Sweetening of the global diet, particularly beverages: patterns, trends, and policy responses

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Evidence suggests that excessive intake of added sugars has adverse effects on cardiometabolic health, which is consistent with many reviews and consensus reports from WHO and other unbiased sources. 74% of products in the US food supply contain caloric or low-calorie sweeteners, or both. Of all packaged foods and beverages purchased by a nationally representative sample of US households in 2013, 68% (by proportion of calories) contain caloric sweeteners and 2% contain low-calorie sweeteners. We believe that in the absence of intervention, the rest of the world will move towards this pervasiveness of added sugars in the food supply. Our analysis of trends in sales of sugar-sweetened beverages around the world, in terms of calories sold per person per day and volume sold per person per day, shows that the four regions with the highest consumption are North America, Latin America, Australasia, and western Europe. The fastest absolute growth in sales of sugar-sweetened beverages by country in 2009–14 was seen in Chile. We believe that action is needed to tackle the high levels and continuing growth in sales of such beverages worldwide. Many governments have initiated actions to reduce consumption of sugar-sweetened beverages in the past few years, including taxation (eg, in Mexico); reduction of their availability in schools; restrictions on marketing of sugary foods to children; public awareness campaigns; and positive and negative front-of-pack labelling. In our opinion, evidence of the effectiveness of these actions shows that they are moving in the right direction, but governments should view them as a learning process and improve their design over time. A key challenge for policy makers and researchers is the absence of a consensus on the relation of beverages containing low-calorie sweeteners and fruit juices with cardiometabolic outcomes, since decisions about whether these are healthy substitutes for sugar-sweetened beverages are an integral part of policy design.

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Introduction

Over the past several decades, the world has become increasingly aware of the role of added sugars, particularly in beverages, as a major driver of increased weight gain and diabetes. This problem is especially evident in high-income countries such as the USA, the UK, and Australia, where consumption of sugar-sweetened beverages increased throughout the 20th century.[1–5]

In this Personal View, we briefly discuss the role of caloric sweeteners (also known as nutritive sweeteners) and low-calorie sweeteners (also known as non-nutritive sweeteners) in weight gain, diabetes, and other cardiometabolic health problems. We then provide an update, based on a new dataset, of global trends in sales of beverages containing caloric and low-calorie sweeteners, with a focus on understudied countries outside North America, Europe, and Australasia. We group sugar-sweetened beverages into three categories: caloric soft drinks, fruit drinks, and sports and energy drinks. To illustrate anticipated global trends in the next decade, we also provide an in-depth analysis of trends for added caloric sweeteners and low-calorie sweeteners in both foods and beverages in the USA. We end with a review of the policy responses that have been put into place around the world.

Cardiometabolic effects of caloric and low-calorie sweeteners

The past 25 years have seen a revolution in our understanding of the effect of caloric sweeteners (including sugar) on energy intake, obesity, and diabetes. Although the relation between sugar and insulin control has been understood since the 1920s,[6] appeals to view sugar as a danger to health were ignored by most of the health profession during the 1950s and 1960s.[7,8] Public health and biomedical scholars' focus on sugar-sweetened beverages increased substantially after groundbreaking work by Richard Mattes and others showing that intake of caloric beverages in any form are not compensated for by an equivalent reduction in food intake.[9–12] Although the reason behind this finding is not fully understood,

Key messages

- The addition of caloric sweeteners to foods and beverages is linked to an increased risk of a range of cardiometabolic problems.
- Evidence of the cardiometabolic outcomes of beverages containing low-calorie sweeteners and 100% fruit juice remains inconclusive.
- 68% of packaged foods and beverages available in the USA contain caloric sweeteners, 74% include both caloric and low-calorie sweeteners, and 5% include only low-calorie sweeteners.
- We expect that the US pattern of caloric sweeteners and low-calorie sweeteners in the food supply will also be seen in most high-income countries and around the world in the next few decades.
- In most low-income and middle-income countries, sales of sugar-sweetened beverages in daily calories per person are increasing, whereas intake is declining in a few high-income regions (eg, North America, Australasia, and western Europe).
- Because of the associated cardiometabolic risks, WHO and many countries are promoting a major reduction in intake of added caloric sweeteners.
- Governments around the world are increasingly developing and implementing policies that aim to reduce intake of sugar-sweetened beverages.
- Evidence from Mexico shows that taxation policies can be effective; other policies and regulations in Chile and other countries are too new to be assessed.

some potential biological mechanisms (eg, an evolutionary explanation centred on the extreme seasonality of food and the need to drink water constantly to survive) have been identified.[13,14]

Extensive meta-analyses show that the risk of weight gain and other cardiometabolic problems, especially diabetes, resulting from added sugars in beverages is substantial and that the risk increases with the amount consumed.[4,15–21] The exceptions are studies funded by the sugar and beverage industries, which the authors of some reviews suggest are biased.[22,23] Two important randomised controlled trials link intake of sugar-sweetened beverages in children and adolescents with excessive weight gain.[24,25] In the past 3 years, two major meta-analyses of the effect of added sugars in food show that the risk of adverse cardiometabolic outcomes from caloric sweeteners in food is lower than the risk of caloric sweeteners in beverages.[15,16] Nevertheless, WHO, the British Government dietary guidance committee, and many other countries and organisations recommend the reduction of added-sugar intake not only in beverages, but also in food.[26–28] Partly on the basis of this risk, WHO published a revised guideline in 2015, in which it urged the reduction of added-sugar intake to less than 10% of total energy intake (strong recommendation), and a further reduction to below 5% of total energy intake (conditional recommendation).[27] Several countries and medical associations (eg, Public Health England's Scientific Advisory Committee on Nutrition and the World Cancer Research Fund) have promoted the lower limit of 5%.[27,28]

Although a consensus regarding the health effects of sugar-sweetened beverages has been reached, the cardiometabolic effects of 100% fruit juice need to be further studied. Some epidemiological studies suggest an adverse effect,[11,12,29–35] whereas other reviews and studies identified minimal evidence to support this conclusion.[36] No randomised controlled trials have been done in either children or adults, which represents a major gap in research.

The effect of low-calorie sweeteners such as saccharin and aspartame (appendix p 8) on weight gain and diabetes risk is even more controversial than that of 100% fruit juice. Although careful reviews and randomised controlled trials did not identify evidence that low-calorie sweeteners increase energy intake,[14,37] results from several longitudinal cohort studies implicate low-calorie sweeteners as a cause of increased weight, diabetes, and other adverse cardiometabolic outcomes.[38–40] However, the investigators of these studies paid little attention to challenges presented by reverse causation and, potentially, effect modification by an existing unhealthy diet. Conclusions of adverse cardiometabolic effects of low-calorie sweeteners have been reversed in two cases when these issues were taken into account,[41,42] and results from two randomised controlled trials did not show an adverse effect of beverages containing low-calorie sweeteners on cardiometabolic outcomes.[43,44] However, no consensus has been reached on the role of low-calorie sweeteners in weight gain and diabetes risk; several ongoing randomised controlled trials should hopefully help to reach a consensus on the effects of low-calorie sweeteners on cardiometabolic health outcomes.

Another issue that has received renewed attention is the role of fructose. Fructose and glucose are the two main components of sugar (sucrose), and fructose levels can vary widely in different forms of sugar (roughly 45–55% of sugar in some high-fructose corn syrups and roughly 55–65% in some fruit juices).[45,46] Glucose has important effects on obesity and other adverse health responses;[47] however, fructose, which is metabolised in the liver, seems to have unique adverse effects, such as increased liver fat, uric acid, visceral fat, muscle fat, and triglycerides.[48–62]

Almost all of this research into the health effects of beverages has been done in western Europe and North America, with the exceptions of longitudinal studies or randomised controlled trials in Singapore,[33,63] Japan,[64] and Mexico.[65] Research in the USA shows that the relations between BMI and intake of sugar-sweetened beverages might be stronger in Hispanic[66–69] and Asian individuals than in white individuals, suggesting the importance of doing further research in other countries—especially in India and China, since the dearth of studies in these two countries represents a major gap in research.

In summary, existing evidence shows that increased sugar intake amplifies the risk of weight gain, diabetes, and many other cardiometabolic problems. Many beverages containing caloric sweeteners have adverse health effects, but further research is needed to investigate the health effects of beverages containing low-calorie sweeteners and 100% fruit juices.

Caloric and low-calorie sweeteners in the US food supply

The USA has one of the world's most complex food supplies in terms of the number of products with unique ingredients; however, our research and that of others show that this modern supermarket-based system is growing rapidly in most low-income and middle-income countries. Thus, study of the US food supply can help to illustrate global trends—eg, the extent to which sweeteners are added in packaged foods and beverages.[70–74] We analysed data from the Nielsen Homescan Services nationally representative sample of US households, which are based on scans from all barcoded food sold in 2000, 2006, and 2013 with "unique formulations of ingredients" (1·2 million foods in the USA between 2000 and 2013; appendix pp 1–2). We linked food sales to nutrition fact panels, ingredients, and components of each of the listed ingredients to ascertain the extent of the use of caloric sweeteners and low-calorie sweeteners in packaged foods and beverages. Published work shows

See Online for appendix

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that a large proportion of US foods and beverages include the natural sweetener, fruit juice concentrate.[75] We included as an added sugar any beverage with both fruit juice concentrate and water as a caloric sweetener rather than as 100% fruit juice (see appendix pp 5–8 for all the types of sweeteners included in our search). In many foods and beverages, fruit juice concentrate is not shown as a stand-alone ingredient on the label, so we also searched the components of the ingredients on the nutrition fact panel for various juice concentrates (appendix p 6). We excluded sugar alcohols, as does the US Food and Drug Administration, since their caloric effect is minimal; we also excluded two new, rarely used low-calorie sweeteners, allulose and tagatose.

Our analysis shows a significant increase in the proportion (by weight) of purchased products, especially beverages, with both caloric sweeteners and low-calorie sweeteners, and also a significant increase in that of purchases, especially beverages, with no added sweeteners between 2000 and 2013 (figure 1A). In 2013, 30% of all food calories and 37% of all beverage calories purchased were in products that did not have added sweeteners (figure 1B), which lends support to earlier work showing that intake of total added sugars in the USA has declined since 2000 and that much of this shift is caused by a reduction in the consumption of caloric beverages.[76,77] 68% of packaged foods and beverages available in the USA contain caloric sweeteners, 74% include both caloric and low-calorie sweeteners, and 5% have only low-calorie sweeteners (figure 1C). The proportion (by weight) of purchases containing fruit juice concentrate remained similar between 2000 and 2013 (figure 1A). Although the number of foods sweetened with fruit juice concentrate remained the same, the number of beverages with fruit juice concentrate declined substantially (figure 1C), as did the proportion of beverages bought, in terms of volume and calories, although to a lesser extent.

Trends in beverage sales

We used data for global trends in beverage sales from the Euromonitor Passport International database,[78,79] which has been used in other studies of sugar-sweetened beverages.[80] Our definition of sugar-sweetened beverages included caloric soft drinks (carbonated and non-carbonated), fruit drinks (sweetened beverages of diluted fruit juice and often other caloric sweeteners and flavourings), and several fast-growing categories—namely,

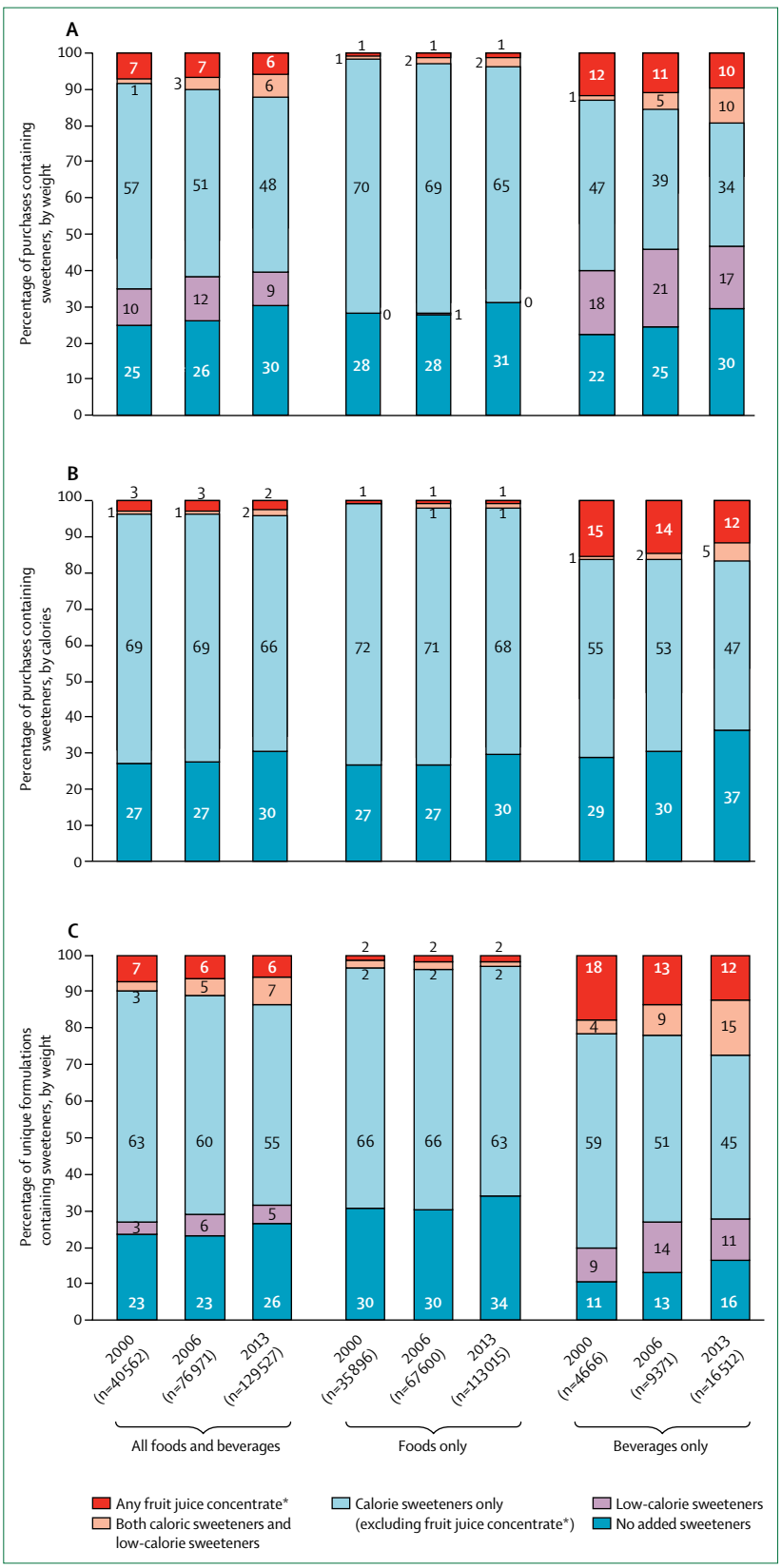

Figure 1: **Food and beverage products containing sweeteners in the US food supply**

Percentage of purchases of uniquely formulated consumer packaged goods containing sweeteners, (A) by weight (g) and (B) by calories (kcal), weighted to be nationally representative. (C) Percentage of unique formulations containing sweeteners, by weight (g). Calculations were partly based on data reported by Nielsen through its Homescan Services for the food and beverage categories. *Fruit juice concentrate includes products in which water is present as an ingredient, but excludes lemon or lime and when reconstituted.

energy drinks, sports drinks, and sugar-sweetened (often flavoured) waters, which we combined in our analysis as sports and energy drinks. Our analysis adds to earlier studies on sales volumes, which had little disaggregation, since ours is the first to include data for trends in caloric levels in sugar-sweetened beverages (appendix pp 2–4).[79] Euromonitor International allowed our research team to beta-test and use these new caloric data to analyse the breakdown of beverages in more detail than is traditionally provided by Euromonitor online. We combined sales for off-trade volume (ie, supermarkets and retailers) and on-trade volume (ie, restaurants and cafeterias) reported in volume (mL) sold per person per day. Caloric data were available only for off-trade sales, and regional averages were weighted by the population of each country in that area.

We compared our results with intake levels of sugar-sweetened beverages from national nutritional surveys and several large-scale studies of such intake across the world (appendix pp 2–3).[19,21] Some limitations of our dataset were that many small local bottlers were likely to have been omitted, and that consumption for a few countries—notably, Colombia—seemed much lower than that in national nutrition surveys and regional dietary intake patterns from 24-h recall studies. Moreover, the data were of average purchases for the country, included waste, and did not include information about per-person consumption of key age groups that are more likely to consume sugar-sweetened beverages (ie, people aged 10–35 years), as was done in a cross-sectional presentation of global dietary data.[21] However, the data do seem to be accurate with respect to the identification of trends in both volume and calories of sugar-sweetened beverages sold, since the results align closely with our own findings on trends in purchases and dietary intake of sugar-sweetened beverages in the USA[76] and Mexico.[77] The trends from our analysis (figures 2–5; appendix pp 2–3) also accord with findings from two recent reports.[19,80] Singh and colleagues' study[19] of cross-sectional dietary intake data of sugar-sweetened beverages from individual surveys showed that the Caribbean region that was not represented by Euromonitor caloric intake data consumed greater volumes of sugar-sweetened beverages than did other regions. Basu and colleagues' ecological analysis of Euromonitor data[80] showed a strong association between sales of such beverages at the country level and the prevalence of diabetes.

North America and Latin America are the largest consumers of sugar-sweetened beverages, with sales in Asia Pacific substantially lower (figure 2A). In 2009–14,

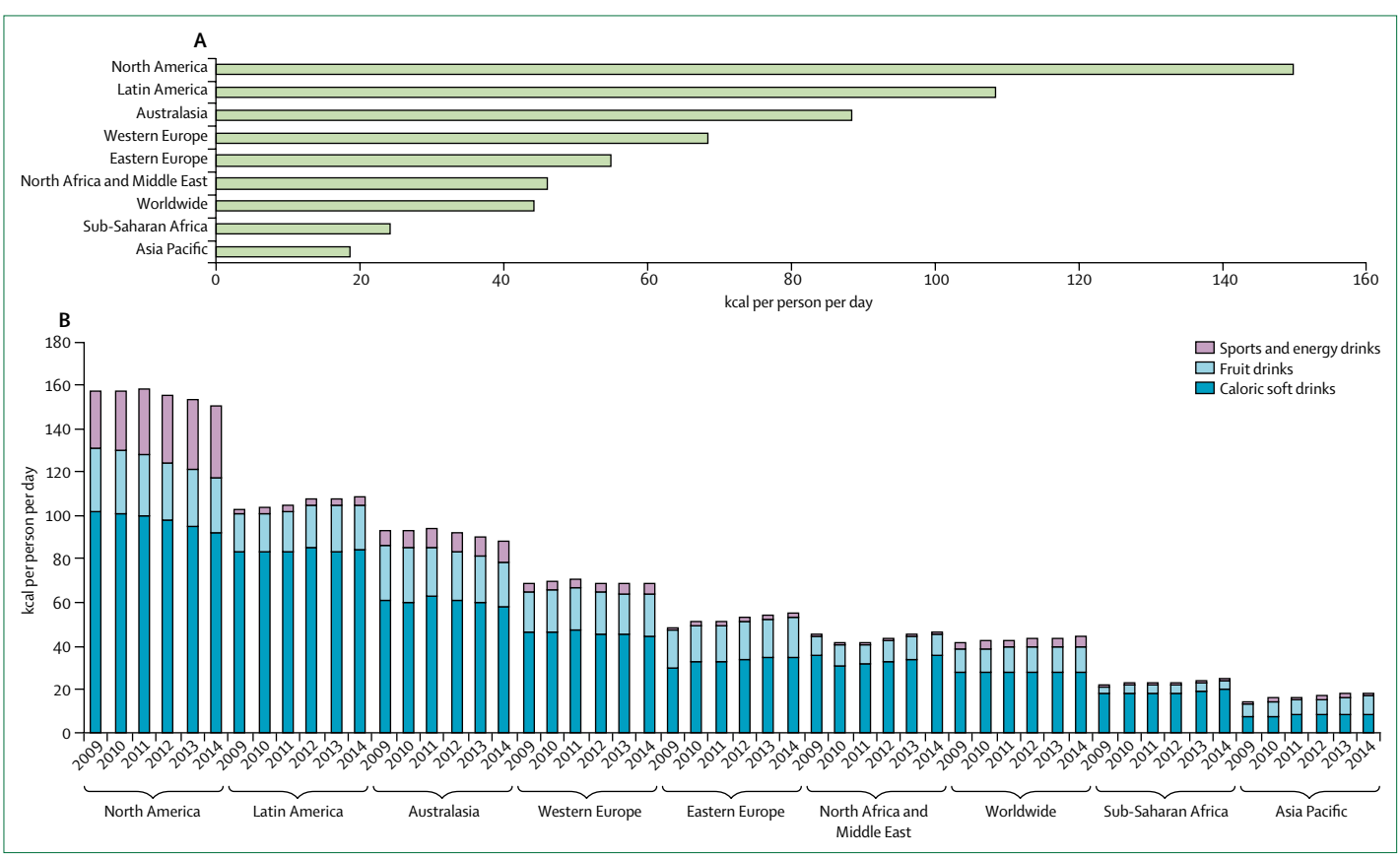

Figure 2: **Sales of sugar-sweetened beverages by region in 2014 (A) and trend in sales, 2009–14 (B)**
Data from Euromonitor Passport International, which were obtained from nutrition fact panels and websites of sugar-sweetened beverage companies. kcal=kilocalories.

sales fell in North America, Australasia, and western Europe, but increased in all other regions (figure 2B; appendix pp 14, 16, 18–22, 24). Important differences between regions are seen in the types of beverages sold. Although caloric soft drinks are a dominant contributor to daily calories sold per person in most regions, fruit drinks contribute equally in Asia Pacific. Sales of caloric soft drinks remained fairly stable in Latin America, while sales of fruit drinks increased. In North America, sales of caloric soft drinks declined substantially, but sales of sports drinks increased significantly. Such an increase in sales of sports drinks was also seen in Australasia, although sales of soft drinks remained stable, with the overall decline being explained mainly by the decrease in fruit drinks sold. Worldwide, sales of caloric soft drinks remained fairly unchanged, whereas sales of fruit drinks and energy drinks increased.

Enormous heterogeneity exists in sales volumes and trends within regions. Three of the six countries with the highest per-person daily calories sold from sugar-sweetened beverages are in Latin America, with Chile being the highest, followed by Mexico in second place and Argentina in fourth place (figure 3; appendix p 10). The USA and Saudi Arabia are also in the top six. This situation is different from that in 2000, when the USA was the largest consumer, before the substantial decline in consumption of sugar-sweetened beverages. National trends in different types of sugar-sweetened beverages reflect regional trends—eg, China shows a large growth in fruit drinks consumed (appendix p 15).

Changes in sales of sugar-sweetened beverages also differ between countries in the same region (figure 4)—eg, Chile and Mexico, two countries where the health effects of sugar-sweetened beverages have received extensive media and political attention. The data in our analysis show that some countries, such as China, Thailand, Brazil, and Chile, are facing growth in sales of sugar-sweetened beverages, whereas others such as the UK, Mexico, and the USA are seeing declines. In the case of Mexico, this decline occurred before the sugar tax was instituted, possibly because of the much more visible and well-funded media campaign linking sugar-sweetened beverages with diabetes (which is called "urino con azucar" in Mexico). By contrast, much of the Chilean effort was aimed at direct discussions with congressional representatives led by several active senators.[81] Decline in overall sales was also apparent in the USA, despite increases in sales of sports and energy drinks.

The caloric trends essentially mimic the 2000–14 trends in sales in volume, with a few exceptions (appendix pp 14–24). The USA is one example in which the two trends diverge, since sales have shifted to beverages with low caloric content, often by replacing caloric sweeteners with low-calorie sweeteners (figures 1–3). Asia, including China, is characterised by the increasing consumption of fruit drinks. China has seen a remarkable increase in sales of sugar-sweetened beverages since 2000, but the change is smaller than that in Chile (figure 4). Both long-term and short-term data show that a major focus of

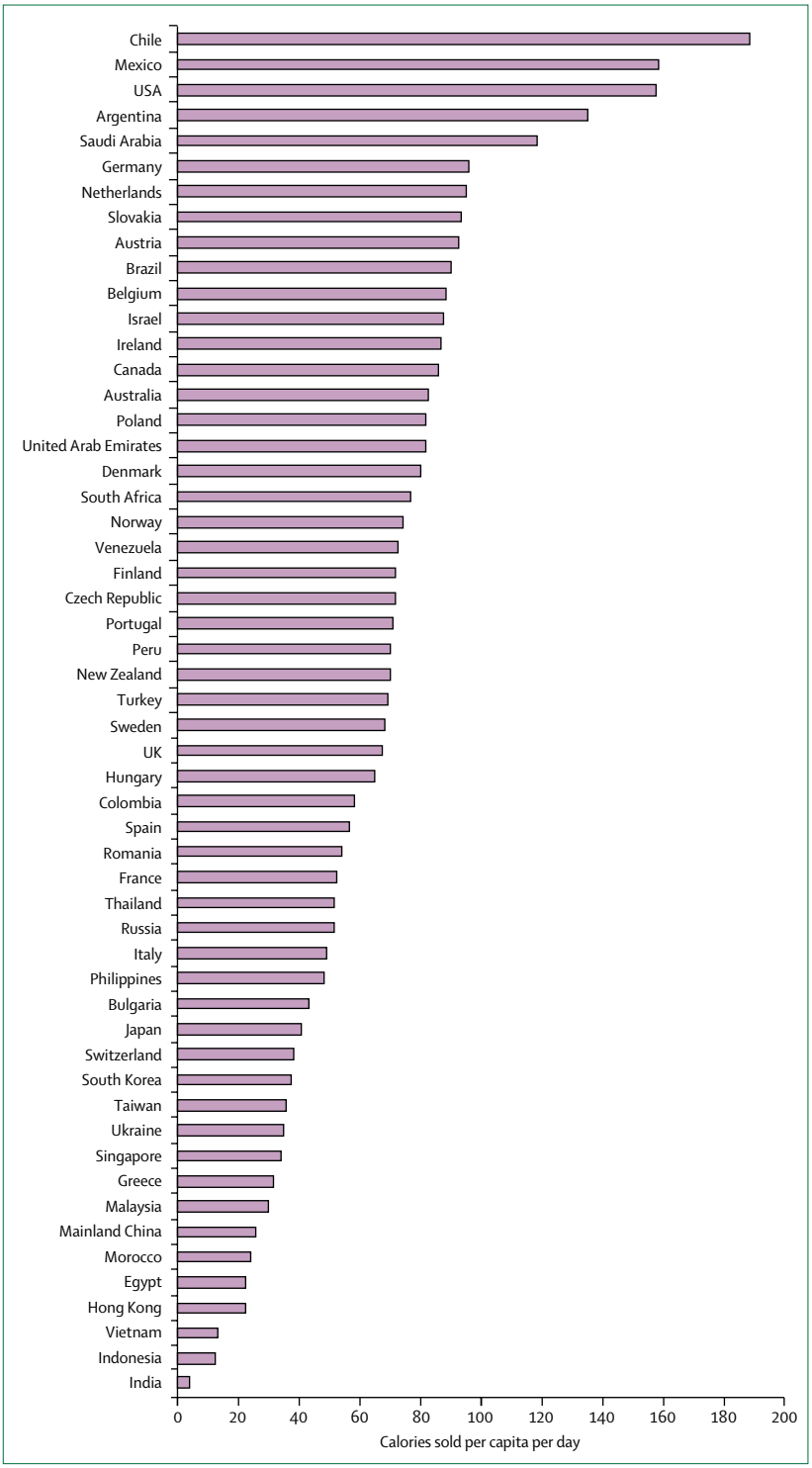

Figure 3: **Sales of caloric beverages in 2014**
Data from Euromonitor Passport International, which were obtained from nutrition fact panels and websites of sugar-sweetened beverage companies.

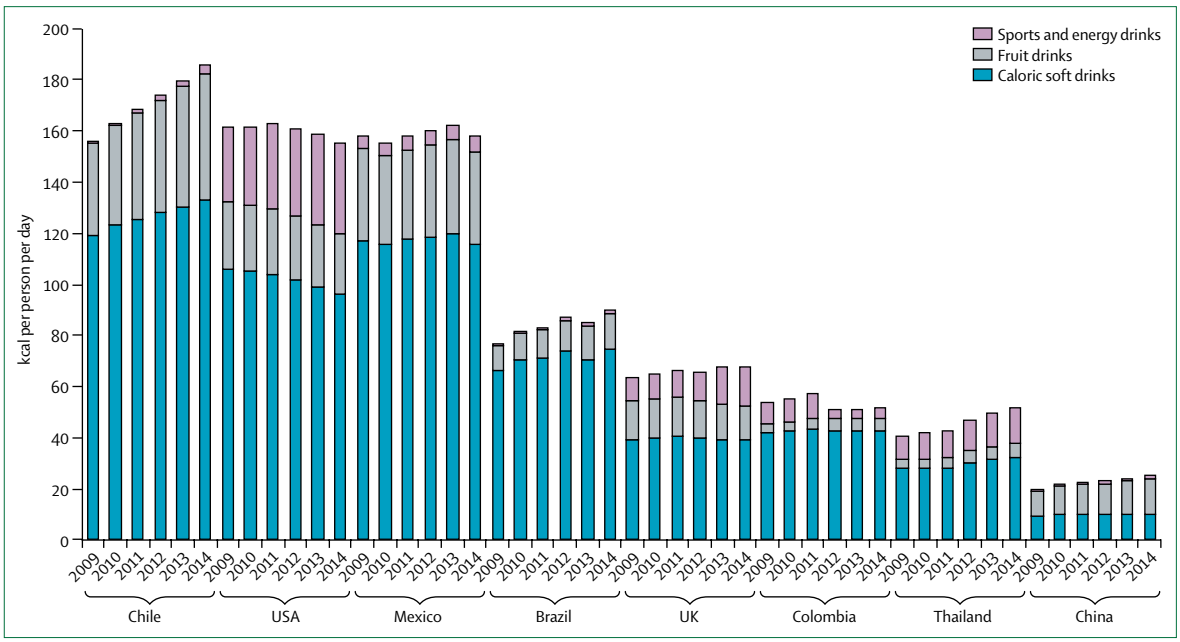

Figure 4: **Sales of beverages in 2009–14 in selected countries**
Data from Euromonitor Passport International, which were obtained from nutrition fact panels and websites of sugar-sweetened beverage companies. kcal=kilocalories.

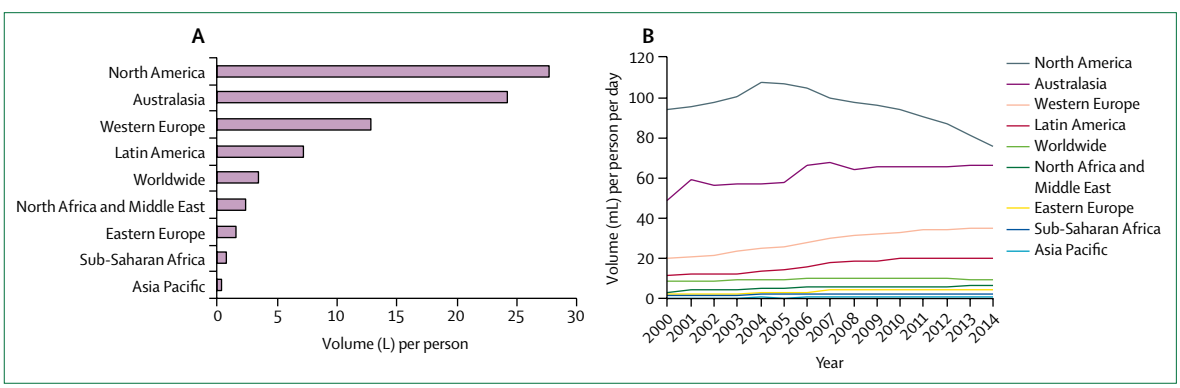

Figure 5: **Sales of diet beverages with only low-calorie sweeteners in 2014 (A) and trends in 2000–14 (B)**

global beverage companies is to promote consumption in less saturated, emerging markets (eg, China [appendix p 15], Thailand, and the Philippines) beyond the established markets in high-income countries such as the USA, Australia, and the UK.[82] Aside from North America, Australasia, and western Europe, few regions consume many beverages containing low-calorie sweeteners; North America, Australia, and New Zealand consume twice as many such beverages as do other regions (figure 5; appendix p 12).

Policy responses

Global overview

In view of the adverse health effects associated with the widespread consumption of sugar-sweetened beverages, many national governments have taken action to reduce consumption.[26,83] We identified such policies from the World Cancer Research Fund (WCRF) International NOURISHING database.[84,85] Actions led by the private sector were not included. This database does not represent a comprehensive global survey, so our review of existing policy actions was selective. We identified the most common actions, the number of actions in low-income and middle-income countries, and how policy makers have dealt with the scientific uncertainty about potential substitutes of sugar-sweetened beverages. We reviewed the effects of some of these policies, on the basis of evaluation of actions taken at the local level (eg, in school districts) and in research settings. Aside from that of the Mexican tax on sugar-sweetened beverages, few national-level and statistically rigorous studies have been done in low-income and middle-income countries.

We also look at trends in consumption of sugar-sweetened beverages in countries that have implemented health-related food taxes.

Many countries have started to attempt to reduce consumption of sugar-sweetened beverages, and the most common actions implemented so far include taxation, reduction of availability in schools, restrictions on marketing to children, public awareness campaigns, and front-of-pack labelling. Most of these actions are not specific to sugar-sweetened beverages, but do include them. Although we identified 72 policy actions that have been implemented in 49 countries, covering all world regions (figure 6),[85] none of these actions is implemented in low-income countries. Only one (2%) lower-middle-income country (Samoa) and 16 (33%) upper-middle-income countries have enacted such actions; most of the actions are implemented in high-income countries, where consumption is generally highest but more likely to be stabilising. This finding suggests that more policy actions are needed beyond high-income countries where rates of consumption are rising.

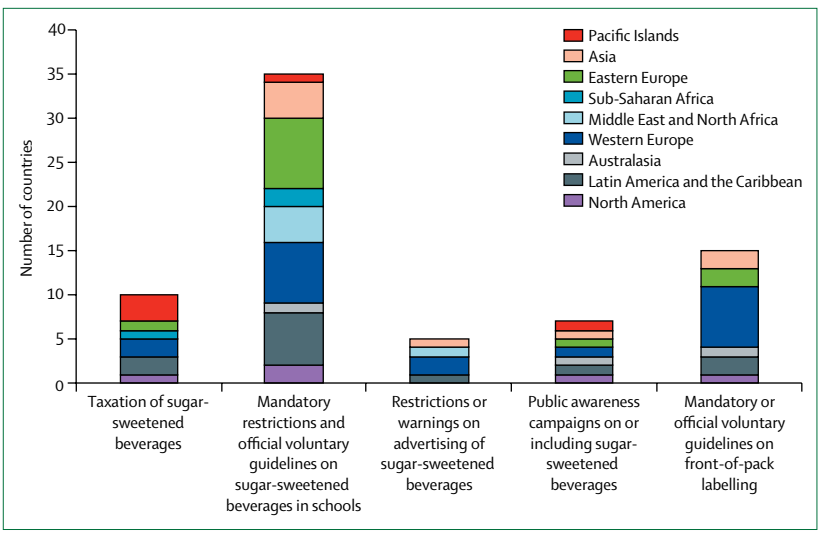

Figure 6: **Number of countries that have implemented policies on sugar-sweetened beverages (including at the sub-national level)**
Data from World Cancer Research Fund International NOURISHING database.

Taxation

The most notable policy development in the past 2 years is the increasing governmental interest in taxation of sugar-sweetened beverages or foods with added sugar, or both. As of May, 2015, national-level taxes have been implemented in five countries in Latin America and Europe (Chile, Mexico, Finland, Hungary, and France), four small island states (Samoa, Mauritius, French Polynesia, and Tonga), one city (Berkeley, CA, USA), and one Native American reservation (Navajo Nation in the USA). So far, taxation rates have mostly been lower than the level of 20% or more recommended by scholars[86]—eg, 2% in Navajo Nation (implemented in April, 2015), 8% in Chile (January, 2015), 10% in Mexico (January, 2014) and France (January, 2012), and higher (around 15–30%) in French Polynesia and other western Pacific Islands.[87] The highest rate is the 12–25% tax (depending on the size of the container) in Berkeley. In several countries, the tax covers more than sugar-sweetened beverages. In Hungary, for example, the tax (adopted in 2012) applies to the sugar, caffeine, and salt content of various categories of ready-to-eat foods and drinks, including energy drinks, which are widely consumed by young people. In Mexico, the tax on sugar-sweetened beverages is combined with a roughly 8% tax on so-called non-essential foods that are high in added sugar, sodium, or unhealthy saturated fats.

What has been the effect of these taxes? In Hungary, an econometric analysis of broad food and beverage categories from household expenditure data showed a 3·4% decrease in the purchase of processed foods and a 1·1% increase in the purchase of unprocessed food after the tax was introduced;[88] other initial reports suggested a much larger decline (27%) in sales of taxed foods and extensive reformulation of food products.[89] This decline is also seen in the Euromonitor data (figure 7). In France, the tax led to a roughly 5% price increase, with Euromonitor data showing a small effect on sales (figure 7) and WHO also reporting a 3·3% reduction in sales.[89] In Chile, a continued increase in consumption was seen up to Jan 1, 2015, when the tax was implemented. The Chilean evaluation will be initiated, with similar data and methods as those used in the Mexican evaluation, in 2016 by the Global Food Research Program of the University of North Carolina and the Institute of Nutrition and Food Technology, University of Chile.

A joint team from the University of North Carolina and the Mexican National Institute of Public Health is investigating the long-term effects of the taxes in Mexico on food and beverage purchase patterns.[77] Their evaluation of the tax on sugar-sweetened beverages showed an average decline of 6% in purchases of taxed beverages in 2014, compared with pre-tax levels. This difference became more pronounced over 2014, and the reduction compared with pre-tax trends reached 12% by December, 2014. All socioeconomic groups purchased fewer taxed beverages. Reductions were higher in households with low socioeconomic status, with a 9% average decline in 2014 and up to a 17% decline by December, 2014. The first year of this tax has therefore already led to the expected significant declines in purchases of sugar-sweetened beverages and increases in purchases of bottled water; in theory, the longer-term effect could be even greater if taxes affect people's long-term preferences and move their habits away from the consumption of sugar-sweetened beverages.[90–93] However, this assumption does not account for changes in industry behaviour in response to taxation policies, so the long-term effects are difficult to predict.

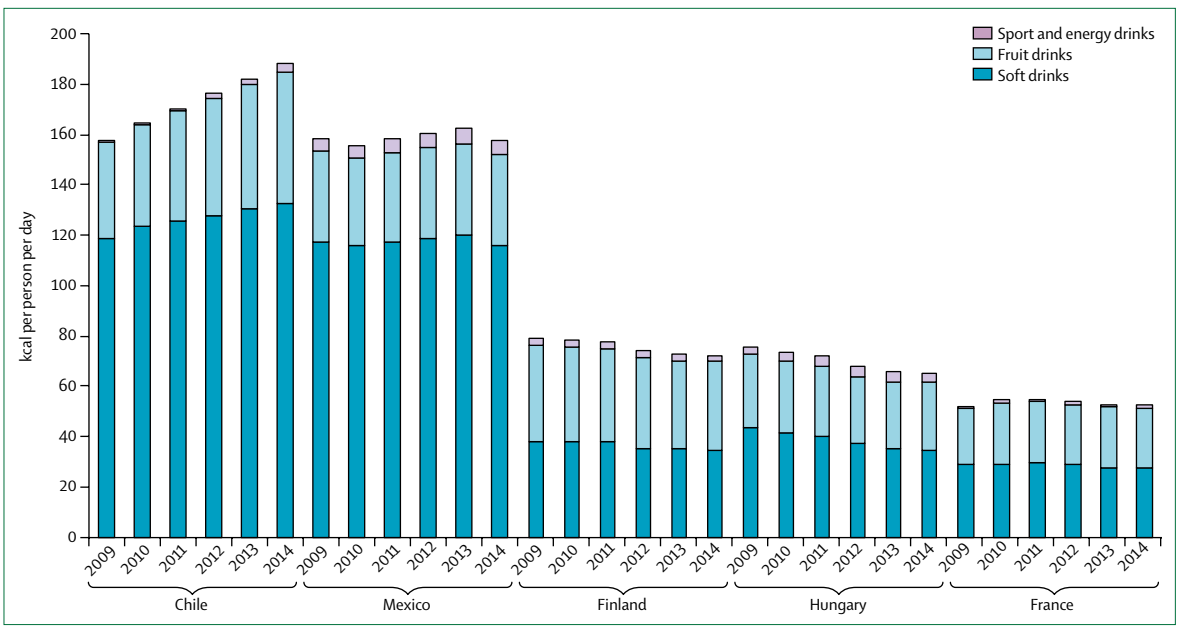

Figure 7: **Sales of caloric beverages in countries with sugar taxes, 2009–14**
Data from Euromonitor Passport International, which were obtained from nutrition fact panels and websites of sugar-sweetened beverage companies. kcal=kilocalories.

Restrictions of availability in schools

A major focus of government actions around the world has been to improve the quality of foods available in schools.[94] Although the policies vary substantially from place to place—eg, some set standards for meals, some for vending, some for all food in schools, and some are specific to sugar-sweetened beverages—a common feature is that they aim to restrict the availability of sugar-sweetened beverages. Such policies have been implemented at the national, state or province, municipal, and school district levels; most of these policies are mandatory, although many examples of official guidelines for voluntary application also exist.

Evidence about the effects of restricting sugar-sweetened beverages on consumption comes mainly from the USA, where state-level bans have consistently led to decreased availability in schools, but the evidence for an effect on daily consumption has been mixed.[95] Restrictions might be less effective if they do not include all sugar-sweetened beverages or are not comprehensive across the school environment.[96] Where bans are comprehensive, they affect in-school purchasing of sugar-sweetened beverages but do not necessarily reduce overall consumption, since children can bring these beverages into school and consume them before and after school.[96,97] These findings suggest that a range of synergistic measures are needed both inside and outside schools,[83,98] since preferences and habits for consumption of such beverages are already deeply entrenched. More evidence is also needed from low-income and middle-income countries, where a range of policies on school snacking, beverages, and meals have been instituted but no large-scale evaluations have been done so far.

Marketing restrictions

Efforts to reduce the exposure and power of marketing of soft drinks have been less widely implemented than the other policy actions reviewed here (figure 6). The UK, Ireland, and South Korea restrict advertising of sugar-sweetened beverages as part of regulations on advertising of foods high in fat, sugar, and salt content, but these are applicable only to specific communications channels (mainly television). Iran is reported to have had a ban on all soft-drink advertising on television since 1994. Since 2007, France has required health messages on all food and drink advertising. On July 1, 2016, Chile will implement a new law to ban marketing to children of foods and beverages high in sugar, sodium, calories, or saturated fats, and will also require these banned products to have front-of-pack warnings.[81,99] Evidence for the effect of marketing restrictions on consumption of sugar-sweetened beverages is not available; at present, the effect of comprehensive marketing bans, which are recommended as the most effective approach by WHO,[100] cannot be assessed, since no country has comprehensively restricted all forms of marketing of sugar-sweetened beverages to children.

Public awareness campaigns

Several governments have also launched public awareness campaigns.[85] In New York City (NY, USA), the Department of Health set a precedent in 2009 with its Pouring on the Pounds campaign to reduce consumption of sugar-sweetened beverages through the use of posters, videos, and slogans such as "Don't drink yourself fat". This campaign has been adapted for use in other US states—eg, the Choose Health LA Sugar Pack campaign in

Los Angeles, CA. Sugary drinks have been included in public awareness campaigns in Australian states and territories, as part of the LiveLighter campaign;[101] in England, where the Change4Life public health programme ran a social marketing campaign called Smart Swaps in January, 2014, to encourage alternatives to sugary drinks;[102] and in Tonga, where the 2012 A Mouthful of Sugar campaign featured an image of a bottle of soda with a label reading "diabetes".

Evidence suggests that public awareness campaigns are effective at reducing consumption of unhealthy foods and drinks if they use several modes of communication and are run for a sustained period.[103] However, few assessments specific to sugar-sweetened beverages have been done. One exception is the Choose Health LA Sugar Pack campaign, which increased the public's knowledge of sugar in drinks. In an evaluation of the campaign (which included a survey), more than 60% of respondents reported that they were likely or very likely to reduce their daily intake of sugary drinks.[26]

Front-of-pack labelling

Front-of-pack labels on food packages that show the levels of sugars have been adopted in several countries. In 2014, the Ecuadorian Government set a precedent by requiring so-called traffic light labels on packaged foods and drinks. The labels display the levels of sugar, fats, and salt with the colour codes: red (high), orange (medium), or green (low). This approach was first implemented in the UK, where voluntary guidelines were produced in 2006 and revised in 2013 by the government. The Chilean approach requires foods high in added sugar, sodium, and saturated fats to carry a warning label about ill-health effects, a requirement that will also be applied to advertising from July 1, 2016.[81] In some countries, the consumer packaged food and beverage industry has adopted an alternative approach of calorie labelling on a voluntary basis. Other labelling systems take a different approach by indicating healthier products, including products lower in sugar; examples are the Healthy Stars Rating labels in Australia and the Green Keyhole labels in Denmark, Norway, Sweden, and Iceland.

The effects of these front-of-pack labels on purchasing and consumption have yet to be fully evaluated.[104,105] Evidence suggests that these types of labels are easier to understand and interpret correctly than are traditional nutrient lists, but that their effect depends on the nature of the population, with highly educated groups and nutritionally aware shoppers being more likely to be responsive than others.[105] Different types of labels seem to result in different responses.[106,107] One small US study specific to sugar-sweetened beverages suggests that provision of prominent caloric information was associated with reduced purchasing.[108] Some evidence suggests that front-of-pack symbols can have a positive effect on reformulation of foods, and this effect has been shown in sugar-sweetened beverages specifically.[109,110]

Reformulation and portion size reduction

Although mandatory or voluntary targets to encourage reformulation of processed foods are fairly widespread around the world, these targets generally apply to salt and trans fats.[111] Only France has made a concerted effort to set sugar reduction targets in foods and drinks; since 2001, it has been implementing a strategy that aims to reduce sugar consumption by 25%, but this seems to apply to foods only (ie, excluding beverages).[26] In New York City, efforts to introduce legislation on portion sizes of sugar-sweetened beverages in restaurants failed to be implemented.[112]

Substitutes for sugar-sweetened beverages

We also examined how policies deal with potential alternatives to sugar-sweetened beverages. This is important because such measures affect what people may choose to consume instead and therefore their overall caloric intake.[113] Although from a public health standpoint, unsweetened or very lightly sweetened water, milk, tea, and coffee are the best alternatives,[43,114–116] policy makers need to make practical decisions about beverages for which the cardiometabolic effects are inconclusive. The difficulty of differentiating added sugars from natural sugars in front-of-pack labels also poses challenges for policy formulation.

For countries that have taxes on sugar-sweetened beverages or foods with added sugars, most tax according to the level of sugar in drinks or foods, and do not tax drinks with no caloric sweeteners or low-calorie sweeteners. France is a rare exception that includes drinks with low-calorie sweeteners, reportedly because no specific category in customs codification is dedicated to sodas.[113] Results from one analysis suggest that this policy reduces the effectiveness of the tax because the prices of all drinks are increased, so that the relative differences between products remain unchanged.[113] The preliminary assessment of the Mexican tax on sugar-sweetened beverages, which does not include drinks with non-caloric sweeteners, shows a roughly 4% increase in purchases of untaxed beverages in 2014, which was mainly driven by an increase in the purchase of bottled plain water (data for tap water intake were not available). No concomitant increase has been reported in sales of 100% fruit juices (which are expensive), nor of drinks with low-calorie sweeteners (which are less well promoted than drinks with caloric sweeteners and are reportedly unpopular in the country[117]).

By contrast with tax policies, school policies—such as those in Queensland, Australia; France; and Brazil—tend to include beverages with low-calorie sweeteners in their restrictions on the basis that they are of minimal nutritional value and therefore have little contribution to school meals.[118] 100% fruit juices are typically permitted with limited portion sizes (eg, 4 ounces [113 g] in the USA). In Mexico, the school food standards implemented in 2013 initially permitted fruit drinks; however, a preliminary

analysis shows that carbonated sugar-sweetened beverages were simply replaced by beverages with equal caloric content.[119] As a result, the Mexican Department of Education has now excluded fruit drinks and has proposed plans to provide potable water in schools with some of the proceeds from the sugar-sweetened beverage tax, although this policy has not been implemented.

Public awareness campaigns tend to promote drinks that are low in calories as alternatives. The slogan used in the New York City campaign in 2009 was "Go with water, seltzer or low-fat milk instead". In England, the Smart Swaps campaign recommends water, drinks containing low-calorie sweeteners, and any drinks with no added sugar as potential swaps for sugar-sweetened beverages.[102] The campaign in Tonga recommended substitution with water or coconut water.[85]

Conclusion

The evidence presented in this Personal View has four important policy implications. First, evidence that added sugars have adverse effects on weight gain and many cardiometabolic risks provides a rationale for government action. Sugar-sweetened beverages and processed food are major sources of added sugars in most countries. WHO has recommended the amount of added sugars be reduced in foods, but the evidence for the effectiveness of this recommendation is less clear than for that for sugar-sweetened beverages; a clear policy priority should be to reduce intake of these beverages. Second, consumption of sugar-sweetened beverages is rising fastest in low-income and middle-income countries in Latin America, the Caribbean, Africa, the Middle East, Asia, and Oceania; therefore, action is urgently needed in these countries to reduce consumption of such beverages. Policies are also needed to continue to decrease the high levels of consumption in Australasia, North America, and western European countries. Third, although intakes of carbonated sugar-sweetened beverages might be stabilising or declining in some countries, governments need to be aware of the rising sales of sports, energy, and fruit drinks with added sugars, which also require policy attention. Fourth, the absence of a consensus on the evidence on beverages containing low-calorie sweeteners and fruit juices creates a practical conundrum for policy formulation. From a public health perspective, unsweetened or very lightly sweetened water, milk, tea, and coffee are appropriate substitutes, depending on context and age group, although policy makers still need to make practical decisions about how to treat drinks with low-calorie sweeteners and fruit juices in the design of policies to tackle consumption of sugar-sweetened beverages.

To conclude, many countries consume high levels of sugar-sweetened beverages, and others with lower intakes are seeing steep increases. We have also shown from trends data that consumption seems to be decreasing in countries with taxes on sugar-sweetened beverages (eg, Mexico, Finland, Hungary, and France). WHO, major scientific bodies, and most countries recognise the importance of reducing consumption of sugar-sweetened beverages to improve public health. The evaluation of not only sugar taxes, but also new marketing controls and front-of-pack labelling, is important and represents one of the next frontiers—namely, can these policies effectively reduce consumption of sugar-sweetened beverages and intake of total added sugars?

Search strategy and selection criteria

We searched for publications on MEDLINE from Jan 1, 2000, to March 31, 2015. We did a selective review of published work on the effect of foods and beverages with added caloric sweeteners and low-calorie sweeteners on cardiometabolic outcomes, from the perspective of the evidence needed to inform policy, referencing key studies and the emergence of the evidence base over time to provide an up-to-date picture. This is not a systematic review but a Personal View in which we cite selected key reports and meta-analyses.

Contributors

Both authors contributed equally to the text. BMP was responsible for the figures and tables on sweeteners; CH was responsible for the figures related to policies.

Declaration of interests

We declare no competing interests.

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References

1 Ng SW, Ni Mhurchu C, Jebb SA, Popkin BM. Patterns and trends of beverage consumption among children and adults in Great Britain, 1986–2009. *Br J Nutr* 2012; **108:** 536–51.

2 Sanigorski AM, Bell AC, Swinburn BA. Association of key foods and beverages with obesity in Australian schoolchildren. *Public Health Nutr* 2007; **10:** 152–57.

3 Bray GA, Popkin BM. Dietary sugar and body weight: have we reached a crisis in the epidemic of obesity and diabetes? Health be damned! Pour on the sugar. *Diabetes Care* 2014; **37:** 950–56.

4 Hu FB. Resolved: there is sufficient scientific evidence that decreasing sugar-sweetened beverage consumption will reduce the prevalence of obesity and obesity-related diseases. *Obes Rev* 2013; **14:** 606–19.

5 The Lancet Diabetes & Endocrinology. Sugar intake: lowering the bar. *Lancet Diabetes Endocrinol* 2015; **3:** 305.

6 Bliss M. Rewriting medical history: Charles Best and the Banting and Best myth. *J Hist Med Allied Sci* 1993; **48:** 253–74.

7 Yudkin J. Dietary fat and dietary sugar in relation to ischemic heart-disease and diabetes. *Lancet* 1964; **2:** 4–5.

8 Yudkin J. Sweet and dangerous: the new facts about the sugar you eat as a cause of heart disease, diabetes, and other killers. New York: P H Wyden, 1972.

9 Mattes RD. Dietary compensation by humans for supplemental energy provided as ethanol or carbohydrate in fluids. *Physiol Behav* 1996; **59:** 179–87.

10 DiMeglio DP, Mattes RD. Liquid versus solid carbohydrate: effects on food intake and body weight. *Int J Obes Relat Metab Disord* 2000; **24:** 794–800.

11 Mourao DM, Bressan J, Campbell WW, Mattes RD. Effects of food form on appetite and energy intake in lean and obese young adults. *Int J Obes (Lond)* 2007; **31:** 1688–95.

12 DellaValle DM, Roe LS, Rolls BJ. Does the consumption of caloric and non-caloric beverages with a meal affect energy intake? *Appetite* 2005; **44:** 187–93.

13 Lennerz BS, Alsop DC, Holsen LM, et al. Effects of dietary glycemic index on brain regions related to reward and craving in men. *Am J Clin Nutr* 2013; **98:** 641–47.

14 Mattes RD, Popkin BM. Nonnutritive sweetener consumption in humans: effects on appetite and food intake and their putative mechanisms. *Am J Clin Nutr* 2009; **89:** 1–14.

15 Te Morenga L, Mallard S, Mann J. Dietary sugars and body weight: systematic review and meta-analyses of randomised controlled trials and cohort studies. *BMJ* 2013; **346:** e7492.

16 Te Morenga LA, Howatson AJ, Jones RM, Mann J. Dietary sugars and cardiometabolic risk: systematic review and meta-analyses of randomized controlled trials of the effects on blood pressure and lipids. *Am J Clin Nutr* 2014; **100:** 65–79.

17 Anand SS, Hawkes C, de Souza RJ, et al. Global food consumption and its impact on cardiovascular disease: importance of solutions focused on the globalized food system: a report from the workshop convened by the World Heart Federation. *J Am Coll Cardiol* 2015; **66:** 1590–614.

18 Vartanian LR, Schwartz MB, Brownell KD. Effects of soft drink consumption on nutrition and health: a systematic review and meta-analysis. *Am J Public Health* 2007; **97:** 667–75.

19 Singh GM, Micha R, Khatibzadeh S, et al. Estimated global, regional, and national disease burdens related to sugar-sweetened beverage consumption in 2010. *Circulation* 2015; **132:** 639–66.

20 Malik VS, Popkin BM, Bray GA, Despres JP, Willett WC, Hu FB. Sugar-sweetened beverages and risk of metabolic syndrome and type 2 diabetes: a meta-analysis. *Diabetes Care* 2010; **33:** 2477–83.

21 Imamura F, O'Connor L, Ye Z, et al. Consumption of sugar sweetened beverages, artificially sweetened beverages, and fruit juice and incidence of type 2 diabetes: systematic review, meta-analysis, and estimation of population attributable fraction. *BMJ* 2015; **351:** h3576.

22 Lesser LI, Ebbeling CB, Goozner M, Wypij D, Ludwig DS. Relationship between funding source and conclusion among nutrition-related scientific articles. *PLoS Med* 2007; **4:** e5.

23 Bes-Rastrollo M, Schulze MB, Ruiz-Canela M, Martinez-Gonzalez MA. Financial conflicts of interest and reporting bias regarding the association between sugar-sweetened beverages and weight gain: a systematic review of systematic reviews. *PLoS Med* 2013; **10:** e1001578.

24 Ebbeling CB, Feldman HA, Chomitz VR, et al. A randomized trial of sugar-sweetened beverages and adolescent body weight. *N Engl J Med* 2012; **367:** 1407–16.

25 de Ruyter JC, Olthof MR, Seidell JC, Katan MB. A trial of sugar-free or sugar-sweetened beverages and body weight in children. *N Engl J Med* 2012; **367:** 1397–406.

26 WCRF. Curbing global sugar consumption: effective food policy actions to help promote healthy diets and tackle obesity. London: World Cancer Research Fund International, 2015. http://www.wcrf.org/int/policy/our-policy-work/curbing-global-sugar-consumption (accessed July 11, 2015).

27 WHO. Guideline: sugars intake for adults and children. Geneva: World Health Organization, 2015.

28 Johnson RK, Appel LJ, Brands M, et al, on behalf of the American Heart Association Nutrition Committee of the Council on Nutrition, Physical Activity, and Metabolism and the Council on Epidemiology and Prevention. Dietary sugars intake and cardiovascular health: a scientific statement from the American Heart Association. *Circulation* 2009; **120:** 1011–20.

29 McKiernan F, Hollis JH, Mattes RD. Short-term dietary compensation in free-living adults. *Physiol Behav* 2008; **93:** 975–83.

30 Flood-Obbagy JE, Rolls BJ. The effect of fruit in different forms on energy intake and satiety at a meal. *Appetite* 2009; **52:** 416–22.

31 Menke A, Casagrande S, Geiss L, Cowie CC. Prevalence of and trends in diabetes among adults in the United States, 1988–2012. *JAMA* 2015; **314:** 1021–29.

32 Mursu J, Virtanen JK, Tuomainen T-P, Nurmi T, Voutilainen S. Intake of fruit, berries, and vegetables and risk of type 2 diabetes in Finnish men: the Kuopio Ischaemic Heart Disease Risk Factor Study. *Am J Clin Nutr* 2014; **99:** 328–33.

33 Odegaard AO, Koh W-P, Arakawa K, Yu MC, Pereira MA. Soft drink and juice consumption and risk of physician-diagnosed incident type 2 diabetes: the Singapore Chinese Health Study. *Am J Epidemiol* 2010; **171:** 701–08.

34 Muraki I, Imamura F, Manson JE, et al. Fruit consumption and risk of type 2 diabetes: results from three prospective longitudinal cohort studies. *BMJ* 2013; **347:** f5001.

35 Bazzano LA, Li TY, Joshipura KJ, Hu FB. Intake of fruit, vegetables, and fruit juices and risk of diabetes in women. *Diabetes Care* 2008; **31:** 1311–17.

36 Xi B, Li S, Liu Z, et al. Intake of fruit juice and incidence of type 2 diabetes: a systematic review and meta-analysis. *PLoS One* 2014; **9:** e93471.

37 Piernas C, Tate DF, Wang X, Popkin BM. Does diet-beverage intake affect dietary consumption patterns? Results from the Choose Healthy Options Consciously Everyday (CHOICE) randomized clinical trial. *Am J Clin Nutr* 2013; **97:** 604–11.

38 Dhingra R, Sullivan L, Jacques PF, et al. Soft drink consumption and risk of developing cardiometabolic risk factors and the metabolic syndrome in middle-aged adults in the community. *Circulation* 2007; **116:** 480–88.

39 Lutsey PL, Steffen LM, Stevens J. Dietary intake and the development of the metabolic syndrome: the Atherosclerosis Risk in Communities study. *Circulation* 2008; **117:** 754–61.

40 de Koning L, Malik VS, Rimm EB, Willett WC, Hu FB. Sugar-sweetened and artificially sweetened beverage consumption and risk of type 2 diabetes in men. *Am J Clin Nutr* 2011; **93:** 1321–27.

41 Duffey KJ, Steffen LM, Van Horn L, Jacobs DR Jr, Popkin BM. Dietary patterns matter: diet beverages and cardiometabolic risks in the longitudinal Coronary Artery Risk Development in Young Adults (CARDIA) Study. *Am J Clin Nutr* 2012; **95:** 909–15.

42 de Koning L, Malik VS, Kellogg MD, Rimm EB, Willett WC, Hu FB. Sweetened beverage consumption, incident coronary heart disease, and biomarkers of risk in men. *Circulation* 2012; **125:** 1735–41, S1.

43 Tate DF, Turner-McGrievy G, Lyons E, et al. Replacing caloric beverages with water or diet beverages for weight loss in adults: main results of the Choose Healthy Options Consciously Everyday (CHOICE) randomized clinical trial. *Am J Clin Nutr* 2012; **95:** 555–63.

44 Raben A, Vasilaras TH, Møller AC, Astrup A. Sucrose compared with artificial sweeteners: different effects on ad libitum food intake and body weight after 10 wk of supplementation in overweight subjects. *Am J Clin Nutr* 2002; **76:** 721–29.

45 Goran MI, Tappy L, Le K-A, Ulijaszek S. Dietary sugars and health. Oxford: Taylor and Francis, 2014.

46 Walker RW, Dumke KA, Goran MI. Fructose content in popular beverages made with and without high-fructose corn syrup. *Nutrition* 2014; **30:** 928–35.

47 Ludwig DS. Examining the health effects of fructose. *JAMA* 2013; **310:** 33–34.

48 Wolf A, Bray GA, Popkin BM. A short history of beverages and how our body treats them. *Obes Rev* 2008; **9:** 151–64.

49 Bray GA, Nielsen SJ, Popkin BM. Consumption of high-fructose corn syrup in beverages may play a role in the epidemic of obesity. *Am J Clin Nutr* 2004; **79:** 537–43.

50 Maersk M, Belza A, Stødkilde-Jørgensen H, et al. Sucrose-sweetened beverages increase fat storage in the liver, muscle, and visceral fat depot: a 6-mo randomized intervention study. *Am J Clin Nutr* 2012; **95:** 283–89.

51 Stanhope KL, Havel PJ. Fructose consumption: recent results and their potential implications. *Ann NY Acad Sci* 2010; **1190:** 15–24.

52 Stanhope KL, Bremer AA, Medici V, et al. Consumption of fructose and high fructose corn syrup increase postprandial triglycerides, LDL-cholesterol, and apolipoprotein-B in young men and women. *J Clin Endocrinol Metab* 2011; **96:** E1596–605.

53 Stanhope KL. Role of fructose-containing sugars in the epidemics of obesity and metabolic syndrome. *Annu Rev Med* 2012; **63:** 329–43.

54 Johnson R, Moorthy SN, Padmaja G. Production of high fructose syrup from cassava and sweet potato flours and their blends with cereal flours. *Food Sci Technol Int* 2010; **16:** 251–58.

55 Johnson RJ, Andrews P. Fructose, uricase, and the Back-to-Africa hypothesis. *Evol Anthropol Issues News Rev (Melb)* 2010; **19:** 250–57.

56 Johnson RJ, Murray R. Fructose, exercise, and health. *Curr Sports Med Rep* 2010; **9:** 253–58.

57 Johnson RJ, Nakagawa T, Sanchez-Lozada LG, et al. Sugar, uric acid, and the etiology of diabetes and obesity. *Diabetes* 2013; **62:** 3307–15.

58 Johnson RJ, Sanchez-Lozada LG, Nakagawa T. The effect of fructose on renal biology and disease. *J Am Soc Nephrol* 2010; **21:** 2036–39.

59 Johnson RJ, Segal MS, Sautin Y, et al. Potential role of sugar (fructose) in the epidemic of hypertension, obesity and the metabolic syndrome, diabetes, kidney disease, and cardiovascular disease. *Am J Clin Nutr* 2007; **86:** 899–906.

60 Dekker MJ, Su Q, Baker C, Rutledge AC, Adeli K. Fructose: a highly lipogenic nutrient implicated in insulin resistance, hepatic steatosis, and the metabolic syndrome. *Am J Physiol Endocrinol Metab* 2010; **299:** E685–94.

61 Lustig RH. Fructose: it's "alcohol without the buzz". *Adv Nutr* 2013; **4:** 226–35.

62 Lustig RH, Schmidt LA, Brindis CD. Public health: the toxic truth about sugar. *Nature* 2012; **482:** 27–29.

63 Mueller NT, Odegaard A, Anderson K, et al. Soft drink and juice consumption and risk of pancreatic cancer: the Singapore Chinese Health Study. *Cancer Epidemiol Biomarkers Prev* 2010; **19:** 447–55.

64 Sakurai M, Nakamura K, Miura K, et al. Sugar-sweetened beverage and diet soda consumption and the 7-year risk for type 2 diabetes mellitus in middle-aged Japanese men. *Eur J Nutr* 2014; **53:** 251–58.

65 Hernández-Cordero S, Barquera S, Rodríguez-Ramírez S, et al. Substituting water for sugar-sweetened beverages reduces circulating triglycerides and the prevalence of metabolic syndrome in obese but not in overweight Mexican women in a randomized controlled trial. *J Nutr* 2014; **144:** 1742–52.

66 Davis JN, Whaley SE, Goran MI. Effects of breastfeeding and low sugar-sweetened beverage intake on obesity prevalence in Hispanic toddlers. *Am J Clin Nutr* 2012; **95:** 3–8.

67 Davis JN, Ventura EE, Weigensberg MJ, et al. The relation of sugar intake to beta cell function in overweight Latino children. *Am J Clin Nutr* 2005; **82:** 1004–10.

68 Davis JN, Alexander KE, Ventura EE, et al. Associations of dietary sugar and glycemic index with adiposity and insulin dynamics in overweight Latino youth. *Am J Clin Nutr* 2007; **86:** 1331–38.

69 Schwimmer JB, Deutsch R, Kahen T, Lavine JE, Stanley C, Behling C. Prevalence of fatty liver in children and adolescents. *Pediatrics* 2006; **118:** 1388–93.

70 Zhou Y, Du S, Su C, Zhang B, Wang H, Popkin BM. The food retail revolution in China and its association with diet and health. *Food Policy* 2015; **55:** 92–100.

71 Popkin BM. Nutrition, agriculture and the global food system in low and middle income countries. *Food Policy* 2014; **47:** 91–96.

72 Reardon T, Timmer CP, Barrett CB, Berdegue JA. The rise of supermarkets in Africa, Asia, and Latin America. *Am J Agric Econ* 2003; **85:** 1140–46.

73 Reardon T, Timmer CP, Minten B. Supermarket revolution in Asia and emerging development strategies to include small farmers. *Proc Natl Acad Sci USA* 2012; **109:** 12332–37.

74 Reardon T, Chen KZ, Minten B, et al. The quiet revolution in Asia's rice value chains. *Ann NY Acad Sci* 2014; **1331:** 106–18.

75 Ng SW, Slining MM, Popkin BM. Use of caloric and noncaloric sweeteners in US consumer packaged foods, 2005–2009. *J Acad Nutr Diet* 2012; **112:** 1828–34.

76 Ng SW, Slining MM, Popkin BM. Turning point for US diets? Recessionary effects or behavioral shifts in foods purchased and consumed. *Am J Clin Nutr* 2014; **99:** 609–16.

77 Arantxa Colchero M, Popkin BM, Rivera JA, Ng SW. Beverage purchases from stores since the start of the Mexican sugar-sweetened beverage excise tax: a year out. *BMJ* (in press).

78 Euromonitor. Euromonitor International. 2014. http://www.euromonitor.com/ (accessed March 30, 2015).

79 Euromonitor International. Passport Nutrition. 2015. http://www.euromonitor.com/ (accessed April 5, 2015).

80 Basu S, Yoffe P, Hills N, Lustig RH. The relationship of sugar to population-level diabetes prevalence: an econometric analysis of repeated cross-sectional data. *PLoS One* 2013; **8:** e57873.

81 Corvalán C, Reyes M, Garmendia ML, Uauy R. Structural responses to the obesity and non-communicable diseases epidemic: the Chilean Law of Food Labeling and Advertising. *Obes Rev* 2013; **14** (suppl 2)**:** 79–87.

82 Kleiman S, Ng SW, Popkin B. Drinking to our health: can beverage companies cut calories while maintaining profits? *Obes Rev* 2012; **13:** 258–74.

83 Thow AM, Hawkes C. Global sugar guidelines: an opportunity to strengthen nutrition policy. *Public Health Nutr* 2014; **17:** 2151–55.

84 Hawkes C, Jewell J, Allen K. A food policy package for healthy diets and the prevention of obesity and diet-related non-communicable diseases: the NOURISHING framework. *Obes Rev* 2013; **14** (suppl 2)**:** 159–68.

85 WCRF International. NOURISHING framework. London: World Cancer Research Fund, 2015. http://www.wcrf.org/int/policy/nourishing-framework (accessed July 10, 2015).

86 Brownell KD, Farley T, Willett WC, et al. The public health and economic benefits of taxing sugar-sweetened beverages. *N Engl J Med* 2009; **361:** 1599–605.

87 Snowdon W, Thow AM. Trade policy and obesity prevention: challenges and innovation in the Pacific Islands. *Obes Rev* 2013; **14** (suppl 2)**:** 150–58.

88 Bíró A. Did the junk food tax make the Hungarians eat healthier? *Food Policy* 2015; **54:** 107–15.

89 WHO Regional Office for Europe (Nutrition Physical Activity and Obesity Programme). Using price policies to promote healthier diets. Brussels: WHO European Regional Office, 2015. http://www.euro.who.int/__data/assets/pdf_file/0008/273662/Using-price-policies-to-promote-healthier-diets.pdf?ua=1 (accessed Oct 28, 2015).

90 Richards TJ, Patterson PM, Tegene A. Obesity and nutrient consumption: a rational addiction? *Contemp Econ Policy* 2007; **25:** 309–24.

91 Zhen C, Wohlgenant MK, Karns S, Kaufman P. Habit formation and demand for sugar-sweetened beverages. *Am J Agric Econ* 2011; **93:** 175–93.

92 Becker GS, Murphy KM. A theory of rational addiction. *J Polit Econ* 1988; **96:** 675–700.

93 Grossman M, Chaloupka FJ. The demand for cocaine by young adults: a rational addiction approach. *J Health Econ* 1998; **17:** 427–74.

94 Hawkes C. The worldwide battle against soft drinks in schools. *Am J Prev Med* 2010; **38:** 457–61.

95 Chriqui JF, Pickel M, Story M. Influence of school competitive food and beverage policies on obesity, consumption, and availability: a systematic review. *JAMA Pediatr* 2014; **168:** 279–86.

96 Taber DR, Chriqui JF, Vuillaume R, Chaloupka FJ. How state taxes and policies targeting soda consumption modify the association between school vending machines and student dietary behaviors: a cross-sectional analysis. *PLoS One* 2014; **9:** e98249.

97 Cullen KW, Watson K, Zakeri I. Improvements in middle school student dietary intake after implementation of the Texas Public School Nutrition Policy. *Am J Public Health* 2008; **98:** 111–17.

98 ChangeLab Solutions. Sugar-sweetened beverages playbook. ChangeLab Solutions, 2013. http://changelabsolutions.org/publications/SSB-playbook (accessed July 12, 2015).

99 Republica of Chile. Modifica Decreto Supremo No 977, DE 1996, Relglamento Sanitrario de los Alimentos (Regulation for food safety). 918813 (no 41193). Santiago: Republic of Chile printing office, 2015: 1–12 (in Spanish).

100 WHO. Set of recommendations on the marketing of foods and non-alcoholic beverages to children. Geneva: World Health Organization, 2010. http://apps.who.int/iris/bitstream/10665/44416/1/9789241500210_eng.pdf (accessed Nov 20, 2015).

101 LiveLighter. About sugary drinks. LiveLighter, 2015. https://livelighter.com.au/The-Facts/About-Sugary-Drinks (accessed July 11, 2015).

102 Change for Life. Let's make some sugar swaps! 2015. http://www.nhs.uk/Change4Life/Pages/low-sugar-healthy-snacks.aspx (accessed July 11, 2015).

103 Mozaffarian D, Afshin A, Benowitz NL, et al, on behalf of the American Heart Association Council on Epidemiology and Prevention, Council on Nutrition, Physical Activity and Metabolism, Council on Clinical Cardiology, Council on Cardiovascular Disease in the Young, Council on the Kidney in Cardiovascular Disease, Council on Peripheral Vascular Disease, and the Advocacy Coordinating Committee. Population approaches to improve diet, physical activity, and smoking habits: a scientific statement from the American Heart Association. *Circulation* 2012; **126:** 1514–63.

104 Roodenburg AJ, Popkin BM, Seidell JC. Development of international criteria for a front of package food labelling system: the International Choices Programme. *Eur J Clin Nutr* 2011; **65:** 1190–200.

105 Hawkes C, Smith TG, Jewell J, et al. Smart food policies for obesity prevention. *Lancet* 2015; **385:** 2410–21.

106 Emrich TE, Qi Y, Mendoza JE, Lou W, Cohen JE, L'abbé MR. Consumer perceptions of the Nutrition Facts table and front-of-pack nutrition rating systems. *Appl Physiol Nutr Metab* 2014; **39:** 417–24.

107 Roberto CA, Bragg MA, Seamans MJ, Mechulan RL, Novak N, Brownell KD. Evaluation of consumer understanding of different front-of-package nutrition labels, 2010–2011. *Prev Chronic Dis* 2012; **9:** E149.

108 Bleich SN, Barry CL, Gary-Webb TL, Herring BJ. Reducing sugar-sweetened beverage consumption by providing caloric information: how Black adolescents alter their purchases and whether the effects persist. *Am J Public Health* 2014; **104:** 2417–24.

109 Vyth EL, Steenhuis IH, Roodenburg AJ, Brug J, Seidell JC. Front-of-pack nutrition label stimulates healthier product development: a quantitative analysis. *Int J Behav Nutr Phys Act* 2010; **7:** 65.

110 Piernas C, Ng SW, Popkin B. Trends in purchases and intake of foods and beverages containing caloric and low-calorie sweeteners over the last decade in the United States. *Pediatric Obes* 2013; **8:** 294–306.

111 Webster J, Trieu K, Dunford E, Hawkes C. Target salt 2025: a global overview of national programs to encourage the food industry to reduce salt in foods. *Nutrients* 2014; **6:** 3274–87.

112 New York City Department of Health and Mental Hygiene. Maximum Size For Sugary Drinks: Proposed Amendment of Article 81. New York City, NY: Department of Health and Mental Hygiene, 2012: 16.

113 ECSIP Consortium. Food taxes and their impact on competitiveness in the agri-food sector. Rotterdam: European Competitiveness and Sustainable Industrial Policy Consortium, 2014. http://ec.europa.eu/DocsRoom/documents/5827/attachments/1/translations/en/renditions/pdf (accessed Oct 28, 2015).

114 Popkin BM, Armstrong LE, Bray GM, Caballero B, Frei B, Willett WC. A new proposed guidance system for beverage consumption in the United States. *Am J Clin Nutr* 2006; **83:** 529–42.

115 Popkin BM, D'Anci KE, Rosenberg IH. Water, hydration, and health. *Nutr Rev* 2010; **68:** 439–58.

116 Daniels MC, Popkin BM. Impact of water intake on energy intake and weight status: a systematic review. *Nutr Rev* 2010; **68:** 505–21.

117 Stern D, Piernas C, Barquera S, Rivera JA, Popkin BM. Caloric beverages were major sources of energy among children and adults in Mexico, 1999–2012. *J Nutr* 2014; **144:** 949–56.

118 Queensland Department of Education and the Arts, Queensland Health. Smart Choices: healthy food and drink supply strategy for Queensland schools. 2004. http://education.qld.gov.au/schools/healthy/docs/smart-choices-strategy.pdf (accessed July 11, 2015).

119 Barquera S, Tolentino M, Safdie M, Levesque L. National guidelines for healthy nutrition in Mexican schools: an independent preliminary evaluation. *Obes Rev* 2014; **15** (suppl 2)**:** 258 (abstr).

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Supplementary appendix

This appendix formed part of the original submission and has been peer reviewed. We post it as supplied by the authors.

Supplement to: Rubinstein A, Miranda JJ, Beratarrechea A, et al, for the GISMAL group. Effectiveness of an mHealth intervention to improve the cardiometabolic profile of people with prehypertension in low-resource urban settings in Latin America: a randomised controlled trial. *Lancet Diabetes Endocrinol* 2015; published online Nov 30. http://dx.doi.org/10.1016/S2213-8587(15)00381-2.

Supplement 1. Data Sources

A. **Nielsen Homescan data on household CPG calorie purchases and prices**

Nielsen Homescan (www.nielsen.com) data from 2000 through 2013. Homescan acquires reported information on food and beverage products with Universal Product Codes (UPC) purchased by household per shopping episode. These data are collected using scanners distributed to participating households that were sampled in 76 markets (52 metropolitan and 24 non-metropolitan, each comprised of a number of counties) and weighted to be nationally representative, with 40,000 to 65,000 households sampled each year in 2000-2013.[1-4]

Homescan provides detailed information about each CPG food and beverage purchase from all major outlet channels, including grocery, drug, mass-merchandise, club, supercenter, and convenience stores, including date of the shopping episode, number of units or packages, total weight, and total amount paid for each UPC.[5] It also includes socio-demographic information including about household composition, nominal income, education and race/ethnicity of the head of the household, age and gender of all household members, and household sampling weights. These data are used by researchers, particularly agricultural and marketing economists, to analyze food demand, consumption, branding and promotion strategies.[6-9]

For this paper, Nutrition Facts Panel (NFP) label and ingredient information for each uniquely barcoded food: We have used an array of data base sources to link both the NFP and ingredients for each item to the exact commercial product. Nielsen Homescan (The Nielsen Co.)[10] is a commercial data set that contains information on food products with a UPC that a household purchases over a year (acquired using scanners provided to participating households), along with important socio-demographic information and sampling weights.

Linking NFP and ingredients and Nielsen Homescan Food Purchase data: We used a variety of sources discussed elsewhere to link the NFP and ingredients data with the 2000-2013 Homescan data on household purchases at the UPC level in order to create a more complete measure of the nutritional content of UPCs reported purchased. This was successful for over 98% of the volume and dollar sales of foods reported purchased in Homescan.

Identifying the use of sweeteners in US CPG products

To identify foods and beverages containing various types of CS and LCS, we conducted searches for key terms in the ingredients lists (listed in **Supplementary Table A2**). In this study, we include fruit juice concentrate (FJC) (not reconstituted) as a CS.

We then determined for each food and beverage group the proportion of the unique food products with various combinations of CS, LCS, and the average total sugar calories per 100g for unique products with various combinations. We are defining unique food products as those with unique formulations (e.g., a 1.5 liter bottle of Coca-cola Classic will be nutritionally equivalent to a 12 fl oz can of Coca-cola Classic and a 20 fl oz bottle of Coca-cola Classic, so even though they will have different barcodes, they only count as one food product). These sweetener categories are: no sweeteners (in which case total sugars are equal to intrinsic sugars); CS only (including FJC); LCS only; and both CS and LCS. To measure how frequently the various kinds of CS and NCS are used we ranked the top five sweetener types used within each food group. The categorization of the CS and LCS are provided in **Supplementary Table A2**.

Lastly, to understand how much of the US processed and packaged foods and beverages purchased contain CS and LCS, we determined the total calories and volume (or gram weight) of each product using the Homescan purchase and NFP data. We then calculated the proportion of total calories and total volume purchased by Americans that contain any CS, and any LCS for each food group and all food groups.

B. Euromonitor Passport International Data

Passport: Nutrition is a first-of-its-kind database that examines the total amount of nutrients purchased through packaged food and soft drink products worldwide, evaluating eight key nutrients in 54 countries. Euromonitor: Nutrition collects per 100 grams of each brand at the lowest unique category the nutrient information. We used kcal/100 grams [l] for this paper. They did this for 2014 and the previous six years. The geographic coverage is listed below. The UNC team worked to beta test these data. We compared them with other trends data as well as with a cross-sectional caloric intake of SSB data provided by a recent publication.[11] In general, the patterns and trends were fairly accurate except for one country, Colombia, where they appear to represent less than 50% of consumption and also India, Morocco and Venezuela.

In the following table, we evaluated the Euromonitor nutrition data by comparing this with a recent global review of SSB consumption from individual dietary intake surveys.

A comparison of the Euromonitor Sales Data with that of Individual Dietary Intake Data

	SSB sales in 2014 (8 oz/capita/day) Total volume	**Value from Global trends paper (range of means)**
Argentina	1.60	0.33 - 1.17
Australia	0.88	0.28 - 0.97
Austria	1.05	0.21 - 0.96
Belgium	1.21	0.35 - 1.54
Brazil	1.00	0.23 - 0.88
Bulgaria	1.11	0.14 - 0.50
Canada	1.06	0.34 - 1.29
Chile	1.84	0.35 - 1.25
China	0.39	0.03 - 0.10
Colombia	0.83	0.97 - 3.27
Czech Republic	0.76	0.15 - 0.55
Denmark	0.84	0.27 - 1.15
Egypt	0.31	0.18 - 0.66
Finland	0.77	0.21 - 0.81
France	0.61	0.15 - 0.62
Germany	1.25	0.22 - 0.97
Greece	0.49	0.12 - 0.52
Hong Kong, China	0.77	N/A
Hungary	0.73	0.09 - 0.42
India	0.05	0.16 - 0.62
Indonesia	0.18	0.13 - 0.50
Ireland	0.96	0.18 - 0.69
Israel	1.04	0.20 - 0.91
Italy	0.63	0.06 - 0.21
Japan	1.09	0.15 - 0.59

Malaysia	0.42	0.36 - 1.23
Mexico	1.93	0.71 - 2.40
Morocco	0.26	0.28 - 0.95
Netherlands	1.18	0.36 - 1.23
New Zealand	0.87	0.13 - 0.52
Norway	0.77	0.26 - 1.14
Peru	0.83	0.39 - 1.52
Philippines	0.51	0.24 - 0.82
Poland	0.98	0.06 - 0.21
Portugal	0.76	0.13 - 0.58
Romania	0.72	0.12 - 0.45
Russia	0.59	0.21 - 0.83
Saudi Arabia	1.36	0.22 - 0.79
Singapore	0.73	0.19 - 0.64
Slovakia	0.82	0.29 - 1.17
South Africa	0.86	0.33 - 1.19
South Korea	0.46	0.07 - 0.26
Spain	0.92	0.15 - 0.63
Sweden	0.79	0.27 - 1.16
Switzerland	1.12	0.13 - 0.56
Taiwan	0.88	0.28 - 1.02
Thailand	0.62	0.32 - 1.21
Turkey	0.71	0.21 - 0.76
Ukraine	0.46	0.22 - 0.87
United Arab Emirates	0.84	0.27 - 0.90
United Kingdom	0.84	0.24 - 1.06
USA	2.01	0.52 - 2.15
Venezuela	0.91	0.99 - 3.00
Vietnam	0.38	0.12 - 0.46

*Euromonitor 2014, total volume (off trade+on trade volume)

SSB include regular cola carbonates, non-cola carbonates, fruit-flavored drinks, juice drinks (up to 24% juice), nectars (25-99% juice), ready-to-drink tea.

To define SSB categories we included the same drinks that the Global SSB dietary intake paper considered as SSBs: regular cola carbonates, non-cola carbonates, fruit-flavored drinks, juice drinks (up to 24% juice), nectars (25-99% juice), ready-to-drink tea.

Blue: Euromonitor estimates that are greater than the means (range from the different age-gender groups) of the Singh et al(015) Global trends paper[11].

Red: Euromonitor estimates that are below the means (range from the different age-gender groups) of the Global trends paper.

White: Euromonitor estimates that are within the means (range from the different age-gender groups) of the Global trends paper.

Singh, G. M., R. Micha, S. Khatibzadeh, S. Lim, M. Ezzati and D. Mozaffarian (2015). "Estimated Global, Regional, and National Disease Burdens Related to Sugar-Sweetened Beverage Consumption in 2010." Circulation: CIRCULATIONAHA. 114.010636.

Caloric Euromonitor Coverage

AFRICA AND MIDDLE EAST	AUSTRALASIA	NORTH AMERICA
Egypt	Australia	Canada
Israel	New Zealand	USA
Morocco	**EASTERN EUROPE**	**WESTERN EUROPE**
Saudi	Bulgaria	Austria
South Africa	Czech Republic	Belgium
United Arab Emirates	Hungary	Denmark
ASIA PACIFIC	Romania	France
China	Russia	Germany
Hong Kong	Slovakia	Greece
India	Ukraine	Ireland
Indonesia	**LATIN AMERICA**	Italy
Japan	Argentina	Netherlands
Malaysia	Brazil	Norway
Philippines	Chile	Portugal
Singapore	Colombia	Spain
South Korea	Mexico	Sweden
Taiwan	Peru	Switzerland
Thailand	Venezuela	Turkey
Vietnam		United Kingdom

Supplementary Table 2. Categories of Caloric, Low Caloric Sweeteners

1. Added Sugars: These are the typical ingredients we consider an “added sugar” e.g., sugar, HFCS, honey, etc.			
dextrose	brown sugar	browCSugar	date sugar
datesugar	maple sugar	maplesugar	turbinado sugar
turbinadosugar	granulated sugar	granulatedsugar	confectioners powdered sugar
confectionerspowdered sugar	confectioners powderedsugar	confectionerspowderedsugar	confectioners sugar
confectionerssugar	powdered sugar	powderedsugar	glaze & icing sugar
glaze and icing sugar	glaze icing sugar	glazeicingsugar	glazeicing sugar
glaze icingsugar	cane sugar	canesugar	cane juice
canejuice	cane syrup	Canesyrup	turbinado
golden syrup	goldeCSyrup	Treacle	sucanat
beet sugar	Beetsugar	sugar beet	sugarbeet
trusweet	tru sweet	Versatose	clintose
corCSweet	corn sweet	Sucrose	table sugar
tablesugar	corn syrup	corCSyrup	dri-sweet
dri sweet	Drisweet	corn glucose syrup	cornglucose syrup
corn glucosesyrup	Cornglucosesyrup	high fructose corn syrup	highfructosecorCSyrup
highfructosecorn syrup	highfructose corn syrup	high fructosecorCSyrup	high fructose corCSyrup
highfructose corCSyrup	high fructosecorn syrup	hi-fructose corn syrup	hifructose corn syrup
hi fructose corCSyrup	hi fructosecorn syrup	agave nectar	agavenectar
agave syrup	Agavesyrup	agave sap	agavesap
agave juice	Agavejuice	honey	honi-bake
honi bake	Honibake	honi-flake	honi flake
honiflake	sweet’n’neat	sweetnneat	sweetn neat
sweet nneat	sweet n neat	molasses	dri-mol
dri mol	Drimol	maple	sorghum
malt	Maltose	malt sweetener	maltsweetener
malt syrup	Maltsyrup	sorghum syrup	sorghumsyrup
flo-malt	flo malt	flomalt	mizu-ame
mizu ame	Mizuame	kona-ame	kona ame
konaame	rice syrup	ricesyrup	fructose
fructose sweetener	Fructosesweetener	edible lactose	ediblelactose
invert sugar	Invertsugar	inverted sugar	invertedsugar
sugar invert	Sugarinvert	nulomoline	sucrovert
isoglucose	Trehalose	gomme	starch sweetener
starchsweetener	corn sweetener	corCSweetener	liquid sweetener

liquidsweetener	granular sweetener	granularsweetener	dried raisin sweetener
driedraisiCSweetener	driedraisin sweetener	dried raisiCSweetener	brown rice syrup
brownricesyrup	brownrice syrup	brown ricesyrup	maple syrup
maplesyrup	Isomaltulose	lactose	
If any of the above terms are found in an ingredient, flag UPC as containing an added sugar. "In addition to the list of ingredients as sweeteners, the SAS program does a search for 'sugar' as long as sugar is not found as 'sugar free', 'sugar-free', 'sugar and [some other ingredient] free', 'sugar & [some other ingredient] free' or 'no sugar'."			
2. Sugar Alcohols: Lower kcal/g compared to sucrose. As with the FDA, we exclude these from the added sugar measure.			
sorbitol	Glucitol	erythritol	xylitol
mannitol	Lactitol	maltitol	isomalt
glycerol	hydrogenated starch hydrolysate	hydrogenated starch hydrolysate	hydrogenated starch hydrolysates
arabitol	hydrogenated isomaltulose	polyglycitol	threitol
ribitol	Galactitol	fucitol	iditol
inositol	Volemitol	maltotritol	maltotetraitol
3. Juice concentrates: Please note, if both water and FJC appear in an ingredient list (at any point), that UPC was flagged as containing single-strength fruit juice, not FJC. Otherwise it is an added sugar.			
apple	Pear	grape	grapefruit
orange	Peach	plum	mango
apricot	Nectarine	prune	pineapple
pine apple	Blueberry	strawberry	raspberry
blackberry	Boysenberry	lingonberry	gooseberry
elderberry	Mulberry	currant	cherry
pomegranate	Cranberry	kiwi	melon
lychee	Mangosteen	coconut	acerola
tangerine	goji berry	passion fruit	passionfruit
watermelon	Raisin	prune	aronia
aronia berry	Chokeberry	banana	cantaloupe
honeydew	Carambola	fig	dewberry
date	Guanabana	soursop	guava
loganberry	Papaya	youngberry	blackcherry
bloodorange	Blackcurrant	mandarinorange	pinkgrapefuit
huckleberry	Marionberry	apple cider concentrate	clementine
concentrate (fruit) juice	**concentrated (fruit) juice**	**conc. (fruit) juice**	**(fruit) juice concentrate**
(fruit) juice conc	**(fruit) juice conc.**	**(fruit) juice sweetener**	**(fruit) syrup**

(fruit) juice syrup			
If any of these terms appear in an ingredient list, the UPC should be flagged for containing fruit juice concentrate EXCEPT in cases where the ingredient list also contaiCS the ingredient "water" and/or the phrase "not from concentrate" (because ingredients are sometimes listed as "not from concentrate apple juice")			
4. Juice: Single-strength, or if both FJC and water appear in ingredient list. List of fruits the same as list for FJC. For all foods, adding fruit juice is measured as an added sugar but not for beverages.			
apple	Pear	grape	grapefruit
orange	Peach	plum	mango
apricot	Nectarine	prune	pineapple
pine apple	Blueberry	strawberry	raspberry
blackberry	Boysenberry	lingonberry	gooseberry
elderberry	Mulberry	currant	cherry
pomegranate	Cranberry	kiwi	melon
lychee	Mangosteen	coconut	acerola
tangerine	goji berry	passion fruit	passionfruit
watermelon	Raisin	prune	aronia
aronia berry	Chokeberry	banana	cantaloupe
honeydew	Carambola	fig	dewberry
date	Guanabana	soursop	guava
loganberry	Papaya	youngberry	blackcherry
bloodorange	Blackcurrant	mandarinorange	pinkgrapefuit
huckleberry	Marionberry	apple cider	clementine
(fruit) juice	**(fruit) juices**	**(fruit) juice from concentrate**	**(fruit) juices from concentrate**
(fruit) juice form concentrate	**(fruit) juices form concentrate**		

- **Exclude ingredient if it meets any of the nine criteria for fruit juice concentrate (e.g., if an ingredient list contaiCS "apple juice concentrate" the search term "apple juice" should not flag the UPC as containing "fruit juice" as the actual ingredient is "fruit juice concentrate"**
- **Exclude ingredient from flagging if it contaiCS the phrase "for color"**
  - **Example: "Water, apple juice from concentrate, blueberry juice (for color)" and "Water, apple juice from concentrate, blueberry juice added for color" should still be flagged for containing juice, but "Water, sugar, natural flavor, blueberry juice (for color)" and "Water, sugar, natural flavor, blueberry juice added for color" should not.**
- **Exclude ingredient from flagging if it contaiCS the word "powder", "solids", or "dry"**
  - **Example: "blueberry juice powder" "blueberry juice solids" "dry blueberry juice"**

• **Complete match not needed** ○ **Example: ("grape juice" should still be able to flag "white grape juice ")**			
5. High-intensity Sweeteners: Low-caloric sweeteners(LCS). Both synthetic (e.g., aspartame) and natural (e.g., stevia, lo han guo.) These are called low calorie sweeteners (LCS).			
aspartame	Neotame	equal	nutrasweet
nutra sweet	twiCSweet	twin sweet	iCStasweet
iCSta sweet	Natrataste	natra taste	saccharin
sweet'n low	Sweetnlow	sweetn low	sweet nlow
nectasweet	necta sweet	sucralose	splenda
altern	Kaltame	cyclamate	syclamate
sugartwin	sugar twin	acesulfame potassium	acesulfamepotassium
acesulfame k	acesulfame-k	acesulfamek	sunett
sweet one	Sweetone	stevia	rebiana
truvia	rebaudioside a	purevia	enliten
erylite stevia	reb a	reb-a	steviol glycoside
candy leaf	Candyleaf	sugar leaf	sugarleaf
sweetleaf	monk fruit extract	luo han guo	luohanguo
luohan guo	luo hanguo	luo han kuo	luohankuo
luohan kuo	luo hankuo	brazzein	cweet
pentadin	oubli	mabinlin	monellin
thaumatin	curculin	lumbah	monatin
osladin	cyclamic acid	alitame	neohesperidine dihydrochalcone
advantame	aspartame-acesulfame salt		
• **If any of the above terms are found in an ingredient, flag UPC as containing a High InteCSity Sweetener.**			
6. Low-calorie sugar: Only includes two ingredients, allulose and tagatose. Expect to see allulose (90% less calories than sucrose) more in the coming years. Only a few foods use these and we excluded them from our analysis of sweeteners.			
tagatose	allulose		
• **If any of the above terms are found in an ingredient, flag UPC as containing a low-calorie sugar.**			

Supplemental Table 3. Sugar-sweetened beverage Trends in sales for Regions (kcal/capita/day)

	2009	2010	2011	2012	2013	2014
World	41	42	43	43	44	44
Asia Pacific	15	16	16	17	18	19
Australasia	93	93	94	92	91	89
Eastern Europe	49	51	51	53	54	55
Latin America	103	104	105	108	107	108
North Africa and Middle East	45	41	41	43	45	46
North America	158	158	158	156	153	150
Western Europe	69	70	70	69	69	68
Sub-Saharan Africa	21	22	22	22	23	24

Supplemental Table 4. Sugar-sweetened beverage sales in 2014, (kcal/capita/day)

Country	2014 kca/cap/day	Country	2014 kca/cap/day
Chile	188	United Kingdom	68
Mexico	158	Hungary	65
USA	157	Colombia	59**
Argentina	135	Spain	57
Saudi Arabia	118	Romania	54
Germany	96	France	53
Netherlands	95	Thailand	52
Slovakia	93	Russia	51
Austria	93	Italy	49
Brazil	90	Philippines	48
Belgium	88	Bulgaria	43
Israel	88	Japan	41
Ireland	87	Switzerland	39
Canada	86	South Korea	37
Australia	82	Taiwan	36
Poland	82	Ukraine	35
United Arab Emirates	82	Singapore	35
Denmark	80	Greece	32
South Africa	77	Malaysia	30
Norway	75	China	26
Venezuela	73	Morocco	25
Finland	72	Egypt	23
Czech Republic	72	Hong Kong, China	23
Portugal	71	Vietnam	14
Peru	70	Indonesia	13
New Zealand	70	India	5
Turkey	69		
Sweden	68		

**See supplemental table 1b for an evaluation of these data which shows that several of these countries data are very low compared with nationally representative dietary intake surveys for Colombia, India, Morocco and Venezuela.

Supplemental Table 5. Sugar Sweetened Beverage Sales Trends for selected countries (kcal/capita/day)

Country	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
Chile	157	163	168	174	180	188
United States	161	162	163	161	159	155
Mexico	154	151	153	155	157	152
United Kingdom	154	151	153	155	157	152
Brazil	77	82	82.87	87	85	90
Thailand	41	42	43	47	50	52
China	20	22	23	23	24	26

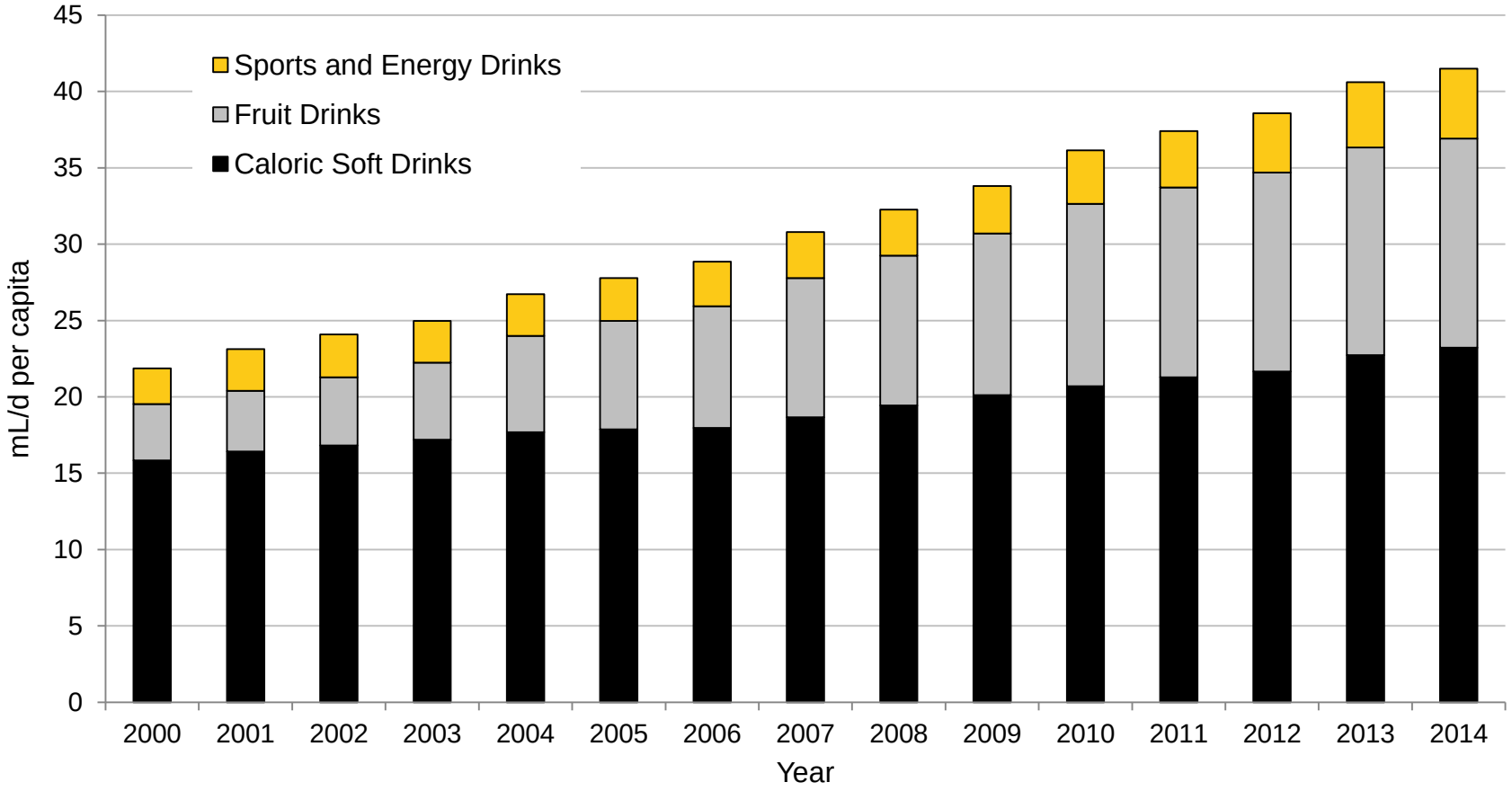
Supplemental Table 6. Low calorie (diet) sweetened beverage sales trends by region, 2000-2014 (ml/capita/day)

	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
Asia Pacific	0	0	0	0	1	0	1	1	1	1	1	1	1	1	1
Eastern Europe	2	2	2	2	3	3	3	4	4	4	4	4	4	4	4
North Africa and Middle East	3	4	4	5	5	5	6	6	6	6	6	6	6	6	7
World	8	8	8	9	9	9	10	10	10	10	10	10	10	9	9
Latin America	11	12	12	12	13	15	16	18	19	19	20	20	20	20	20
Western Europe	20	21	22	24	25	26	28	30	31	32	33	34	34	35	35
Australasia	49	59	56	57	57	58	66	67	64	65	65	65	65	66	66
North America	94	95	97	101	108	107	105	99	97	96	94	90	87	81	76
Sub-Saharan Africa	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2

References for Supplement 1

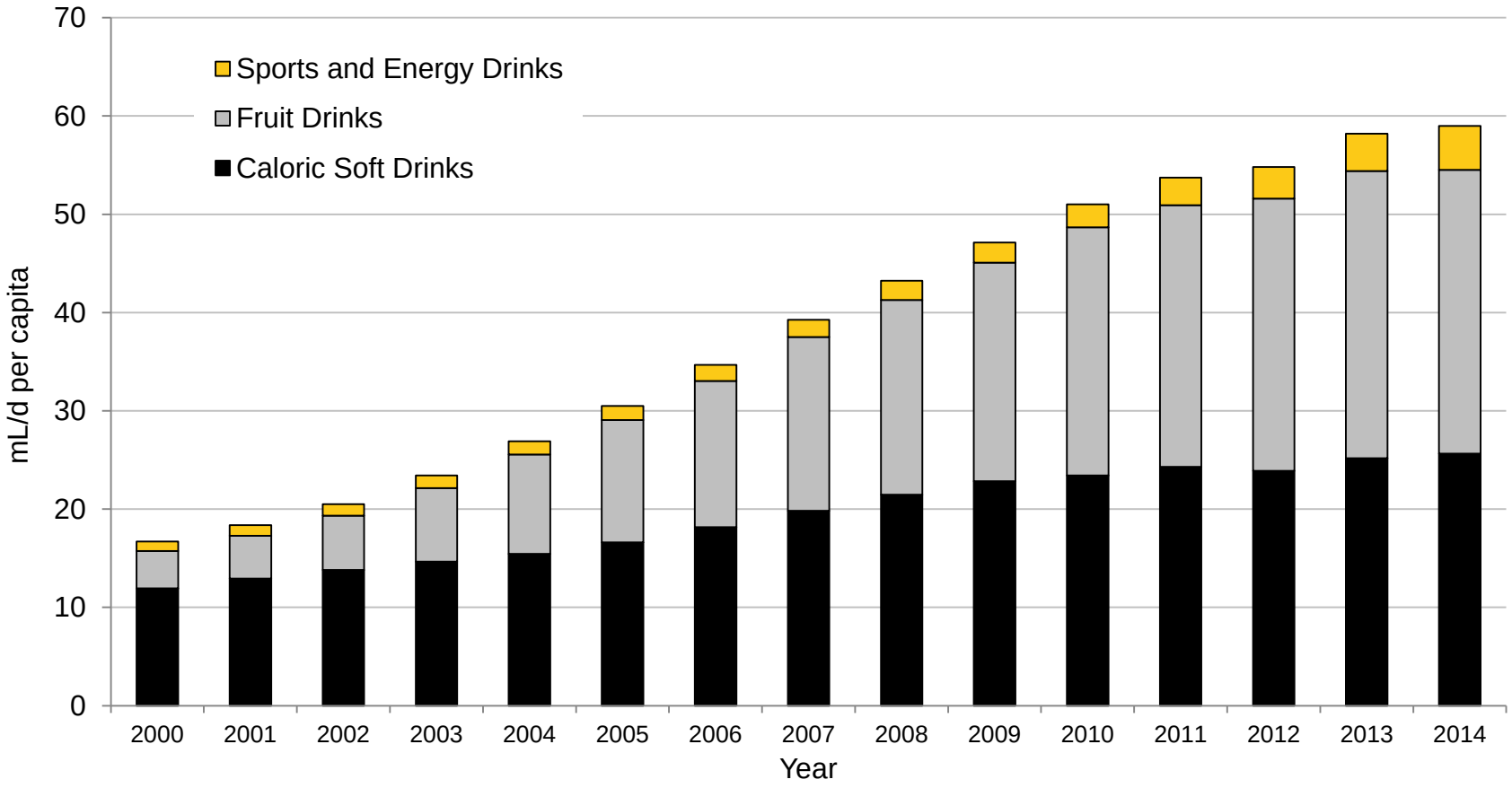
1. Nielsen. Consumer panel & Retail measurement. 2014. http://www.nielsen.com/us/en/nielsen-solutions/nielsen-measurement/nielsen-retail-measurement.html (accessed April 2014).
2. Ng SW, Slining MM, Popkin BM. Turning point for US diets? Recessionary effects or behavioral shifts in foods purchased and consumed. *Am J Clin Nutr* 2014; **99**(3): 609-16.
3. Ng SW, Slining MM, Popkin BM. Use of Caloric and Noncaloric Sweeteners in US Consumer Packaged Foods, 2005-2009. *Journal of the Academy of Nutrition and Dietetics* 2012; **112**(11): 1828-34.e6.
4. Ng SW, Popkin BM. Monitoring Foods and Nutrients Sold and Consumed in the United States: Dynamics and Challenges. *Journal of the Academy of Nutrition and Dietetics* 2012; **112**(1): 41-5.e4.
5. Ng SW, Popkin BM. Monitoring foods and nutrients sold and consumed in the United States: Dynamics and challenges. *J Acad Nutr Diet* 2012; **112**(1): 41-5.e4.
6. Einav L, Leibtag E, Nevo A. On the Accuracy of Nielsen Homescan Data. Washington, DC: USDA,, 2008.
7. Einav L, Leibtag E, Nevo A. Recording discrepancies in Nielsen Homescan data: Are they present and do they matter? *Quant Market Econ* 2010; **8**(2): 207-39.
8. Zhen C, Taylor JL, Muth MK, Leibtag E. Understanding differences in self-reported expenditures between household scanner data and diary survey data: A comparison of homescan and consumer expenditure survey. *Rev Ag Econ* 2009; **31**(3): 470-92.
9. Aguiar M, Hurst E. Life-cycle prices and production. *Am Econ Rev* 2007; **97**(5): 1533-59.
10. The Nielsen Co. Nielsen Retail Measures. http://en-us.nielsen.com/ (accessed May 1, 2012.
11. Singh GM, Micha R, Khatibzadeh S, Lim S, Ezzati M, Mozaffarian D. Estimated Global, Regional, and National Disease Burdens Related to Sugar-Sweetened Beverage Consumption in 2010. *Circulation* 2015: CIRCULATIONAHA. 114.010636.

Supplemental Figure 1. Volume (mL) Trends in per Capita per Day Sales of Sugar-Sweetened Beverages in Asia Pacific Region, 2000-2014



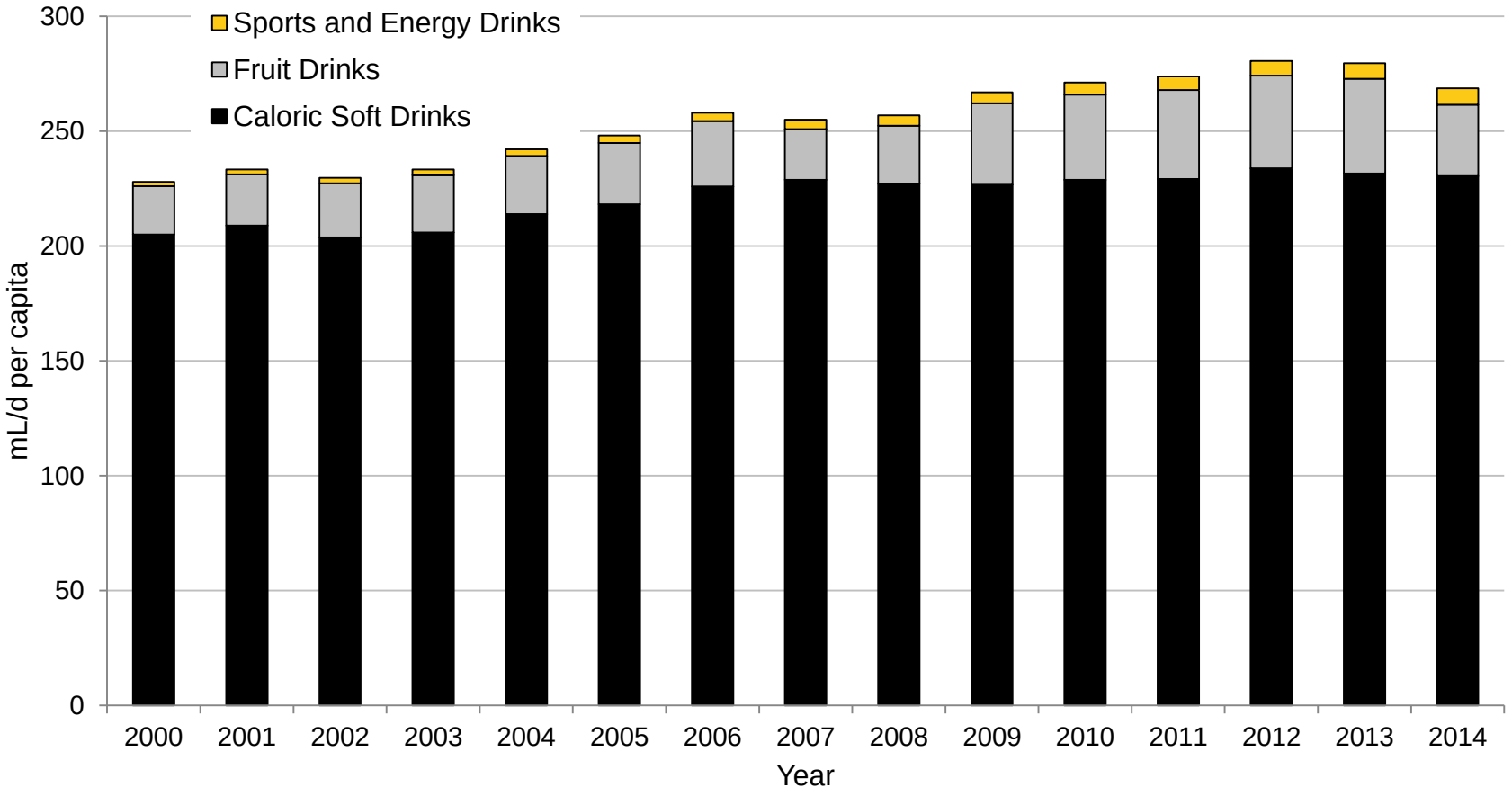
Source: Euromonitor Passport International

Supplemental Figure 2. Volume (mL) Trends in Sugar-Sweetened Beverage Sales per Capita per Day in China, 2000-2014



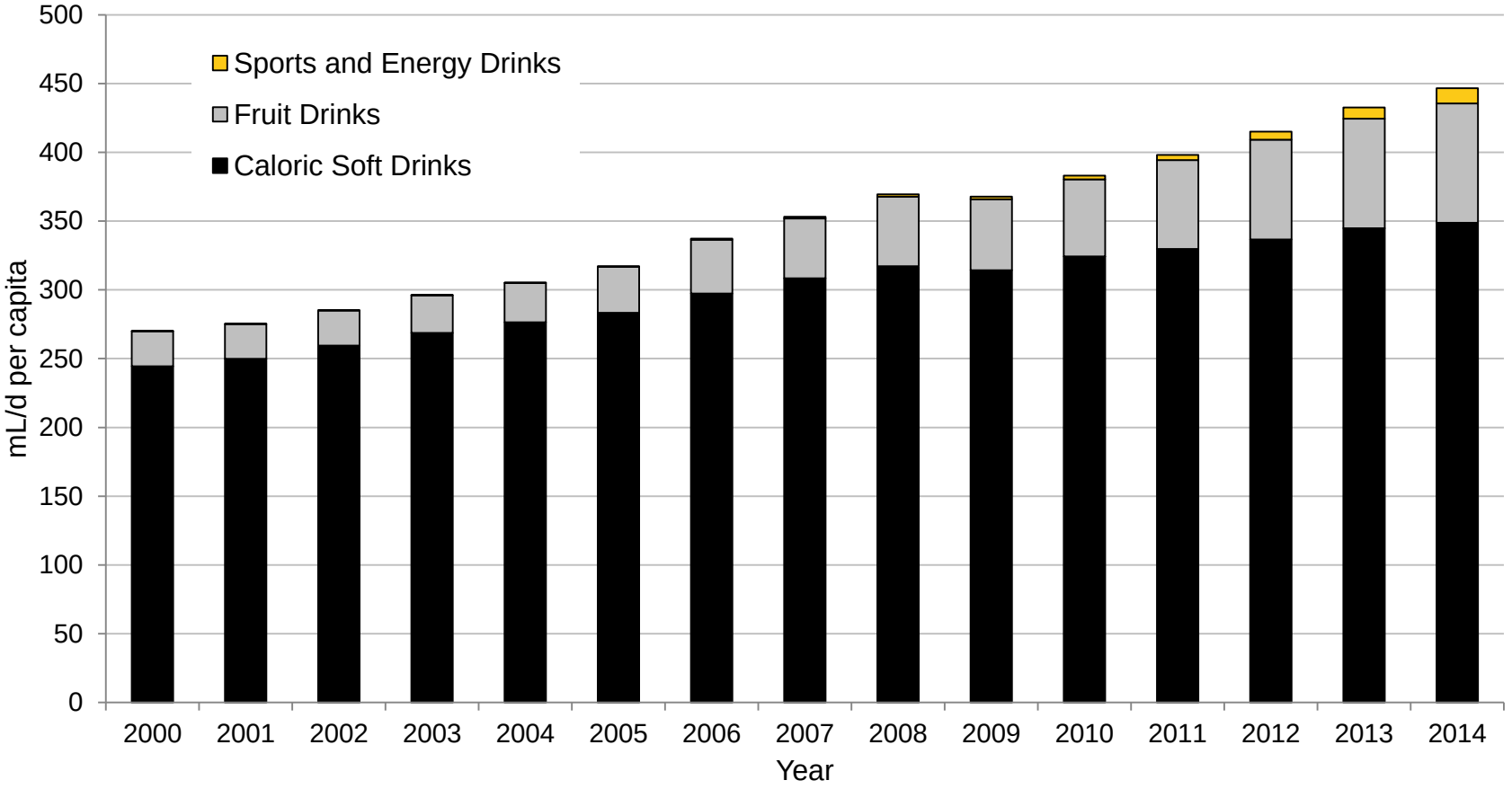
Source: Euromonitor Passport International with country-specific kcal data added . Only caloric beverages included

Supplemental Figure 3. Volume (mL) Trends in per Capita per Day Sales of Sugar-Sweetened Beverages in Latin America Region, 2000-2014



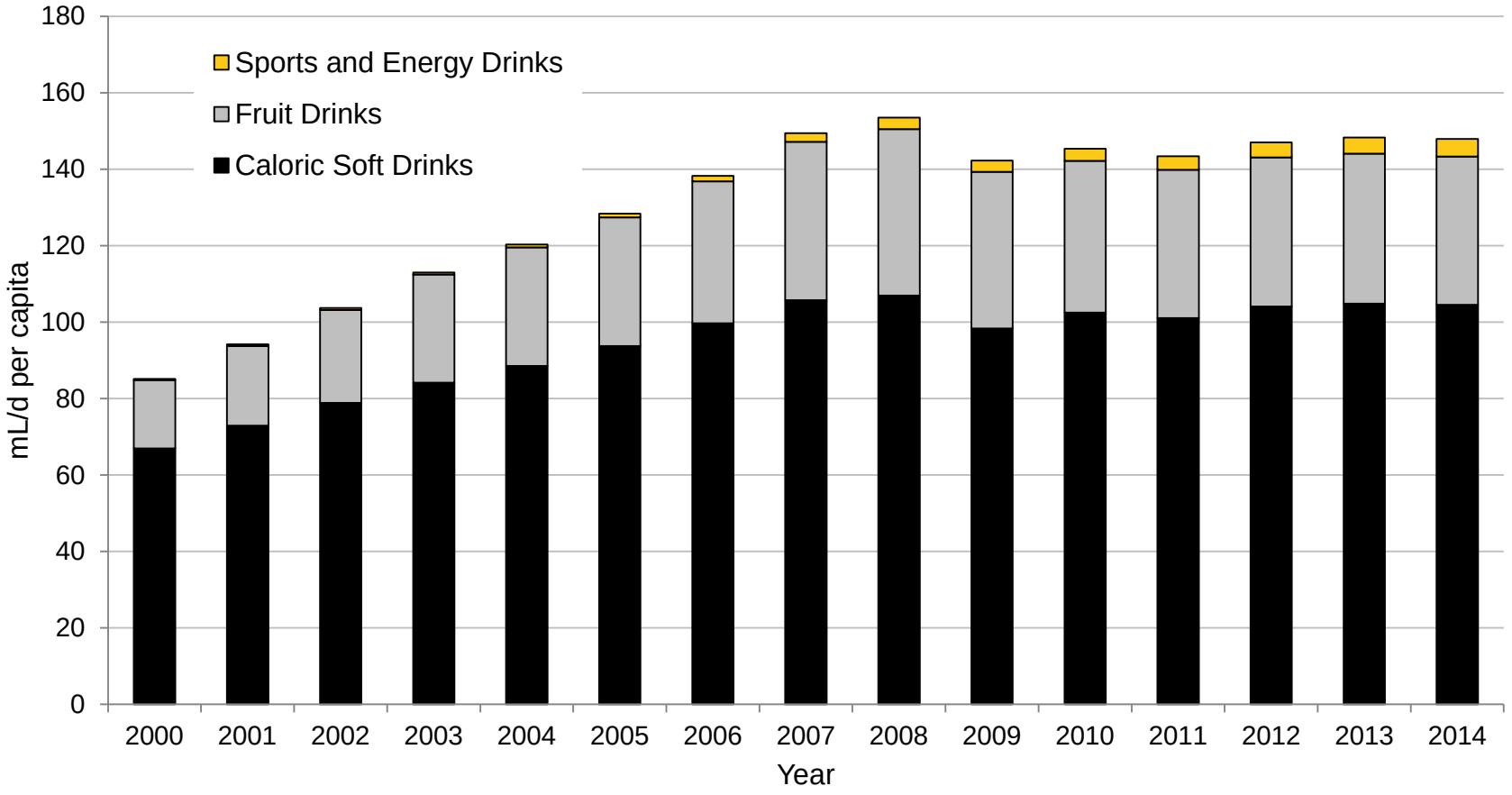
Source: Euromonitor Passport International with country-specific kcal data added . Only caloric beverages included

Supplemental Figure 4. Volume (mL) Trends in Sugar-Sweetened Beverage Sales per Capita per Day in Chile, 2000-2014



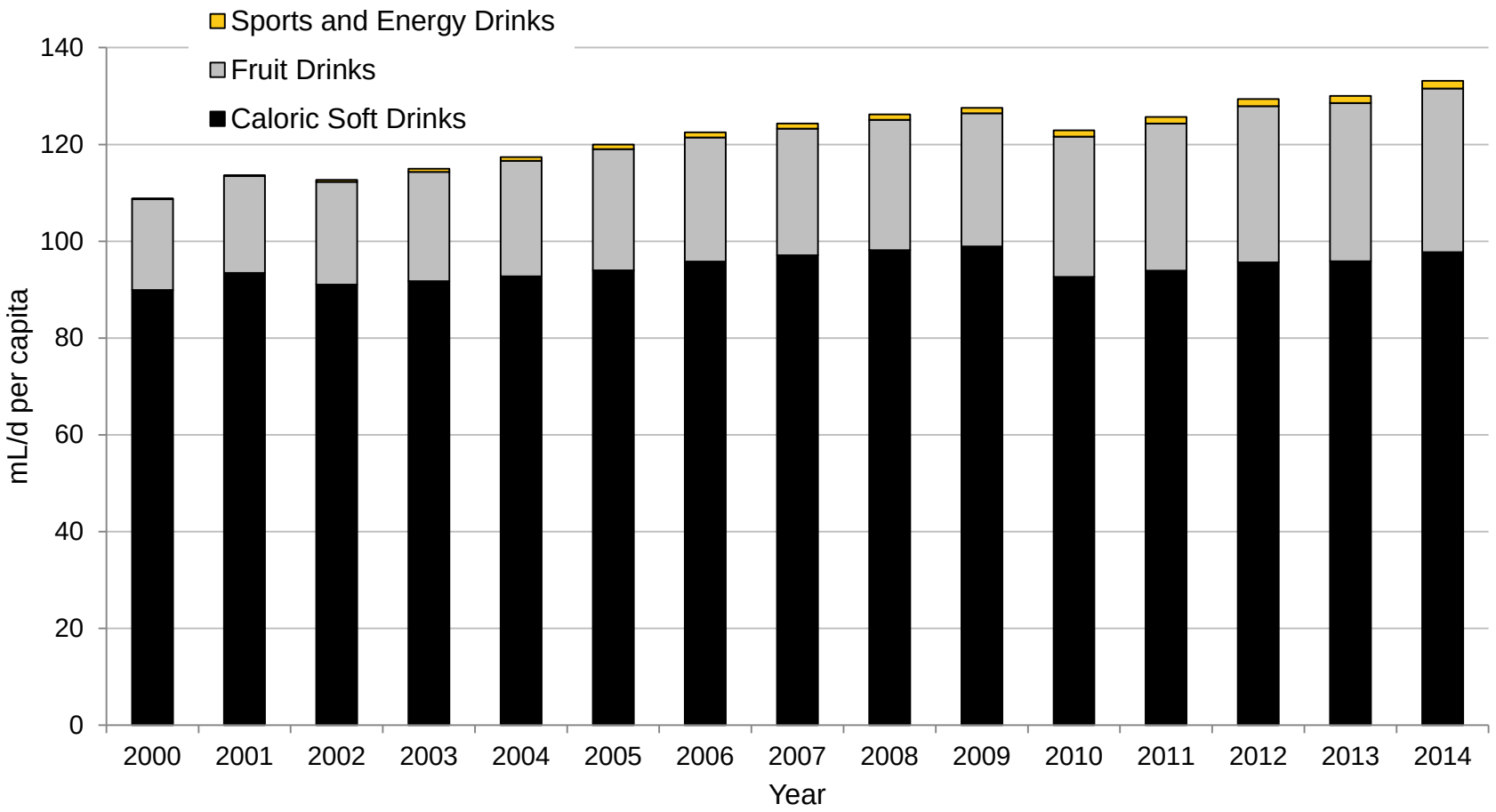
Source: Euromonitor Passport International with country-specific kcal data added . Only caloric beverages included

Supplemental Figure 5. Volume (mL) Trends in per Capita per Day Sales of Sugar-Sweetened Beverages in Eastern Europe Region, 2000-2014



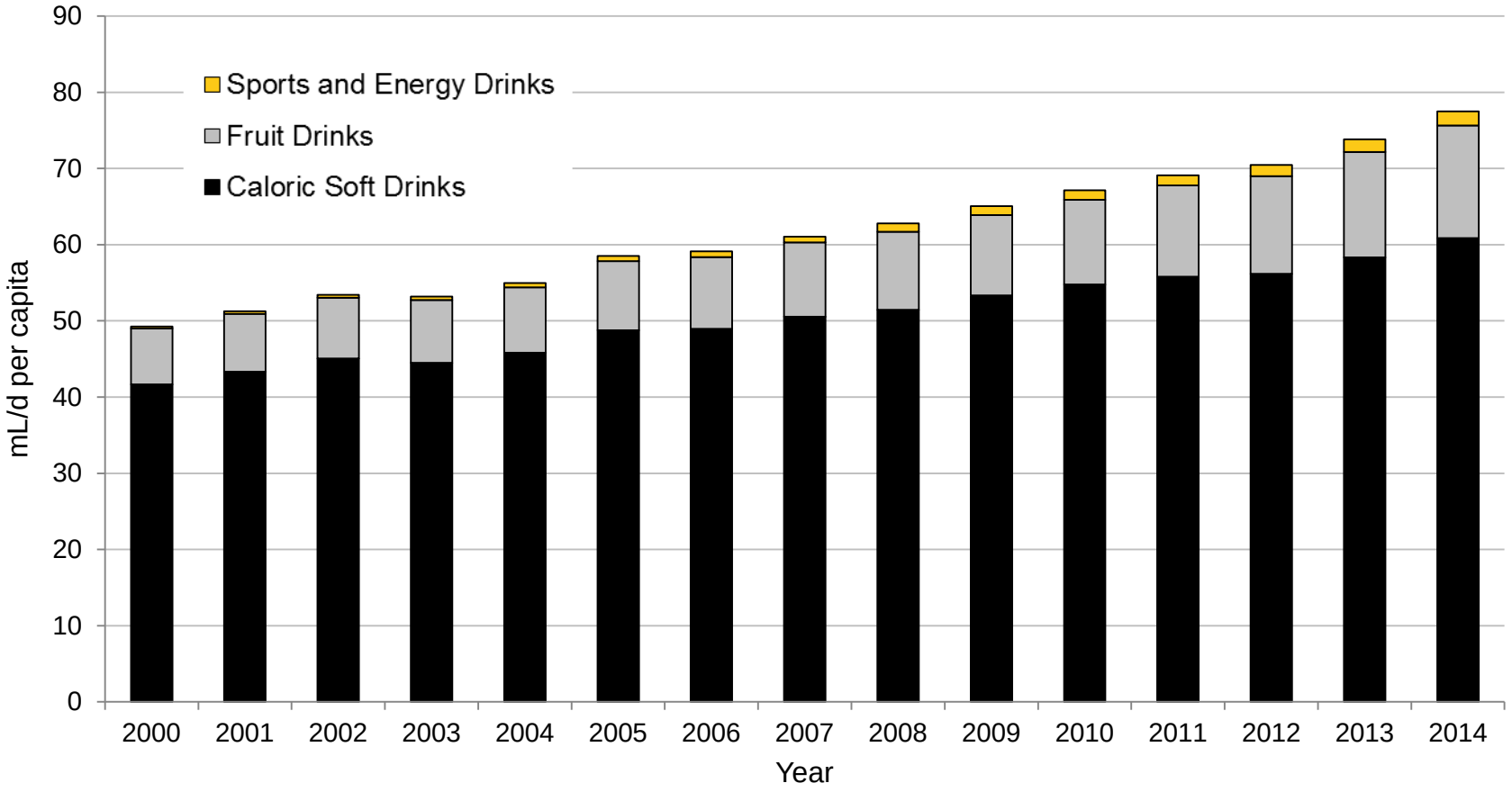
Source: Euromonitor Passport International with country-specific kcal data added . Only caloric beverages included

Supplemental Figure 6. Volume (mL) Trends in per Capita per Day Sales of Sugar-Sweetened Beverages in Middle East and North Africa region, 2000-2014



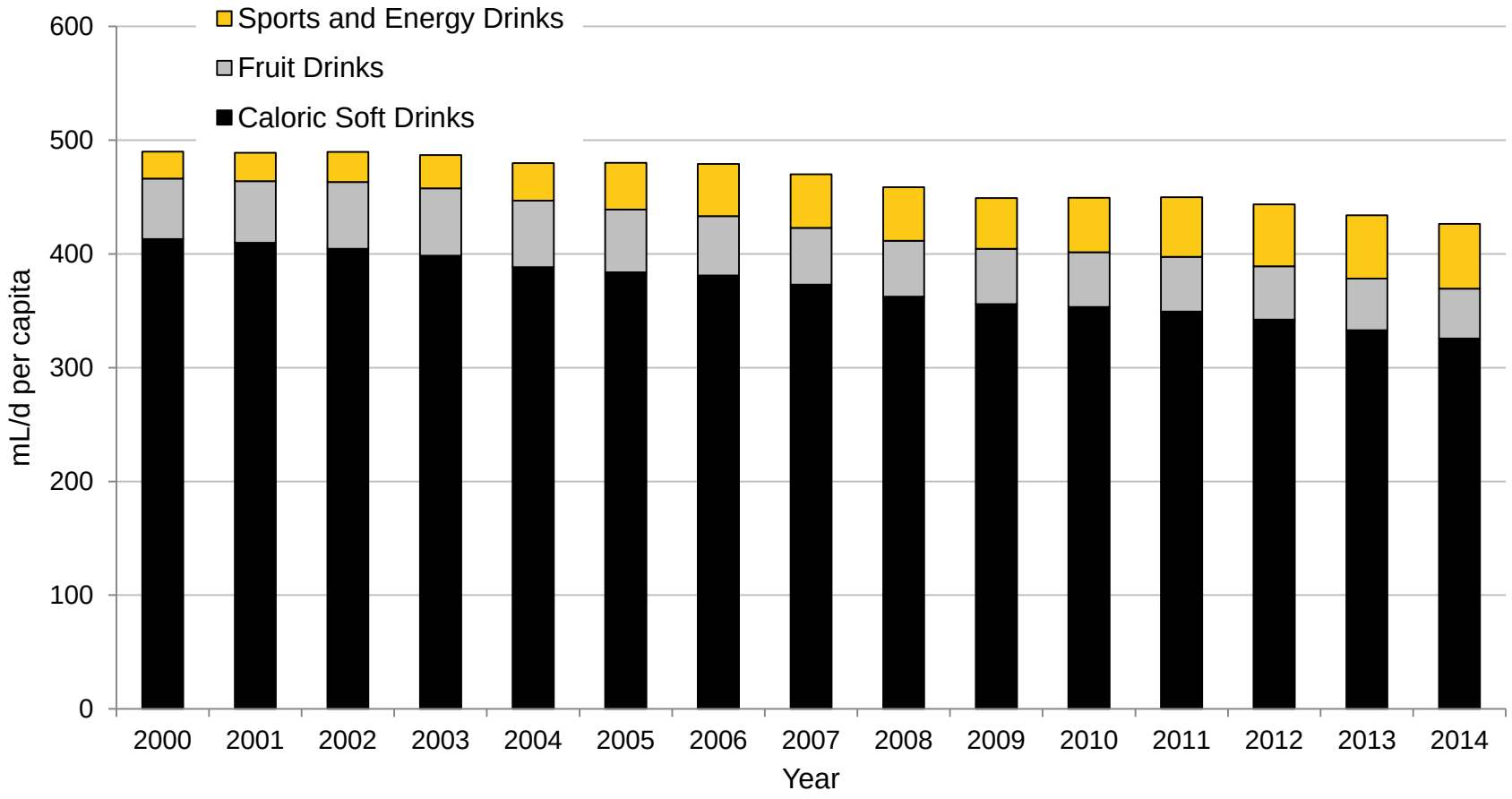
Source: Euromonitor Passport International with country-specific kcal data added .Only caloric beverages included
Middle East and North African Countries included those for which data were available: Algeria, Egypt, Iran, Israel, Morocco, Saudi Arabia, Tunisia, and United Arab Emirates. Values were weighted to be representative using population statistics (and proportions) from 2013

Supplemental Figure 7. Volume (mL) Trends in per Capita per Day Sales of Sugar-Sweetened Beverages in Sub-Saharan Africa Region, 2000-2014



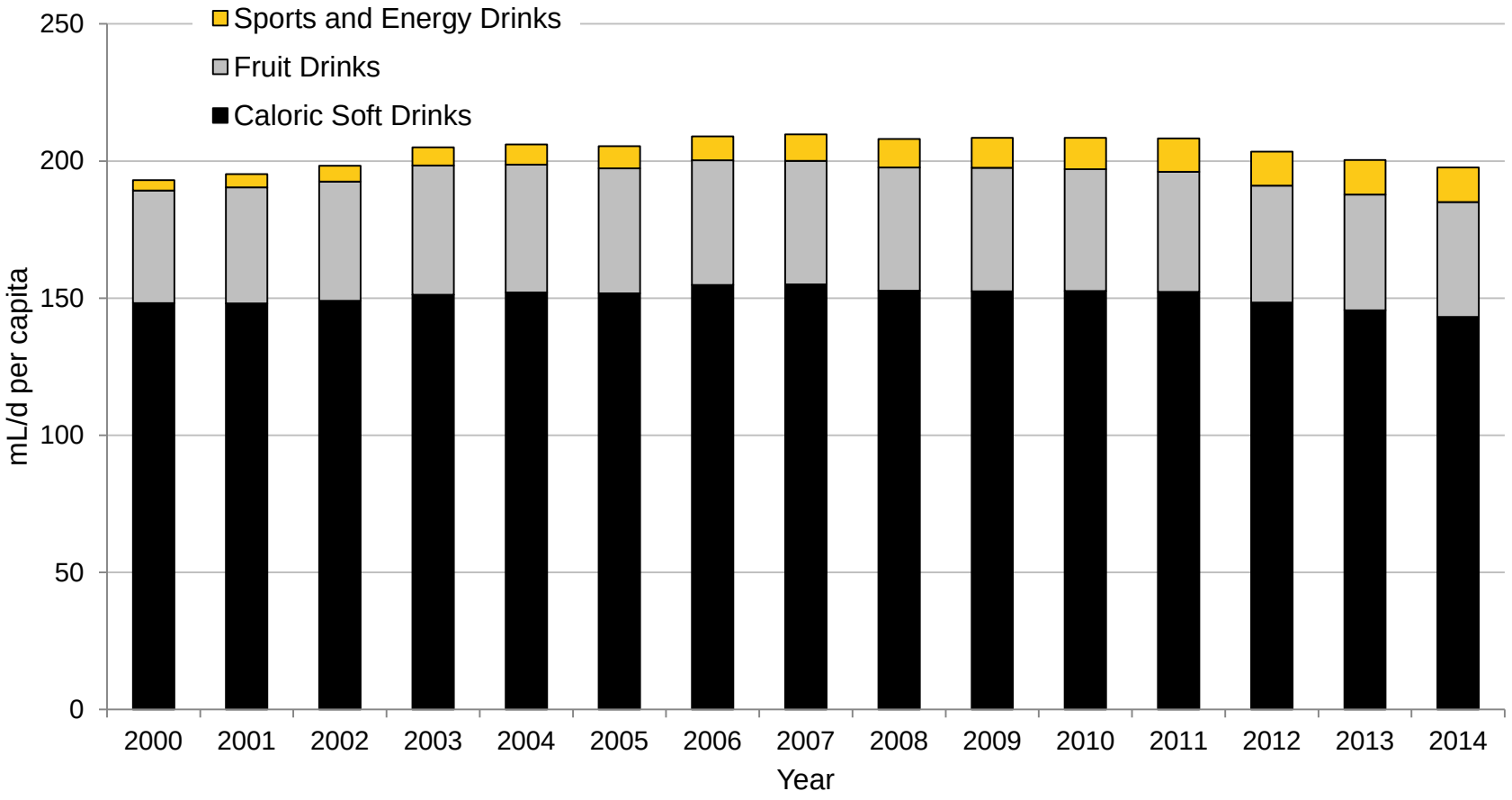
Source: Euromonitor Passport International with country-specific kcal data added . Only caloric beverages included Sub-Saharan Africa Countries included those for which data were available: Cameroon, Kenya, Nigeria, and South Africa. Values were weighted to be representative using population statistics (and proportions) from 2013

Supplemental Figure 8. Volume (mL) Trends in per Capita per Day Sales of Sugar-Sweetened Beverages in North America Region, 2000-2014



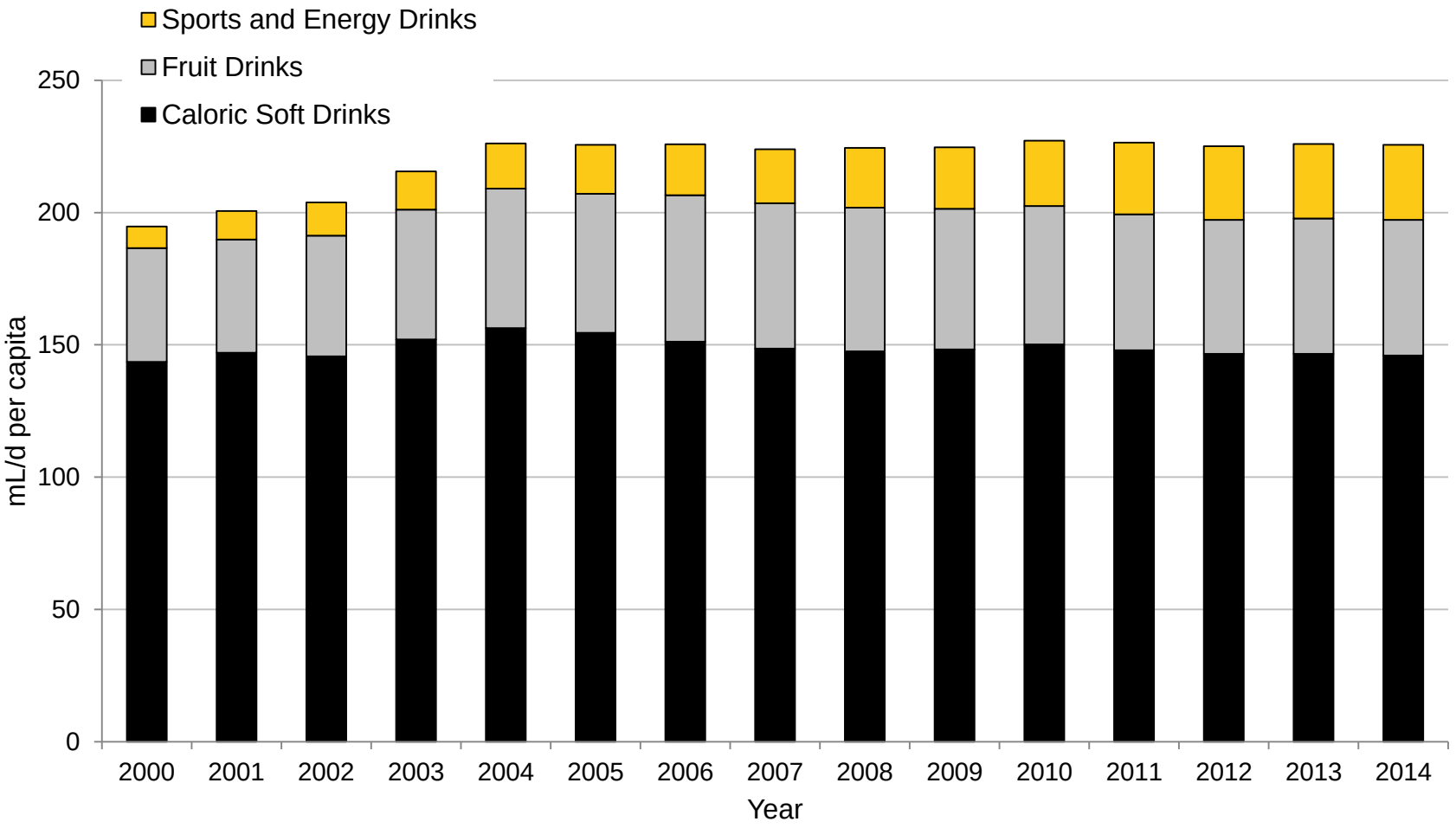
Source: Euromonitor Passport International with country-specific kcal data added . Only caloric beverages included

Supplemental Figure 9. Volume (mL) Trends in per Capita per Day Sales of Sugar-Sweetened Beverages in Western Europe Region, 2000-2014



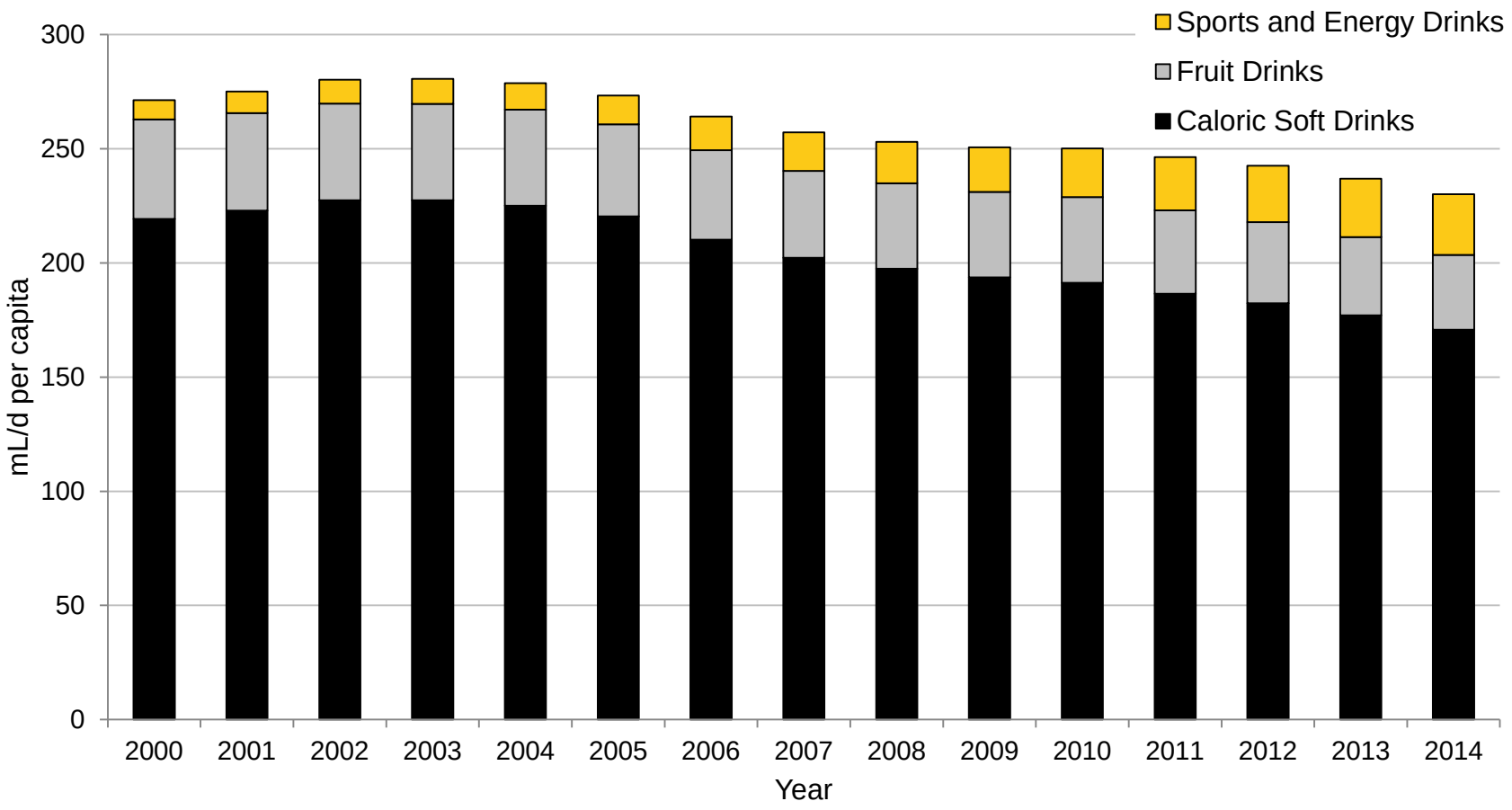
Source: Euromonitor Passport International with country-specific kcal data added . Only caloric beverages included

Supplemental Figure 10. Volume (mL) Trends in Sugar-Sweetened Beverage Sales per Capita per Day in the United Kingdom, 2000-2014



Source: Euromonitor Passport International with country-specific kcal data added . Only caloric beverages included

Supplemental Figure 11. Volume (mL) Trends in per Capita per Day Sales of Sugar-Sweetened Beverages in Australasia Region, 2000-2014



Source: Euromonitor Passport International with country-specific kcal data added . Only caloric beverages included