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Public Health

Assessing the potential effectiveness of food and beverage taxes and subsidies for improving public health: a systematic review of prices, demand and body weight outcomes

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Summary

Taxes and subsidies are increasingly being considered as potential policy instruments to incentivize consumers to improve their food and beverage consumption patterns and related health outcomes. This study provided a systematic review of recent U.S. studies on the price elasticity of demand for sugar-sweetened beverages (SSBs), fast food, and fruits and vegetables, as well as the direct associations of prices/taxes with body weight outcomes. Based on the recent literature, the price elasticity of demand for SSBs, fast food, fruits and vegetables was estimated to be –1.21, –0.52, –0.49 and –0.48, respectively. The studies that linked soda taxes to weight outcomes showed minimal impacts on weight; however, they were based on existing state-level sales taxes that were relatively low. Higher fast-food prices were associated with lower weight outcomes particularly among adolescents, suggesting that raising prices would potentially impact weight outcomes. Lower fruit and vegetable prices were generally found to be associated with lower body weight outcomes among both low-income children and adults, suggesting that subsidies that would reduce the cost of fruits and vegetables for lower-socioeconomic populations may be effective in reducing obesity. Pricing instruments should continue to be considered and evaluated as potential policy instruments to address public health risks.

Keywords: Body mass index, food consumption, food prices, obesity.

obesity reviews (2012)

Introduction

Given the obesity epidemic in the United States and the escalation of associated diet-related comorbidities, taxes and subsidies are increasingly being considered as potential policy instruments to incentivize consumers to improve their food and beverage consumption patterns and related health outcomes. In 2009–2010, obesity rates among children and adults were 16.9 and 36.9%, respectively (1,2).

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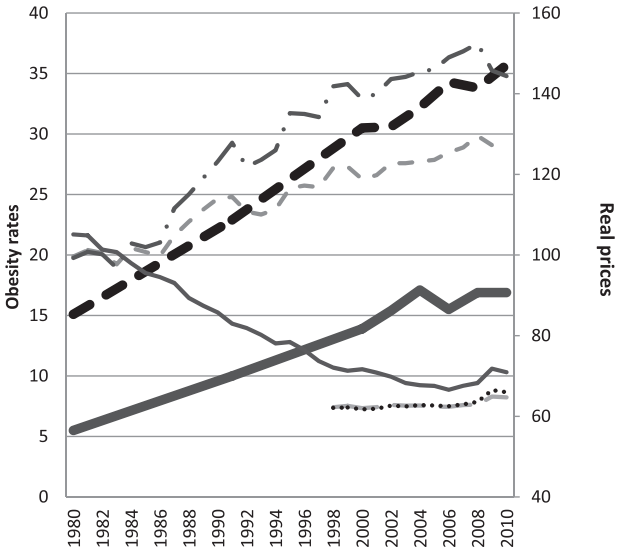

Figure 1 Trends in selected food and beverage prices and obesity rates among children and adults in the United States, 1980–2011.
Note: Authors' calculations based on data obtained from the Bureau of Labor Statistics, 2012.

The annual healthcare cost burden associated with obesity was recently estimated to be as high as $209.7 billion (3).

Parallel to the rise in obesity over the past few decades, the real inflation-adjusted price of fruits and vegetables has risen, while the price of carbonated soda has fallen and that of fast-food prices has remained fairly flat (Fig. 1), although it should be noted that such price indices, particularly for fresh fruits and vegetables, may not account for changes in quality or variety (4). In particular, between 1980 and 2011, it became 2.2 times more expensive to purchase fresh fruits and vegetables compared to purchasing carbonated beverages.

Intakes of sugar-sweetened beverages (SSBs) and fast food have been significant contributors to increased caloric intake and higher body weight (5–7). SSBs have been identified as the leading source of added sugar and calories in the American diet (8–10). Estimates from 1988–1994 to 1999–2004 show that among adults, average daily caloric intake of SSBs increased from 157 to 203 kcal, with 63% of adults consuming SSBs daily (11). Over the same period, SSB intake among children aged 2–19 increased from 204 to 224 kcal, and was particularly prevalent (84%) among adolescents aged 12–19, with an average SSB intake of 301 kcal in 1999–2004 (5). However, recent evidence shows that between 1999–2000 and 2007–2008 intake of sugared beverages decreased across all age groups, although sugar intake from energy drink sources rose for adults (10). Consumption of food-away-from home, particularly fast food, has increased over time across all age groups. Between 1977–1978 and 1994–1996, the contribution of fast food to total energy intake increased from 4 to 12% for adults and from 2 to 10% for children, and was highest among older children aged 12–19, reaching 19% (12). Recent evidence for children aged 2–19 shows that fast-food restaurant sources contributed 13% of daily energy intake by 2003–2006 (13). At the same time, studies show that fruit and vegetable consumption is relatively low with less than one-half of Americans meeting the U.S. Department of Agriculture (USDA) guidelines for fruit and vegetable intake, and recent trend analyses show that there has been limited change in such intake over the last two decades (14–16).

In order to incentivize healthy vs. unhealthy food consumption patterns with the related aim of reducing obesity rates, taxes on SSBs and fast food have been suggested along with subsidies targeted to fruits and vegetables (17,18). Soda, other SSBs and restaurant consumption are currently taxed in some states and localities, but at relatively low rates that were not intended to impact behaviour but for revenue-generation purposes (19,20). Limited specific subsidies for fruits and vegetables have been introduced through a federal food security programme (21).

Standard economic theory provides a framework for using pricing instruments to alter the relative prices of less- vs. more-healthful food and beverage products with the aim of changing consumer demand at the broad population level (18). A previous comprehensive review of studies of consumer demand that ranged from 2007 back to 1938 reported that, on average, a 10% increase in price would reduce consumption of soft drinks, food-away-from home, fruits and vegetables by 7.9, 8.1, 7.0 and 5.8%, respectively (22). More recent empirical studies reviewed herein suggest SSB and regular soft drink consumption to be more price sensitive than previously reported, which is particularly important given the current policy debates and legislative activity related to SSB tax proposals in jurisdictions nationwide.

Whether changes in prices for particular products result in overall weight changes hinges on both the extent to which consumption responds to own-price and the extent

of cross-price effects that result in substitution across products, which, in turn, affects net caloric intake and ultimately weight and obesity outcomes. Previous reviews showed that the studies that examined associations between food prices/taxes and weight outcomes found mixed or small effects, suggesting that taxes would need to be significantly higher in order to translate into any meaningful changes in weight (18,23). In the United States, evidence on the effectiveness of higher taxes in reducing tobacco use and its consequences has led to sharp increases in tobacco taxes and prices, with taxes accounting for nearly half of cigarette prices in recent years. These tax and price increases have contributed to significant reductions in tobacco use among youth and adults as have mass media anti-smoking campaigns, smoke-free policies and other tobacco control interventions. At the same time, the tax increases have generated considerable new revenues that some states have used to support tobacco use cessation and prevention efforts that have further reduced tobacco use (24).

This study extends a previous review study (22) to provide a systematic review of recent U.S. studies on the price elasticity of demand for SSBs, fast food, and fruits and vegetables. It also builds on prior reviews (18,20) to systematically review the direct associations of prices/taxes with weight outcomes. The paper provides a detailed description of the way in which SSBs and restaurant items are currently taxed, and fruits and vegetables are subsidized in the United States. Moreover, it provides examples of the nature and scope of current fiscal pricing proposals in the United States. This paper concludes by outlining fiscal policy instrument designs that are likely to be the most effective for improving diet and weight outcomes and highlights areas of future work that are needed to build the evidence base.

Methods

We reviewed studies published between January 2007 and March 2012. English-language studies were identified from computer-assisted searches from the following databases: Medline, PubMed, EconLit and PAIS. To assess the relationship of prices with consumption, each of the following six terms 'price elasticity', 'demand elasticity', 'tax', 'taxation', 'price' and 'prices' were separately included in searches with the combined terms of 'soda' or 'soft drinks' or 'sugar sweetened beverages' or 'beverage' or 'beverages' or 'fast food' and the following five terms 'price elasticity', 'demand elasticity', 'subsidy', 'price' and 'prices' were each included in searches with the combined terms of 'fruits' or 'vegetables'. This yielded a total of 2047 studies (including duplicates) for consideration across the four databases. To assess prices and weight outcomes, the searches included the terms 'price', 'prices', 'tax', 'taxation' and 'subsidy' each with the following combined terms of 'obesity' or 'body mass index' or 'BMI' or 'body weight', yielding a total of 1102 papers (including duplicates) for consideration across the four databases. In addition, research reports from the Economic Research Service (ERS) of the USDA were reviewed.

The criteria for including a study in this review were that the paper (i) used U.S. data; (ii) was a peer-reviewed study (exception for ERS studies); (iii) provided original quantitative evidence on the relationship between prices/taxes/subsidies and consumption or weight outcomes; (iv) was not an intervention study; (v) was not a pilot study; (vi) assessed demand for product categories (i.e. regular carbonated soda) rather than brands (i.e. Coke or Pepsi) and (vii) for weight outcomes, contained direct estimates and was not a modelling study that drew on price elasticity estimates to derive simulated impacts on weight. Initial screening for relevance was based on titles, information in the abstracts, and used U.S. data. Next, based on the subset of potentially relevant papers from the initial screening, the final screening was undertaken to check whether it met our full list of inclusion criteria. The papers were reviewed independently by two study authors. A total of 21 and 20 studies met the full set of criteria for inclusion as part of the review of the effect of prices on consumption and body weight outcomes, respectively.

Consumer demand analysis

The aim of the consumer demand review was to provide an examination of the price elasticity of demand for (i) SSBs, including specific selected subcategories of regular carbonated soft drinks, sports drinks and fruit drinks; (ii) fast food and (iii) fruits and vegetables. SSBs are generally defined to include any beverage with added sugars such as regular carbonated soft drinks, fruit drinks (non-100% fruit juice), sports and energy drinks, ready-to-drink teas and coffees, and flavoured waters. In this review, we were particularly interested in identifying the elasticity of demand for SSBs, in general, compared to narrower sub-categories of SSBs and in distinguishing SSB demand from soft drink demand where the latter includes both regular and diet versions of soft drinks. For comparative purposes, elasticity estimates were reported for soft drinks.

Price elasticity is a common metric defined as the percentage change in quantity demanded (consumption or purchases) of a good resulting from a 1% change in the own-price of the good. Demand for a good is said to be 'price inelastic' when the price elasticity is smaller than the absolute value of one and 'price elastic' when its price elasticity is greater than one in absolute value. For example, an inelastic price elasticity of demand for soft drinks of –0.8 implies that the consumption of soft drinks will fall by 8% if the price of soft drinks rises by 10%. If a study presented

both compensated and uncompensated price elasticity estimates, the uncompensated measure that accounts for the income effect of the price change was used. If a study reported multiple results across different populations such as low- and high-income or if it reported results based on multiple model specifications, we reported those in the detailed review presented in Table 1 and used mean estimates across models and sub-populations to derive a mean estimate which then went into the summary measures for each category reported in Table 2. To derive an overall mean estimate of the elasticity of demand for SSBs, we used all available SSB estimates from both the studies that focused on aggregated SSB measures and the estimates available for the three subcategories of SSBs (regular carbonated soda, sports drinks and fruit drinks) and we weighed each estimate by its relative consumption share of SSBs based on caloric intake data from 24-h dietary recalls for individuals ages two and older from the 2007–2008 National Health and Nutrition Examination Survey (25).

Body weight analysis

The aim of this review of studies that examined prices and weight outcomes was to assess the extent to which changes in food or beverage prices have the potential to translate into significant changes in body weight. These studies can be thought of as reduced form studies that assess the direct effect on weight implicitly accounting for all changes in food consumption including substitution across food products. Weight outcomes were measured by body weight, body mass index (BMI; weight in kilograms divided by height in meters squared) and obesity prevalence (BMI $\geq$ 30 for adults and defined by age- and gender-specific BMI $\geq$ 95th percentile for children). We assessed direction, magnitude and significance of associations. If available, price elasticity estimates of weight outcomes were reported.

Results

SSB consumer demand

As shown in panel (a) of Table 1, the review identified 14 studies that estimated price effects for SSB and soft drink demand with 10 studies that provided price elasticity of demand measures. Four studies provided estimates of soft drink demand that combined regular (calorically sweetened) and non-caloric soft drinks using retail scanner data. Three papers used annual national time series data. Five papers were based on individual-level survey data, four of which did not provide price elasticity estimates.

Summary measures of mean price elasticities for SSBs overall and by each beverage category are presented in Table 2. The results suggest that SSBs are more price elastic than implied by the previously reported estimate of –0.79 for soft drinks which included regular and diet soft drinks (22). The estimated overall mean price elasticity of demand for SSBs was –1.21. This estimate was based on all 12 available SSB elasticity estimates including those for the aggregated SSB measures and those estimates available for each of the three subcategories of SSBs (regular soft drinks, sports drinks and fruit drinks) where each estimate was weighed by its relative consumption share of SSBs. The mean SSB price elasticity estimate of –1.21 implies that a tax that raises the price of SSBs by 20% would reduce overall consumption of SSBs by 24%.

As summarized in Table 2, based on the three studies that included an aggregated SSB category within the beverage demand system, the price elasticity of SSBs was –1.08 (range of –0.87 to –1.26) (26–28). Consistent with economic theory, the estimates from models that separately assessed subcategories of SSBs generally were found to be more price elastic. The mean price elasticity of demand for regular carbonated soda of –1.25 (range –0.71 to –2.26) (27,29–31) suggested that a 20% increase in price would reduce consumption by 25%. Only two studies provided specific estimates for sports drinks with an average elasticity of –2.44 (range –1.01 to –3.87) (30,31) and three studies assessed fruit drinks with a mean elasticity of –1.40 (range –0.69 to –1.91) (30–32). With respect to model specification, all but one (29) of the SSB elasticity measures reported in Table 1 were based on estimates from demand system models. The one study on regular carbonated soda that was not based on a demand system yielded the lowest estimated elasticity. Excluding this study increased the mean elasticity of demand for regular carbonated soda from –1.25 to –1.44 and increased the overall mean SSB elasticity from –1.21 to –1.27.

Four recent studies assessing soft drink demand aggregated both regular and artificially sweetened soft drinks and one study included bottled water (32–35). Using such estimates to assess the potential impact of SSB taxes would not be appropriate given that SSB-specific taxes would not be applied to non-SSB soft drinks. If consumers faced higher prices for both SSB and non-SSB soft drinks, they are likely to reduce overall soft drink demand to a lesser extent than demand for regular soft drinks would be reduced in response to a tax on regular soft drinks only, given that they would be unable to substitute to a lower-priced non-caloric alternative soft drink. Indeed, the estimated price elasticity of demand for soft drinks based on our review was inelastic at –0.86, which was similar to the previous soft drink estimate of –0.79 (22).

Fast-food consumer demand

As shown in panel (b) of Table 1, six studies provided price parameter estimates for fast-food consumption. All six studies merged fast-food price data available from the

Table 1 Evidence on price effects on consumption

Author	Price/Tax variable [Source]	Data set	Population (sample size)	Model	Outcome variable	Price effect: direction/elasticity*
(a) Evidence for sugar-sweetened beverages and soft drinks						
Brown (2008) (32)	Price ($ per gallon) [Nielsen Retailer Scanner Data]	Nielsen Retail Scanner Data, 2003–2006	National sample of retailers (n = NR)	Rotterdam model (two specifications)	Juice drink sales (gallons per capita) CSD sales (gallons per capita)	**–1.715**, **–1.527** **–1.756**, **–1.956**
Zheng and Kaiser (2008) (33)	Price ($ per gallon) [CPI Detailed report from BLS]	Food Availability (Per Capita) Data System from ERS, 1974–2005	Aggregated U.S. national sample (n = NR)	AIDS, Rotterdam model	CSD consumption per capita (gallons per person)	**–0.521**, **–0.306**
Zheng and Kaiser (2008) (34)	Price ($ per gallon) [CPI Detailed Report from BLS]	Food Availability (Per Capita) Data System from ERS, 1974–2005	Aggregated US national sample (n = NR)	AIDS	CSD consumption per capita (gallons per person)	**–0.609**
Duffey, Gordon-Larsen, Shikany, Guilkey, Jacobs and Popkin (2010) (29)	Price ($) [C2ER\ACCRA]	CARDIA, 1985–1986, 1992–1993, 2005–2006	Adults aged 18–30 in baseline year (n = 5,115)	Cross-sectional	RCSD consumption probability RCSD consumption (kcal per day)	–0.30 **–0.712**
Finkelstein, Zhen, Nonnemaker and Todd (2010) (27)	Price ($) [Nielsen Homescan Data]	Nielsen Homescan Data, 2006	National sample of households (n = NR)	Demand system	Carbonated SSB1 purchases All SSB2 purchases	**–0.73** **–0.87**
Fletcher, Frisvold and Teft (2010) (51)	State-level soft drink tax [LexisNexis Academic, States' Departments of Revenue]	NHANES, 1988–1994, 1999–2006	Children 3–18 years old (n = 20,968)	Cross-sectional	SSB3 consumption (kcal)	–
Fletcher, Frisvold and Teft (2010) (50)	State-level soft drink tax [LexisNexis Academic, States' Departments of Revenue]	NHANES, 1989–1994, 1999–2006	Children aged 3–18 (n = 21,040)	Cross-sectional	SSB3 consumption probability SSB3 consumption (g) SSB3 consumption (kcal)	– **–** **–**
Smith, Lin and Lee (2010) (28)	Price ($ per gallon) [Nielsen Homescan Data]	Nielsen Homescan Data, 1998–2007	National sample of households (n = NR)	AIDS	SSB2 purchases (oz per day)	**–1.264**
Sturm, Powell, Chriqui and Chaloupka (2010) (52)	State-level carbonated soda sales tax [BTG]	ECLS-K, 2004	5th grade children (n = 7,300)	Cross-sectional	SSB2 consumption (times per week) SSB2 purchases in-school (times per week)	All students: Tax amt/ind: –/– Tax amt/**ind**: –/**–** Available in school: Tax amt/**ind**: –/**–** Tax amt/ind: –/–
Zheng, Kinnucan and Kaiser (2010) (35)	Price ($ per gallon) [CPI Detailed Report from BLS]	USDA Food Disappearance Data, 1970–2004	Aggregated U.S. national sample (n = NR)	Linear, semi-log, Rotterdam and AIDS model	CSD consumption per capita (gallons per person)	**–0.604**, **–0.366**, **–0.428**, **–0.772**

Table 1 *Continued*

Author	Price/Tax variable [Source]	Data set	Population (sample size)	Model	Outcome variable	Price effect: direction/elasticity*
Dharmasena and Capps (2011) (30)	Price ($ per gallon) [Nielsen Homescan Data]	Nielsen Homescan Data, 1998–2003	National sample of households (n = NR)	AIDS	RCSD purchases (gallons per month per capita) Sports/energy purchases (gallons per month per capita) Fruit drink purchases (gallons per month capita)	**–2.2552** **–3.8650** **–0.6892**
Lin, Smith, Lee and Hall (2011) (26)	Price ($ per gallon) [Nielsen Homescan Data]	Nielson National Consumer Panel†, 1998–2007	National sample of households (n = NR)	AIDS	SSB2 purchases (g per day) SSB2 (calories per day)	Low income: **–0.949** High income: **–1.292** –
Sturm and Datar (2011) (39)	Prices ($) [C2ER\ACCRA]	ECLS-K, 2004	5th grade children (n = 4,896)	Cross-sectional	SSB2 consumption (times per week)	+
Zhen, Wohlgenant, Karns and Kaufman (2011) (31)	Price ($ per gallon) Nielsen Homescan Data]	Nielsen Homescan Data, 2004–2006	National sample of households (n = NR)	AIDS	RCSD purchases (oz per month) Sports/energy beverage purchases (oz per month) Fruit drink purchases (oz per month)	**–1.06 to –1.54** **–0.53 to –1.52** **–1.44 to –2.65**
(b) Evidence for fast food (FF)						
Beydoun, Powell and Wang (2008) (37)	Prices ($) [C2ER\ACCRA]	CSFII, 1994–1996	Adults aged 20–65 (n = 7,331)	Cross-sectional	FF consumption (items per 24 h)	–
Duffey, Gordon-Larsen, Shikany, Guilkey, Jacobs and Popkin (2010) (29)	Price ($) [C2ER\ACCRA]	CARDIA, 1985–1986, 1992–1993, 2005–2006	Adults aged 18–30 in baseline year (n = 5,115)	Cross-sectional	FF consumption probability FF consumption (change kcal)	Pizza: –0.71; Burger: 0.00 Pizza: **–1.150;** Burger: +0.203; Pizza & Burger: –
Gordon-Larsen, Guilkey and Popkin (2011) (40)	Price ($) [C2ER\ACCRA]	Add Health, 1996 and 2001–2002	7th–12th grade children in wave I and adults aged 18–28 in wave II (n = 11,088)	Longitudinal	FF consumption (days per week)	–
Beydoun, Powell, Chen and Wang (2011) (38)	Price ($) [C2ER\ACCRA]	CSFII, 1994–1998	Children aged 2–9 (n = 6,759) Adolescents aged 10–18 (n = 1,679)	Cross-sectional	FF consumption (items per 24 h)	Children: **–** Low-income children: **–** Adolescents: –

Table 1 *Continued*

Author	Price/Tax variable [Source]	Data set	Population (sample size)	Model	Outcome variable	Price effect: direction/elasticity*
Sturm and Datar (2011) (39)	Price ($) [C2ER\ACCRA]	ECLS-K, 2004	5th grade children (n = 4,896)	Cross-sectional	FF consumption (times per week)	+
Khan, Powell and Wada (2012) (36)	Price ($) [C2ER\ACCRA]	ECLS-K, 2004, 2007	5th and 8th grade children (n = 11,700)	Longitudinal	FF consumption (times per week)	**–0.565**
(c) Evidence for fruits and vegetables (FV)						
Powell, Auld, Chaloupka, O'Malley and Johnston (2007) (41)	Price ($) [C2ER\ACCRA]	MTF, 1997–2003	8th and 10th grade adolescents (n = 47,675)	Cross-sectional	FV consumption (prevalence of frequent consumption)	–0.08
Beydoun, Powell and Wang (2008) (37)	Prices ($) [C2ER\ACCRA]	CSFII, 1994–96	Adults aged 20–65 (n = 7,331)	Cross-sectional	FV consumption (g per day)	+
Dong and Lin (2009) (43)	Price ($) [Nielsen Homescan Data]	Nielsen Homescan Data, 2004	National sample of households (n = NR)	Demand system	FV purchases (cups per day)	Fruit: **–0.52 low income;** –0.58 high income Vegetable: **–0.69 low income;** –0.57 high income
Powell, Zhao and Wang (2009) (44)	Price ($) [C2ER\ACCRA]	NLSY97, 2002	Young adults aged 18–23 (n = 3,739)	Cross-sectional	FV consumption (times per week)	**–0.32**
Lin, Yen, Dong and Smallwood (2010) (42)	Price ($ per lb) [National Food Stamp Program Survey]	National Food Stamp Program Survey, 1996–1997	Households using food stamps (n = 900)	Translog demand system	FV purchases ($ per week)	Vegetable: **–0.717** Fruit: **–0.813**
Sturm and Datar (2011) (39)	Price ($) [C2ER\ACCRA]	ECLS-K, 2004	5th grade children (n = 4,896)	Cross-sectional	FV consumption (times per week)	**–0.26**
Beydoun, Powell, Chen and Wang (2011) (38)	Price ($) [C2ER\ACCRA]	CSFII, 1994–98	Children aged 2–9 (n = 6,759) Adolescents aged 10–18 (n = 1,679)	Cross-sectional	FV consumption (g per day)	Children: + Adolescents: +

*All directions and elasticity are statistically significant when in bold. Elasticity measures provided when available. Results for selected subsamples noted.
†Also formerly known as Nielsen homescan data.
Add Health, National Longitudinal Study of Adolescent Health; AIDS, almost ideal demand system; BLS, Bureau of Labor Statistics; BTG, Bridging the Gap-Robert Johnson Foundation – supported project, Health Policy Center, University of Illinois at Chicago; C2ER\ACCRA, Council for Community and Economic Research formerly American Chamber of Commerce Researchers Association; CARDIA, Coronary Artery Risk Development in Young Adults; CPI, consumer price index; CSD, regular and diet carbonated soft drinks; CSFII, Continuing Survey of Food Intakes by Individuals; ECLS-K, Early Childhood Longitudinal Study – Kindergarten cohort 1998; ERS, Economic Research Service; FF, fast food; FV, fruits and vegetables; MTF, Monitoring the Future Survey; NHIS, National Health and Nutrition Examination Survey; NLSY97, National Longitudinal Study of Youth 1997; NR, not reported; RCSD, regular carbonated soft drinks; SSB1, regular carbonated soft drinks; SSB2, regular carbonated soft drinks, sports/energy drinks, and fruit drinks; SSB3, non-alcoholic beverages with added natural or artificial sweeteners (carbonated and non-carbonated); USDA, United States Department of Agriculture.

Table 2 Mean estimates of price elasticity of demand for selected beverages, fast food, and fruits and vegetables, 2007–2012

Food and beverage category	Mean price elasticity estimate	Range	No. of estimates
(a) Sugar-sweetened beverages (SSBs and soft drink beverages)			
SSBs overall*	–1.21	–0.71 to –3.87	12
SSBs	–1.08	–0.87 to –1.26	3
Regular carbonated soft drinks	–1.25	–0.71 to –2.26	4
Sports drinks	–2.44	–1.01 to –3.87	2
Fruit drinks	–1.41	–0.69 to –1.91	3
Soft drinks	–0.86	–0.41 to –1.86	4
(b) Fast food			
Fast food	–0.52	–0.47 to –0.57	2
(c) Fruits and vegetables			
Fruits	–0.49	–0.26 to –0.81	4
Vegetables	–0.48	–0.26 to –0.72	4

*Overall mean (weighted mean based on SSB consumption shares) SSB elasticity estimate based on the estimates from the aggregated SSB category and the estimates from the various disaggregated (regular carbonated soda, sports drinks and fruit drinks) categories within the beverage demand system.

Council for Community and Economic Research (C2ER), formally known as the American Chamber of Commerce Researchers Association (ACCRA), to individual-level survey data using geographic identifiers and the majority (four of six) of the studies estimated cross-sectional models. Only two (29,36) of the six studies reported price elasticity estimates with a mean elasticity of –0.52, which is lower than the food-away-from-home estimate of –0.81 reported previously (22). The elasticity estimates from one study that examined adults found that higher fast-food pizza prices (–1.15) but not burger prices (0.20) were associated with significantly lower consumption (based on caloric intake) (29) and another study found fast-food prices were negatively associated with consumption, but the parameter estimates were not statistically significant (37). Among a sample of children, higher fast-food prices were associated with significantly lower frequency of weekly fast-food consumption (–0.52) (36). Overall, there were mixed results among the studies on children, with two finding significant negative associations (36,38) but one finding an unexpected positive association (39). Two studies that included adolescent populations found negative but statistically insignificant effects (38,40).

Fruit and vegetable consumer demand

Panel (c) of Table 1 summarizes the seven studies that provided price estimates for fruits and vegetables. Two studies did not report price elasticities nor did they find statistically significant associations between prices and fruit and vegetable consumption (37,38). Table 2 reports that the mean price elasticity for fruits and vegetables was –0.49 and –0.48, respectively. The one study that examined the probability of frequent consumption rather than a continuous or count of consumption was not included in the overall summary estimate (41). The studies with estimates based on demand system models yielded relatively higher elasticity estimates of –0.52 to –0.81 for fruits and –0.57 to –0.72 for vegetables (42,43). The two studies that had outcome measures that combined fruits and vegetables had the lowest prices elasticity estimates of –0.26 and –0.32 (39,44).

Weight outcomes

Table 3 summarizes the 20 studies identified that examined the relationship between weight outcomes and SSB, fast-food restaurant or fruit and vegetable prices/taxes from 2007 to 2012, parallel to the period of our consumption review. Building on our previous reviews (18,20), 15 are new studies published after 2008, 10 of which have been published since 2009. Also, it is worth noting that adding the search term 'body weight' in addition to body mass index, BMI and obesity used in our previous review work yielded two additional papers in this review that otherwise would not have been retrieved. Another recent review (45) that covered 5 of the 15 weight-related studies published from 2009 through 2012 reported coefficient estimates, whereas we report elasticities when available. Other recent reviews provide international evidence and focus to a large extent on studies that use price elasticities to simulate effects on weight outcomes (23,46). The weight outcome papers in this present review all used individual-level survey data that were directly linked to prices or taxes by geographic identifiers. Thirteen studies drew their price data from C2ER/ACCRA, one from the ERS Quarterly Food-at-Home Price Database (QFAHPD), and one from the Bureau of Labor Statistics Consumer Price Index series, and five studies used state-level soda taxes. Even if included in the models as controls, we did not report on price effects

Table 3 Evidence on price effects on body weight outcomes

Author	Price/Tax measure [Source]	Data set	Population (sample size)	Model	Outcome measure	Evidence for tax effects – fast-food prices and sugar-sweetened beverage prices/taxes: direction/elasticity*	Evidence for subsidy effects – fruit and vegetable prices: direction/elasticity*
(a) Evidence for adults							
Beydoun, Powell and Wang (2008) (37)	Prices ($) of fast food and fruits and vegetables [C2ER\ACCRA]	CSFII, 1994–1996	Adults aged 20–65 ($n = 7331$)	Cross-sectional	BMI	FFP: +	FVP: **–** FVP: **– near poor**
					Obesity	FFP: +	FVP: – FVP: **– near poor**
Schroeter and Lusk (2008) (56)	Prices ($) of fast food [state-level BLS CPI series]	BRFSS, 2003	Adults aged 18 and older ($n = 202,323$)	Cross-sectional	BMI Weight	FFP: –0.044, quadratic FFP: –0.044, log-linear FFP: –0.036, translog	N/A
Fletcher, Frisvold and Tefft (2010) (47)	State-level soft drink tax [LexisNexis Academic, States' Departments of Revenue]	BRFSS, 1990–2006	Adults aged 18 and older ($n = 2,709,422$)	Cross-sectional	BMI	SDT: – **(– in 17 subpopulations)**	N/A
					Obese	SDT: – **(– in 9 subpopulations)**	
					Overweight	SDT: – **(– in 15 subpopulations)**	
Han and Powell (2011) (48)	Prices ($) of regular carbonated soft drinks and fruits and vegetables [C2ER\ACCRA]	MTF, 1992–2003	Young adults 12th grade through age 32 ($n = 5,324$ men and 6,537 women)	Longitudinal	Obese	FFP: –men RE; –men FE FFP: –women RE; –women FE RCSDP: +men RE; +men FE RCSDP: –women RE; +women FE	FVP: –men RE; –men FE FVP: –women RE; –women FE
Powell and Han (2011) (55)	Prices ($) of fast food and fruits and vegetables [C2ER\ACCRA]	PSID 1999, 2001, 2003, 2005	Adults aged 18–65 years old ($n = 17,479$ men and 19,747 women)	Cross-sectional and Longitudinal	BMI	FFP: –men, CS; +men FE FFP: –women CS; +women FE	FVP: +men CS; +men FE FVP: +women CS; **+0.02, women FE** FVP: **+0.09, poor women FE; +0.03, women with children FE**

Table 3 *Continued*

Author	Price/Tax measure [Source]	Data set	Population (sample size)	Model	Outcome measure	Evidence for tax effects – fast-food prices and sugar-sweetened beverage prices/taxes: direction/elasticity*	Evidence for subsidy effects – fruit and vegetable prices: direction/elasticity*
Zhang, Chen, Diawara and Wang (2011) (57)	Prices ($) of fast food [C2ER\ACCRA]	NLSY79, 1985–2002	Female adults aged 20–45 eligible for SNAP ($n = 6,622$)	Longitudinal	BMI	*Non-SNAP participants:* FFP: +RE; +FE; –RE IV; –FE IV *SNAP* vs *Non-SNAP:* FFP: **–RE; –FE;** –RE IV; –FE IV	N/A
					Obesity	*Non-SNAP participants:* FFP: +RE; +FE; +RE IV; +FE IV *SNAP* vs *Non-SNAP:* FFP: +RE; +FE; +RE IV; +FE IV	
Han, Powell and Isgor (2012) (54)	Prices ($) of fast food and fruits and vegetables [C2ER\ACCRA]	PSID, 1999, 2001, 2003	Low-income adults aged 18–65 ($n = 1351$ men and 2,391 women)	Cross-sectional and longitudinal	BMI	*Non-SNAP participants:* FFP: –men CS; –men FE FFP: –women CS; +women FE	*Non-SNAP participants:* FVP: +men CS; –men FE FVP: +women CS; +women FE *SNAP* vs *Non-SNAP:* FVP: **+men CS; +men FE** FVP: **+women CS; +women FE**
					Obesity	*Non-SNAP participants:* FFP: –men CS; –men FE FFP: –women CS; –women FE	*Non-SNAP participants:* FVP: –men CS; –men FE; FVP: +women CS; +women FE
(b) Evidence for children and adolescents							
Powell, Auld, Chaloupka, O'Malley and Johnston (2007) (41)	Prices ($) of fast food and fruits and vegetables [C2ER\ACCRA]	MTF, 1997–2003	Adolescents in 8th and 10th grade ($n = 72,854$)	Cross-sectional	BMI	FFP: **–0.04**	FVP: +
					Overweight	FFP: **–0.59**	FVP: +
Chou, Rashad and Grossman (2008) (58)	Price ($) of fast food [C2ER\ACCRA]	NLSY79, 1996, 1998, and 2000	Children aged 3–11 years ($n = 6,034$)	Cross-sectional	BMI	FFP: –children FFP: **–adolescents** FFP: **–adolescent female**	N/A
		NLSY97, 1997–1999	Adolescents aged 12–18 years ($n = 7,069$)		Overweight	FFP: –children FFP: **–children female** FFP: –adolescents	N/A
Sturm and Datar (2008) (63)	Price (S) of fruits and vegetables [C2ER\ACCRA]	ECLS-K, 1998–2004	Children K through 5th grade ($n = 4,557$)	Longitudinal	BMI	N/A	FVP: **+**

Table 3 *Continued*

Author	Price/Tax measure [Source]	Data set	Population (sample size)	Model	Outcome measure	Evidence for tax effects – fast-food prices and sugar-sweetened beverage prices/taxes: direction/elasticity*	Evidence for subsidy effects – fruit and vegetable prices: direction/elasticity*
Auld and Powell (2009) (59)	Prices ($) of fast food and fruits and vegetables [C2ER\ACCRA]	MTF, 1997–2003	Adolescents in 8th and 10th grade (n = 34,451 male, 38,590 female)	Cross-sectional	BMI	FFP: –0.03 male FFP: **–0.10 male at 90th quantile** FFP: –0.03 female FFP: **–0.11 female at 90th quantile**	FVP: +0.01 male FVP: **+0.05 male at 95th quantile** FVP: **+0.03 female** FVP: **+0.03 female at 50th quantile; +0.04 female at 90th quantile; +0.06 female at 95th quantile**
Powell (2009) (60)	Price ($) of fast food [C2ER\ACCRA]	NLSY97, 1997–2000	Adolescents aged 12–17 in 1997 (n = 11,900)	Cross-sectional and longitudinal	BMI	FFP: –0.10 CS; **–0.08 RE; –0.08 FE** FFP: **–0.13 mother low education FE; –0.31 middle income FE**	N/A
Powell and Bao (2009) (62)	Prices ($) of fast food and fruits and vegetables [C2ER\ACCRA]	NLSY79, 1998–2002	Children aged 6–18 (n = 6594)	Longitudinal	BMI	FFP:–0.07 FFP: **–0.26 low income; –0.13 mother low education**	FVP: **+0.07** FVP: **+0.14 low income; +0.09 mother low education**
Powell, Chriqui and Chaloupka (2009) (49)	State-level carbonated soda sales tax (Grocery store and VM) [BTG]	MTF, 1997–2006	Adolescents aged 13–19 (n = 153,673)	Cross-sectional	BMI	Grocery CST: + VM CST: +	N/A
Fletcher, Frisvold and Tefft (2010) (50)	State-level soft drink tax [Council of State Governments, LexisNexis Academic]	NHANES, 1989–1994, 1999–2006	Children aged 3–18 (n = 22,132)	Cross-sectional	BMI Obese Overweight Underweight	SDT: + SDT: + SDT: + SDT: –	N/A
Fletcher, Frisvold and Tefft (2010) (51)	State-level soft drink tax [LexisNexis Academic, States' Departments of Revenue]	NHANES, 1988–1994, 1999–2006	Children 3–18 years old (n = 20,968)	Cross-sectional	BMI Obese	SDT: + SDT: +	N/A
Sturm, Powell, Chriqui and Chaloupka (2010) (52)	State-level carbonated soda sales tax [BTG]	ECLS-K, 2004	Children in 5th grade (n = 7,300)	Cross-sectional	BMI	CST: – CST: **–at risk of overweight**	N/A

Table 3 *Continued*

Author	Price/Tax measure [Source]	Data set	Population (sample size)	Model	Outcome measure	Evidence for tax effects – fast-food prices and sugar-sweetened beverage prices/taxes: direction/elasticity*	Evidence for subsidy effects – fruit and vegetable prices: direction/elasticity*
Beydoun, Powell, Chen and Wang (2011) (38)	Prices ($) of fast food and fruits and vegetables [C2ER\ACCRA]	CSFII, 1994–1998	Children aged 2–9 ($n = 6,759$) Adolescents aged 10–18 ($n = 1,679$)	Cross-sectional	BMI	FFP: –children FFP: +adolescents	FVP: **+children** FVP: **+children low income** FVP: **–adolescents**
Powell and Chaloupka (2011) (61)	Prices ($) of fast food and fruits and vegetables [C2ER\ACCRA]	CDS-PSID, 1997 and 2002/2003	Children aged 2–18 ($n = 1,629$)	Cross-sectional and Longitudinal	BMI	FFP: –0.16 CS; +0.24 FE FFP: **–0.77 low income CS**	FVP: **+0.24 CS;** +0.25 FE FVP: **+0.60 low income, FE**
Wendt and Todd (2011) (53)	Prices ($) of carbonated beverages, fruit drinks and green vegetables [QFAHPD]	ECLS-K, 1998–2007	Children K through 8th grade ($n = 51,160$)	Cross-sectional and longitudinal	BMI	CBP: –0.03 CS; **–0.04 FE** CBP: **–0.06 male FE; –0.09 near-poor FE; –0.03 white FE; –0.07 Hispanic FE; –0.03 children metro areas FE** **CBP: –0.03 at 25th quantile FE; –0.03 at 50th quantile FE** FDP: +0.00 CS; –0.01 FE FDP: **–0.02 at 25th quantile FE; –0.01 at 50th quantile FE**	GVP: **+0.05 CS;** + 0.01 FE GVP: **+0.03 female FE; –0.07 near-poor FE; +0.02 children metro areas FE** GVP: **+0.04 at 50th quantile FE; +0.08 at 85th quantile FE** SVP: –0.03 CS; **–0.03 FE** SVP: **–0.04 male FE; –0.02 female FE; –0.04 white FE; –0.03 poor FE** SVP: **–0.04 at 25th quantile FE; –0.02 at 50th quantile FE**

*All directions and elasticity are statistically significant at 5 or 1% level when in bold. Elasticity measures provided when available. Results for selected subsamples noted when statistically significant. BLS, Bureau of Labor Statistics; BMI, body mass index; BRFSS, Behavior Risk Factor Surveillance System; BTG, Bridging the Gap-Robert Johnson Foundation – supported project, Health Policy Center, University of Illinois at Chicago; C2ER\ACCRA, Council for Community and Economic Research formerly American Chamber of Commerce Researchers Association; CBP, carbonated beverage price; CDS-PSID, Child Development Supplement – Panel Study of Income Dynamics; CPI, consumer price index; CS, cross-sectional model; CSFII, Continuing Survey of Food Intakes by Individuals; CST, carbonated soda sales tax; ECLS-K, Early Childhood Longitudinal Study – Kindergarten cohort 1998; FDP, fruit drink price; FE; longitudinal individual-level fixed effects; FFP, fast-food price; FVP, fruit and vegetable price; GVP, green vegetable price; MTF, Monitoring the Future Survey; N/A, not available; NHANES, National Health and Nutrition Examination Survey; NLSY79, National Longitudinal Study of Youth 1979; NLSY97, National Longitudinal Study of Youth 1997; PSID, Panel Study of Income Dynamics; QFAHPD, Quarterly Food-at-Home Price Database; RCSDP, regular carbonated soft drink price; RE, longitudinal individual-level random effects; SDT, soft drink tax – 'Soft drinks' are defined broadly to include non-alcoholic, artificially sweetened or 'diet' drinks and carbonated water.; SNAP, Supplemental Nutrition Assistance Program; SVP, starchy vegetable price; VM, vending machine.

for items such as general food-at-home price indices, general food-away-from-home prices or full-service restaurant prices as the focus of this review was on evidence for SSBs and fast food as possible items for taxation and fruits and vegetables as candidates for subsidies. Overall, 11 of the studies were cross-sectional and 9 used longitudinal estimation methods to control for unobserved individual-level heterogeneity. The study findings for the 7 papers on adults are described in panel (a) and panel (b) presents the 13 papers focused on child and adolescent populations.

Overall, the evidence on the extent to which changes in food or beverage prices may significantly impact weight outcomes remains mixed. A recent study that examined associations between existing soda sales taxes and weight outcomes among adults found statistically significant but small associations (47), whereas a study of young adults found no significant association between obesity and the price of regular carbonated soft drinks (48). The studies that assessed associations between existing soda sales taxes and children's or adolescents' weight outcomes found no or limited associations with weight outcomes (49–52). Just one study found that higher soda sales taxes were significantly associated with lower weight gain, particularly among those children who were overweight (52). Another study that examined carbonated beverage prices rather than taxes found that higher prices were statistically significantly related to lower BMI among children in a longitudinal model (53). Furthermore, this latter study found that the negative relationship between carbonated beverage prices and BMI were greater for near-poor compared to poor and non-poor children and greater for Hispanic and white compared to black children but did not find differential effects across the BMI distribution (53).

Among adults, the six recent studies identified that examined fast-food prices generally found statistically insignificant associations with weight outcomes (37,48,54–57). However, one study found that among adults who were eligible for the Supplemental Nutrition Assistance Program (SNAP) higher fast-food prices were significantly associated with lower BMI among SNAP vs. non-SNAP recipients (57). For adolescents, among the five studies that examined associations of weight outcomes with fast-food prices, there was fairly consistent evidence (in four out of five studies) that suggested that higher fast-food prices were significantly associated with lower weight outcomes, particularly among those who were low- to middle-SES and in the upper tail of the BMI distribution (41,58–60). Furthermore, the associations between fast-food prices and weight outcomes were generally found to be significant in longitudinal estimation models that controlled for individual-level fixed effects, although the cross-sectional vs. longitudinal estimate was shown to overestimate the association by about 25% (60). No significant effect of fast-food prices on younger children's (age 2–9) BMI was found overall or among lower-income children in one study (38), and in another study of children aged 2–18, the effect among low-income children was significant in the cross-sectional analysis but not in the longitudinal analysis (61). However, one longitudinal study of children aged 6–18 found that higher fast-food prices were statistically significantly associated with lower BMI among low-socioeconomic status (SES) children (62).

The potential effect of reducing adult weight through subsidies to fruits and vegetables was mixed for the adult population overall but significant effects were found for female adults, including in longitudinal models, with larger effects for poor women and those with children (55). Furthermore, one study found that reductions in the price of fruits and vegetables would decrease BMI significantly more for SNAP participants than non-SNAP participants (54). These findings are particularly pertinent to the policy debate given that subsidies are likely to be targeted to low-income or SNAP participants. Furthermore, in all of the studies that examined child populations (38,53,61–63) (with the exception of two individual fixed effects estimates) and in all but two studies (38,41) focused on adolescents, lower fruit and vegetable prices were consistently estimated to be associated with lower weight outcomes. One study (53) that drew price data from the ERS QFAHPD, which was able to distinguish dark green vs. starchy vegetable prices, found that higher prices for dark green vegetables was positively associated with children's BMI, whereas higher prices for starchy vegetables had the opposite effect. In general, the evidence suggested that fruit and vegetable subsidies would have the greatest effects on improving weight outcomes among children and adolescents from low-SES families (38,53,61,62) and among those in the upper tail of the BMI distribution (53,59).

Current and proposed food and beverage fiscal pricing policies

No jurisdictions in the United States currently apply sizable taxes (i.e. in the order of 20% as have been recently proposed) to SSBs or fast-food purchases and subsidies for fresh fruit and vegetable purchases are often limited in scope or magnitude and are not readily available nationwide. The following discussion summarizes where the current system of taxation and subsidies stands and provides examples of recent policy proposals.

A patchwork system of food and beverage taxation exists in the United States. Currently, there are no federal taxes on foods and/or beverages, and some, but not all, states and localities apply relatively small taxes at variable rates (19,64). Most food and beverage items are exempt from state sales taxes or are included in a general definition of food products that, when taxed, are taxed at a markedly

lower rate than sales taxes applied to other goods and services (20).

For the most part, any foods or beverages purchased in a restaurant, including both fast-food restaurants and full-service or sit-down establishments, follow the general state sales tax scheme. The few exceptions are in the District of Columbia, New Hampshire and Vermont – each applies a restaurant-specific tax that is higher than the state's general sales tax (i.e. restaurant taxes of 10, 8 and 9%, respectively). As of the beginning of 2012, the average state sales tax on restaurant (including fast food) sales was 5.31% across all states and the District of Columbia and was 5.76% in the 47 states with such a tax (65).

As Table 4 illustrates, state sales taxes on beverages vary greatly by beverage category. For example, as of 1 January 2012, 35 states apply their sales tax to regular and diet carbonated beverages, while 31 states tax isotonic beverages or sports drinks and 28 tax ready-to-drink teas which often contain added sugars. Across all states, the average sales taxes on beverages range from 3.55% for regular and diet sodas to 0.99% on 100% juices; in taxing states, the average rates range from 5.17% for regular and diet carbonated beverages to 3.59% for 100% juices (65). As the table illustrates, the taxes on some beverage categories are higher than food products generally and, thus, they are considered 'disfavoured' relative to other food products (19,20,66). Notably, none of the revenues generated from beverage sales taxes are dedicated to obesity prevention efforts or programmes.

At the same time, in addition to sales taxes, seven states – Alabama, Arkansas, Rhode Island, Tennessee, Virginia, Washington and West Virginia – currently impose other types of taxes or levy fees for the sale of certain beverages (19,20,65,67). These additional taxes generally apply to bottles, syrups and/or powders/mixes and are targeted at various levels of the distribution chain, including wholesalers, bottlers, manufacturers and distributors; however, none of the revenue generated from these additional taxes/fees is currently dedicated to obesity prevention programming. With the exception of the license fees and taxes imposed on manufacturers, wholesalers and/or retailers in Alabama (Ala. Code §§ 40-12-65, -69, -70 [2010]), most of these additional taxes or levies are based on volume of beverage (typically in gallons) (19,20).

In recent years, a number of jurisdictions have proposed placing sizable and specific excise taxes on SSBs as recommended in the above-mentioned literature and, most recently, by the Institute of Medicine (68). The impetus behind such taxes generally is based on the fact that, as noted earlier, SSBs are the leading source of calories and added sugars in the American diet and that overconsumption of SSBs is associated with obesity, combined with the budgetary shortfalls faced by governments nationwide. Table 5 illustrates a few such examples from 2012 alone

Table 4 State sales taxes on selected beverages as of 1 January 2012 (Source: Bridging the Gap Program 2012)

Type of beverage*	State sales taxes on beverages			Disfavoured† sales taxes on beverages		
	No. of states applying a sales tax to beverage	Mean sales tax, taxing states only	Mean sales tax, all states‡	No. of states with a disfavoured sales tax	Mean disfavoured sales tax, taxing states only	Mean disfavoured sales tax, all states‡
Regular soda	35	5.17	3.55	23	5.68	2.56
Diet soda	35	5.17	3.55	23	5.68	2.56
Isotonic beverages (sports drinks)	31	5.07	3.08	19	5.63	2.10
<50% juice	30	5.04	2.97	18	5.61	1.98
Ready-to-drink teas	28	5.01	2.75	16	5.68	1.77
Bottled water	18	3.85	1.36	4	4.75	0.37
51–99% juice	16	3.77	1.18	2	5.00	0.20
100% juice	14	3.59	0.99	0	–	–

*Type of beverage assumes beverages available for individual purchase from a supermarket/grocery store.
†Disfavoured sales tax refers to the amount of the given beverage sales tax that is greater than the state sales tax on food items generally.
‡All states include the 50 states and the District of Columbia.

Table 5 Examples of state excise tax-related proposals with legislative action during calendar year 2012

State*	Bill number	Proposed tax/fee	Proposed revenue dedication
Hawaii	S.B. 2480	$0.01 per teaspoon of added sugar	Revenues would be dedicated to community health centres special fund, the trauma system special fund, and establish the John A. Burns School of Medicine medical loan forgiveness programme special fund
Illinois	S.B. 396	$0.01 per ounce	Revenues would be used to create the Illinois Health Promotion Fund
Mississippi	S.B. 2642	$2.56 per gallon of sweetened beverage produced or $0.02 per ounce	20% of revenue would go to the Children's Health Promotion Fund
Vermont	H.B. 615	$0.01 per ounce	Revenue would be used t to create the Vermont Oral Health Improvement Fund

*State examples were identified through the Yale Rudd Center for Food Policy & Obesity Legislative Database available at http://www.yaleruddcenter.org/legislation/search.aspx (last accessed 24 May 2012).

(although, to date, none have been enacted into law). While each of the examples included in Table 5 aims to dedicate a portion of the revenue generated from the tax to health-related programmes, none are specifically calling for funding obesity-specific programs as recommended by the public health community (17).

Subsidies available for food in the United States have not generally been designed with the aim to change consumption patterns but rather to alleviate food insecurity for low-income individuals and families through programs such as the SNAP; the Women, Infant and Children (WIC) Nutrition Program; the Child and Adult Care Food Program; and the National School Lunch and Breakfast Programs. However, there have been some recent changes that were made, for instance, to the WIC program that added monthly cash value vouchers specifically for fruits and vegetables in the amount of $10 for fully breastfeeding women, $8 for non-breastfeeding women and $6 for children (21). In addition, recent changes have been made to the national school breakfast and lunch programs to ensure that all foods and beverages sold/served are aligned with the latest scientific evidence and the 2010 *Dietary Guidelines for Americans* (69). The new regulations, effective as of the 2012–2013 school year, will ensure that school meals will offer more fruits and vegetables, more whole grains, only fat-free or low-fat milk, less sodium, and will limit the number of calories to within a range appropriate for each of three grade groupings (70). At the same time, as part of the congressionally mandated wellness policy required of all school districts in the United States participating in the federal school meal programmes (P.L. 108–265, Section 204), some districts have taken specific steps to require a minimum number of fruits and vegetables, whole grains and skim/low-fat milk daily as part of the school meal offerings (71).

Although no formal subsidies for fruits and vegetables beyond those in the WIC package presently exist in the United States, the potential provision of providing such subsidies more broadly for low-income populations is increasingly being assessed. The USDA undertook a 'Healthy Purchase' pilot programme in California that targeted subsidies within the SNAP programme such that for each dollar of food stamps spent on fresh produce, participants were subsidized a portion of the cost (72). Currently, the USDA is undertaking the Healthy Incentives Pilot project in Hampden County, Massachusetts, to test whether point-of-sale subsidies provided to SNAP participants increases purchases of fruits and vegetables (73).

Discussion

The recent studies reviewed from 2007 to 2012 showed that the empirical evidence on prices, food and beverage demand, and weight outcomes continues to emerge. Our search yielded a total of 21 recent consumption-related papers and 20 weight-related studies. Most of the SSB-related consumption papers were based on models of demand systems and provided elasticity estimates, whereas the methods and outcomes in studies for fast food and fruits and vegetables were more varied. An increasing number of currently reviewed weight papers used longitudinal estimation methods (almost one-half), whereas the evidence base previously reviewed was mainly comprised of cross-sectional or modelling studies (18,20,23). Studies that provided both cross-sectional and longitudinal estimates (53–55,60,61) revealed that the associations mostly but not always remained statistically significant in the longitudinal models. However, the longitudinal fixed effects estimates showed that the cross-sectional estimates often overestimated the associations highlighting the importance of controlling for individual-level unobserved heterogeneity.

This review is timely given the recent recommendations by the IOM Committee to Accelerate Progress in Obesity Prevention that suggested consideration be given to fiscal pricing instruments for beverages (68). The new evidence presented herein suggested that SSBs are price elastic and that a tax that raises prices by 20% would reduce SSB consumption by 24% (elasticity of –1.21). As expected,

narrower categories of SSBs were found to be more price elastic with elasticity estimates for regular carbonated soda, sports drinks and fruit drinks of –1.25, –2.44 and –1.41, respectively. Soft drink demand was estimated to be less price elastic (–0.86), consistent with previous available estimates (22). However, studies that aim to assess the potential impact of existing SSB or regular soda/soft drink taxes should not draw on soft drink elasticity estimates as they typically include diet alternatives which would not likely be included as part of the tax base for a SSB-specific tax.

Despite evidence on the price responsiveness of SSB and carbonated soda consumption, the studies that linked existing soda sales taxes to weight outcomes showed the least consistent impact on weight, although one study (53) that used a carbonated beverage price rather than tax measure found a significant association with children's weight. The results based on studies that used existing tax measures are not surprising given that current taxes imposed, primarily state-based sales taxes, are relatively low. All 35 states that apply a sales tax to regular, sugar-sweetened soda also apply the sales tax to diet varieties and fewer states apply their sales taxes to other SSBs, although a number of jurisdictions in recent years have considered imposing sizable excise taxes specifically on SSBs which, if enacted, could lead to reduced SSB consumption and improved weight outcomes, particularly at the broad population level. In addition to the magnitude of the tax, the design of a given SSB tax is important to ensure its effectiveness in incentivizing behaviour change. In this regard, several key arguments can be made in favour of an excise vs. a sales tax, regardless of whether the tax is at the federal, state or local level (20). Excise taxes have the benefit of being incorporated into the shelf price of the given product (and, hence, are part of the visible price seen by consumers), whereas a sales tax is only applied at the point of purchase, after the decision to select and purchase the item has been made. Excise taxes that are applied on a per unit measure are more effective in raising prices when volume discounts are given, compared to sales taxes that generally are applied as a percentage of price. Finally, consideration should be given to the harmonization between tax policies and broader public program design as it is preferable not to have certain segments of the population exempt from the given tax as is currently the case where food or beverage purchases under the SNAP are exempt from any state and local-level tax (7 CFR §272.1).

A smaller body of evidence examined price effects on fast-food consumption and the limited number of price elasticity estimates available suggested that consumption was price inelastic with an average estimate of –0.52, suggesting that a tax that raised the price of fast food by 20% would reduce consumption by about 10%. Previous studies similarly found that food-away-from home was price inelastic, with a mean estimated price elasticity of –0.81 (22). Nonetheless, such a tax could have large implications at the population level given the extent of caloric intake from fast food among the U.S. population, particularly among youths. Indeed, the review of fast-food prices and weight outcomes revealed that there was fairly consistent evidence, suggesting that higher fast-food prices would reduce body weight among adolescents.

However, taxing fast-food consumption is more challenging than taxing a specific category of beverages. Fast-food restaurants often sell a variety of food and beverage items including both healthy options (e.g. salads and bottled water) as well as other options that tend to be high in fats, sugars and calories; however, given the prevalence of fast-food consumption in the United States and its association with increased BMI, fiscal policies, including specific excise taxes and subsidies, should be considered to ensure that a variety food and beverage options are available and that healthier options that are lower in fats, calories and added sugars are readily available, promoted and competitively priced at such outlets (68).

The evidence for fruits and vegetables showed that consumption was price inelastic with a mean estimated price elasticity of demand for fruits at –0.49 and vegetables at –0.48, suggesting that subsidizing fruits and vegetables by 20% would increase consumption by 10%. The evidence that linked prices to weight outcomes demonstrated fairly consistent findings that lower fruit and vegetable prices were associated with lower body weight among low-income populations, including SNAP participants. These results also suggest that the income effect of the subsidy would not likely result in higher overall net caloric intake. The weight-related evidence base for fruit and vegetable prices has grown substantially since our previous reviews (18,20) including an increasing number of studies that used longitudinal data. The consistent findings provide increased evidence on the potential effectiveness of using fruit and vegetable subsidies targeted to low-income populations. Also, new evidence that was able to take advantage of the more detailed price data from the ERS QFAHPD suggested that subsidies that would lower the price of dark green vegetables may be expected to reduce children's weight outcomes, whereas subsidies inclusive of starchy vegetables may have unintended effects of increasing weight (53). Further research linking the more detailed ERS QFAHPD price data vs. the more limited but commonly used C2ER/ACCRA to additional individual-level data sets including those for adult and adolescent populations and analyses by income levels is needed to provide important evidence relevant to the effective design of subsidies aimed at improving weight outcomes.

This review documented the recent evidence relevant to current fiscal policies being considered as potential pricing instruments to incentivize individuals to consume more healthy diets and improve weight outcomes. Given the

consistent evidence that lower prices for fruits and vegetables were associated with lower weight outcomes among SNAP participants and low-income populations, it is important to continue to pilot test the delivery of subsidies such as is currently being done through the Healthy Incentives Pilot programme and to test their associations with consumption and if possible with weight outcomes using longitudinal study designs. It is also important that future research assesses the extent to which subsidies for more healthy food products impact on total caloric intake as some recent research based on an experimental study design suggests such subsidies may increase total energy intake (74). Experimental studies were not assessed in this review due to the fact that such designs often require participants to spend their entire budget, have limited choices and generally may lack external validity (75).

Particularly relevant to the SSB tax debate, this present study was the first to our knowledge to review the price sensitivity of SSB demand specifically with comparisons to aggregated and disaggregated measures and to broader soft drink estimates. In particular, a substantial body of new evidence emerged on the price elasticity of SSBs – 12 estimates were provided in seven new studies published since a previous review (22) of studies through to 2007. However, despite the increasing evidence base, more study estimates are needed to improve the precision and applicability of the expected effect. Future studies on demand should avoid grouping sugar-sweetened and non-sugar-sweetened drinks in the same category. Additional research is needed to assess price elasticity of demand for SSBs. In particular, sensitivity analysis within demand systems on single vs. multiple categorization of SSBs would make a strong contribution to the literature and would help us understand the nature of substitution between and across SSBs and non-SSBs. Additional research also is needed on linking soda and SSB prices to weight outcomes given the limited variability in current soda taxes and the fact that they apply equally to diet soda. Most of the price elasticity estimates were derived from household-level or time series data, which did not provide differential impacts by age groups. Future studies that use individual-level data would provide further evidence on the extent of differential effects across various populations. Indeed, evidence for other risky behaviours shows that young people are more responsive than adults to changes in the prices of tobacco products and alcoholic beverages (76,77).

The growing evidence base assessed herein indicates that changes in the relative prices of less healthy and healthier foods and beverages can significantly change consumption patterns and may have significant impacts on weight outcomes at the population level, particularly among populations most at risk for obesity and its consequences. Raising the prices of less healthy options by taxing them has the added benefit of generating considerable revenues that can be used to support costly programmes and other interventions aimed at improving diets, increasing activity and reducing obesity, including subsidies for healthier foods and beverages.

Conflict of Interest Statement

The authors have no conflict of interests for this manuscript.

References

1. Flegal KM, Carroll MD, Kit BK, Ogden CL. Prevalence of obesity and trends in the distribution of body mass index among US adults, 1999–2010. *JAMA* 2012; **307**: 491–497.
2. Ogden CL, Carroll MD, Kit BK, Flegal KM. Prevalence of obesity and trends in body mass index among US children and adolescents, 1999–2010. *JAMA* 2012; **307**: 483–490.
3. Cawley J, Meyerhoefer C. The medical care costs of obesity: an instrumental variables approach. *J Health Econ* 2012; **31**: 219–230.
4. Kuchler F, Stewart H. Price trends are similar for fruits, vegetables, and snack foods. Economic Research Report No. 55, 2008. U.S. Department of Agriculture, Economic Research Service.
5. Wang YC, Bleich SN, Gortmaker SL. Increasing caloric contribution from sugar-sweetened beverages and 100% fruit juices among US children and adolescents, 1988–2004. *Pediatrics* 2008; **121**: e1604–e1614.
6. Malik VS, Schulze MB, Hu FB. Intake of sugar-sweetened beverages and weight gain: a systematic review. *Am J Clin Nutr* 2006; **84**: 274–288.
7. Vartanian LR, Schwartz MB, Brownell KD. Effects of soft drink consumption on nutrition and health: a systematic review and meta-analysis. *Am J Public Health* 2007; **97**: 667–675.
8. Reedy J, Krebs-Smith SM. Dietary sources of energy, solid fats, and added sugars among children and adolescents in the United States. *J Am Diet Assoc* 2010; **110**: 1477–1484.
9. U.S. Department of Agriculture and U.S. Department of Health and Human Services. *Dietary Guidelines for Americans, 2010*, 7th edn. U.S. Government Printing Office: Washington, DC, 2010.
10. Welsh JA, Sharma AJ, Grellinger L, Vos MB. Consumption of added sugars is decreasing in the United States. *Am J Clin Nutr* 2011; **94**: 726–734.
11. Bleich SN, Wang YC, Wang Y, Gortmaker SL. Increasing consumption of sugar-sweetened beverages among US adults: 1988–1994 to 1999–2004. *Am J Clin Nutr* 2009; **89**: 372–381.
12. Guthrie JF, Lin BH, Frazao E. Role of food prepared away from home in the American diet, 1977–78 versus 1994–96: changes and consequences. *J Nutr Educ Behav* 2002; **34**: 140–150.
13. Poti JM, Popkin BM. Trends in energy intake among US children by eating location and food source, 1977–2006. *J Am Diet Assoc* 2011; **111**: 1156–1164.
14. Guenther PM, Dodd KW, Reedy J, Krebs-Smith SM. Most Americans eat much less than recommended amounts of fruits and vegetables. *J Am Diet Assoc* 2006; **106**: 1371–1379.
15. Blanck HM, Gillespie C, Kimmons JE, Seymour JD, Serdula MK. Trends in fruit and vegetable consumption among U.S. men and women, 1994–2005. *Prev Chronic Dis* 2008; **5**: A35.
16. Casagrande SS, Wang Y, Anderson C, Gary TL. Have Americans increased their fruit and vegetable intake? The trends between 1988 and 2002. *Am J Prev Med* 2007; **32**: 257–263.

17. Brownell KD, Frieden TR. Ounces of prevention – the public policy case for taxes on sugared beverages. *N Engl J Med* 2009; **360**: 1805–1808.
18. Powell LM, Chaloupka FJ. Food prices and obesity: evidence and policy implications for taxes and subsidies. *Milbank Q* 2009; **87**: 229–257.
19. Chriqui JF, Eidson SS, Bates H, Kowalczyk S, Chaloupka FJ. State sales tax rates for soft drinks and snacks sold through grocery stores and vending machines, 2007. *J Public Health Policy* 2008; **29**: 226–249.
20. Powell LM, Chriqui JF. Food taxes and subsidies: evidence and policies for obesity prevention. In: Cawley J (ed.). *The Handbook of the Social Science of Obesity*. Oxford University Press: Oxford, 2011, pp. 639–664.
21. Oliveira V, Frazao E. The WIC program background, trends, and economic issues. Economic Research Report No. 73. 2009. U.S. Department of Agriculture, Economic Research Service.
22. Andreyeva T, Long M, Brownell KD. The impact of food prices on consumption: a systematic review of research on price elasticity of demand for food. *Am J Public Health* 2010; **100**: 216–222.
23. Thow AM, Jan S, Leeder S, Swinburn B. The effect of fiscal policy on diet, obesity and chronic disease: a systematic review. *Bull World Health Organ* 2010; **88**: 609–614.
24. Chaloupka FJ. Tobacco control lessons learned: the impact of state and local policy. *ImpacTeen Research Paper Number 38 Chicago: ImpacTeen, Health Policy Center, Institute for Health Research and Policy, University of Illinois at Chicago*, 2010.
25. Centers for Disease Control and Prevention (CDC) National Center for Health Statistics (NCHS). National Health and Nutrition Examination Survey Data. Hyattsville, MD: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, 2011. [WWW document]. URL http://www.cdc.gov/nchs/nhanes.htm (accessed April 2012).
26. Lin BH, Smith TA, Lee JY, Hall KD. Measuring weight outcomes for obesity intervention strategies: the case of a sugar-sweetened beverage tax. *Econ Hum Biol* 2011; **9**: 329–341.
27. Finkelstein EA, Zhen C, Nonnemaker J, Todd JE. Impact of targeted beverage taxes on higher- and lower-income households. *Arch Intern Med* 2010; **170**: 2028–2034.
28. Smith TA, Lin B-H, Lee J-Y. Taxing caloric sweetened beverages: Potential effects on beverage consumption, calorie intake, and obesity. Economic Research Report No. 100. 2010. U.S. Department of Agriculture, Economic Research Service.
29. Duffey KJ, Gordon-Larsen P, Shikany JM, Guilkey D, Jacobs DR Jr, Popkin BM. Food price and diet and health outcomes: 20 years of the CARDIA study. *Arch Intern Med* 2010; **170**: 420–426.
30. Dharmasena S, Capps O. Intended and unintended consequences of a proposed national tax on sugar-sweetened beverages to combat the U.S. obesity problem. *Health Econ* 2011; **21**: 669–694.
31. Zhen C, Wohlgenant MK, Karns S, Kaufman P. Habit formation and demand for sugar-sweetened beverages. *Am J Agric Econ* 2011; **93**: 175–193.
32. Brown MG. Impact of income on price and income responses in the differential demand system. *J Agric Appl Econ* 2008; **40**: 593–608.
33. Zheng Y, Kaiser HM. Advertising and U.S. nonalcoholic beverage demand. *Agric Resour Econ Rev* 2008; **37**: 147–159.
34. Zheng Y, Kaiser HM. Estimating asymmetric advertising response: an application to U.S. nonalcoholic beverage demand. *J Agric Appl Econ* 2008; **40**: 837–849.
35. Zheng Y, Kinnucan H, Kaiser H. Measuring and testing advertising-induced rotation in the demand curve. *Appl Econ* 2010; **42**: 1601–1614.
36. Khan T, Powell LM, Wada R. Fast food consumption and food prices: evidence from panel data on 5th and 8th grade children. *J Obes* 2012. doi:10.1155/2012/857697.
37. Beydoun MA, Powell LM, Wang Y. The association of fast food, fruit and vegetable prices with dietary intakes among US adults: is there modification by family income? *Soc Sci Med* 2008; **66**: 2218–2229.
38. Beydoun MA, Powell LM, Chen X, Wang Y. Food prices are associated with dietary quality, fast food consumption, and body mass index among U.S. children and adolescents. *J Nutr* 2011; **141**: 304–311.
39. Sturm R, Datar A. Regional price differences and food consumption frequency among elementary school children. *Public Health* 2011; **125**: 136–141.
40. Gordon-Larsen P, Guilkey DK, Popkin BM. An economic analysis of community-level fast food prices and individual-level fast food intake: a longitudinal study. *Health Place* 2011; **17**: 1235–1241.
41. Powell LM, Auld CM, Chaloupka FJ, O'Malley PM, Johnston LD. Access to fast food and food prices: relationship with fruit and vegetable consumption and overweight among adolescents. *Adv Health Econ Health Serv Res* 2007; **17**: 23–48.
42. Lin BH, Yen ST, Dong D, Smallwood DM. Economic incentives for dietary improvement among food stamp recipients. *Contemp Econ Policy* 2010; **28**: 524–536.
43. Dong D, Lin BH. Fruit and vegetable consumption by low-income Americans: would a price reduction make a difference? Economic Research Service Report No. 70. 2009. U.S. Department of Agriculture, Economic Research Service.
44. Powell LM, Zhao Z, Wang Y. Food prices and fruit and vegetable consumption among young American adults. *Health Place* 2009; **15**: 1064–1070.
45. Wilde P, Llobrera J, Valpiani N. Household food expenditures and obesity risk. *Curr Obes Rep* 2012; **1**: 123–133.
46. Mytton OT, Clarke D, Rayner M. Taxing unhealthy food and drinks to improve health. *BMJ* 2012; **344**: e2931.
47. Fletcher JM, Frisvold D, Tefft N. Can soft drink taxes reduce population weight? *Contemp Econ Policy* 2010; **28**: 23–35.
48. Han E, Powell LM. Effect of food prices on the prevalence of obesity among young adults. *Public Health* 2011; **125**: 129–135.
49. Powell LM, Chriqui J, Chaloupka FJ. Associations between state-level soda taxes and adolescent body mass index. *J Adolesc Health* 2009; **45**: S57–S63.
50. Fletcher JM, Frisvold DE, Tefft N. The effects of soft drink taxes on child and adolescent consumption and weight outcomes. *J Public Econ* 2010; **94**: 967–974.
51. Fletcher JM, Frisvold D, Tefft N. Taxing soft drinks and restricting access to vending machines to curb child obesity. *Health Aff* 2010; **29**: 1059–1066.
52. Sturm R, Powell LM, Chriqui JF, Chaloupka FJ. Soda taxes, soft drink consumption, and children's body mass index. *Health Aff* 2010; **29**: 1052–1058.
53. Wendt M, Todd JE. The effect of food and beverage prices on children's weights. Economic Research Service Report No. 118. 2011. U.S. Department of Agriculture, Economic Research Service.
54. Han E, Powell LM, Isgor Z. Supplemental nutrition assistance program and body weight outcomes: the role of economic contextual factors. *Soc Sci Med* 2012; **74**: 1874–1881.
55. Powell LM, Han E. Adult obesity and the price and availability of food in the United States. *Am J Agric Econ* 2011; **93**: 378–384.

56. Schroeter C, Lusk JL. Economic factors and body weight: an empirical analysis. *J Agric Appl Econ* 2008; **40**: 523–538.
57. Zhang Q, Chen Z, Diawara N, Wang Y. Prices of unhealthy foods, food stamp program participation, and body weight status among U.S. low-income women. *J Fam Econ Issues* 2011; **32**: 245–256.
58. Chou SY, Rashad I, Grossman M. Fast food restaurant advertising on television and its influence on childhood obesity. *J Law Econ* 2008; **51**: 599–618.
59. Auld MC, Powell LM. Economics of food energy density and adolescent body weight. *Economica* 2009; **76**: 719–740.
60. Powell LM. Fast food costs and adolescent body mass index: evidence from panel data. *J Health Econ* 2009; **28**: 963–970.
61. Powell LM, Chaloupka FJ. Economic contextual factors and child body mass index. In: Grossman M, Mocan HN (eds). *Economic Aspects of Obesity*. University of Chicago Press: Chicago, 2011, pp. 127–144.
62. Powell LM, Bao YJ. Food prices, access to food outlets and child weight outcomes. *Econ Hum Biol* 2009; **7**: 64–72.
63. Sturm R, Datar A. Food prices and weight gain during elementary school: 5-year update. *Public Health* 2008; **122**: 1140–1143.
64. Jacobson MF, Brownell KD. Small taxes on soft drinks and snack foods to promote health. *Am J Public Health* 2000; **90**: 854–857.
65. Bridging the Gap Program University of Illinois at Chicago. Soda/snack taxes. [WWW document]. URL http://www.bridgingthegapresearch.org/research/sodasnack_taxes/. http://www.bridgingthegapresearch.org [serial online] (accessed April 2012).
66. Stone GR, Seidman LM, Sunstein C (eds). *Constitutional Law*, 4th edn. Aspen: New York, 2001.
67. Chaloupka FJ, Powell LM, Chriqui JF. Sugar-sweetened beverage taxes and public health. [WWW document]. URL http://www.rwjf.org/content/dam/farm/reports/issue_briefs/2009/rwjf43487 [serial online] (accessed April 2012). Available from: Robert Wood Johnson Foundation.
68. Committee to Accelerate Progress in Obesity Prevention Institute of Medicine. *Accelerating Progress in Obesity Prevention: Solving the Weight of the Nation*. The National Academies Press: Washington, DC, 2012.
69. U.S. Department of Agriculture. Nutrition standards in the National School Lunch and School Breakfast Programs: final rule. *Fed Regist* 2012; **77**: 4088–4167.
70. Hirschman J, Chriqui JF. School food and nutrition policy, monitoring, and evaluation in the United States. *Public Health Nutr* 2012. doi: 10.1017/S1368980012004144.
71. Chriqui JF, Schneider L, Chaloupka FJ *et al*. School District Wellness Policies: Evaluating Progress and Potential for Improving Children's Health Three Years after the Federal Mandate. School Years 2006–07, 2007–08, and 2008–09. Vol. 2. Chicago, IL, Bridging the Gap, Health Policy Center, Institute for Health Research and Policy, University of Illinois at Chicago, 2010.
72. Guthrie J, Frazão E, Andrews M, Smallwood D. Improving food choices-Can food stamps do more? *Amber Waves* 2007; **5**: 22–28.
73. U.S. Department of Agriculture. Healthy incentives pilot (HIP). [WWW document]. URL http://www.fns.usda.gov/snap/HIP/default.htm. [serial online] (accessed May 2012).
74. Epstein LH, Dearing KK, Roba LG, Finkelstein E. The influence of taxes and subsidies on energy purchased in an experimental purchasing study. *Psychol Sci* 2010; **21**: 406–414.
75. Epstein LH, Jankowiak N, Nederkoorn C, Raynor HA, French SA, Finkelstein E. Experimental research on the relation between food price changes and food-purchasing patterns: a targeted review. *Am J Clin Nutr* 2012; **95**: 789–809.
76. Xu X, Chaloupka FJ. The effects of prices on alcohol use and its consequences. *Alcohol Res Health* 2011; **34**: 236–245.
77. International Agency for Research on Cancer. *Effectiveness of Tax and Price Policies for Tobacco Control*. International Agency for Research on Cancer: Lyon, France, 2011.