A systematic review of the effectiveness of taxes on nonalcoholic beverages and high-in-fat foods as a means to prevent obesity trends

Nikolaos Maniadakis¹
Vasiliki Kapaki¹,²
Louiza Damianidi³
Georgia Kourlaba⁴

¹Department of Health Services Organization and Management, National School of Public Health, Athens, ²University of Peloponnese, Peloponnese, ³Department of Allergy, Second Pediatric Clinic, National and Kapodistrian University of Athens School of Medicine, Athens, ⁴The Stavros Niarchos Foundation – Collaborative Center for Clinical Epidemiology and Outcomes Research (CLEO), First and Second Departments of Pediatrics, National and Kapodistrian University of Athens School of Medicine, Athens, Greece

Background: As part of the efforts to curb obesity, a new focus seems to be put on taxing foods that are perceived as being associated with obesity (eg, sugar-sweetened beverages and foods high in fat, sugar, and salt content) as a policy instrument to promote healthier diets.

Objective: To assess the possible effects of such taxation policies by identifying and analyzing all studies which investigate the impact of price increases on consumption, caloric intake, or weight outcomes.

Methods: Electronic databases were searched with appropriate terms and their combinations. Thereafter, abstracts were reviewed and studies were selected based on predefined criteria. The characteristics of the selected studies and the results were extracted in a special form and consequently were reviewed and synthesized.

Results: Price increase may lead to a reduction in consumption of the targeted products, but the subsequent effect on caloric intake may be much smaller. Only a limited number of the identified studies reported weight outcomes, most of which are either insignificant or very small in magnitude to make any improvement in public health.

Conclusion: The effectiveness of a taxation policy to curb obesity is doubtful and available evidence in most studies is not very straightforward due to the multiple complexities in consumer behavior and the underlying substitution effects. There is need to investigate in-depth the potential underlying mechanisms and the relationship between price-increase policies, obesity, and public health outcomes.

Keywords: price, fat tax, sugar-sweetened beverages, calorie(s), elasticity, weight, body mass index

Introduction

Obesity prevalence is increasing worldwide, affecting both developed and developing countries. The prevalence of overweight and obese adults was estimated at 1.5 billion globally in 2008 by the World Health Organization, and this figure is projected to reach 2.3 billion by 2015.¹ There is accumulated scientific evidence indicating that obesity is strongly related to a vast number of diseases, including hypertension, hypercholesterolemia, type 2 diabetes mellitus, respiratory conditions, arthritis, and certain types of cancer. Moreover, obesity reduces the quality of life of individuals.²

Along with morbidity and mortality, obesity also imposes a great economic burden upon society, which stems from the resources expended in the health care system to manage it, the expenditures incurred by sufferers and their families to cope with its consequences, and also the lost production caused by informal care, premature death, and inability to work.³ Several studies in European countries estimate the health...
care-related costs of obesity at 1.7%–3.0% of total health expenditure,3 while in the USA, it has been estimated that obesity accounts for almost 5%–10% of the total health care expenditure.4 At the individual level, studies indicate that an obese person incurs health care expenditures at least 25% higher than those of a normal-weight person.5,6 On the other hand, indirect cost, ie, increased production as a result of a health condition, is also significant. Notably, employers in some countries often pay higher insurance premiums for employees who are obese in comparison to employees who are not.7 In this context, some studies have also shown that obesity is associated with lower wages and lower household income.5,9 In this light, obesity constitutes a growing public health problem and concern throughout the world. Therefore, strategies aiming to prevent obesity are of paramount importance for both health and economic reasons.

Several factors have been linked to obesity, including socioeconomic, environmental, behavioral, and genetic. Total energy intake increase in conjunction with physical activity decrease has been indicated as a contributor to the obesity trend.10 In this context, it has been argued that overconsumption of sugar-sweetened beverages (SSBs) and high-in-fat, salt, and sugar foods (HFSSFs) may be associated with excess caloric intake and eventually increases in body weight.11,12 Thus, some authors suggest that mediating consumption of SSBs and HFSSFs in populations that exhibit relatively excess consumption rates could prove an effective intervention in reducing subsequently obesity rates.10 In this context, taxes on HFSSFs and SSBs, often called “fat or sugar taxes,” have been introduced or are being considered in several countries as a means to regulate the consumption of these products and eventually to curb obesity, to trim health care costs, to raise revenue, and ultimately improve public health.13 On the other hand, a number of countries have abandoned the policy route of taxing foods either by abolishing existing taxes, eg, Denmark and the Netherlands, or by shelving respective ideas, eg, Italy.14

In any case, such taxes have provoked considerable controversy among the various stakeholders: the government, academic, scientific, health, and medical communities, consumers and their associations, and the food industry. Based on economic theory, the main rationale underpinning the adoption of such policies is that a tax and price increase on the targeted products may avert consumers from their consumption and divert them to healthier alternatives, and in this way there may be improvements in diet quality, weight status, and health outcomes in the long-term. Supporters of the fat taxation often also emphasize its signaling power to the food industry and consumers and its efficiency in raising revenue.15

On the other hand, opponents of such taxes argue that there are many factors which make such policies ineffective and even detrimental in certain circumstances.16 Firstly, interventions of these kinds of taxes/policies represent a violation of consumer sovereignty, ie, the freedom of individuals to choose freely for themselves in order to satisfy their needs. Regardless, it is difficult to attain the desired results because consumer behavior is complex and multifactorial and there are notable substitution effects which make the reduction in total energy intake by specific taxes unattainable. Taxes are also regressive in nature and the burden is proportionally higher on lower-income households, which generates significant equity concerns. Also, the approach presumes well-informed and price-sensitive consumers, which is not always the case, and hence there is a market failure that makes the specific policy ineffective. Therefore, many commentators argue that the aim of improving public health is unquestionably important, but taxes may not be the most appropriate policy measure to attain it.13

Hence, given the controversy around this issue, a systematic review was undertaken to synthesize the results of original studies examining the possible impact of tax policies and price increases upon the consumption of SSBs and HFSSFs and eventually upon caloric intake, weight, and outcomes in order to provide useful insights for decision makers and other stakeholders nationally and internationally.

Methods

Search strategy

Research papers were identified through web-based searches in PubMed, Web of Science, Cochrane Library, AgEcon, EconLit, and the National Agricultural Library databases and searches in other potentially relevant internet sources such as Google. Searching in the aforementioned bibliographical databases was conducted in the title and abstract on grounds of all potential combinations of three groups of terms presented in Figure 1. The reference lists of all relevant papers originally selected for inclusion in the review and relevant reviews were also searched manually to identify potentially relevant articles which were not identified by the original electronic search. The search spanned from 1990 to February 2013. The stated aim of this fiscal measure was not only to offset this price imbalance but also—as is often the case with excise taxation—to raise revenue, in particular to collect resources to be invested in nutrition programs.17,18
Study selection and data extraction

Following the literature search, identified studies were checked to exclude duplicates. The remaining articles were independently screened by two researchers to identify studies that met the predetermined inclusion criteria. Original studies including the four types of primary research methods – existing data, experiments, surveys, and observation – that focused on the association between SSBS and HFSSFs prices and taxes and their corresponding consumption or energy intake or obesity-related outcomes were included in the present systematic review. On the other hand, systematic reviews, meta-analyses, qualitative studies, case studies, case reports, and letters to the editor were excluded. Moreover, only studies published in English with available full text and studies concerning human subjects were included.

The studies were selected following specific methodologically driven steps. Firstly, all identified studies were imported electronically into EndNote® bibliographic database (Thomson Reuters, New York, NY, USA) and were evaluated on the basis of titles and/or abstracts against the prespecified eligibility criteria. A check for double entries among the selected studies was made to ensure that the list contained unique studies for review. Subsequently, study abstracts and titles were reviewed and those which were deemed irrelevant were excluded and reasons for exclusion were noted. Obviously, rejected studies were those clearly not relevant to the subject of investigation. Whenever the information provided in titles/abstracts was insufficient to reach a clear decision on inclusion or exclusion or when the titles/abstracts indicated that studies met the inclusion criteria, the full papers were retrieved to be further screened. In cases where the information reported in the full text continued to be insufficient to make a decision about inclusion, studies were excluded. Then, essential details and data of studies meeting the inclusion criteria were extracted by two researchers into a spreadsheet and were classified according to their design – demand modeling, cross-sectional, longitudinal, mathematical modeling, cohort retrospective, and experimental. The overall study selection process was also documented through a flow chart showing the number of studies/papers remaining at each stage, although a screening process to identify articles using the studies bibliography had been done. The review was based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) criteria.

Results

The initial literature review identified 3,700 citations for screening. Of these, 3,250 were excluded on the basis of title/abstract and 395 after screening the full paper. Subsequently, a total of 55 were finally included in the review (Figure 2).

In terms of geographical location, most of the studies were conducted in the USA (n = 40) and the remaining in the UK (n = 2), Norway, Italy (n = 2), Denmark, Germany, France, the Netherlands, Mexico (n = 2), Brazil, Taiwan, Singapore, and Australia. In terms of methodologies utilized, there was significant variation in terms of the research designs applied. In particular, there were several demand studies (n = 22), followed by longitudinal studies (n = 11), cross-sectional studies (n = 11), modeling studies (n = 6), experimental studies (n = 4), and cohort studies (n = 1). The majority of the studies were mainly focused on estimating price elasticity of demand (n = 30), others mainly focused on the effects of imposing certain taxation (n = 18), and the remaining studies considered both elements (n = 8). Health-related food taxes...
were either considered as excise or sales taxes. In terms of the targeted products, about half (n = 28) of the studies focused on SSBs only and the remaining (n = 36) either on HFSSFs alone or on HFSSFs in conjunction with SSBs.

In terms of the main outcomes considered, about half of the studies (n = 24) were concerned mainly with the effects of various interventions upon the consumption of products and the remaining (n = 31) upon other outcomes such as energy intake and/or weight and/or body mass index (BMI). Notably, some studies reported results for all three outcomes of interest: energy intake, weight, and BMI.

The studies considered are presented in the Supplementary material. In particular, among the demand studies, nine presented the association between prices and taxes with the consumption of SSBs and three with the consumption of HFSSFs. These studies indicated that the price elasticity of demand for beverages is in the range of −0.5 to −1.6 depending on the beverage considered, with most of them falling below 1.0. This implies that the percentage changes in the quantities demanded were proportionally lower than the corresponding changes in prices. It should be noted that there was a lot of variation across the studies. There were also notable substitution effects detected between different products. The studies also pointed out that the negative effects on the consumption by price increases and taxes depend on factors such as the income group, and are more regressive towards the lowest income categories. Similar effects were found in the studies that focused on foods, also indicating a small or modest impact from price increase and taxes on the consumption of the targeted foods.

Moreover, six studies and five studies examined the association between beverage/food prices and taxes and energy and weight outcomes, respectively. These studies indicated that there is a very small impact of prices and taxes on energy intake and weight outcomes. These studies indicated that the caloric effect of a 10% increase in prices or a corresponding imposition of a tax reduces energy intake by a maximum of 50 calories per day, 450 per month, and up to 0.3 kilograms or 1.5 pounds per year, which cannot be considered significant. The specific studies also indicated the regressive nature of taxes and that their use is promoted mostly in order to generate revenue for the public purse.

Two studies assessed the effect of prices and taxes on the consumption of beverages and foods based on longitudinal studies. These studies indicated that the price elasticity of demand for beverages and foods is in the range of −0.05 to −0.35 depending on the beverage and food considered. Notably, the figures reported are much lower than those reported in demand studies. The findings in this group of studies also indicated that there are negative effects on consumption in most cases, which are more significant in certain groups, eg, overweight.

All studies investigated the effect of beverages/food prices or taxes with possible outcomes. For two studies, the outcome was energy intake, while for 16 studies, weight outcomes were considered. Elasticities were low and in some cases not significant, and results were heterogeneous and dependent on income, weight, sex, and age group. Notwithstanding the above, these studies indicated that there is a modest and insignificant impact from price increases and taxes on energy intake, weight, and BMI, which makes the authors argue that any taxes would have to be quite large to generate any meaningful effect. These studies also highlighted the regressive nature of taxes and that their usefulness is to mostly generate revenue.

Barquera et al and Claro et al examined the effect of prices on beverages consumption; Sturm and Datar examined the effect on food consumption only. However, elasticities on this occasion for beverages and foods were a bit contradictory. A Mexican and a Brazilian study derived elasticities for sodas to be about −1.0, indicating that soda consumption is elastic whilst other beverages are in the inelastic range. By contrast, a USA study indicated that the elasticity of fast foods and soda in students is inelastic and effects of prices are inconsistent and marginal.

Moreover, six cross-sectional studies examined the association between prices and energy outcomes, while two other studies examined the association between prices and weight outcomes. The majority of the studies concluded that taxes are having trivial or modest effects on weight outcomes. These studies also indicated the regressive nature of taxes and that their use is mostly to generate revenue.

Some of the studies included in the review conducted behavioral experiments in the Netherlands, Taiwan, Singapore, and the USA. Particularly, four studies reported results on the effects of prices and taxes on the consumption and other outcomes of beverages and foods, respectively. Elasticities on this occasion between beverages and food were close to −1.0, ie, the association is in the elastic range. The effect on caloric intake and weight outcomes was higher in other studies, assumedly due to much higher taxes in the range of 35%–50%.

Finally, six of the 55 studies reviewed were modeling studies undertaken in the USA (n = 3), UK (n = 2), and Australia (n = 1). Two of them used cross-sectional data and the others were based on census data.
Discussion

The current study presents the results of a literature review undertaken to establish whether the available evidence supports use of fat taxes as a means to improve weight and health outcomes. The existing literature fails to draw consistent and undisputed evidence on the effectiveness of pricing and tax policies to reduce obesity rates. The heterogeneity observed in the findings of the included studies could be partially explained by the significant heterogeneity in policy settings and study designs employed to investigate the issue. It is evident that price and tax increases on beverages and fatty foods may reduce their consumption. However, there is controversy as to whether this also may result in meaningful reductions in caloric intake and weight. The studies that show some positive impact of economic policies also indicate that any potential reductions in weight are statistically insignificant to trigger desired effects. Moreover, elasticities indicate that significant weight outcome effects may be reached with very large tax rates, which would, however, exacerbate equity concerns related to their adverse implications for low-income groups.

At this point it should be noted that there are several important factors – obesity prevalence, consumption levels, behavioral patterns, and baseline tax rate – that should be considered within local contexts when contemplating the potential benefits of taxation.66 When any of these factors shift, the potential impact of fat taxation becomes less certain and unpredictable. However, it is very difficult to estimate how a population would respond to a tax on certain foods.57 Some consumers may respond by reducing their consumption of fruits and vegetables in order to pay for the more expensive HFSSFs, thus defeating the purpose of the tax. Others may seek substitutes for the taxed products, which may have similar or even higher fat, sugar, or salt content than the taxed products originally consumed. Thus, although there may be a decrease in the purchasing of the taxed food, consumers may end up consuming the same or even more calories from other substitute foods or drinks. This is in accordance with the findings of many studies in the literature.57,68–72

Moreover, to effectively apply policies to reduce consumption of high-calorie, high-fat, or high-carbohydrates foods, policy analysts need to disaggregate food-specific demand estimates according to socioeconomic status and assess the possible impacts of policy changes on food consumption and welfare outcomes at a more disaggregated level in addition to the total effects. This could be explained by the fact that the expenditure shared for food and consumption behaviors may differ significantly among different socioeconomic groups.73 The Organization for Economic Co-operation and Development in 2010 reported that the impact of fiscal measures aiming to change behaviors may be unpredictable; because the price elasticity of demand varies across individuals and population groups, these measures can bear more heavily on low-income groups than on those with higher incomes, and substitution effects are not always obvious.74 Further to considering the above, one needs to consider which products will be the targets of intervention.

Moreover, in regard to SSBs, the association between their consumption and overweight is a complex metabolic relationship and there are many behavioral and environmental factors that may be influencing beverage and food consumption and weight. Many of the food tax policies implemented are focusing on soft drinks as a number of influential reports assert that sugary drinks play a key role in the etiology of obesity. Contrary to this premise, a 2012 report from the National Center for Health Statistics, US Centers for Disease Control and Prevention examined data on consumption of added sugars among US children and adolescents and reported that added sugar from food (59%) was higher than sugar from beverages (41%).75 Moreover, research published in 2010 from Queen Margaret University, Edinburgh, UK, shows that SSBs consumed in moderate quantities do not promote short-term weight gain, do not trigger additional carbohydrate intake, and do not generate changes in the moods of overweight women.76

In 2007, there was a similar study performed on average-weight women and came out with similar conclusions.77 Hence, evidence suggests that the hypothetic contribution of SSBs on weight gain perhaps has been overestimated.78–80

Moreover, broader taxes on HFSSFs would possibly allow less substitution than narrow taxes.81 However, a concern with taxing a wide range of products would be the fact that people should be encouraged to consume a wide range of food and beverage products, eg, milk and olive oil, that would be difficult to include in the tax category.82 Furthermore, in some cases, taxing many food groups could possibly lead to nutrient deficiencies, in which case economic policies may have harmful nutritional and health effects.83,84

Based on the above, there is no doubt that a public health approach to develop population-based strategies for the prevention of excess weight gain is of great importance.85,84 Some effective strategies involve changes to personal, environmental, and socioeconomic factors associated with obesity. A proposed framework by Sacks et al85 suggests that policy actions on the development and implementation of effective public health strategies on obesity prevention should (1) deal with the food environments, the physical activity environments, and the
broader socioeconomic environments; (2) directly influence behavior, aiming at improving eating and physical activity behaviors; and (3) support health services and clinical interventions. There are abundant examples of the effectiveness of such measures.\textsuperscript{85-95} Lastly, a number of barriers to an effective obesity management program have been identified in the literature that policy makers need to be aware of in order to address them adequately.\textsuperscript{96-107} However, the development and implementation of obesity prevention strategies should target those factors that can effectively control obesity.

For instance, in Greece it is proven that obesity is a growing health problem and concern. However, there is accumulating evidence indicating that SSBs may not be a determinant of obesity in Greece. For instance, a 2006 study examined energy intake, energy expenditure, diet composition, and obesity of adolescents in Northern Greece, and showed that cola drink consumption did not significantly differ between overweight and non-overweight adolescents.\textsuperscript{108} Additionally, in another recent study in children aged 10–12 years old, it was found that although Spain and Greece had the highest obesity rates among the European countries examined, they also had the lowest soft drink daily consumption.\textsuperscript{109} It is important to note, however, that Greek children had lower physical activity levels and were reported to skip breakfast more often than their counterparts in other countries.\textsuperscript{109} Finally, the European Prospective Investigation into Cancer and Nutrition (EPIC) study showed that Greek adults over 35 years have the lowest consumption of sugar among the European countries that participated in the research program. Additionally, in the same study, it was also shown that nonalcoholic and carbonated drinks contribute a minor percentage of total carbohydrate daily intake – indicatively 2.8% of total carbohydrate intake in men and 1.8% of total carbohydrate intake in women – and an even lower percentage of total energy daily intake.\textsuperscript{110} The above data suggest that soft drink consumption may be a minor contributor to energy and carbohydrate intake in Greece in children, adolescents, and adults. The high obesity phenomenon in Greece is probably due to excess fat consumption in combination with lack of exercise. Therefore, targeting SSBs for obesity management or prevention in Greece is not an effective approach to curtail obesity epidemic trends. Proper policies and interventions need to be designed based on the grounds of this local evidence.

The results of this review must be interpreted cautiously. First of all, in many studies, transformation of consumption figures to energy and weight outcomes was often based on extrapolation models, which require careful consideration. Caution must be directed to the model that is used to translate energy intake changes to weight changes. Using static weight models may provide quite different estimates in comparison to dynamic weight models. Static models generate a linear reduction in body weight over time, based on the assumption that every pound in weight reduction accounts for almost 3,500 calories, which is an assumption that has been challenged in the literature, and if not true undermines many findings. On the other hand, dynamic models account for the effects of weight loss by assuming changes in energy requirements due to weight reduction and fat and lean mass proportion, but they also involve various assumptions.\textsuperscript{35} Secondly, when weight outcomes in certain studies are obtained directly and not through modeling, it is important to consider whether the measurements were obtained with objective assessments or were based on self-reporting.

Thirdly, in regards to the estimation of caloric intake effects, it is important to consider whether any potential changes are referring to energy intake related to the targeted product taxed or to the total energy intake in general. Due to the substitution effects, the total outcome is far more interesting from a policy perspective. Additionally, when total energy intake is considered, it is essential to clarify how it was estimated and whether possible substitution was taken into account as there are strong substitution dynamics between different foods. For instance, a soft drink tax may lead to reduction in calories due to consumption of soft drinks, but this reduction may be completely offset by the increase in the consumption of milk.\textsuperscript{56}

Last but not least, in some studies, the populations investigated were not representative or adequately described and the studies have been undertaken in specific settings, which are difficult to extrapolate to European populations and policy environments in light of the fact that results are dependent on population behavioral aspects.

**Conclusion**

The systematic review of the literature demonstrated that the effect of price and tax increase upon the consumption of SSBs and HFSSFs and eventually upon caloric intake and obesity-related outcomes is controversial. To be more precise, there is strong evidence that such measures influence the consumption of SSBs and HFSSFs, but there is no significant effect on obesity-related outcomes, ie, weight, BMI, and obesity. Thus, more research is needed in this area to gain better insights on the use of economic policies aimed at addressing obesity trends, especially from a European perspective. Moreover, when considering environmental, socioeconomic, and genetic contributors to obesity, it is advisable that policies focus first on...
cognitive behavioral changes and then on environmental factors. Such policies would create conscious people who are aware of the obesity problem and the main cause of weight gain, which is energy imbalance, and also its possible solutions, including encumbrances due to genetic or habitual factors.

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The authors report no conflicts of interest in this work.

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### Supplementary material

#### Table S1: Studies on price and tax interventions and their effects on different outcomes

| Authors          | Objectives                                                                 | ◊ Country / Products | Data/population                                                                 | Price/tax variable       | Results                                                                 | Conclusion                                                                 |
|------------------|------------------------------------------------------------------------------|----------------------|---------------------------------------------------------------------------------|--------------------------|--------------------------------------------------------------------------|----------------------------------------------------------------------------|
| **DEMAND STUDIES ON CONSUMPTION OF BEVERAGES** | | | | | | |
| Gustavsen et al³ | Explore sodas purchasing and factors influencing demand; the effect of price changes due to tax on consumers; model demand; analyze policies | ◊ Norway             | Cross sectional samples from the household expenditure surveys of Statistic Norway (1989–1999) with 14,000 observations from 1,200–1,400 households; prices from CPI monthly index | 10.8% price increase due to tax; 7.3% price increase due to tax; Use of Swedish prices that are 29.8% lower | −5.1 L/year/capita<sup>16</sup> (−9.5%<sup>16</sup>); −12.9 L/year/capita<sup>16</sup> (−24%<sup>16</sup>); 10.2 L/year/capita<sup>16</sup> (19.1%<sup>16</sup>) | Taxes on carbonated soft drinks lead to a small reduction in the consumption for small and moderate consumers, and larger one for heavy consumers |
| Yen et al<sup>2</sup> | Investigate the effects of economic policies and other variables on household beverage consumption | ◊ USA               | Cross sectional samples of 908 households from a nationally representative sample coming from the National Food Stamp Program Survey (1996–1997) | Price elasticity of demand | Uncompensated elasticities: soft drinks, −0.80<sup>6</sup>; juice, −0.52<sup>6</sup>; whole milk, −0.69<sup>6</sup>; low fat milk, −1.40<sup>6</sup>; coffee and tea, −0.89<sup>6</sup> Compensated elasticities: soft drinks, −0.52<sup>6</sup>; juice, −0.35<sup>6</sup>; whole milk, −0.59<sup>6</sup>; low fat milk, −1.36<sup>6</sup>; coffee and tea, −0.47<sup>6</sup> | Prices do not explain the displacement of milk by soft drink; demand for both is responsive to prices; price interventions can be effective tool in controlling soft drink use; education and advertising campaigns may also be effective policies |
| Brown et al<sup>6</sup> | Study how income and prices influence consumer juice beverage demand       | ◊ USA               | Panel data, Nielsen Scan Track data on juice beverage consumption (1988–1992) of weekly observations | Price elasticity of demand | Elasticities: juices, −0.70<sup>6</sup> to −1.81<sup>6</sup>; soda, −1.56<sup>6</sup>; tea, −0.787<sup>6</sup>; milk, −0.62<sup>6</sup> | Goods have quite price elastic demand functions and exhibit high substitution effects |
| Polshl et al<sup>4</sup> | Investigate the demand for various nonalcoholic beverages, get elasticities of demand, test different analytical models | ◊ USA               | Individual and economic data from 26,255 households from a nationally representative sample from the AC Nielsen Home Scan panel data (1998–2001) set | Price elasticity of demand | Compensated elasticities: milk, −1.16<sup>6</sup>; carbonated soft drinks, −0.64<sup>6</sup>; powdered soft drinks, −0.68<sup>6</sup>; isotonics, −1.93<sup>6</sup>; fruit juices, −0.67<sup>6</sup>; bottled water, −0.67<sup>6</sup>; coffee, −1.14<sup>6</sup>; tea, −0.93<sup>6</sup> | Elasticities for milk, isotonics, water and coffee are elastic, whilst those of soft drinks, fruit juices, and tea are in the inelastic range; prominent substitution effects are evident |
| Authors | Model the demand and the interrelationships of at home nonalcoholic beverage consumption |
|---------|----------------------------------------------------------------------------------------------------------------------------------|
| Dharmasena et al⁹ | Model the demand and the interrelationships of at home nonalcoholic beverage consumption | Nielsen Home Scan panel data, (1998–2003) with 72 monthly observations which are demographically balanced in 53 markets, adjusted using the consumer price index |
| Price elasticity of demand | Uncompensated elasticities: isotonics, −5.97%; soft drinks, −2.19%; diet soft drinks, −1.13%; fruit drinks, −0.18%; fruit juices, −0.93%; Compensated elasticities: isotonics, −5.94%; soft drinks, −1.90%; diet soft drinks, −0.98%; fruit drinks, −0.08%; fruit juices, −0.82% |

| Authors | Estimate own and cross price elasticities of selected no alcoholic beverages and the direct and indirect effects of a proposed excise tax on SSBs consumption |
|---------|----------------------------------------------------------------------------------------------------------------------------------|
| Dharmasena et al⁹ | Estimate own and cross price elasticities of selected no alcoholic beverages and the direct and indirect effects of a proposed excise tax on SSBs consumption | Nielsen Home Scan panel data, (1998–2003) 72 monthly observations which are demographically balanced in 53 markets, which were adjusted using the consumer price index |
| Excise ad valorem tax 20% tax on sugar sweetened nonalcoholic beverages | Total percentage per capita change: regular soft drinks, −14.33%; diet soft drinks, 2.70%; fruit drinks, −13.43%; fruit juices, 12.75%; high fat milk, −5.48%; low fat milk, 9.26%; bottled water, −3.40%; coffee, 21.05%; tea, 6.64%; isotonics, −79.05% |

| Authors | Estimation of a conditional demand system for different beverages |
|---------|----------------------------------------------------------------|
| Brown et al⁸ | Estimate own and cross price elasticities of selected no alcoholic beverages and the direct and indirect effects of a proposed excise tax on SSBs consumption | Nielsen Home Scan panel data, (1998–2003) 72 monthly observations which are demographically balanced in 53 markets, which were adjusted using the consumer price index |
| Price elasticity of demand | Elasticiites: juice, −1.56%; milk, −1.20%; soda, −0.61 |

| Authors | To analyze the impacts of income levels on the price and income responses in the differential demand system |
|---------|----------------------------------------------------------------|
| Brown⁸ | To analyze the impacts of income levels on the price and income responses in the differential demand system | Nielsen Home Scan panel data, (1998–2003) 72 monthly observations which are demographically balanced in 53 markets, which were adjusted using the consumer price index |
| Price elasticity of demand | Elasticiites: juices, −1.42 to −2.17; sodas, −1.57; milk, −1.10; tea, −1.17; carbonated water, −1.61 |

| Authors | To model nonalcoholic beverage demand and to measure the effects of advertisement on the demand |
|---------|----------------------------------------------------------------|
| Zheng et al⁸ | To model nonalcoholic beverage demand and to measure the effects of advertisement on the demand | Nielsen Home Scan panel data, (1998–2003) 72 monthly observations which are demographically balanced in 53 markets, which were adjusted using the consumer price index |
| Price elasticity of demand | Elasticiites: soft drinks, −0.52; milk, −0.30; juice, −0.27; bottled water, −0.50; coffee and tea, −0.42 |

The findings indicated that price changes in soft drinks may affect consumption, as well as advertisement of them

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Effectiveness of taxes in preventing obesity
Table S1: Studies on price and tax interventions and their effects on different outcomes (Continued)

| Authors             | Objectives                                                                 | Country / Methods | Data/population                                                                 | Price/tax variable                                                                 | Results                                                                 | Conclusion                                                                 |
|---------------------|------------------------------------------------------------------------------|-------------------|--------------------------------------------------------------------------------|----------------------------------------------------------------------------------|--------------------------------------------------------------------------|---------------------------------------------------------------------------|
| Zhen et al          | To estimate demand for nine nonalcoholic beverages under habit formation     | USA               | Nielsen Home Scan household scanner data (2004–2006), from a panel of more than 100,000 households recording purchases made at retail outlets on a weekly basis over a period of at least a year | Elasticities estimation and modeling effects of a half-cent per ounce tax on store purchased regular CSD, sports and energy and sugar sweetened drinks | Elasticities: regular CSD, −0.36 to −0.53; diet CSD, −0.65 to −0.79; energy drinks, −0.34 to −0.49; fruit juice, −0.52 to −0.59; sugar sweetened fruit drinks, −0.46 to 0.75; long run tax effect on SSB annual demand, −110 to −135 | A half-cent per ounce tax on SSBs will result in moderate reduction in consumption for both income strata; long run tax revenue is 15% to 20% lower to short-run; results indicate that a sugar-sweetened beverage tax is regressive in nature |
| Pieroni et al       | To examine the role of relative food prices in determining the recent increase in bodyweight in Italy | Italy             | A series of cross sections of the Italian Household Budget Survey (1997–2005); the IHBS provides information about the socio-demographic characteristics and expenditure levels of Italian households | Price elasticity of demand                                                                                                      | Compensated elasticities of demand: healthy food, −0.77, 0.40, and 0.97; unhealthy foods, 0.56, −0.57, and 0.04; other goods, 0.08, 0.01 and −0.09 | The relative increase of healthy food prices has produced nontrivial substitution elasticities towards higher consumption of unhealthy foods, affecting disadvantaged groups |
| Kuchler et al       | Investigate consumer likely response to a proposed tax on snack foods, that addresses public health issues generated by rising US obesity rates | USA               | AC Nielsen Home Scan panel data, 7,195 representative households (1999)          | Price elasticity of demand                                                                                                      | Annual consumption effect (per ounces per capita): potato chips tax, −0.28, −2.77, −5.54; potato and all chips tax, −0.09, −0.93, −1.87; all snack and all chips tax, −0.23, −2.26, −4.51; all salty and other salty snacks tax, −0.28, −2.79, −5.57; | The impact on dietary quality are small and negligible for lower tax rates and insufficient at higher tax rates; price changes are not effective and a tax could be used only to raise revenues for nutrition education |
| Chouinard et al     | Estimate demand systems for dairy products, which are used to simulate substitution effects among dairy products and the welfare impacts of fat taxes on various consumer groups | USA               | Weekly information resources incorporated's (IR) Infoscan scanner data, with 3,583 observations years (1997–1999) for 23 cities | Price elasticity of demand and modeling effects of 10% and 50% and valorem fat tax                                                                 | Elasticities: milks, −0.63\(^{\text{NS}}\) to −2.05\(^{\text{NS}}\); cream, −0.41\(^{\text{NS}}\); cheeses, −0.40\(^{\text{NS}}\) to −0.73\(^{\text{NS}}\); butter, −0.30\(^{\text{NS}}\); ice cream, −0.74\(^{\text{NS}}\); yogurts, −0.91\(^{\text{NS}}\) to −0.80\(^{\text{NS}}\); impact of 10\(^{\text{NS}}\) to 50\(^{\text{NS}}\) tax per week: | A 10% tax would reduce consumption only by 1% and thus given the inelastic demand a tax is a good means mainly to raise revenue; fat taxes are unattractive because they are extremely regressive, and the elderly and poor suffer much |
| Author          | Country | Study Title                                                                 | Method                                                                 | Outcomes                                                                 | Products                                                                 |
|-----------------|---------|-----------------------------------------------------------------------------|----------------------------------------------------------------------|--------------------------------------------------------------------------|--------------------------------------------------------------------------|
| Dharmasena et al | USA     | Estimate own and cross price elasticities of selected no alcoholic beverages | Demand study and modeling                                             | Per capita change in calories per month; regular soft drinks, -552.04;   | milks, -1.44\% to 0.59\%; /-1.75\% to 0.51\%; cheese, 0.64\%-0.88\%;;   |
|                 |         | and the direct and indirect effects of a proposed excise tax on SSBs        | □ Caloric intake and weight                                            | diet soft drinks, -2.81; fruit drinks, -112.69; fruit juices, 207.67;    | butter, -1.86\%-7.50\%; ice cream, 1.2\%-1.92\%;; yogurt, -0.03\% to   |
|                 |         | consumption                                                                 | □ Isotonics, drinks, juices, milk, water, coffee and tea               | high fat milk, -15.94; low fat milk, 45.02; coffee, 6.76; tea, 0.43;    | 0.09\%-0.00\% total –13.22\% greater welfare losses from the taxes than do younger and richer consumers |
|                 |         |                                                                            |                       | isotonics, -26.04; total average, -449; body weight, -1.54 pounds/ year; -0.13 pounds/ month |                                                                          |                                                                          |
| Dharmasena et al | USA     | To ascertain stochastic partial and general calorie body weight and revenue      | Demand study and modeling                                             | Impact on total calories per person per month from beverages: -450 kcal  |                                                                          |                                                                          |
|                 |         | effects of a tax on SSBs as well as incidence of such tax                    | □ Caloric intake and weight                                            | (–707 to –1.99); impact on weight in pounds per person per year: -1.5    |                                                                          |                                                                          |
|                 |         |                                                                            | □ SSBs                                                                | (-2.6 to -0.7) Own price elasticities, -2.41\% to -0.84\%; consumption per  |                                                                          |                                                                          |
| Gustavsen et al | Norway  | Investigate the effects on purchases of increasing the VAT for SSBs from    | Demand study and modeling                                             | annum: light drinkers, 5.1 L\%; moderate drinkers, -6.8 L\% to          |                                                                          |                                                                          |
|                 |         | 13\% to 25\%                                                                | □ Consumption and weight                                              | -11.5 L\%; heavy drinkers, -13.9 L\% to -19.2 L\%; weight per annum/capita, |                                                                          |                                                                          |
|                 |         |                                                                            | □ SSBs                                                                | -0.3 kg\%(-0.3 to -1.0 kg\% range) Low-purchasing households will reduce their purchases by about 5L and the reduction in high purchasers will be 20L per year, yielding a 0.3 kg of body weight reduction on an annual perspective |                                                                          |                                                                          |
### Table S1: Studies on price and tax interventions and their effects on different outcomes (Continued)

| Authors          | Objectives                                                                 | Country / Methods | Data/population                                                                 | Price/tax variable                                                                 | Results                                                                 | Conclusion                                                                 |
|------------------|-----------------------------------------------------------------------------|-------------------|--------------------------------------------------------------------------------|----------------------------------------------------------------------------------|------------------------------------------------------------------------|---------------------------------------------------------------------------|
| Lin et al16       | Demonstrate the bias of a static model of 3,500 calories for one pound of body weight | USA                | Individual data from 7,291 children, 8,322 adults of the National Consumer Panel dataset and the National and Nutritional Examination Survey (CDC), NHANES, (1998–2007, 2003–2006) and price NCP data (1998–2007) | Price elasticity of demand and effects of a 20% tax | Uncompensated elasticities of demand in low/high income population: sugary drinks, -0.95\(^{**}\) to 0.05\(^{*}\) to 1.30\(^{**}\) to 0.06\(^{**}\); Effects on sugary drinks (kcal/d) of a 20\(^{**}\) tax: adults, -38\(^{**}\)/-35\(^{**}\); children, -46\(^{**}\)/-54\(^{**}\); Weight change (kg) after 10 years: dynamic model, -1.84\(^{**}\); static model, -15.98\(^{**}\) | Taxes may cause reductions in consumption and body weight; however notably the static model overestimates the effects of a tax compared to the dynamic model; this is due to the 3500 calorie rule which is biased and that he energy requirements of the body are determined by body weight amongst others |
| Smed et al17      | Analyze the effects of using economic policy tools in nutrition policy by developing a system of an two models: an econometric consumption one and another that converts it to nutrition intake | Denmark            | About 2,000 households from a representative panel data of Danish food consumers from GfK Consumer Scan Panel data (1997–2000) with weekly home purchased data | Tax on all fats: 7.75DKK/kg; Tax on saturated fats: 7.90DKK/kg; Tax on added sugar: 6.23DKK/kg | Energy intake/day/ scenario: -17 to -11% (\(\text{age}\)): -7 to 2% (\(\text{social class}\)): -9 to 1% (\(\text{location}\)): -12 to -4% (\(\text{age}\)): -6 to 3% (\(\text{social class}\)): -8 to -4% (\(\text{location}\)): -1 to -1% (\(\text{age}\)): -2 to 2% (\(\text{social class}\)): 5 to -2% (\(\text{location}\)) | Differing effects of tax per age, social class and location; tax on fat as greater impact than on sugar; tax on fat increases energy intake from sugar and vice versa; taxes cannot solve obesity problems, but may interact well with other instruments |
| Thiele18          | Calculate food price elasticities and estimate the effects of a fat tax      | Germany            | Cross sectional data of 12,000 households, representative of German population (2003) | Tax of 0.5 cents per gram of saturated fat | Consumption: -4g/d\(^{**}\) of food; fat intake, -7.4 g/d\(^{**}\) (-87\(^{**}\)); saturated fat, -3.1 g/d\(^{**}\) (-85\(^{**}\)); Energy intake: purchases, -68 kcal/d\(^{**}\); intake, -20.4 kcal/d; Weight, -1.0 kg/y\(^{**}\) | Taxation of fat changes purchasing structure; there may be deficient nutrient intake in low income groups; net health effects per group are unclear; higher fat tax premiums oriented to obese may be preferable |
| Authors | Objectives | Price/tax variable | Results | Discussion |
|---------|-----------|--------------------|--------|------------|
| Meyerhoefer et al | Investigate the impact of changes in the relative price of low and high carbohydrate foods on medical expenditures for diabetes care | ◊ USA | Nielsen Home Scan price data (2000–2005) merged to Medical Expenditure Panel data Survey, from which a diabetic sample of 3,990 men and 4,984 women was derived | Price elasticity of demand and modeling | An increase of 10% in the price of low carbohydrate foods impacts BMI by 1.15% in men and by −0.7% in women |
| Zhen et al | Estimate demand with more sophisticated substitution modeling and assess the impact of food taxes on total calorie intake with focus on the case of a 10% tax to sugar | ◊ USA | Cross Sectional data of 3,015 individuals, age >20 years, nonpregnant, from the NHANES, (2003–2004) survey | Elastocities estimation and modeling of increases in prices by a 10% food tax proportional to calories from added sugar in different foods | Tax consumption effect: carbonated soft drinks, −8.92%; fruit juices and non-alcoholic beverages, −3.29%; fats, 0.05%; Calories/day: carbonated soft drinks, −1.689%; fruit juices and non-alcoholic beverages, −2.98%; total, −2.17% or 47 calories/day |
| Allais et al | Assess effects of a fat tax on the nutrients purchased by French households across different income groups | ◊ France | TNS World panel data in France, with 5,000 households (1996–2001), which is an annual survey with weekly observations | Elastocities estimation and modeling of 10% increase in price done for one month due to tax | Elastocities of soft drinks, −0.97 to −0.99; Effect of sugar products tax on nutrients purchased: well-off, −0.79; modest, −1.20; Effect on nutrients purchased from cheese/butter/cream tax: well-off, −1.24; modest, −1.17 |
| Gordon-Larsen et al | Examine how community-level food price variation is associated with individual-level fast food intake | ◊ USA | Data from waves II (1996) and III (2001–2002) of the national Longitudinal Study of adolescent Health (Add Health), a cohort study of 20,745 adolescents representative of the US school based population; Price data from the Council for Community and economic research (C2ER) | Effect of a 20% price increase | Effect on fast foods eating occasions for burger/soda: male White, −0.15/−0.05; male Black, −0.10/−0.24; male Hispanic, −0.09/−0.16; male Asian, −0.20/0.13; female White, −0.11/−0.00; female Black, −0.06/0.16; female Hispanic, −0.05/−0.19; female Asian, −0.15/0.08 |

LONGITUDINAL STUDIES ON CONSUMPTION OF BEVERAGES AND FOODS

Gordon-Larsen et al | Examine how community-level food price variation is associated with individual-level fast food intake | ◊ USA | Data from waves II (1996) and III (2001–2002) of the national Longitudinal Study of adolescent Health (Add Health), a cohort study of 20,745 adolescents representative of the US school based population; Price data from the Council for Community and economic research (C2ER) | Effect of a 20% price increase | Effect on fast foods eating occasions for burger/soda: male White, −0.15/−0.05; male Black, −0.10/−0.24; male Hispanic, −0.09/−0.16; male Asian, −0.20/0.13; female White, −0.11/−0.00; female Black, −0.06/0.16; female Hispanic, −0.05/−0.19; female Asian, −0.15/0.08 |

The paper gives more emphasis on methodological aspects; small reductions in energy intake are estimated.
### Table S1: Studies on price and tax interventions and their effects on different outcomes (Continued)

| Authors            | Objectives                                                                 | Data/population                                                                 | Price/tax variable                  | Results                                                                 | Conclusion                                                                 |
|--------------------|-----------------------------------------------------------------------------|--------------------------------------------------------------------------------|-------------------------------------|--------------------------------------------------------------------------|---------------------------------------------------------------------------|
| Khan et al\(^31\)  | To examine the relationship between children's fast food consumption and prices of fast food and food at home and also whether price responsiveness differ across subpopulations | Individual level data (2004, 2007) from the ECLS-K and price data from the American Chamber of Commerce Researchers Association (ACCRA) | Price elasticity and 0.17 USA dollars increase in price that is one standard deviation | Weekly fast food consumption price elasticity, −0.57; coefficient of income per $10,000 increments, −0.13; high school mother, −0.22; mother in college, −0.35; hours of television watching, 0.14 | Higher fast food prices were associated with lower frequency of fast food consumption; price elasticity of home food is half that of fast food; price of fast food has stronger relation with consumption in overweight |
| Longitudinal studies on energy intake and weight outcomes of beverages | USA                                                                 | Individual data from 7,300 children, 9–13 years on the ECLS-K and tax and price data from the Robert Wood Johnson Foundation (2004) | Price elasticity BMI will change by −0.013 if tax increases by 1%; there is no significant change in consumption | Small taxes are not having significant effect on overall levels of soda consumption or obesity rates; larger effects are observed in heavier children from low income who watch a lot of television | The results of the study indicate that large taxes on SSBs have the potential to positively influence weight outcomes, especially for middle-income households; these taxes may generate significant revenue which could be used to fund obesity prevention efforts |
| Finkelstein et al\(^32\) | Investigate the differential impact of targeted beverage taxes on energy intake and weight of higher- and lower-income households | Nationally representative sample of households from the Nielsen Home Scan Panel, (2006) | Effect of 20%/40% tax on carbonated SSBs and 20%/40% tax on all SSBs | Effect on purchase of tax on CSSBs, −0.60/−10.4 kcal/d per person; SSBs price elasticity, −0.73; annual weight change, −0.20/−0.37; Effect on purchase of tax on all SSBs, −11.0/−17.0 kcal/d; SSBs price elasticity, −0.87; annual weight change, −0.32/−0.59 | The results of the study indicate that large taxes on SSBs have the potential to positively influence weight outcomes, especially for middle-income households; these taxes may generate significant revenue which could be used to fund obesity prevention efforts |
| Longitudinal studies on energy intake and weight outcomes of foods | USA                                                                 | Individual data (11,900 person years) of adolescents (12–17 years) from the National Longitudinal Survey of Youth (NLSY97) in 392 USA counties; price data are from the ACCRA cost of living index reports; outlet density data from the Dun and Bradstreet business list | Price elasticity BMI fast food price elasticity: adolescents, −0.12; low income, −0.26; near low income, −0.04; middle income, −0.16; near high income, −0.06; high income, −0.20; mother at high school, −0.13; mother at college or above, 0.02 | Higher fast food prices are associated with lower BMI, but results were not statistically significant; fiscal food pricing policies may have modest but measurable effects, on average, on the weight outcomes of children ages 6 to 17 | Higher fast food prices were associated with lower frequency of fast food consumption; price elasticity of home food is half that of fast food; price of fast food has stronger relation with consumption in overweight |
| Study          | Title                                                                 | Country | Design/Type of Study | Data Source                                                                 | Findings                                                                                                                                 |
|---------------|----------------------------------------------------------------------|---------|---------------------|----------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|
| Wendt et al   | Explore the effect of food prices on children's BMI                   | USA     | Longitudinal study  | Individual data from 5,090 children 4-16 years old, of a nationally representative sample of the ECLS-K (1998-1999); price data from the Quarterly Food-at-Home Price Database (QFAHPD) | Price elasticity of BMI: 1st quarter price elasticities in fixed effects/OLS models. Carbonated beverages, -0.01/-0.03; fruit drinks, 0.01/-0.01; juices, -0.01/-0.01; milk, 0.00/-0.01; snacks, -0.03/0.01; carbonated beverages, -0.04/-0.03; fruit drinks, -0.01/0.01; juices, -0.03/0.03; milk, 0.01/-0.02; snacks, 0.01/0.00 |
| Powell et al  | Examine the association between fast food prices and restaurant and food store outlet availability with adolescents BMI | USA     | Longitudinal study  | Individual panel data of about 6,594 observations of NLSY79 survey for 1998, 2000, 2002 on adolescents and price data from the American Chamber of Commerce researchers Association and density data from Dun and Bradstreet list | Price elasticity of BMI change per dollar of price increase and BMI price elasticity: OLS model. -0.78 and -0.10; longitudinal fixed effects model. -0.65 and -0.08; longitudinal random effects model. -0.70 and -0.08 |
| Duffey et al  | Assess the associations between food price, dietary intake, overall energy intake, weight, and homeostatic model assessment insulin resistance (HOMA-IR) scores | USA     | Longitudinal study  | Individual data from the CARDIA longitudinal study with 5,115 young adults (18-30 years), followed periodically from 1985 to 2006 and price data from the American Chamber of Commerce Research Association | Price elasticity of consumption: soda, -0.19; milk, -0.07; burgers, 0.07; pizza, -0.43; Energy: soda, -0.71; milk, 0.24; burgers, 0.20; pizza, -1.15; calories (daily kcals), -124; milk, -130; burgers, -71; pizza, -42; weight (pounds), -2.3; milk, -0.3; burgers, -0.5; pizza, -1.3 |
| Wendt et al   | Investigate the impact of prices of soda, fruit drinks and alternative beverages on children's BMI | USA     | Longitudinal study  | Individual data from the ECLS-K with a representative sample of 8,730 students in the school (1998-1999), and price data from the Quarterly Food at Home Price Database (QFAHPD) (1998-2006) | Price elasticity of BMI price elasticities: soda, -0.02; fruit drinks, -0.02; juices, -0.03; low fat milk, 0.01; whole milk, 0.01; sweet snacks, -0.01; salty snacks, -0.03 |

Food prices have small statistically significant effects on children BMI; there is a significant delay between price changes and BMI effects; there are heterogeneous responses to changes in price across household incomes and the distribution of BMI. Higher fast food prices are related to lower BMI in the teens; maternal working status and parental income did not influence BMI; the low elasticities mean that taxes would have to be significant to have any effect.
| Authors                  | Objectives                                                                 | Country / Products | Data/population                                                                 | Price/tax variable                                                                 | Results                                                                                      | Conclusion                                                                                     |
|-------------------------|----------------------------------------------------------------------------|--------------------|---------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|
| Auld and Powell          | To show that decrease in the price of energy dense foods increase body weight if the price of obtaining a calorie from dense food is lower than that of less dense food | USA                | Individual level national data for eighth and tenth grade students from the MTF surveys, 1997–2003 and price data from ACCRA and outlet density data from Dun and Bradstreet (2007) | Price elasticity                                                                    | Elasticities: fast food price, −0.03/−0.42; fast food restaurant density, 0.00/−0.016; Female BMI/ weight elasticities: fast food price, −0.03/−0.72; fast food restaurant density, −0.01/0.02 | The price of energy dense food is negatively associated with weight, whereas the price of less energy dense foods is positively associated with weight outcomes; taxing fast food may be effective policy in addressing obesity, but is hindered by potential adverse effects |
| Zhang et al              | To examine the interactive effect between the price of unhealthy foods and food stamp program participation on body weight status among low income women in the US | USA                | Panel data of the National Longitudinal Survey of Youth (NLSY) 1979 cohort (1985–2002) with 12,686 individuals, and price data from the ACCRA | Price elasticity                                                                    | BMI elasticity in two models: unhealthy basket 1, −0.13/−0.11; unhealthy basket 2, −0.06/−0.05; unhealthy basket 3, −0.04/−0.04; Obesity odds ratios in two models: unhealthy basket 1, 0.58/0.98; unhealthy basket 2, 0.99/097; unhealthy basket 3, 1.0/0.97 | The higher prices for unhealthy food can partially offset the positive association between food stamp program participation and bodyweight among low income women; considerable interactions exist |
| Han et al                | Examine the extent to which various food prices were associated with the obesity status of young adults | USA                | Individual data from the MTF study, (1992–2003), annual follow up, 11,861 observations (6,537 men, 5,324 women) 14–32 years old and price data from the ACCRA | Price elasticity                                                                    | Obesity probability change in women: fast food, −1.88; soft drinks, −2.03; fruits and vegetables, 1.26 Obesity probability change in men: fast food, −2.07; soft drinks, −1.01; fruits and vegetables, 0.40 | The findings indicate a significant negative association of the probability of obesity with the prices of fast food and soft drinks and a positive one with the prices of vegetables and fruits |
| Barquera et al           | Calculation of own price elasticities, cross price elasticities of demand, and income elasticities of demand for beverages | Mexico             | Individual data from a national representative sample of 416 adolescents and 2,180 adults from the Mexican Nutrition Survey (1999) | Price elasticity                                                                    | Purchase: soda, −1.09; whole milk, 0.05; sweet drinks, −0.11; juice, −0.20; mL/capita/day: overall, −5.00; poor, −5.30; rich, −4.61; income, 0.16 | Income elasticities indicate that intakes will increase if incomes increase; soda price elasticities were both modest and increasing over time |
| Study | Investigate/Examine | Location | Data Sources | Price Elasticity | Results |
|-------|---------------------|----------|--------------|-----------------|---------|
| Claro et al. | Investigate whether taxing SSBs would improve the diets of households in Brazil | Brazil | Individual and economic data from 443 geographically and socioeconomically homogeneous Households Budget Survey from the Brazilian Institute of Geography and Statistics, (2002–2003) | Price elasticity | Elasticities: all groups, -0.85; first income quartile, -1.03; second, third and fourth income quartiles, -0.63 |
| Sturm and Datar | To examine price of food is associated with consumption patterns among different socio economic and at risk groups of students | USA | ECLS-K (1998–1999) and economic data from the ACCRA | Price elasticity | Own price elasticity: SSBs, 0.10; fast food, 0.21; Cross price effects: SSBs, 0.29; fast food, -0.14 |
| Fletcher et al. | Evaluate the impact of changes in state soft drink taxes on BMI, obesity, and overweight | USA | Individual data from 2,709,422 adults older than 17 years, from BRFSS (1990–2006), nationally representative survey and price and tax data from the Book of the States, the All States Tax Handbook, and web searches | Price elasticity | Tax effect on BMI, -0.003; male, 0.57; age, 0.31; Tax effect on obese, -0.01; male, -0.01; age, 0.06; Tax rate effect on overweight, -0.0002; male, 0.14; age, 0.00 |
| Fletcher et al. | Investigate the potential for soft drink taxes to combat rising levels of child and adolescent obesity through a reduction in consumption | USA | Individual data: youths aged 3–18 years from NHANES III (1988–1994) and IV (1999–2006) and price and tax data from the published annually Book of the States (1990–2007), LexisNexis academic, state departments of revenue and websites | Price elasticity | Soft drink calories, -5.92; soft drink grams, -18.05; consumption of soft drink, -0.01; total caloric intake, -7.84; BMI, 0.02; obese, 0.01; overweight, 0.002; underweight, -0.002 |

Effectiveness of taxes in preventing obesity indicating the potential use of price measures.

High SSB price elasticity indicates that a tax on purchased volume may lead to reductions in consumption, even though it is not possible to predict how diet quality will change.

The price effects for fast food and soft drink consumption were very small and inconsistent.

Soft drink taxes may influence BMI, but the impact is small and different across socio economic groups; a down side of the tax is that is regressive.

Taxation may cause a modest reduction in soft drink consumption by children and adolescents; but is offset by increases in consumption of other high-calorie drinks, and there is no effect on BMI and weight.

(Continued)
Table S1 Studies on price and tax interventions and their effects on different outcomes (Continued)

| Authors          | Objectives                                                                 | Country / Products | Data/population                                                                 | Price/tax variable                                                                 | Results                                                                 | Conclusion                                                                 |
|------------------|-----------------------------------------------------------------------------|--------------------|--------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|----------------------------------------------------------------------|--------------------------------------------------------------------------|
| Powel et al⁶⁹    | Examine the effects of grocery store and vending machine soda taxes and adolescent BMI | □ USA              | Individual data from 1,536,737 students (13–19 years) of Panel data from the MTF study (1997–2006) and price data from the ayaTech Corporation for the Robert Wood Johnson Foundation (1997–2006) | Price elasticity                                                                  | BMI: grocery store tax, 0.01; presence of grocery store tax, 0.06; vending machine soda tax, 0.01; presence of soda vending machine tax, 0.05; risk of overweight tax, -0.01; risk of overweight tax presence, -0.03 | Taxes are not significantly associated with adolescent weight outcomes; it is likely that taxes would need to be raised substantially to affect adolescent weight; there is a small negative association in overweight adolescents |
| Fletcher et al⁷⁰ | Examine the effects of taxing soft drinks on children consumption            | □ USA              | Individual data from 22,438 subjects, 3–18 years from the NHANES III (1988–1994) and IV (1999–2006) | Price elasticity and tax scenario                                                  | Non statistically significant results on BMI, calories intake, obesity prevalence from a 6% tax, as children may substitute soda with other high in calories goods; little difference in obesity in states with an without tax | Neither vending machines restrictions nor soft drink taxes will lead to noticeable weight reduction in children; typically imposed taxes aren’t significant and transparent enough for behavior changes |
| Wang et al⁷¹     | Examine the potential impact on health and health spending of a nationwide penny-per-ounce excise tax on these beverages | □ USA              | NHANES data for subjects 25–64 years the age (2003–2006) and Heart Disease Policy Model | Effect of 1 penny per ounce excise tax (−22%)                                      | SSB consumption, −15%; energy intake, −9 kcal/d; weight, 0.9 pounds (−0.45 kg); obesity prevalence, −1.5% | The tax may reduce consumption of SSBs, by 15% among adults, improve health outcomes and reduce health care costs |
| Beydoun et al⁷²  | Study the associations of price indices of fast foods (FF-Pi) and fruits and vegetables (FV-Pi) with dietary intakes and BMI among US children and adolescents | □ USA              | Individual data from a nationally representative multi-stage stratified sample of 6,759 children (2–9 years) and 1,679 adolescents (10–18 years) from CSFII, (1994–1998) and price data from the ACCRA | Price elasticity                                                                | Children/adolescents: energy (kcal/d), 324.0/253.3; fat (% energy), −2.1/−0.9; sodium (mg/d), −141.8 /−87.1; sugar (g/d), 10.0/6.9; dairy products (g/d), 172.5/195.5; calcium (mg/d), 223.7/309.2; fiber (g/d), 2.7/2.5; BMI, −0.2/−0.4 kg/m² | Among children higher fast food price is associated with better dietary quality and lower BMI; association exists between fast food and vegetable consumption; price varied by family income; higher taxes may improve dietary quality but not weight outcomes |
### CROSS SECTIONAL STUDIES ON ENERGY INTAKE and WEIGHT OUTCOMES OF FOODS

| Study | Countries | Methods | Data | Price Elasticity |
|-------|-----------|---------|------|-----------------|
| Arroyo et al<sup>36</sup> | ◊ Mexico | ○ Repeated Cross Sectional Study □ Consumption and energy ◊ Cereals, condiments, eggs, milk, dairy, fish, fruits, legumes, meat, oils, soft drinks, sugars | Data from 5 biannual surveys (1992–2000) with >10,000 Mexican representative households, collected by INEGI (National Institute of Statistics, Geography and Informatics) | Price Elasticity of kcal/year: cereals, –1.0; condiments, 1.5; eggs-milk-dairy, 0.2; legumes, –2.5; meat, 0.01; sugars, –1.3; soft drinks, 2.1 |
| Beydoun et al<sup>44</sup> | ◊ USA | ○ Cross Sectional Study □ Consumption, energy, BMI, ◊ Fast foods | Individual data of 7,331 adults (20–65 years) from the USA Department of Agriculture of a nationally representative Survey of Food Intakes by Individuals (CSFII) (1994–1996); price data from the American Chamber of Commerce Researchers Association | Price Elasticity |
| Block et al<sup>45</sup> | ◊ USA | ○ Experimental study □ Consumption ◊ Soft drinks | Individual data from consumers in two hospitals in Boston in 2008; prices were increased and consumption was evaluated | Effect of a $0.45 or 35% increase in price on soft drinks |
| Yang et al<sup>46</sup> | ◊ Taiwan | ○ Experimental study □ Consumption and BMI ◊ SSBS | Individual data from 108 undergraduates 18–22 years old recruited through online and printed advertisements | Impact on sales of regular soft drinks, –26%; impact on sales of regular soft drinks, 20% |
| Nederkoorn et al<sup>47</sup> | ◊ Netherlands | ○ Experimental study □ Consumption and energy intake ◊ High energy dense foods | Individual data from 306 participants >18 years old (76% women) recruited through advertisements on Dutch websites, GoogleAds | In the tax group a 50% price increase on high energy dense foods was applied versus no tax in the other group |

### EXPERIMENTAL STUDIES ON CONSUMPTION OF BEVERAGES

| Study | Countries | Methods | Data | Effect of a $0.45 or 35% increase in price on soft drinks |
|-------|-----------|---------|------|--------------------------------------------------------|
| Block et al<sup>45</sup> | ◊ USA | ○ Experimental study □ Consumption ◊ Soft drinks | Individual data from consumers in two hospitals in Boston in 2008; prices were increased and consumption was evaluated | Effect of a $0.45 or 35% increase in price on soft drinks |

### EXPERIMENTAL STUDIES ON CONSUMPTION OF FOODS

| Study | Countries | Methods | Data | Own price elasticity: unhealthy beverage, –0.91; healthy, 0.69; BMI, 0.14; cross price elasticity—healthy, 0.53; cross price elasticity—unhealthy, 0.69 |
|-------|-----------|---------|------|--------------------------------------------------------|
| Yang et al<sup>46</sup> | ◊ Taiwan | ○ Experimental study □ Consumption and BMI ◊ SSBS | Individual data from 108 undergraduates 18–22 years old recruited through online and printed advertisements | Students were given money to purchase different beverages in different price scenarios |
| Nederkoorn et al<sup>47</sup> | ◊ Netherlands | ○ Experimental study □ Consumption and energy intake ◊ High energy dense foods | Individual data from 306 participants >18 years old (76% women) recruited through advertisements on Dutch websites, GoogleAds | In the tax group a 50% price increase on high energy dense foods was applied versus no tax in the other group |

The economic crisis did not affect total calories intake and in fact calorie sources were contrary to any crisis effect.
| Authors         | Objectives                                                                 | Data/population                                                                 | Price/tax variable                                                                 | Results                                                                                                      | Conclusion                                                                                          |
|-----------------|------------------------------------------------------------------------------|---------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|
| Epstein et al   | Evaluate the effects of price changes in high and low calorie-for-nutrient foods on mothers' purchases for 68 common foods and drinks | Data from individuals recruited from a family database, including: 42 mothers, 20 lower income/22 higher income, of whom 45% were obese | Price increase of high calorie for nutrient foods by 12.5% or by 25%                | Price elasticity of energy intake for healthy foods, -0.98; Tax elasticity of total calories purchased, -0.647 | Taxing less healthy food reduces energy intake and fat purchases, and increases the proportion of protein purchased |
| Andreyeva et al | Develop a method for estimating revenues from an excise tax on SSBs that governments could direct towards obesity prevention | Estimated state and city data based on 2008 sales in the USA allocated and combined with Census population projections from 2007 to 2015 and price elasticities from the literature | Consumption and revenue impact from a penny-per-ounce excise tax on SSBs and diet varieties | Consumption: CSDs, -17.8%; fruit drinks, -11.4%; sports drinks, -16.0%; teas, -8.9%; energy drinks, -4.6%; coffees, 4.0%; flavored water, -14.6; total, -16.3% | A modest tax on SSBs could both raise significant revenues and improve public health by reducing obesity |
| Mytton et al    | Examine the effects on nutrition, health and expenditure of extending VAT to a wider range of foods in the UK | Cross-sectional data on consumption and elasticities were obtained from the National Food Survey in Britain of 2000; these were combined with data on effect of dietary fat and cardiovascular, metabolic and other health outcomes from meta-analyses | 17.5% price increase due to extending the VAT on food with saturated fat; O Food with SSB <3 d score ≥ 9 | ○ Calories consumed, 2.29%; annual number of CVD deaths, 2.500 to 3.500; Calories consumed, -4.3%; annual number of CVD deaths, -2.500 to -3.500 | Taxing can have unpredictable effects if cross elasticities are ignored, due to consumptions interdependence; a carefully targeted fat tax could have modest but meaningful results in food consumption and cardiovascular outcomes |
| Schroeter et al | Identify conditions under which price and income changes are most likely to change weight, based on a three good model (low and high calorie food and exercise) used to estimate metabolic equivalents (MET) in energy accounting models | Modeling based on price energy and weight elasticities from the literature; baseline cross-sectional population data from 1963–1965 National Health Examination Survey (NHES) and 1999–2002 NHANES | 10% tax on food away from home and 10% tax on soft drinks | ○ Male weight change, 0.170 kg (0.196%); female weight change, 0.146 kg (0.196%); ○ Male weight change, 0.086 kg (0.099%); female weight change, 0.091 kg (0.122%) | Income increase and food subsidies increase weight; a tax on food away from home would also increase body weight; a tax on soft drinks may decrease weight modestly; a tax to be equitable must be combined with income redistribution |
| Study                | Objective                                                                 | Methods                                                                                                                                  | Products                                                                                                                                     | Notes: |
|---------------------|---------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|--------|
| Nnoaham et al⁵²     | To examine the effects, by income group, of targeted food taxes and subsidies on nutrition, health and expenditure in the UK | cross-sectional data from the Expenditure and Food Survey 2003–2006 and National Food Survey for price elasticities and health outcome data from meta-analysis | Cross sectional data from the Expenditure and Food Survey 2003–2006 and National Food Survey for price elasticities and health outcome data from meta-analysis |        |
| Finkelstein et al⁵³ | To estimate the changes in energy, fat and sodium purchases resulting from a tax that increases the price of SSBs by 20% and the effect of such a tax on body weight | Cross sectional data from the Nielsen Home Scan National Consumer Panel combined with the USDA National Nutrient Database for Each quarter of 2006, giving a sample of 114,336 observations over 28,584 households | Cross sectional data from the Nielsen Home Scan National Consumer Panel combined with the USDA National Nutrient Database for Each quarter of 2006, giving a sample of 114,336 observations over 28,584 households |        |
| Sacks et al⁵⁴       | To estimate the cost-effectiveness of two commonly used obesity prevention policy interventions: traffic light labeling and unhealthy food tax | Data on elasticities were obtained from the National Food Survey in Britain; these were combined with data from the 1995 National Nutrition Survey | Data on elasticities were obtained from the National Food Survey in Britain; these were combined with data from the 1995 National Nutrition Survey |        |

**Notes:** *statistically significant results; *no reported statistical significance.

**Abbreviations:** SSBs, sugar-sweetened beverages; CSSBs, carbonated SSBs; BMI, body mass index; VAT, value added tax; ACCRA, American Chamber of Commerce Researchers Association; ECLS-K, Early Childhood Longitudinal study, Kindergarten Class; MTF, Monitoring The Future; NHANES, National Health and Nutrition Examination Survey; CPI, consumers price index; CVD, cardiovascular disease; CSFII, Continuing Survey of Food Intakes by Individuals; BRFSS, Behavioral Risk Factor Surveillance System; CARDIA, Coronary Artery Risk Development in Young Adults; DKK, Danish Krone per kilogram; CSD, carbonated soft drinks; NLSY79, National Longitudinal Survey of Youth.
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