

## PERSPECTIVE

## Sugar-sweetened beverage taxes: Lessons to date and the future of taxation

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To date, across the globe, over 45 countries, cities, and regions have instituted sugar-sweetened beverage (SSB) taxes. [Fig 1](#) is a map of the world highlighting the diversity of countries where SSB taxes now exist and options in tax formats [1].

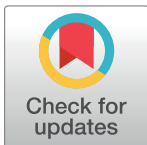
### Why tax SSBs?

We see at least 2 major health-related reasons to focus on SSBs. First, excess sugar consumption is a major cause of obesity and the increasing risk of type 2 diabetes, hypertension, liver and kidney damage, heart disease, and some cancers [2–4]. Second, high-caloric beverages offer little caloric compensation, so reducing their consumption lowers obesity risk [5,6]. Furthermore, we are beginning to understand the potential impacts of these beverages on stunting as well as obesity [7–11]. A less emphasized reason that deserves greater attention as we consider the links between our diets and planetary health is the environmental costs related to the production of sugary drinks, particularly in water use and carbon emissions. Estimates of total water lifecycle costs to produce a half-liter (or 17-ounce) regular soft drink range from 168 to 309 liters, depending on the sugar source and farm technology [12–14]. Finally, from a practical standpoint, SSB taxes have gained momentum because of their relative ease of implementation compared to other food/nutrition policy options. Taxes collected from manufacturers, bottlers, and distributors can often be built into existing taxation frameworks and collection systems, and these health taxes are a potential source of revenue.

### What have we learned from major evaluations to date?

Three recent papers published in *PLOS Medicine* highlight the potentials of different methods of discouraging SSB consumption among the public and encouraging reformulations by the beverage industry. In the United Kingdom, the multitiered Sugar Drinks Industry Levy based on sugar content has prompted remarkable reformulations and shifts in purchases with new low-calorie beverages emerging [15]. In Portugal, earlier findings suggest both sugar reduction in beverage formulations and reduced sales [16], and the latest paper by Goiana-da-Silva and colleagues simulates its implication for lowering new cases of obesity in children, adolescents, and adults [17]. Likewise, reformulations are an important driver of change in response to Chile's integrated food labeling, marketing, and school food regulations [18]. Taillie and colleagues' new study found a 23.7% reduction overall in the volume of SSBs purchased and a 27.5% decline in calories consumed per capita per day [19]. While reductions in SSB purchases and modeled improvements in obesity outcomes address the objectives of these policies, the implications of reformulations are unclear and need monitoring.

Overall, price changes are heterogeneous depending on the baseline levels of consumption, market shares of beverage brands given the geographic coverage of the tax, and reflect strategic



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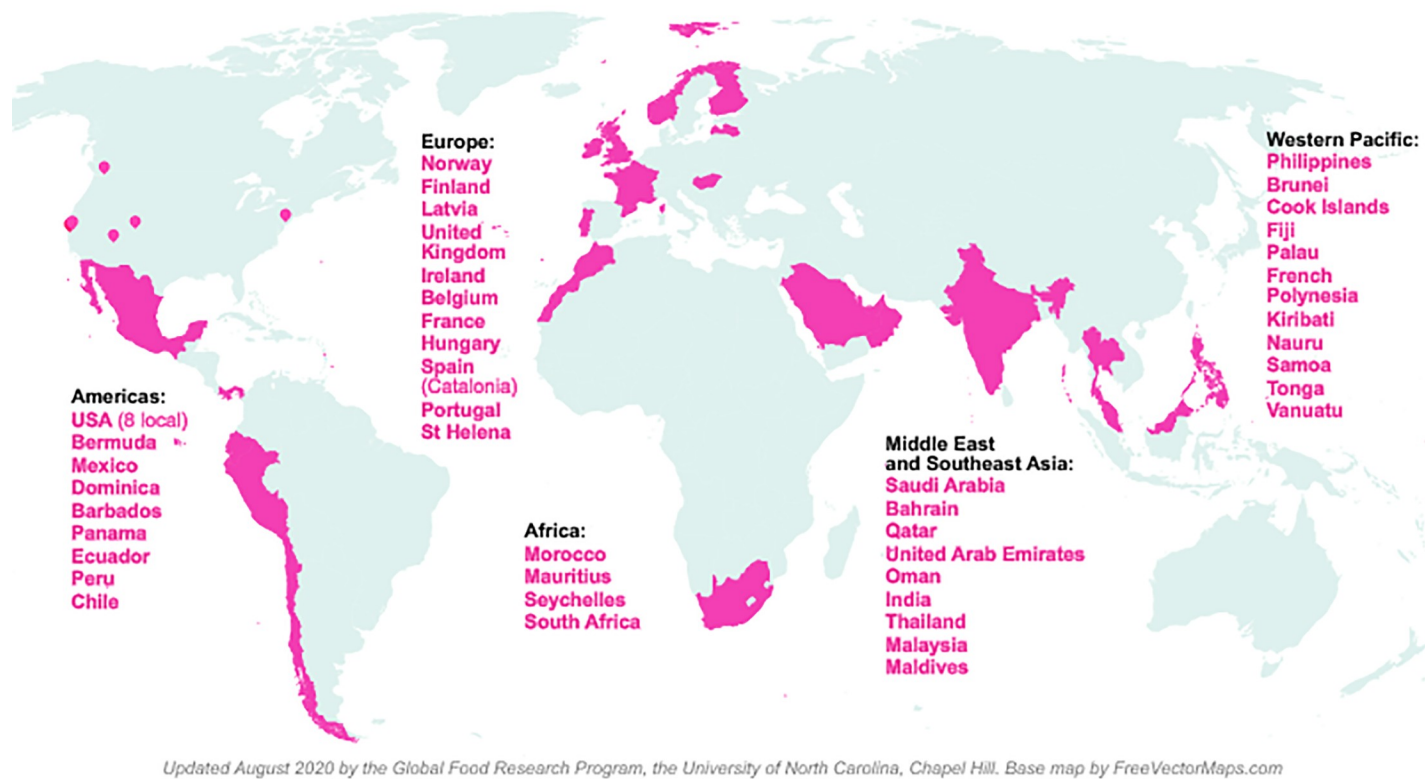
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**Abbreviations:** kcal, kilocalorie; NNS, nonnutritive sweetener; SSB, sugar-sweetened beverage.

## Sugary drink taxes around the world



**Fig 1. Global map of countries with SSB taxes.** SSB, sugar-sweetened beverage.

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behaviors by beverage companies and retailers [20,21]. Consequently, changes in consumption are also heterogeneous, particularly across income levels, age groups, and baseline beverage levels [21–23]. Nonetheless, a meta-analysis shows that the average consumer will lower his/her SSB purchases by 10% if SSB prices rise 10% (price elasticity of demand of  $-1$ ) [24]. Health implications (e.g., weight change, flattening of diabetes prevalence rates, or reductions in obesity incidence) take years to emerge at the population level, so researchers have used the available results to estimate longer-term health and economic implications, such as in the recent analysis by Goiana-da-Silva and colleagues [17].

The findings to date suggest that future SSB tax designs need to consider the baseline levels of consumption of various beverages stratified by income and the price elasticities of demand that can guide the scope of the products covered. Second, the tax structure should be aligned with the primary objectives. If the goal is reduction of sugar consumption, then one based on sugar density is more likely to achieve the goal, as the Portugal and UK results suggest. If the goal is revenue generation, then a volume-based specific tax across a broad scope of beverages may result in greater revenue given a weaker incentive to reformulate. Meanwhile, studies have shown that ad valorem taxes on SSBs are less likely to be fully pass through onto prices compared to specific taxes in the form of sales taxes (rather than excise taxes) [25]. Finally, the geographic coverage of the tax jurisdiction has implications for ease of cross-border shopping and highlights the need for national- or province/state-level taxes over local taxes.

A critical concern from the health perspective is the reductions in sugar and caloric intakes through reduced SSB consumption. While these taxes specifically affect high consumers [22,26], evaluations to date suggest that the reductions affected by SSB taxes translate to 5 to 22 kilocalories (kcal) per capita per day. These levels of reductions, even if sustained, are insufficient to meaningfully impact the broad swath of health outcomes in a timely manner, although research shows that the 10- to 20-year time horizon will produce important results [27,28]. One way to address this is to raise the current tax rates that are in the 5% to 20% range. A few Middle Eastern countries (e.g., Saudi Arabia, Qatar, and the United Arab Emirates) have instituted 50% to 100% excise taxes on subsets of SSBs [29], and Bermuda has implemented a 75% import tax on sugar, SSBs, and candies [30]. We can learn from tax levels for tobacco (another product with no health benefits and many costs) where the taxation rates range from 100% to 1,000% [31,32].

### Potential unknown consequences

Evidence to date demonstrates that sugar reduction policies will and have resulted in the introduction of beverages with both sugar and nonnutritive sweeteners (NNSs) [15,16,33–36].

NNS consumption is growing in high-income countries, but it is less clear what will happen in low- and middle-income countries, where consumption of diet beverages is minimal [36]. The Mexican and Berkeley evaluations found a shift toward water [37,38]. The few studies in low-income countries have found a small movement toward NNS-sweetened beverages [39], but that might change with large tax rates on SSBs or ultraprocessed foods.

So why the concern around NNSs? One fear is the impact on sweetness preference and habituation among children. Among adults, we see different outcomes in widely conflicting human studies looking at gut health, brain response, and heart health [40–43]. At present, no global consensus on the longer-term health implications of prolonged and/or larger doses of NNS intake exists. The dearth of information on their use (the types and amounts) in our food supply means that it is challenging to study these questions.

A few Latin American countries are exploring front of package labeling to inform consumers if products contain NNSs. Additional information on the amounts of the various NNSs will allow monitoring of our exposure to these additives and population-based observational studies on health outcomes of the types and amounts of NNSs in diets. Currently, Chile is the only country, to our knowledge, that requires the amount of each type of NNS on nutrition labels.

Of course, the food industry constantly undertakes research and development, and the scientific community's understanding of how the various combinations of foods, ingredients, and chemicals we are exposed to affects our health over time is still growing. Any new regulations targeting current attributes of concern will meet subsequent introductions of new ingredients and products to avoid or minimize such regulations. Researchers and regulatory agencies must be vigilant and thoughtful in establishing mechanisms with which to periodically assess and improve these regulations to ensure that they evolve with the food landscape to best protect people's health.

### Conclusions

Taxation of SSBs is an important start to using fiscal policy to correct the large human and planetary costs of the modern food supply chain and promote improved diet and eventually health [44]. SSB taxes to date have varied in design, and continued assessments can allow us to better understand how to improve them to sharpen their effects. To date, tax rates are often too low, and the net impact, while important for public health, needs to be increased significantly. Increasing SSB taxation levels or expanding the tax base to include unhealthy

ultraprocessed foods and beverages offer options. Additionally, the tax revenues should be directed toward human capital investments, particularly those targeting lower-income individuals or households, to address equity concerns and strengthen public support. Regardless, careful monitoring of industry responses to taxes is important due to industry investments in new food technologies with unknown, longer-term implications on human and planetary health.

## References

1. Global Food Research Program. Sugary drink taxes around the world. Chapel Hill; 2020. <https://doi.org/10.17615/2x4b-sr12>
2. World Cancer Research Fund International. Curbing global sugar consumption: Effective food policy actions to help promote healthy diets and tackle obesity 2015. London: World Cancer Research Fund International; 2015.
3. Malik VS, Hu FB. Sugar-Sweetened Beverages and Cardiometabolic Health: An Update of the Evidence. *Nutrients*. 2019; 11(8). Epub 2019 Aug 11. <https://doi.org/10.3390/nu11081840> PMID: [31398911](https://pubmed.ncbi.nlm.nih.gov/31398911/); PubMed Central PMCID: PMC6723421.
4. World Health Organization. Global Health Observatory (GHO) data: Raised blood pressure. Geneva; 2019.
5. DiMeglio DP, Mattes RD. Liquid versus solid carbohydrate: effects on food intake and body weight. *Int J Obes Relat Metab Disord*. 2000; 24(6):794–800. <https://doi.org/10.1038/sj.ijo.0801229> PMID: [10878689](https://pubmed.ncbi.nlm.nih.gov/10878689/)
6. 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(11):1688–95. Epub 2007 Jun 21. <https://doi.org/10.1038/sj.ijo.0803667> PMID: [17579632](https://pubmed.ncbi.nlm.nih.gov/17579632/).
7. Jaacks LM, Kavle J, Perry A, Nyaku A. Programming maternal and child overweight and obesity in the context of undernutrition: current evidence and key considerations for low- and middle-income countries. *Public Health Nutr*. 2017; 20(7):1286–96. Epub 2017 Jan 9. <https://doi.org/10.1017/S1368980016003323> PMID: [28065195](https://pubmed.ncbi.nlm.nih.gov/28065195/)
8. Audain K, Levy L, Ellahi B. Sugar-sweetened beverage consumption in the early years and implications for type-2 diabetes: a sub-Saharan Africa context. *Proc Nutr Soc*. 2019; 78(4):547–53. Epub 2019 Mar 1. <https://doi.org/10.1017/S0029665118002860> PMID: [30816084](https://pubmed.ncbi.nlm.nih.gov/30816084/).
9. Pries AM, Rehman AM, Filteau S, Sharma N, Upadhyay A, Ferguson EL. Unhealthy Snack Food and Beverage Consumption Is Associated with Lower Dietary Adequacy and Length-for-Age z-Scores among 12-23-Month-Olds in Kathmandu Valley, Nepal. *J Nutr*. 2019; 149(10):1843–51. Epub 2019 Jul 17. <https://doi.org/10.1093/jn/nxz140> PMID: [31309223](https://pubmed.ncbi.nlm.nih.gov/31309223/); PubMed Central PMCID: PMC6768809.
10. Pries AM, Filteau S, Ferguson EL. Snack food and beverage consumption and young child nutrition in low- and middle-income countries: A systematic review. *Matern Child Nutr*. 2019; 15(Suppl 4):e12729. Epub 2019 Jun 22. <https://doi.org/10.1111/mcn.12729> PMID: [31225715](https://pubmed.ncbi.nlm.nih.gov/31225715/); PubMed Central PMCID: PMC6618154.
11. Nordhagen S, Pries AM, Dissieka R. Commercial Snack Food and Beverage Consumption Prevalence among Children 6–59 Months in West Africa. *Nutrients*. 2019; 11(11). Epub 2019 Nov 14. <https://doi.org/10.3390/nu11112715> PMID: [31717487](https://pubmed.ncbi.nlm.nih.gov/31717487/); PubMed Central PMCID: PMC6893794.
12. Erzin AE, Aldaya MM, Hoekstra AY. Corporate Water Footprint Accounting and Impact Assessment: The Case of the Water Footprint of a Sugar-Containing Carbonated Beverage. *Water Resour Manag*. 2011; 25(2):721–41. <https://doi.org/10.1007/s11269-010-9723-8>
13. Hoekstra AY, Chapagain AK. Water footprints of nations: Water use by people as a function of their consumption pattern. *Water Resour Manag*. 2007; 21(1):35–48. <https://doi.org/10.1007/s11269-006-9039-x>
14. Hoekstra AY. *The Water Footprint of Modern Consumer Society*. London: Routledge; 2013.
15. Bandy LK, Scarborough P, Harrington RA, Rayner M, Jebb SA. Reductions in sugar sales from soft drinks in the UK from 2015 to 2018. *BMC Med*. 2020; 18(1):20. <https://doi.org/10.1186/s12916-019-1477-4> PMID: [31931800](https://pubmed.ncbi.nlm.nih.gov/31931800/)
16. Goiana-da-Silva F, Cruz ESD, Gregório MJ, Miraldo M, Darzi A, Araújo F. The future of the sweetened beverages tax in Portugal. *Lancet Public Health*. 2018; 3(12):e562. Epub 2018 Dec 14. [https://doi.org/10.1016/S2468-2667\(18\)30240-8](https://doi.org/10.1016/S2468-2667(18)30240-8) PMID: [30522681](https://pubmed.ncbi.nlm.nih.gov/30522681/).
17. Goiana-da-Silva F, Severo M, Cruz ESD, Gregório MJ, Allen LN, Muc M, et al. Projected impact of the Portuguese sugar-sweetened beverage tax on obesity incidence across different age groups: A

- modelling study. *PLoS Med.* 2020; 17(3):e1003036. Epub 2020 Mar 13. <https://doi.org/10.1371/journal.pmed.1003036> PMID: 32163412; PubMed Central PMCID: PMC7067376.
18. Reyes M, Smith Taillie L, Popkin B, Kanter R, Vandevijvere S, Corvalán C. Changes in the amount of nutrient of packaged foods and beverages after the initial implementation of the Chilean Law of Food Labelling and Advertising: A nonexperimental prospective study. *PLoS Med.* 2020; 17(7):e1003220. <https://doi.org/10.1371/journal.pmed.1003220> PMID: 32722710
  19. Taillie LS, Reyes M, Colchero MA, Popkin B, Corvalán C. An evaluation of Chile's Law of Food Labeling and Advertising on sugar-sweetened beverage purchases from 2015 to 2017: A before-and-after study. *PLoS Med.* 2020; 17(2):e1003015. <https://doi.org/10.1371/journal.pmed.1003015> PMID: 32045424
  20. Salgado JC, Ng SW. Understanding heterogeneity in price changes and firm responses to a national unhealthy food tax in Mexico. *Food Policy.* 2019; 89:101783. <https://doi.org/10.1016/j.foodpol.2019.101783> PMID: 32489228
  21. Cawley J, Thow AM, Wen K, Frisvold D. The Economics of Taxes on Sugar-Sweetened Beverages: A Review of the Effects on Prices, Sales, Cross-Border Shopping, and Consumption. *Annu Rev Nutr.* 2019; 39:317–38. Epub 2019 May 23. <https://doi.org/10.1146/annurev-nutr-082018-124603> PMID: 31116649.
  22. Ng SW, Rivera JA, Popkin BM, Colchero MA. Did high sugar-sweetened beverage purchasers respond differently to the excise tax on sugar-sweetened beverages in Mexico? *Public Health Nutr.* 2018:1–7. Epub 2018 Dec 19. <https://doi.org/10.1017/S136898001800321X> PMID: 30560754; PubMed Central PMCID: PMC6581622.
  23. Colchero MA, Rivera-Dommarco J, Popkin BM, Ng SW. In Mexico, Evidence Of Sustained Consumer Response Two Years After Implementing A Sugar-Sweetened Beverage Tax. *Health Affairs.* 2017; 36(3):564–71. <https://doi.org/10.1377/hlthaff.2016.1231> PMID: 28228484
  24. Teng AM, Jones AC, Mizdrak A, Signal L, Genç M, Wilson N. Impact of sugar-sweetened beverage taxes on purchases and dietary intake: Systematic review and meta-analysis. *Obes Rev.* 2019; 20(9):1187–204. <https://doi.org/10.1111/obr.12868> PMID: 31218808
  25. Alvarado M, Unwin N, Sharp SJ, Hambleton I, Murphy MM, Samuels TA, et al. Assessing the impact of the Barbados sugar-sweetened beverage tax on beverage sales: an observational study. *Int J Behav Nutr Phys Act.* 2019; 16(1):13. <https://doi.org/10.1186/s12966-019-0776-7> PMID: 30700311
  26. Taillie LS, Rivera JA, Popkin BM, Batis C. Do high vs. low purchasers respond differently to a nonessential energy-dense food tax? Two-year evaluation of Mexico's 8% nonessential food tax. *Prev Med.* 2017; 105s:S37–S42. Epub 2017 Jul 22. <https://doi.org/10.1016/j.ypmed.2017.07.009> PMID: 28729195; PubMed Central PMCID: PMC5732875.
  27. Barrientos-Gutierrez T, Zepeda-Tello R, Rodrigues ER, Colchero-Aragón A, Rojas-Martínez R, Lazcano-Ponce E, et al. Expected population weight and diabetes impact of the 1-peso-per-litre tax to sugar sweetened beverages in Mexico. *PLoS ONE.* 2017; 12(5):e0176336. <https://doi.org/10.1371/journal.pone.0176336> PMID: 28520716
  28. Sánchez-Romero LM, Penko J, Coxson PG, Fernández A, Mason A, Moran AE, et al. Projected Impact of Mexico's Sugar-Sweetened Beverage Tax Policy on Diabetes and Cardiovascular Disease: A Modeling Study. *PLoS Med.* 2016; 13(11):e1002158. <https://doi.org/10.1371/journal.pmed.1002158> PMID: 27802278
  29. Alsukait R, Bleich S, Wilde P, Singh G, Folta S. Sugary drink excise tax policy process and implementation: Case study from Saudi Arabia. *Food Policy.* 2020; 90:101789. <https://doi.org/10.1016/j.foodpol.2019.101789>
  30. Pfinder M, Heise TL, Hilton Boon M, Pega F, Fenton C, Griebler U, et al. Taxation of unprocessed sugar or sugar-added foods for reducing their consumption and preventing obesity or other adverse health outcomes. *Cochrane Database Syst Rev.* 2020;(4). <https://doi.org/10.1002/14651858.CD012333.pub2> CD012333. PMID: 32270494
  31. The World Bank. Curbing the epidemic: governments and the economics of tobacco control. *Tobacco Control.* 1999; 8(2):196–201. <https://doi.org/10.1136/tc.8.2.196> PMID: 10478406
  32. World Health Organization. WHO report on the global tobacco epidemic, 2017: monitoring tobacco use and prevention policies. Geneva, Switzerland: World Health Organization; 2017.
  33. 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. Epub 2013 Mar 27. <https://doi.org/10.1111/j.2047-6310.2013.00153.x> PMID: 23529974; PubMed Central PMCID: PMC3711951.
  34. Scarborough P, Adhikari V, Harrington RA, Elhussein A, Briggs A, Rayner M, et al. Impact of the announcement and implementation of the UK Soft Drinks Industry Levy on sugar content, price, product size and number of available soft drinks in the UK, 2015–19: A controlled interrupted time series analysis. *PLoS Med.* 2020; 17(2):e1003025. <https://doi.org/10.1371/journal.pmed.1003025> PMID: 32045418

35. Dunford EK, Taillie LS, Miles DR, Eyles H, Tolentino-Mayo L, Ng SW. Non-Nutritive Sweeteners in the Packaged Food Supply-An Assessment across 4 Countries. *Nutrients*. 2018; 10(2). Epub 2018 Mar 3. <https://doi.org/10.3390/nu10020257> PMID: 29495259; PubMed Central PMCID: PMC5852833.
36. Popkin BM, Hawkes C. Sweetening of the global diet, particularly beverages: patterns, trends, and policy responses. *Lancet Diabetes Endocrinol*. 2016; 4(2):174–86. Epub 2015 Dec 15. [https://doi.org/10.1016/S2213-8587\(15\)00419-2](https://doi.org/10.1016/S2213-8587(15)00419-2) PMID: 26654575; PubMed Central PMCID: PMC4733620.
37. 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. <https://doi.org/10.1136/bmj.h6704> PMID: 26738745
38. Silver LD, Ng SW, Ryan-Ibarra S, Taillie LS, Induni M, Miles DR, et al. Changes in prices, sales, consumer spending, and beverage consumption one year after a tax on sugar-sweetened beverages in Berkeley, California, US: A before-and-after study. *PLoS Med*. 2017; 14(4):e1002283. Epub 2017 Apr 19. <https://doi.org/10.1371/journal.pmed.1002283> PMID: 28419108; PubMed Central PMCID: PMC5395172.
39. Caro JC, Corvalán C, Reyes M, Silva A, Popkin B, Taillie LS. Chile's 2014 sugar-sweetened beverage tax and changes in prices and purchases of sugar-sweetened beverages: An observational study in an urban environment. *PLoS Med*. 2018; 15(7):e1002597. <https://doi.org/10.1371/journal.pmed.1002597> PMID: 29969444
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(6):1321–7. Epub 2011 Mar 25. <https://doi.org/10.3945/ajcn.110.007922> PMID: 21430119; PubMed Central PMCID: PMC3095502.
41. Lutsey Pamela L, Steffen Lyn M, Stevens J. Dietary Intake and the Development of the Metabolic Syndrome. *Circulation*. 2008; 117(6):754–61. <https://doi.org/10.1161/CIRCULATIONAHA.107.716159> PMID: 18212291
42. 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(4):909–15. Epub 2012 Mar 2. <https://doi.org/10.3945/ajcn.111.026682> PMID: 22378729; PubMed Central PMCID: PMC3302365.
43. de Koning L, Malik Vasanti S, Kellogg Mark D, Rimm Eric B, Willett Walter C, Hu Frank B. Sweetened Beverage Consumption, Incident Coronary Heart Disease, and Biomarkers of Risk in Men. *Circulation*. 2012; 125(14):1735–41. <https://doi.org/10.1161/CIRCULATIONAHA.111.067017> PMID: 22412070
44. Griffith R, O'Connell M, Smith K. Corrective Taxation and Internalities from Food Consumption. *CESifo Econ Stud*. 2017; 64(1):1–14. <https://doi.org/10.1093/cesifo/ifx018>