

POLICY FORUM

Artificially Sweetened Beverages and the Response to the Global Obesity Crisis

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Abbreviations: ADA, American Diabetes Association; AHA, American Heart Association; ASB, artificially sweetened beverage; ILSI, International Life Sciences Institute; NCP, National Caries Program; PAHO, Pan-American Health Organization; RCT, randomized controlled trial; SSB, sugar-sweetened beverage; USDA, US Department of Agriculture; WHO, World Health Organization.

Summary Points

- In March 2015, the World Health Organization (WHO) published revised guidelines on sugar intake that call on national governments to institute policies to reduce sugar intake and increase the scope for regulation of sugar-sweetened beverages (SSBs).
- In face of the growing threat of regulatory action on SSBs, transnational beverage companies are responding in multiple ways, including investing in the formulation and sales of artificially sweetened beverages (ASBs), promoted as healthier alternatives to SSBs.
- The absence of consistent evidence to support the role of ASBs in preventing weight gain and the lack of studies on other long-term effects on health strengthen the position that ASBs should not be promoted as part of a healthy diet.
- The promotion of ASBs must be discussed in a broader context of the additional potential impacts on health and the environment. In addition, a more robust evidence base, free of conflicts of interest, is needed.

Introduction

Dietary intake of added sugars has increased dramatically worldwide during the past few decades, coinciding with increases in obesity and noncommunicable diseases. About 75% of all processed foods and beverages contain added sugar in the United States [1]. Consumption of sugar-sweetened beverages (SSBs), including carbonated soft drinks, fruit-flavored drinks, sports/energy drinks, and ready-to-drink coffees and teas, contribute to over 46% of added sugar in the US diet [2], are the second largest source in Brazilians' diet [3], and constitute nearly a third of sugar intake among British adolescents [4]. Though SSBs are a major contributor to total calorie intake, they contain few, if any, essential nutrients. There is convincing epidemiological evidence linking SSB consumption to increased risk of overweight and obesity and type II diabetes [5–7].

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In March 2015, the World Health Organization (WHO) published revised guidelines on sugar intake [8], calling on national governments to institute policies to reduce sugar intake to less than 10% of total energy. The guidance notes that additional health benefits would be derived if sugar intake could be reduced to less than 5% of total energy. These recommendations have prompted an increased focus on policy actions to reduce sugar intake worldwide; particularly, interventions to curb SSB consumption have been implemented or proposed within a small number of jurisdictions [9]. These include taxes on SSBs in Mexico [10], France [11], Hungary [12], and the US (Philadelphia [13] and Berkeley [14]) and most recently proposed in the United Kingdom [15] and Ireland [16]. Warning labels have been implemented or proposed in California [17] and Chile [18], and advertising restrictions and banning of sales in schools in Brazil [19] and Chile [18]. While evidence on the effectiveness of these interventions is still emerging, recent research has found that the introduction of an SSB tax in Mexico was associated with a 6% reduction in sales, with a larger impact in low socioeconomic status households [10].

Response of Transnational Beverage Companies to Increasing Pressure for SSB Regulation

Transnational beverage companies recognize that addressing growing health concerns about their products is needed to guarantee share of sales, volume growth, and overall financial results. As an example, in the 2014 official annual mandatory report for the US Securities and Exchange Commission, Coca-Cola declared that “some researchers, health advocates and dietary guidelines are suggesting that consumption of sugar-sweetened beverages. . . is a primary cause of increased obesity rates and are encouraging consumers to reduce or eliminate consumption of such products” [20]. In the same report, it is stated that “possible new or increased taxes on sugar-sweetened beverages by government entities to reduce consumption or to raise revenue; additional governmental regulations concerning the marketing, labeling, packaging or sale of our sugar-sweetened beverages; and negative publicity resulting from actual or threatened legal actions against us or other companies in our industry relating to the marketing, labeling or sale of sugar-sweetened beverages may reduce demand for or increase the cost of our sugar-sweetened beverages, which could adversely affect our profitability” [20].

In face of the growing threat of regulatory action on SSBs, transnational beverages companies are responding in multiple ways, including lobbying for voluntary self-regulation [21], influencing scientific research [22], promoting sports and physical activity events and research as part of their social responsibility strategy [23], and contributing to election campaigns [21]. They are also targeting emerging markets (e.g., China, India, and Latin America), making substantial investments in global marketing and in the reformulation of products [24]. Within this context, artificially sweetened beverages (ASBs), such as soft drinks, flavored water, juices, and ready-to-drink tea and coffee containing artificial sweeteners, have emerged as an important alternative to maintain industries’ sales and profits. Global beverage industries have been investing in expanding their portfolios and shifting production to these products, perceived as healthier by some consumers.

ASB sales account for approximately one-quarter of the soft drink market globally [25,26]. There is evidence of a shift towards greater ASB consumption in some settings. In the US, the proportion of children consuming ASBs doubled between 1999–2000 and 2007–2008 [27,28]. In Australia, purchases of carbonated ASBs increased by 24% between 1997 and 2011 [29,30], representing an annual growth rate of 3.3% in contrast to an annual decline of 0.7% in SSBs [30]. Global sales data indicate substantial heterogeneity across regions, with SSBs predominately accounting for growth in soft drink sales in emerging economies, such as Chile, Brazil, and

China [31]. However, ASB consumption may increase in these settings as concerns about growing rates of obesity influence both consumer preference and government willingness to act.

Current Evidence Regarding the Health Impact of ASBs

ASBs are marketed as healthy alternatives to SSBs based on their characteristic of mimicking the sensory properties of SSBs while providing null (or low) energy content. The potential benefits from ASBs rely on the assumption that they elicit no (or incomplete) energy compensation. However, there are long-standing concerns that ASBs may trigger compensatory mechanisms [32,33], which could offset a reduction in energy and sugar intake provided by their replacement of SSBs. The main proposed mechanisms are that ASBs stimulate sweet taste receptors—which could theoretically increase appetite, induce preference for sweet taste, and modulate gut hormone secretion—or result in overconsumption of solid foods due to awareness of the low calorie content of ASBs [33].

Evidence of the long-term impact of ASBs on weight management and related health outcomes is limited. Systematic reviews of observational studies indicate that ASB intake is positively associated with increased body mass index in both children [34] and adults [6,35] and to cardiometabolic disease risk (e.g., type 2 diabetes [6] and stroke [36]). However, findings from observational studies might be biased by residual confounding, due to the clustering of lifestyle factors, and reverse causality, as overweight/obese people are more likely to consume ASBs in an attempt to control weight [37].

The effect of ASBs on weight management has been tested in some randomized controlled trials (RCTs). These have produced mixed findings, with some studies indicating a null effect [38–45], while others have found modest reductions in weight [43,46–51]. Most of these studies have numerous limitations, including short intervention and follow-up periods, small sample size, absence of intention-to-treat analysis, multicomponent intervention (e.g., motivational calls and visits for the ASB group only), and participant losses. A systematic review published in 2012 [35], funded by the International Life Sciences Institute (ILSI), a non-governmental organization largely funded by the food/beverage industry [52], reported that replacement of SSBs by ASBs resulted in modest weight loss.

More recently published data suggest that artificial sweeteners may contribute to the development of glucose intolerance by altering the composition and functions of gut microbiota [53]. Observational prospective studies suggest that ASB intake is positively related to glucose levels, although these results might be influenced by publication bias and residual confounding [6,35]. Few RCTs have been conducted in the general population, and the results are inconclusive [54].

An important consideration when interpreting these findings is the potential for conflicts of interest, as industry-sponsored research is common [55]. Systematic reviews sponsored by food or beverage companies or with other conflicts of interest are more likely to report a conclusion of no positive association between SSB consumption and obesity than those reporting having no industry sponsorship or conflicts of interest [55]. Recently, a systematic review found that ASB industry-sponsored reviews were also more likely to report favorable results and conclusions regarding ASB effects on weight control than nonsponsored reviews. The opposite occurred with reviews sponsored by competitor food companies (e.g., the sugar industry), which were more likely to report negative results compared to nonsponsored reviews. Importantly, the authors estimated that “almost half of the reviews had authors that failed to disclose relevant conflicts of interest with the food industry” [56]. These findings underscore the substantial and complex nature of bias from conflicts of interest in ASB research.

In summary, the available evidence does not directly support a role of ASBs in inducing weight gain or metabolic abnormalities but also does not consistently demonstrate that ASBs are effective for weight loss or preventing metabolic abnormalities. Evidence on the impact of ASBs on child health is even more limited and inconclusive than in adults.

Environmental Impacts of Sweetened Beverages

The environmental consequences of ASBs and SSBs should also be closely scrutinized given their negligible nutritional benefits and potential detrimental health impacts. High consumption of sweetened beverages leads to high generation of solid waste and cumulative chemical pollution, affecting marine life and contaminating the food chain, which raise concerns regarding food safety for human health [57–59]. The volume of water required to produce a 0.5 L plastic bottle of carbonated soft drink is estimated to range from 150 up to 300 L of water [60]. In the UK, the consumption of soft drinks in 2011 (14.685 billion L) contributed about 4.5 million tonnes CO₂e in the atmosphere [61], or approximately 300 g of CO₂e per L. In addition, artificial sweeteners have been recently recognized as an emerging environmental contaminant of the aquatic environment. Households, small business enterprises, and industry contribute to releasing sweeteners into the aquatic environment, with scarce research on their ecotoxicological profile and consequences for planetary health [62,63].

Implications for Policy

Although current guidelines developed for public health authorities and consumers consistently recommend that SSB consumption should be discouraged [8,64–66], they provide contrasting recommendations regarding ASB intake. As an example, the American Heart Association (AHA) and the American Diabetes Association (ADA) guidance states that replacing sugar for artificial sweeteners in foods and drinks may result in modest weight loss, although it is acknowledged that supporting evidence may be insufficient [66], while the Pan-American Health Organization (PAHO) indicates that both beverages with excessive free sugar ($\geq 10\%$ of total energy) and beverages with any amount of other sweeteners (“food additives that impart a sweet taste to a food”) should be subjected to regulatory measures [64,67].

Overall, there is consensus across national food-based dietary guidelines, which recommend avoiding or reducing SSB intake. However, guidance on ASB consumption is mixed (see [S1 Table](#) for a list of guidelines) [68]. Guidelines that discourage ASB intake for the general population (e.g., Australia, Brazil, Bulgaria, Guatemala, Honduras, Italy, Panama, Qatar, and Switzerland) argue that ASBs are not adequate sources of hydration, may not help in weight reduction/control, or may increase the risk of dental erosion due to acidity levels (in the case of carbonated beverages). A few guidelines (e.g., France, Georgia, Turkey, and the US) recommend ASBs as an alternative to SSBs for weight control, but with several caveats, such as stating that water is always the best choice and that ASBs may not be an effective long-term weight management strategy.

Few food policies targeting SSBs also address ASBs. In Mexico, the soft drink tax only covered SSBs (excluding ASBs and alcoholic and dairy beverages) [10], while the French soda tax covers both SSBs and ASBs [69]. The Brazilian school feeding program guidelines forbid the acquisition of any soft drinks [19], while the US Department of Agriculture (USDA) Smart Snacks in School standards allow the availability of low-calorie flavored and/or carbonated beverages for high school students [70]. On 16 June 2016, Philadelphia’s city council voted to pass a tax of 1.5 cents per ounce on both SSBs and ASBs. To what degree SSB-focused policies encourage the consumption of ASBs is not yet clear. Recent experiences from California and

Mexico suggest that taxing SSBs led to a partial substitution of SSBs with nontaxed beverages, mainly bottled water [10,71].

Caution should be exercised in engaging transnational beverage companies in future research. The US National Caries Program (NCP) was launched in 1971 with an aim of preventing tooth decay. There is evidence that the sugar industry acted to influence research priorities, and several strategies were adopted that focused on reducing the harms of sugar consumption rather than restricting intake [72].

Given the lack of consistent data on the effectiveness of ASBs on weight control, the potential impact of bias from industry sponsorship in ASB research, the high generation of solid waste and water use, and the largely unknown long-term impacts of ASBs on human health and on the environment, we argue that there are sufficient grounds to advise against policies that directly or indirectly promote their consumption. In practice, this means that ASBs should not be recommended in dietary guidance and be subject to the same restrictions on advertising and promotion as those imposed on SSBs. New taxes implemented on SSBs should be applied at the same level to ASBs. The impact of these policies on SSB and ASB consumption, as well as health and environmental outcomes, should be subject to rigorous and independent evaluation.

Conclusion

The absence of evidence to support the role of ASBs in preventing weight gain and the lack of studies on other long-term effects on health strengthen the position that ASBs should not be promoted as part of a healthy diet. The promotion of ASBs must be discussed in a broader context of the additional potential impacts on health and the environment. In addition, a more robust evidence base, free of conflicts of interest, is needed. Far from helping to solve the global obesity crisis, characteristics related to ASB composition (low nutrient density and food additives), consumption patterns (potential promotion of sweet taste preference), and environmental impact (misuse of natural resources, pollution, or ecotoxicity) make them a potential risk factor for highly prevalent chronic diseases.

Supporting Information

S1 Table. List of food-based dietary guidelines published after the year 2000 in countries with a prevalence of obesity higher than 15%.
(DOCX)

References

1. 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(4):950–6. doi: [10.2337/dc13-2085](https://doi.org/10.2337/dc13-2085) PMID: [24652725](https://pubmed.ncbi.nlm.nih.gov/24652725/).
2. Drewnowski A, Rehm CD. Consumption of added sugars among US children and adults by food purchase location and food source. *Am J Clin Nutr*. 2014; 100(3):901–7. doi: [10.3945/ajcn.114.089458](https://doi.org/10.3945/ajcn.114.089458) PMID: [25030785](https://pubmed.ncbi.nlm.nih.gov/25030785/); PubMed Central PMCID: [PMCPMC4135498](https://pubmed.ncbi.nlm.nih.gov/PMC4135498/).
3. Levy RB, Claro RM, Bandoni DH, Mondini L, Monteiro CA. Availability of added sugars in Brazil: distribution, food sources and time trends. *Rev Bras Epidemiol*. 2012; 15(1):3–12. PMID: [22450488](https://pubmed.ncbi.nlm.nih.gov/22450488/).
4. Scientific Advisory Committee on Nutrition (SACN). *Carbohydrates and Health*. London: TSO, 2015.
5. 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(8):606–19. doi: [10.1111/obr.12040](https://doi.org/10.1111/obr.12040) PMID: [23763695](https://pubmed.ncbi.nlm.nih.gov/23763695/).
6. Imamura F, O'Connor L, Ye Z, Mursu J, Hayashino Y, Bhupathiraju SN, 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. doi: [10.1136/bmj.h3576](https://doi.org/10.1136/bmj.h3576) PMID: [26199070](https://pubmed.ncbi.nlm.nih.gov/26199070/); PubMed Central PMCID: PMC4510779.
7. 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. PMID: [23321486](https://pubmed.ncbi.nlm.nih.gov/23321486/).
 8. World Health Organization. Guideline: Sugars intake for adults and children. Geneva: World Health Organization, 2015.
 9. Wise J. Sugar tax could stop 3.7 million UK people becoming obese, claims report. *BMJ*. 2016; 352: i1064. doi: [10.1136/bmj.i1064](https://doi.org/10.1136/bmj.i1064) PMID: [26895790](https://pubmed.ncbi.nlm.nih.gov/26895790/).
 10. Colchero MA, Popkin BM, Rivera JA, Ng SW. Beverage purchases from stores in Mexico under the excise tax on sugar sweetened beverages: observational study. *BMJ*. 2016; 352:h6704. doi: [10.1136/bmj.h6704](https://doi.org/10.1136/bmj.h6704) PMID: [26738745](https://pubmed.ncbi.nlm.nih.gov/26738745/).
 11. Julia C, Mejean C, Vicari F, Peneau S, Hercberg S. Public perception and characteristics related to acceptance of the sugar-sweetened beverage taxation launched in France in 2012. *Public Health Nutr*. 2015; 18(14):2679–88. doi: [10.1017/S1368980014003231](https://doi.org/10.1017/S1368980014003231) PMID: [25627337](https://pubmed.ncbi.nlm.nih.gov/25627337/).
 12. Holt E. Hungary to introduce broad range of fat taxes. *Lancet*. 2011; 378(9793):755. PMID: [21877327](https://pubmed.ncbi.nlm.nih.gov/21877327/).
 13. Nadolny T. Soda tax passes; Philadelphia is first big city in nation to enact one 16 June 2016. *The Philadelphia Inquirer*. 16 June 2016. http://www.philly.com/philly/news/politics/20160617_Philadelphia_City_Council_to_vote_on_soda_tax.html. Cited 28 October 2016.
 14. Falbe J, Thompson HR, Becker CM, Rojas N, McCulloch CE, Madsen KA. Impact of the Berkeley Excise Tax on Sugar-Sweetened Beverage Consumption. *Am J Public Health*. 2016; 106(10):1865–71. doi: [10.2105/AJPH.2016.303362](https://doi.org/10.2105/AJPH.2016.303362) PMID: [27552267](https://pubmed.ncbi.nlm.nih.gov/27552267/); PubMed Central PMCID: PMC45024386.
 15. Triggle N. Sugar tax: How will it work? 16 March 2016. <http://www.bbc.co.uk/news/health-35824071>. Cited 28 October 2016.
 16. Republic of Ireland. Sugar-Sweetened Drinks Tax: Public Consultation. Dublin: Tax Policy Division, Department of Finance; 2016. http://www.budget.gov.ie/Budgets/2017/Documents/Sugar-Sweetened_Drinks_Tax_Public_Consultation_final.pdf. Cited 28 October 2016.
 17. Schillinger D, Jacobson MF. Science and Public Health on Trial: Warning Notices on Advertisements for Sugary Drinks. *JAMA*. 2016; 316(15):1545–46. doi: [10.1001/jama.2016.10516](https://doi.org/10.1001/jama.2016.10516) PMID: [27479332](https://pubmed.ncbi.nlm.nih.gov/27479332/).
 18. 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. doi: [10.1111/obr.12099](https://doi.org/10.1111/obr.12099) PMID: [24102671](https://pubmed.ncbi.nlm.nih.gov/24102671/).
 19. Silva AC, Bortolini GA, Jaime PC. Brazil's national programs targeting childhood obesity prevention. *Int J Obes Suppl*. 2013; 3(Suppl 1):S9–S11. doi: [10.1038/ijosup.2013.4](https://doi.org/10.1038/ijosup.2013.4) PMID: [27152158](https://pubmed.ncbi.nlm.nih.gov/27152158/); PubMed Central PMCID: PMC4850565.
 20. The Coca-Cola Company. United States Securities and Exchange Commission Form 10-K: Annual Report Pursuant to Section 13 or 15(d) of the Securities Exchange Act of 1934. Washington: 2013.
 21. Moodie R, Stuckler D, Monteiro C, Sheron N, Neal B, Thamarangsi T, et al. Profits and pandemics: prevention of harmful effects of tobacco, alcohol, and ultra-processed food and drink industries. *Lancet*. 2013; 381(9867):670–9. doi: [10.1016/S0140-6736\(12\)62089-3](https://doi.org/10.1016/S0140-6736(12)62089-3) PMID: [23410611](https://pubmed.ncbi.nlm.nih.gov/23410611/).
 22. Gornall J. Sugar: spinning a web of influence. *BMJ*. 2015; 350:h231. PMID: [25673325](https://pubmed.ncbi.nlm.nih.gov/25673325/). doi: [10.1136/bmj.h231](https://doi.org/10.1136/bmj.h231)
 23. de Sá TH. Can Coca Cola promote physical activity? *Lancet*. 2014; 383(9934):2041. doi: [10.1016/S0140-6736\(14\)60988-0](https://doi.org/10.1016/S0140-6736(14)60988-0) PMID: [24931683](https://pubmed.ncbi.nlm.nih.gov/24931683/).
 24. Freudenberg N. *Lethal But Legal: Corporations, Consumption, and Protecting Public Health*. USA: OUP; 2014.
 25. Statistic Brain Research Institute. Coca-Cola Company Statistics 2015. <http://www.statisticbrain.com/coca-cola-company-statistics/>.
 26. Euromonitor International. Passport Global Market Information Database 2011. <http://www.portal.euromonitor.com/Portal/Pages/Magazine/WelcomePage.aspx>.
 27. Sylvestry AC, Welsh JA, Brown RJ, Vos MB. Low-calorie sweetener consumption is increasing in the United States. *Am J Clin Nutr*. 2012; 96(3):640–6. doi: [10.3945/ajcn.112.034751](https://doi.org/10.3945/ajcn.112.034751) PMID: [22854409](https://pubmed.ncbi.nlm.nih.gov/22854409/); PubMed Central PMCID: PMC3417218.
 28. 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. *Pediatr Obes*. 2013; 8(4):294–306. doi: [10.1111/j.2047-6310.2013.00153.x](https://doi.org/10.1111/j.2047-6310.2013.00153.x) PMID: [23529974](https://pubmed.ncbi.nlm.nih.gov/23529974/); PubMed Central PMCID: PMC3711951.

29. Shrapnel W. Trends in Sugar-Sweetened Beverages: Are Public Health and the Market Aligned or in Conflict? *Nutrients*. 2015; 7(9):8189–98. doi: [10.3390/nu7095390](https://doi.org/10.3390/nu7095390) PMID: [26404369](https://pubmed.ncbi.nlm.nih.gov/26404369/); PubMed Central PMCID: [PMC4586584](https://pubmed.ncbi.nlm.nih.gov/PMC4586584/).
30. Levy G, Shrapnel W. Quenching Australia's thirst: A trend analysis of water-based beverage sales from 1997. *Nutrition & Dietetics*. 2014; 71:193–200.
31. Popkin BM, Hawkes C. Sweetening of the global diet, particularly beverages: patterns, trends, and policy responses. *Lancet Diabetes Endocrinol*. 2016; 4(2):174–86. doi: [10.1016/S2213-8587\(15\)00419-2](https://doi.org/10.1016/S2213-8587(15)00419-2) PMID: [26654575](https://pubmed.ncbi.nlm.nih.gov/26654575/); PubMed Central PMCID: [PMC4733620](https://pubmed.ncbi.nlm.nih.gov/PMC4733620/).
32. Blundell JE, Hill AJ. Paradoxical effects of an intense sweetener (aspartame) on appetite. *Lancet*. 1986; 1(8489):1092–3. PMID: [2871354](https://pubmed.ncbi.nlm.nih.gov/2871354/).
33. 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):1–14. doi: [10.3945/ajcn.2008.26792](https://doi.org/10.3945/ajcn.2008.26792) PMID: [19056571](https://pubmed.ncbi.nlm.nih.gov/19056571/); PubMed Central PMCID: [PMC2650084](https://pubmed.ncbi.nlm.nih.gov/PMC2650084/).
34. Brown RJ, de Banate MA, Rother KI. Artificial sweeteners: a systematic review of metabolic effects in youth. *Int J Pediatr Obes*. 2010; 5(4):305–12. doi: [10.3109/17477160903497027](https://doi.org/10.3109/17477160903497027) PMID: [20078374](https://pubmed.ncbi.nlm.nih.gov/20078374/); PubMed Central PMCID: [PMC2951976](https://pubmed.ncbi.nlm.nih.gov/PMC2951976/).
35. Miller PE, Perez V. Low-calorie sweeteners and body weight and composition: a meta-analysis of randomized controlled trials and prospective cohort studies. *Am J Clin Nutr*. 2014; 100(3):765–77. doi: [10.3945/ajcn.113.082826](https://doi.org/10.3945/ajcn.113.082826) PMID: [24944060](https://pubmed.ncbi.nlm.nih.gov/24944060/); PubMed Central PMCID: [PMC4135487](https://pubmed.ncbi.nlm.nih.gov/PMC4135487/).
36. Narain A, Kwok CS, Mamas MA. Soft drinks and sweetened beverages and the risk of cardiovascular disease and mortality: a systematic review and meta-analysis. *Int J Clin Pract*. 2016. doi: [10.1111/ijcp.12841](https://doi.org/10.1111/ijcp.12841) PMID: [27456347](https://pubmed.ncbi.nlm.nih.gov/27456347/).
37. 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(6):1321–7. doi: [10.3945/ajcn.110.007922](https://doi.org/10.3945/ajcn.110.007922) PMID: [21430119](https://pubmed.ncbi.nlm.nih.gov/21430119/); PubMed Central PMCID: [PMC3095502](https://pubmed.ncbi.nlm.nih.gov/PMC3095502/).
38. Maersk M, Belza A, Stodkilde-Jorgensen H, Ringgaard S, Chabanova E, Thomsen 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(2):283–9. doi: [10.3945/ajcn.111.022533](https://doi.org/10.3945/ajcn.111.022533) PMID: [22205311](https://pubmed.ncbi.nlm.nih.gov/22205311/).
39. Gostner A, Schaffer V, Theis S, Menzel T, Luhrs H, Melcher R, et al. Effects of isomalt consumption on gastrointestinal and metabolic parameters in healthy volunteers. *Br J Nutr*. 2005; 94(4):575–81. PMID: [16197583](https://pubmed.ncbi.nlm.nih.gov/16197583/).
40. Gatenby SJ, Aaron JI, Jack VA, Mela DJ. Extended use of foods modified in fat and sugar content: nutritional implications in a free-living female population. *Am J Clin Nutr*. 1997; 65(6):1867–73. PMID: [9174485](https://pubmed.ncbi.nlm.nih.gov/9174485/).
41. Reid M, Hammersley R, Duffy M. Effects of sucrose drinks on macronutrient intake, body weight, and mood state in overweight women over 4 weeks. *Appetite*. 2010; 55(1):130–6. doi: [10.1016/j.appet.2010.05.001](https://doi.org/10.1016/j.appet.2010.05.001) PMID: [20470840](https://pubmed.ncbi.nlm.nih.gov/20470840/).
42. Tate DF, Turner-McGrievy G, Lyons E, Stevens J, Erickson K, Polzien K, 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(3):555–63. doi: [10.3945/ajcn.111.026278](https://doi.org/10.3945/ajcn.111.026278) PMID: [22301929](https://pubmed.ncbi.nlm.nih.gov/22301929/); PubMed Central PMCID: [PMC3632875](https://pubmed.ncbi.nlm.nih.gov/PMC3632875/).
43. Kanders BS, Lavin PT, Kowalchuk MB, Greenberg I, Blackburn GL. An evaluation of the effect of aspartame on weight loss. *Appetite*. 1988; 11(Suppl 1):73–84. PMID: [3190220](https://pubmed.ncbi.nlm.nih.gov/3190220/).
44. Knopp RH, Brandt K, Arky RA. Effects of aspartame in young persons during weight reduction. *J Toxicol Environ Health*. 1976; 2(2):417–28. doi: [10.1080/15287397609529443](https://doi.org/10.1080/15287397609529443) PMID: [796476](https://pubmed.ncbi.nlm.nih.gov/796476/).
45. Njike VY, Faridi Z, Shuval K, Dutta S, Kay CD, West SG, et al. Effects of sugar-sweetened and sugar-free cocoa on endothelial function in overweight adults. *Int J Cardiol*. 2011; 149(1):83–8. doi: [10.1016/j.ijcard.2009.12.010](https://doi.org/10.1016/j.ijcard.2009.12.010) PMID: [20036019](https://pubmed.ncbi.nlm.nih.gov/20036019/).
46. Ebbeling CB, Feldman HA, Chomitz VR, Antonelli TA, Gortmaker SL, Osganian SK, et al. A randomized trial of sugar-sweetened beverages and adolescent body weight. *N Engl J Med*. 2012; 367(15):1407–16. doi: [10.1056/NEJMoa1203388](https://doi.org/10.1056/NEJMoa1203388) PMID: [22998339](https://pubmed.ncbi.nlm.nih.gov/22998339/); PubMed Central PMCID: [PMC3494993](https://pubmed.ncbi.nlm.nih.gov/PMC3494993/).
47. Raben A, Vasilaras TH, Moller 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(4):721–9. PMID: [12324283](https://pubmed.ncbi.nlm.nih.gov/12324283/).
48. 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(15):1397–406. doi: [10.1056/NEJMoa1203034](https://doi.org/10.1056/NEJMoa1203034) PMID: [22998340](https://pubmed.ncbi.nlm.nih.gov/22998340/).

49. Tordoff MG, Alleva AM. Effect of drinking soda sweetened with aspartame or high-fructose corn syrup on food intake and body weight. *Am J Clin Nutr.* 1990; 51(6):963–9. PMID: [2349932](#).
50. Peters JC, Wyatt HR, Foster GD, Pan Z, Wojtanowski AC, Vander Veur SS, et al. The effects of water and non-nutritive sweetened beverages on weight loss during a 12-week weight loss treatment program. *Obesity.* 2014; 22(6):1415–21. doi: [10.1002/oby.20737](#) PMID: [24862170](#).
51. Blackburn GL, Kanders BS, Lavin PT, Keller SD, Whatley J. The effect of aspartame as part of a multi-disciplinary weight-control program on short- and long-term control of body weight. *Am J Clin Nutr.* 1997; 65(2):409–18. PMID: [9022524](#).
52. Butler D. Food agency denies conflict-of-interest claim: *Nature*; 2010. <http://www.nature.com/news/2010/101005/full/news.2010.513.html>. Cited 2016 September 15.
53. Suez J, Korem T, Zeevi D, Zilberman-Schapira G, Thaiss CA, Maza O, et al. Artificial sweeteners induce glucose intolerance by altering the gut microbiota. *Nature.* 2014; 514(7521):181–6. doi: [10.1038/nature13793](#) PMID: [25231862](#).
54. Wiebe N, Padwal R, Field C, Marks S, Jacobs R, Tonelli M. A systematic review on the effect of sweeteners on glycemic response and clinically relevant outcomes. *BMC Med.* 2011; 9:123. doi: [10.1186/1741-7015-9-123](#) PMID: [22093544](#); PubMed Central PMCID: PMC3286380.
55. 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(12):e1001578. doi: [10.1371/journal.pmed.1001578](#) PMID: [24391479](#); PubMed Central PMCID: PMC3876974.
56. Mandrioli D, Kearns CE, Bero LA. Relationship between Research Outcomes and Risk of Bias, Study Sponsorship, and Author Financial Conflicts of Interest in Reviews of the Effects of Artificially Sweetened Beverages on Weight Outcomes: A Systematic Review of Reviews. *PLoS ONE.* 2016; 11(9): e0162198. doi: [10.1371/journal.pone.0162198](#) PMID: [27606602](#).
57. Miranda DeA, de Carvalho-Souza GF. Are we eating plastic-ingesting fish? *Mar Pollut Bull.* 2016; 103(1–2):109–14. doi: [10.1016/j.marpolbul.2015.12.035](#) PMID: [26763323](#).
58. Benno Meyer-Rochow V, Valérie Gross J, Steffany F, Zeuss D, Erren TC. Commentary: Plastic ocean and the cancer connection: 7 questions and answers. *Environ Res.* 2015; 142:575–8. doi: [10.1016/j.envres.2015.08.015](#) PMID: [26298603](#).
59. Seltenrich N. New link in the food chain? Marine plastic pollution and seafood safety. *Environ Health Perspect.* 2015; 123(2):A34–41. doi: [10.1289/ehp.123-A34](#) PMID: [25643424](#); PubMed Central PMCID: PMC4314237.
60. Ercin A, Aldaya M, Hoekstra A. Corporate Water Footprint Accounting and Impact Assessment: The Case of the Water Footprint of a Sugar-Containing Carbonated Beverage. *Water Resour Manage.* 2011; 25:721–4.
61. Department for Food Environment and Rural Affairs. Evidence to Support the Development of a Sustainability Roadmap for Soft Drinks: Phase 2 Final Report. UK: DEFRA, 2013.
62. Lange FT, Scheurer M, Brauch HJ. Artificial sweeteners—a recently recognized class of emerging environmental contaminants: a review. *Anal Bioanal Chem.* 2012; 403(9):2503–18. doi: [10.1007/s00216-012-5892-z](#) PMID: [22543693](#).
63. Neset TS, Singer H, Longrée P, Bader HP, Scheidegger R, Wittmer A, et al. Understanding consumption-related sucralose emissions—A conceptual approach combining substance-flow analysis with sampling analysis. *Sci Total Environ.* 2010; 408(16):3261–9. doi: [10.1016/j.scitotenv.2010.04.003](#) PMID: [20447681](#).
64. Pan American Health Organization. Plan of Action for the Prevention of Obesity in Children and Adolescents. Washington, DC: PAHO, 2014.
65. World Cancer Research Fund International. Curbing global sugar consumption: effective food policy actions to help promote healthy diets and tackle obesity. London: WCRF, 2015.
66. Gardner C, Wylie-Rosett J, Gidding SS, Steffen LM, Johnson RK, Reader D, et al. Nonnutritive sweeteners: current use and health perspectives: a scientific statement from the American Heart Association and the American Diabetes Association. *Diabetes Care.* 2012; 35(8):1798–808. doi: [10.2337/dc12-9002](#) PMID: [22778165](#); PubMed Central PMCID: PMC3402256.
67. Pan American Health Organization. Nutrient profile model. Washington, DC: PAHO, 2016.
68. Food and Agriculture Organization of the United Nations (FAO). Food-based dietary guidelines. <http://www.fao.org/nutrition/education/food-based-dietary-guidelines/regions/countries/en/>. Cited 10 Sep 2016.
69. Berardi N, Sevestre P, Tepaut M, Vigneron A. The impact of a 'soda tax' on prices: Evidence from French micro data. Paris: Banque de France, 2012 (revised version may 2016).

70. United States Department of Agriculture (USDA). Help make the healthy choice the easy choice for kids at school: a Guide to Smart Snacks in School July 2016. <http://www.fns.usda.gov/sites/default/files/tn/USDASmartSnacks.pdf>. Cited 28 October 2016.
71. Falbe J, Thompson HR, Becker CM, Rojas N, McCulloch CE, Madsen KA. Impact of the Berkeley Excise Tax on Sugar-Sweetened Beverage Consumption. *Am J Public Health*. 2016:e1–e7. doi: [10.2105/AJPH.2016.303362](https://doi.org/10.2105/AJPH.2016.303362) PMID: [27552267](https://pubmed.ncbi.nlm.nih.gov/27552267/).
72. Kearns CE, Glantz SA, Schmidt LA. Sugar industry influence on the scientific agenda of the National Institute of Dental Research's 1971 National Caries Program: a historical analysis of internal documents. *PLoS Med*. 2015; 12(3):e1001798. doi: [10.1371/journal.pmed.1001798](https://doi.org/10.1371/journal.pmed.1001798) PMID: [25756179](https://pubmed.ncbi.nlm.nih.gov/25756179/); PubMed Central PMCID: PMC4355299.