therefore, the precise amounts of honey consumed in 1995 were generated from an analysis of changes in food-commodity groups (25). To achieve comparable data sets, sugars that were contributed by honey (adult men: 2.1 g/d; adult women: 1.5 g/d; boys: 1.3 g/d; and girls: 0.8 g/d) were subtracted from added-sugars intake in 1995.

In 2011–2012, the ABS included juice drinks but not pure juices in their definition of sweetened beverages. This definition varied from the 1995 data set in which 100% juices and juice drinks were given as one line of data. Therefore, to obtain comparable data sets, we combined all sweetened beverages including 100% juices and juice drinks.

With the use of the 2011–2012 national survey data set, Lei et al. (26) also estimated intake of added sugars via their own derived database of the added-sugars contents of Australian foods. Lei et al. (26) excluded one in 3 respondents because of extreme levels of underreporting or overreporting of total energy intakes, which left a subgroup of 8332 participants aged from 2 to ≥71 y who provided one 24-h recall.

With the use of both the 1995 and 2011–2012 national dietary survey data sets, Ridoutt et al. (25) disaggregated ~4500 food items into basic foods to determine changes over time in relation to the basic food groups. They adjusted for the underreporting of total food intake by applying scaling factors of 16% and 1% for women and men, respectively, in 1995 and of 21% and 17%, respectively, in 2011.

Industry data on consumption of SSBs

An alternate independent source of information on trends in the consumption of SSBs was industry-sales data. Levy and Shrapnel (27) obtained grocery-sales surveys from the AC Neilsen Scan Track national data set of all ready-to-drink, water-based beverages in Australia, including sugar-based variants (carbonated soft drinks, sports drinks, energy drinks, iced tea, and mineral water), nonsugar-based varieties, and still water. Milk-based drinks and concentrated, syrup-based carbonated drinks were excluded because they did not meet the criterion of being ready to drink. Volume-sales data were adjusted by imputation to include food-service, vending, convenience, and dining purchases. The overall contribution of sugars in these products to the food supply was determined by multiplying volume sales per annum by the concentration of sugars per 100 mL for each category of beverage. The absolute mass of sugars that was contributed by water-based beverages was divided by the annualized population data to determine per capita trends over time.

Statistical treatment

A linear model was used to determine trends over time in the availability of sugars (FAOSTAT data), apparent consumption (ABS data), and sugars that were contributed by SSBs (industry data), for which the response variable was per capita intake, and the predictor was the year in each model. For comparisons between 1995 and 2011–2012 intakes of nutrients, we used means, relative SEs (RSE), and 95% CIs that were provided by the ABS (20, 21) and showed the difference in the point estimate between years by subtraction. To estimate the precision of the difference, we first calculated the SE for each difference by dividing the

respective 95% CIs by 1.96 as was recommended by the ABS (22). We derived the SE for the difference by propagation of error and calculated the 95% confidence limit that surrounded the difference as the estimated difference ± 1.96 multiplied by the SE for the difference. We inferred significance when the 95% confidence limits for the difference did not include zero (28). In instances in which the 1995 ABS data set did not specify the RSE (i.e., the percentage of energy that was derived from SSBs plus 100% juice, soft drinks, sugary products, confectionery, and alcoholic beverages and the percentage of sugars as soft drinks), the RSE was assumed to be the same as in 2011–2012. R computing software (version 3.2.3; https://www.R-project.org/) was used for all statistical analyses. When appropriate, estimates of the percentages of change were rounded to the nearest whole number.

RESULTS

A total of 1427 articles were identified through databases and government- and nongovernment-survey websites. Of these articles, 38 full-text articles were eligible for further consideration on the basis of titles and abstracts. A total of 28 of these 38 articles were excluded (12 analyses were state-based surveys, 10 articles did not provide sufficient information about the amounts of sugars consumed, 4 analyses referred to the same survey, 1 article described the methodology only, and 1 analysis was considered unreliable because volume and dollar values of imports were used to estimate sugar availability) (29–31). Hence, 10 articles and data sources provided reliable national-level estimates of sugars and SSB intake (**Supplemental Figure 1**).

Availability of sugars and sweeteners

The FAOSTAT data indicated that the per capita availability of total sugars and sweeteners in Australia fell 16% over 3 decades from 152 g/d in 1980 to 127 g/d in 2011 (the last year of data collection; P-trend < 0.001) (**Figure 1**). The decline was greater between 1980 and 2000, but the trend over 5 decades was lower.

Apparent consumption of refined sugars

McNeill and Shrapnel (32) compiled data on the longer-term apparent consumption of refined sugars in Australia that was published by the ABS from 1938 to 1998–99 (the ABS ceased the data collection after 1998–1999) and, with the use of the same methodology, extended the time frame to 2011. In their analysis, the per capita apparent consumption of refined sugars declined over a 50-y time frame from 139 g/d in 1961 to 115 g/d in 2011 (−17%) (Figure 1). Trends over time were similar but not identical to the availability of sugars and sweeteners that was recorded by the FAOSTAT. On average, absolute quantities were 11% lower with the use of ABS methodology. However, for the last decade, the data more closely matched those of the FAOSTAT.

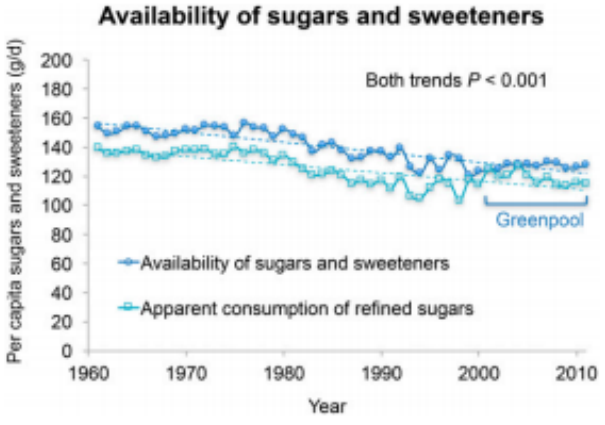

FIGURE 1 Long-term trends in the availability of sugars and sweeteners in Australia (1961–2011) according to the FAO Statistics Division Database (18), Australian Bureau of Statistics, (19), and Greenpool (32).

National dietary survey data of total and added sugars

In adults ≥19 y of age, reported total energy intake declined 8% between 1995 and 2011–2012 (from 9422 to 8672 kJ/d) (21). Much of the decline has been attributed to underreporting with the highest levels of underreporting estimated to have been in young men (22). As a proportion of total energy, total sugar, total fat, and saturated fat intakes declined significantly, whereas protein increased (P-all changes < 0.001) (**Figure 2**). More-marked changes were evident in children and adolescents aged 2–18 y (Figure 2). Absolute intake of total sugars from all sources, including added sugars and naturally occurring sugars in fruit, vegetables, and milk products, fell 10% from 115 to

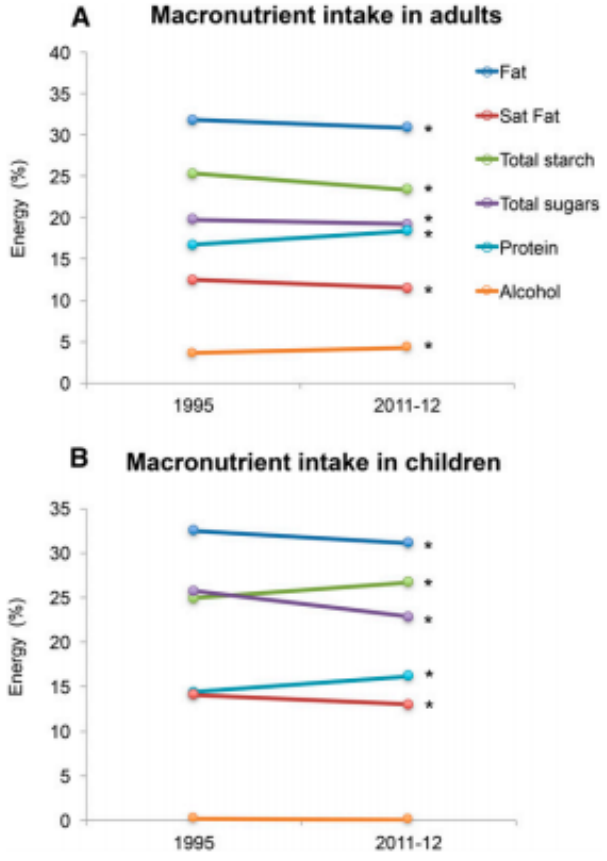

FIGURE 2 Changes in mean macronutrient energy distribution in the Australian population according to national dietary surveys in 1995 and 2011–2012. (A) Changes in adults aged ≥19 y. (B) Changes in children aged 2–18 y. Energy from total sugars included naturally occurring sugars in fruit, vegetables, and milk products in addition to added sugars in processed foods. *Statistical significance was inferred by the 95% CI of the difference between means. Sat, saturated.

103 g/d in adults (20, 21). Adult men showed larger declines in total sugars with a decrease of 14% from 134 to 115 g/d, whereas female intake fell 6% from 97 to 91 g/d (**Table 1**). Total sugar intake fell more steeply in children from 161 to 120 g/d in boys and from 128 to 105 g/d in girls (Table 1).

Added-sugars intake also declined 18% in adult men aged ≥19 y (from 72 to 59 g/d) and 4.5% in adult women (from 44 to 42 g/d) (Table 1). As a proportion of total energy intake, added sugars fell 10% in adult men (from 10% to 9% of energy) but remained essentially the same in adult women (~9%) (Table 1). There were steeper declines in children and youth aged 2–18 y. Specifically, added-sugars intake fell 34% in boys (from 96 to 63 g/d) and 26% in girls (from 72 to 53 g/d) (**Figure 3**). When expressed as a proportion of total energy intake, added sugars fell 25% in boys (from 15% to 11%) and 22% in girls (from 14% to 11%) (Table 1).

With the use of the same 2011–2012 data set, Lei et al. (26) also estimated the intake of added sugars. The weighted mean ± SD added-sugars intake of the study population was 60 ± 53 g/d or 15% higher than that estimated by the ABS.

With the use of both the 1995 and 2011–2012 national dietary survey data sets, Ridoutt et al. (25) calculated that Australians were eating more whole fruit and more wholegrain cereals but consumed less refined sugars and less 100% fruit juice in 2011–2012. Specifically, per capita refined-sugar intake decreased from 78 to 60 g/d in younger Australians aged 2–18 y but remained similar in adults (57–56 g/d).

National dietary survey data: SSBs

With the use of the 1995 and 2011–2012 data sets, the ABS reported that adult consumers (≥19 y of age) of SSBs on the day of the survey decreased from 35% of the population in 1995 to 30.6% in 2011–2012 (−13%) with the steepest decline in younger adults aged 19–30 y (**Figure 4**). By contrast, the consumption of intensely sweetened (diet) beverages increased from 8.4% of adults aged ≥19 y in 1995 to 11.1% of adults aged ≥19 y in 2011–2012 (+32%) (**Table 2**). Per consumer, adults ingested 375 mL diet beverages/d.

The contribution of SSB plus 100% juice to energy intake also declined 10% in adult men (from 5.1% to 4.6% of energy) and 20% in women aged ≥19 y (from 4.4% to 3.5% of energy) (Table 1). The proportion of energy from soft drinks (defined as sugar-sweetened carbonated beverages, flavored mineral waters, and electrolyte, energy, and fortified drinks) also decreased 17% in men (from 3% to 2.5% of energy) and 20% in women (from 2% to 1.6% of energy) (**Figure 5**). As a proportion of total sugars, sugars that were contributed by soft drinks also declined 15% in adult men and 13% in adult women (Table 1).

The proportion of children and youth aged 2–18 y who consumed SSBs on the day of the survey declined 31% (from 68.1% in 1995 to 46.7% in 2011–2012) (Figure 4). The declines were greater in younger children than in teenagers. In children aged 2–18 y, the proportion who consumed diet beverages also declined from 8.5% in 1995 to 5.7% in 2011–2012 (Table 2). The proportion of energy as SSBs plus 100% juice decreased from 9.3% to 6.0% of energy (−35%) in boys and from 9.0% to 5.1% of energy (−44%) in girls (**Figure 6**). The proportion of energy in the form of soft drinks declined 26% in boys (from 3.7% to 2.7% of energy) and 36% in girls (from 3.0% to 1.9% of energy) (Figure 5). Similarly, the proportion of total sugars in the form of soft drinks fell 16% in boys and 27% in girls (Table 1). In 2011–2012, the total volume of SSBs consumed was 217 mL/d across all children and was 355 mL/d in consumers only.

A second source of national-level data on intake of SSBs in children was an analysis of the 2007 Australian Children's Nutrition and Physical Activity Survey (33), which was a computer-assisted 24-h dietary recall survey of 4400 nationally representative children aged 2–16 y. On the day of the survey, 47% of children reported having consumed SSBs, which was

TABLE 1
Changes in intake of total and added sugars, SSBs, sugary products, confectionery, and alcoholic beverages in Australian adults and children according to national dietary surveys in 1995 and 2011–2012[1]

	Change from 1995 to 2011–2012			
	Adults aged ≥19 y		Children aged 2–18 y	
	Men	Women	Boys	Girls
Total sugars, g/d	−18.3 (−22.4, −14.2)	−6.1 (−9.0, −3.2)	−41.7 (−49.5, −33.9)	−23.7 (−30.0, −17.4)
Added sugars, g/d	−13.1 (−15.7, −10.5)	−1.4 (−3.0, +0.2)	−33.4 (−37.5, −29.3)	−18.8 (−21.9, −15.7)
Total energy intake as added sugars, % pt	−1.0 (−1.4, −0.7)	−0.2 (−0.5, +0.1)	−3.8 (−4.4, −3.2)	−3.2 (−3.8, −2.6)
Total energy intake from SSBs plus 100% juice, % pt	−0.5 (−0.8, −0.2)	−0.9 (−1.2, −0.6)	−3.3 (−3.7, −2.9)	−3.9 (−4.4, −3.5)
Total energy intake in the form of soft drinks, % pt	−0.5 (−0.7, −0.3)	−0.4 (−0.6, −0.2)	−1.0 (−1.3, −0.6)	−1.1 (−1.5, −0.6)
Total sugar intake in the form of soft drinks, % pt	−2.3 (−3.8, −0.8)	−1.2 (−2.4, 0.0)	−2.2 (−3.7, −0.7)	−1.1 (−1.5, −0.6)
Total energy intake as sugary products, % pt	−0.8 (−1.1, −0.5)	−0.5 (−0.7, −0.3)	−0.6 (−0.9, −0.2)	−0.3 (−0.8, +0.2)
Total energy intake as confectionery, % pt	+0.7 (0.5, 0.9)	+0.9 (0.5, 1.3)	−0.1 (−0.8, +0.6)	−0.3 (−1.1, +0.6)
Total energy intake as alcoholic beverages, % pt	0.6 (0.1, 1.1)	1.2 (0.7, 1.7)	—	—

[1] Values are mean changes (95% CIs). Total sugars were from all sources and included naturally occurring sugars in fruit, vegetables, and milk products. Added sugars were from all sources and included discretionary sugars and sugars added to processed foods with the exclusion of honey. SSBs were defined as drinks that contained added sugar including cordials; carbonated soft drinks; flavored mineral waters; energy, sports, and electrolyte drinks; fortified waters; and fruit and vegetable drinks (water-based beverages that contained some fruit and vegetable juice in addition to added sugars); the definition excluded 100% fruit and vegetable juices. Soft drinks included carbonated beverages; flavored mineral waters; and electrolyte, energy, and fortified drinks. Sugary products included table sugar, honey, syrups, jams, marmalades, chocolate spreads, meringue, and dishes and products other than confectionery in which sugars were the major component. Confectionery included chocolate; licorice; sweets; and health, muesli, cereal, nut, fruit, and seed bars. Alcoholic beverages included beer, wine, spirits, cider, cocktails, and mixed drinks that contained alcohol. SSB, sugar-sweetened beverage; % pt, percentage point.

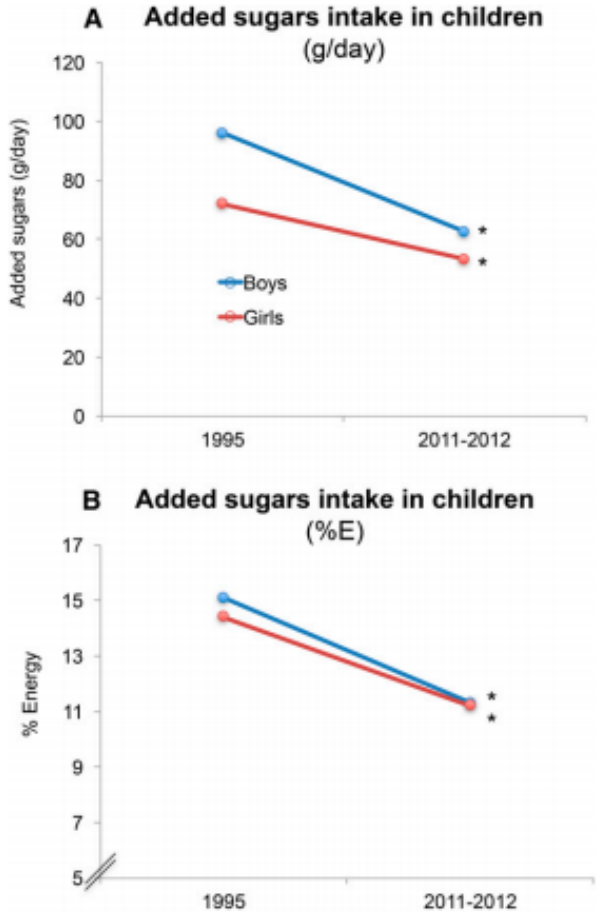

FIGURE 3 Mean changes in intakes of added sugars from all sources, including discretionary sugars and sugars that were added to processed foods, in Australian children (aged 2–18 y) according to national dietary surveys in 1995 and 2011–2012. (A) Changes in intake of added sugars (grams per day). (B) Changes in the %E as added sugars. *Significance was inferred by the 95% CI of the difference between means. %E, percentage of energy.

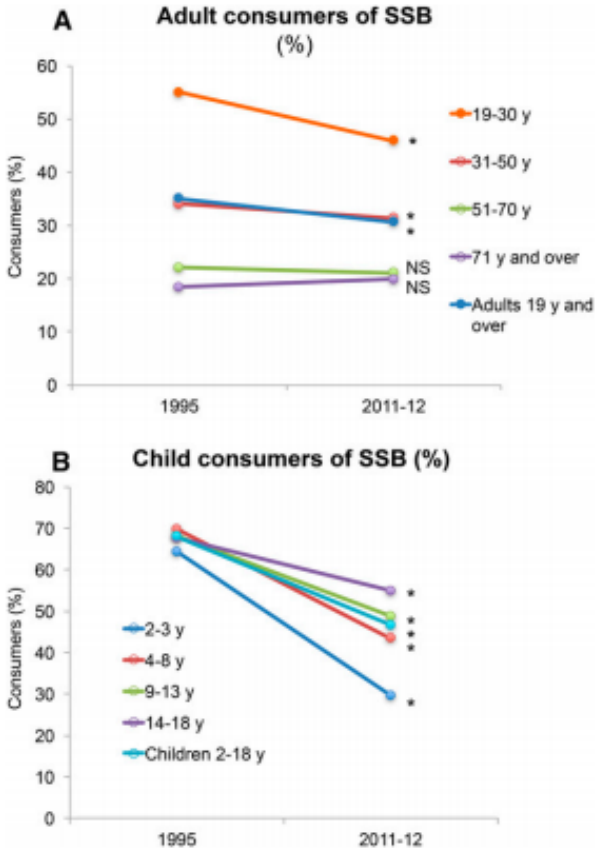

FIGURE 4 Mean changes in the proportion of Australians who reported the consumption of SSBs on the day of the survey. (A) Changes in the proportion (percentage) of adults aged ≥19 y who reported consumption. (B) Changes in the proportion (percentage) of children aged 2–18 y who reported consumption. *Significance was inferred by the 95% CI of the difference between means. SSB, sugar-sweetened beverage.

similar to the percentage that was reported in the 2011–2012 survey. Across all children (including nonconsumers), 1.6% of total energy was contributed by sugar-sweetened soft drinks, 2% of total energy was contributed by 100% juice, and 1.4% of total energy was contributed by cordials and fruit drinks (i.e., 5% of total energy intake).

National dietary survey data: discretionary sugars, foods, and alcoholic beverages

National dietary surveys in 1995 and 2011–2012 also generated information on the consumption and discretionary use of sugars and confectionery (21). Sugary products and dishes were defined as table sugar, honey, syrups, jams, marmalades, chocolate spreads, and dishes and products other than confectionery in which sugars were the major component (e.g., meringue). From 1995 to 2011–2012, intake fell progressively from 2.7% to 1.9% of energy (−30%) in adult men and from 2.3% to 1.8% of energy (−22%) in women (Table 1). In contrast, intake of confectionery [chocolate, licorice, sweets, and health bars (e.g., cereal, nut, fruit, or seed bars)] rose in men (+47%; from 1.5% to 2.2% of energy) and in women (+43%; from 2.1% to 3.0% of energy) (Table 1). Over the same time frame, alcoholic beverage intake also increased from 6.4% to 7.0% of energy (+9%) in adult men and from 3.4% to 6.0% of energy (+77%) in adult women (Table 1). Beer and wine were the main sources (~80% of energy from alcoholic beverages), and the highest

TABLE 2
Changes in the proportion of Australian population consuming beverages on day of survey between 1995 and 2011–2012[1]

Population and age	Sugar-sweetened beverage	Intensively sweetened beverage[2]
Adults, y		
All, 19 to ≥71	−4.4 (−2.7, −6.1)	+2.7 (1.6, 3.8)
19–30	−9.1 (−5.0, −13.2)	+1.7 (−0.8, +4.2)
31–50	−2.6 (−0.1, −5.1)	+2.7 (0.9, 4.5)
51–70	−1.0 (−3.5, +1.5)	+5.4 (3.7, 7.1)
≥71	+1.5 (−2.3, +5.3)	−0.3 (−2.2, +1.6)
Children, y		
All, 2–18	−21.4 (−19.7, −23.1)	+2.8 (1.3, 4.3)
2–3	−34.8 (−30.3, −39.3)	—
4–8	−26.3 (−23.7, −29.9)	—
9–13	−19.4 (−16.8, −22.0)	—
14–18	−12.8 (−9.0, −16.6)	—

[1] Values are percentage points and are expressed as mean changes; 95% CIs in parentheses.

[2] Data on children's intakes of intensively sweetened beverages according to age group were not available in 1995.

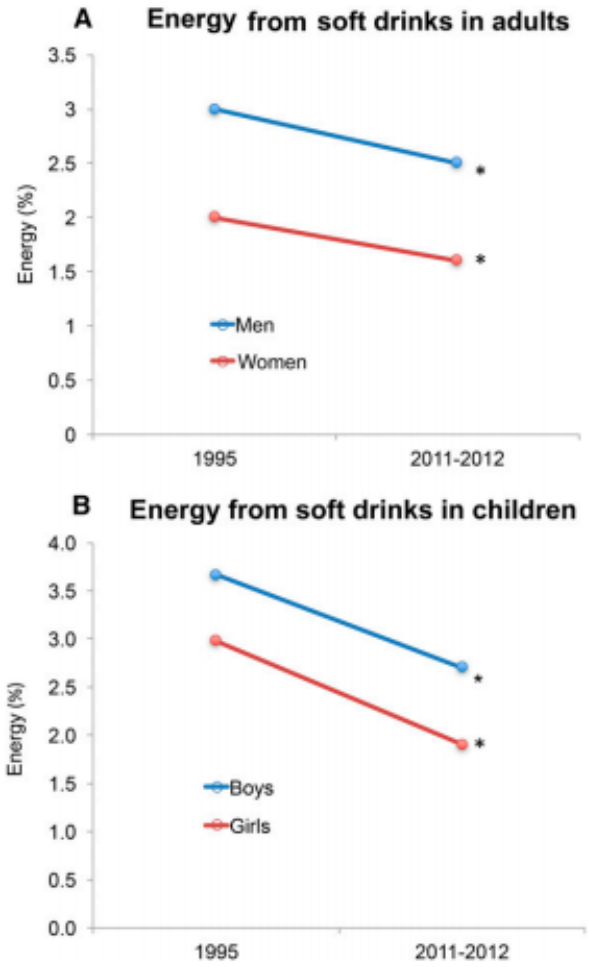

FIGURE 5 Mean changes in the proportion of energy derived from soft drinks according to national dietary surveys in 1995 and 2011–2012. (A) Changes in adults aged ≥19 y. (B) Changes in Australian children aged 2–18 y. Soft drinks were defined as sugar-sweetened carbohydrate beverages; flavored mineral waters; and electrolyte, energy, and fortified drinks. *Significance was inferred by the 95% CI of the difference between means.

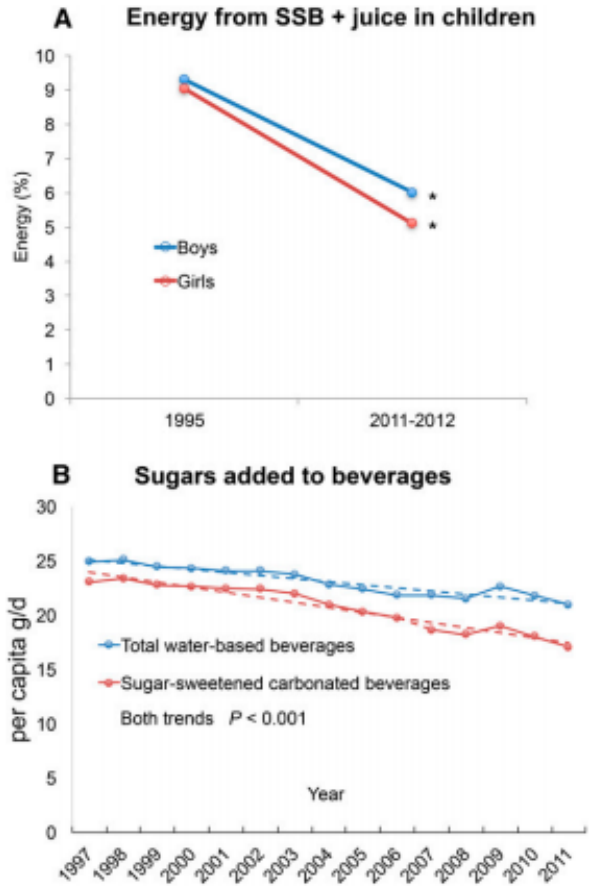

FIGURE 6 Mean changes in energy intake and sugars that were contributed by SSBs according to national surveys and industry sources, respectively. (A) Changes in the proportion of energy consumed as SSBs plus 100% juice by children aged 2–18 y. (B) Per capita changes in the amount of sugars (grams per day) that were contributed by water-based beverages and sugar-sweetened carbonated soft drinks from 1997 to 2011 according to industry sources (27). The data were supplied and redrawn with permission from Levy and Shrapnel (27). SSB, sugar-sweetened beverage.

consumers were men aged 51–70 y (8.5% of energy) and 31–50 y (7.2% of energy), but they were closely followed by women aged 51–70 y (6.0% of energy).

In adults aged ≥19 y who reported the consumption of alcoholic beverages (29% of all adults) in 2011–2012, the ABS reported that alcohol contributed 16% of total energy. In contrast, in those who reported the consumption of SSBs (31% of all adults), the sugars in the SSBs contributed 8.3% of energy.

Industry data on consumption of SSBs

According to an industry analysis (27), total sales of all nonalcoholic, water-based beverages in Australia increased 26% from 1997 to 2011, which was driven largely by increasing sales of nonsugar beverages (+73%). SSB sales also grew modestly (+5%) over the same time frame, which was largely due to sports drinks and other new categories (e.g., vitamin waters) with lower concentrations of sugars than in conventional SSBs. By 2011, the volume share of nonsugar beverages had reached 42%, which was up from 30% in 1997. Per capita, from 1997 to 2011, there was a significant ($P < 0.05$) decline in the volume of SSB purchased (−11 L/y), particularly of carbonated SSBs, and an increase in nonsugar beverages (+16 L/y). Per capita sales of carbonated SSBs lost 18% of volume (−20 L/y) over the 15 y. At the same time, per capita sales of nonsugar carbonated beverages increased 24% (from 22.8 to 28.2 L/y). Sales of nonsugar mineral waters grew 60% and nonflavored still water increased 4-fold from 1997 to 2011.

Although changes in the volume of SSBs consumed are informative, they are not indicative of the sugars and energy that are contributed by SSBs. Changes in the formulation that reduced sugar concentrations also occurred over the 15-y period of study (34). With the use of the raw data provided, we calculated that the per capita amount of sugars that was contributed by water-based beverages declined 16% from 25 g/d in 1997 to 21 g/d in 2011 (Figure 6). The largest per capita decrease (−26%) was in carbonated soft drinks from 23 to 17 g/d.

The industry analysis also provided the usual consumption patterns of SSBs according to the AC Nielsen Home Scan Consumer Panel, which is a survey of 10,000 households that are chosen to be representative of the Australian population (27). Participants used a scanner to record all household purchases from supermarkets, convenience stores, and pharmacies over a 1-y period. The data indicated that 84% of individuals purchased SSBs, and 56% of individuals purchased nonsugar varieties.

Teenage boys had the highest proportion of carbonated SSB purchases, whereas teenage girls had high proportions of both still-water and carbonated SSB purchases. Over time, lower-income families purchased less volume shares of both sugar-sweetened and nonsugar carbonated soft drinks, which were taken up by families in the high-income bracket. This data set revealed changes in the proportion of beverage variants. The ratio of sales of carbonated beverages that were classified as nonsugar compared with sugar-sweetened increased from 1:3 in 1997 to 1:2 in 2011. Similarly, in the sugar-sweetened varieties, there were changes in the proportionate contribution of variants with lower concentration of sugars. SSBs with conventional sugar contents (>10 g sugars/100 mL) dropped from 93% in 1997 to 81% in 2011 of the total sugars that were contributed by all water-based beverages. SSBs that had lower sugar contents (<10 g/100 mL) went from 6.5% to 19.4%, which was a ~3-fold rise, whereas SSBs with <6 g sugar/100 mL increased from 3.6% to 8.9% of total sugar, which was a ~2.5-fold rise.

The main findings in this analysis are summarized in **Figure 7** and include the trend-line changes from 1995 to 2011 for the availability of sugars and sweeteners (FAOSTAT), the apparent consumption of refined sugars (ABS), and sugars added to carbonated soft drinks (industry data) compared with the changes in total sugars, added sugars, and sugars as soft drinks according to national dietary surveys in 1995 and 2011–2012. Similar downward slopes were evident. In contrast, the age-standardized prevalence of obesity in Australia climbed 80% between 1980 and 2013 (1), which was a time frame during which the availability of sugars and sweeteners declined 16% (**Figure 8**).

DISCUSSION

In this analysis of multiple independent data sets that encompassed the availability of added and refined sugars, national dietary surveys, and beverage-industry grocery sales in Australia, we showed a substantial decline in refined sugars and SSB consumption. Compared with our 2011 article (15), the current analysis provides novel data on changes in recorded intakes of total sugars, added sugars, SSB, carbonated soft drinks, juices, confectionery, and alcohol in Australian adults and children between the 2 most recent national dietary surveys. The current analysis extended the FAOSTAT series forward and backward to show 50-y trends and directly compared the FAOSTAT sugar availability with the ABS apparent consumption. Our study included new findings from the CSIRO (25) and Levy and Shrapnel (27), and it showed the concordance of changes within the different data sets.

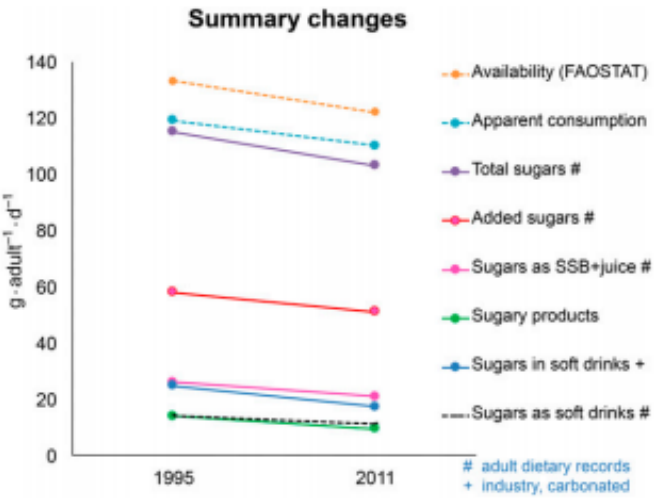

FIGURE 7 Summary of findings. Changes from 1995 to 2011 in sugars availability, apparent consumption of refined sugars, and sugars in sugar-sweetened carbonated beverages were interpolated from the linear trend lines shown in Figures 1 and 6. Changes in total sugars, added sugars, sugary products, and sugars in soft drinks (defined as sugar-sweetened carbonated beverages; flavored mineral waters; and electrolyte, energy, and fortified drinks) were reported intakes from national dietary surveys in 1995 and 2011–2012. FAOSTAT, FAO Statistics Division Database.

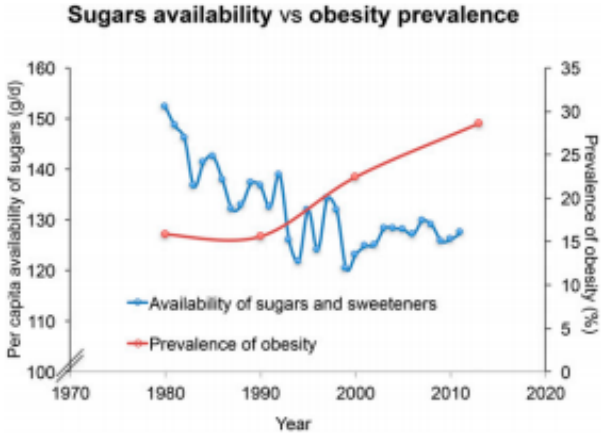

FIGURE 8 Age-standardized trends in obesity in Australian adults aged ≥20 y between 1980 and 2013 (1) compared with trends in the availability of sugars and sweeteners between 1980 and 2011 according to the FAO Statistics Division Database (18).

According to the current study, the per capita availability of sugars and sweeteners fell 16% between 1980 and 2011, which was a fall that was equivalent to a per capita reduction of added-sugars intake by ~230 g/y for 30 y. Between 1995 and 2011, the reported intake of added sugars (grams per day) in national dietary surveys declined 18% in adult men but remained essentially unchanged in adult women (42 g/d). Larger declines of the order of 26–34% occurred in children aged 2–18 y. The proportion of energy consumed as SSBs, including juice, also declined 15% in adults and 40% in children and youth. Currently relatively small amounts of energy are consumed from this category (i.e., 4% in adults and 5.5% in children). Industry data that were based on sales and sugar concentrations of soft drink variants over the same time frame also indicated that the contribution of sugars to carbonated soft drinks decreased 26% on a per capita basis, which was equivalent to 157 g/y for 14 y.

The overall downward trend in the availability of added sugars in Australia during the 3 decades when obesity increased dramatically (1980–2011) was unusual but not unique. According to the food balance sheets that were compiled by the FAOSTAT, the United Kingdom showed a decline of similar magnitude to that shown in Australia. However, the United States, Canada, Switzerland, other countries in Europe, and our near neighbor New Zealand have all experienced an increased availability of added sugars. In the United States, the rise in sugar availability peaked in 2000 and began to fall, which was a pattern that was corroborated by changes in recorded intakes of added sugars according to NHANES data in the same time frame (35).

The driving force behind the downward trend in added sugar consumption likely included an increasing health and weight consciousness, which was principally driven by social forces, but also by a succession of national dietary guidelines that called for a moderation of refined-sugar intake. An extensive advertising campaign by the sugar industry failed to reverse the downward trend (36), and surveys indicated a simultaneous rise in intakes of nonnutritive sweeteners (37). Currently, Australia appears to have one of the highest ratios of diet beverages to conventional sugar-sweetened soft drinks whereby >1 in 2 carbonated beverages that are purchased are intensely sweetened (27). Although reliable data are lacking, one source has suggested that only 20% of total soda sales are of the diet variety in the United States compared with 33% in Norway and 29% in the United Kingdom (38).

The strengths and limitations of this analysis should be noted. Per capita availability, apparent consumption, and grocery data are useful in determining upward or downward trends over time and describing theoretical maximum sugar intake for the entire population. However, like all data of this nature, the data overestimate individual intake because of losses that occur when foods are prepared and consumed including plate wastage. Nutrient intake that is derived from these sources is representative of the whole population but not of subgroups. In contrast, national dietary surveys can provide good estimates of changes in usual intakes of subgroups of the population, including men, women, children, and adults (both sexes), provided that the data are carefully collected. Recall-precision accuracy, low response rates, reporting and classification errors were common in both the 1995 and 2011–2012 dietary surveys (20, 22) and may have introduced confounding. Underreporting was more of a concern in 2011–2012. Compared with 1995, overall energy intake fell (−8%), but the energy from soft drinks fell more (−17% in adult men and −20% in adult women). In our analysis, we addressed underreporting in the following 2 ways: by expressing sugars intake as a percentage of total energy intake and as a proportion of total sugars intake in addition to absolute intake (grams per day). In contrast to SSBs, reported energy intakes from alcoholic beverages and confectionery increased, which suggested that the decrease in SSB intake may have been real rather than underreported. Furthermore, industry data on SSBs have been consistent with the dietary survey data showing that the contribution of sugars to SSBs has fallen by the same amount (−17%) over a similar time frame (27).

The data generated by the sugar and beverage industry for its own purposes has been questioned because of a lack of independent monitoring (32). However, grocery sales provide critical information on product usage and insights into the food environment that influence financial decisions and new-product development (32). The industry figures reported in the current study were corroborated by national dietary surveys that indicated a similar downward trend.

The 2015–2020 US Dietary Guidelines state that added sugars are an important factor in the obesity crisis and have set conservative guidelines for added sugars (39). Specifically, the guidelines recommend ≤10% total energy/d should come from added sugars. The 2011–2012 national survey suggested that the average Australian adult had already met this target (9% of total energy), but usual intake of added sugars by children and adolescents was 11% of energy (21). There are subgroups of the Australian population with larger intakes, particularly teenage males (13% of energy) and indigenous adults and children (13% of energy), for whom continuing efforts to reduce added-sugars intake are needed.

Australia, like other developed nations, has experienced a steep 3-fold increase in the prevalence of adult obesity within a 30-y time frame. Between the 2 national surveys in 1995 and 2011–2012, adult men and women gained, on average, 3.6 and 4 kg, respectively (21). In children aged 2–17 y, the prevalence of overweight and obesity increased from 21% in 1995 to 25% in 2011–2012. Therefore, the overall downward trends in the availability of refined sugars and estimated intakes of added sugars and SSBs are at odds with an incremental weight gain in the population as a whole. These findings challenge the widespread belief that energy from sugars is uniquely linked to changes in the incidence of obesity (1). Other studies that have used individual dietary intakes have also reported inverse associations between added-sugars intake and body weight. In an analysis of obesity and energy supply in the WHO MONICA (Multinational MONItoring of trends and determinants in CArdiovascular disease) Project, which encompassed Western European countries, Australia, the United States, and China, there was a small effect of total fat, but the energy supply from total sweeteners per capita showed no relation with obesity (40). Sugar availability has increased in some countries (e.g., Switzerland) where the women have remained the same BMI for >4 decades (1).

The downward trends over time argue against the assumption that the reduced consumption of refined sugars and SSB will, in themselves, help to reverse societal trends in obesity and chronic disease. Although an overconsumption of energy relative to needs must be addressed to halt the obesity epidemic, our analysis provides little evidence to support a particular focus on any one source of energy. Inappropriately high intakes of savory foods or, indeed, of any energy source (alcohol, fat, protein, starch, or sugars) will result in weight gain.

Our findings suggest that there may be unintended consequences of a singular focus on refined sugars and SSBs. One possibility is that potentially more-important sources of excess energy, such as alcoholic beverages in adults and energy-dense savory snacks in children, are being overlooked with the current emphasis on the restriction of soft drinks. From 1995 to 2011–2012, the proportion of energy from alcohol increased 77% in Australian women, whereas that from soft drinks fell 20% (21). The 2007 National Children's Survey showed the quantity of food consumed as pizza, potato crisps, and similar salty products had increased, whereas that of SSBs fell (41).

In conclusion, our analysis suggests that Australians have adopted dietary recommendations to limit intake of refined sugars by reducing intakes of SSBs, discretionary sugars, and sugary products. Over a time frame of >30 y, downward trends in the availability of sugars and sweeteners, reported intake of energy in the form of added sugars and SSBs, and industry data on sugar contributions to SSBs have been paralleled by a sustained rise in the prevalence of obesity and its comorbidities (42). A coordinated approach to lowering intakes of all discretionary foods and beverages is needed to balance energy intake with energy expenditure. The current findings warrant consideration by other nations in their efforts to identify effective interventions for obesity prevention.

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The authors' responsibilities were as follows—JCB-M: had primary responsibility for the final content of the manuscript; and both authors: designed and conducted the research, analyzed the data, performed the statistical analysis, wrote the manuscript, and read and approved the final manuscript. JCB-M is President of the Glycemic Index Foundation and manages a food-testing service at the University of Sydney. JCB-M and AWB are co-authors of books about the glycemic index of foods. AWB is a consultant to the Glycemic Index Foundation and Merisant (Australasia) and is a member of the Scientific Advisory Boards of Roche and Nestle (Australasia). AWB received an honorarium from Coca-Cola Ltd. for a presentation in 2011. JCB-M reported no conflicts of interest related to the study.

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