

# Cost-Effectiveness of Fiscal Policies to Prevent Obesity

Marj Moodie · Lauren Sheppard · Gary Sacks ·  
Catherine Keating · Anna Flego

Published online: 28 June 2013

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**Abstract** Cost-effective, sustainable strategies are urgently required to curb the global obesity epidemic. To date, fiscal policies such as taxes and subsidies have been driven largely by imperatives to raise revenue or increase supply, rather than to change population behaviours. This paper reviews the economic evaluation literature around the use of fiscal policies to prevent obesity. The cost-effectiveness literature is limited, and more robust economic evaluation studies are required. However, uncertainty and gaps in the effectiveness evidence base need to be addressed first: more studies are needed that collect ‘real-world’ empirical data, and larger studies with more robust designs and longer follow-up timeframes are required. Reliability of cross-price elasticity data needs to be investigated, and greater consideration given to moderators of intervention effects and the sustainability of outcomes. Economic evaluations should adopt a societal perspective, incorporate a broader spectrum of economic costs and consider other factors likely to affect the implementation of fiscal measures. The paucity of recent cost-effectiveness studies means that definitive conclusions about the value for money of fiscal policies for obesity prevention cannot yet be drawn. However, as in other public health areas such as alcohol and

tobacco, early indications are that population-level fiscal policies are likely to be potentially effective and cost-saving.

**Keywords** Obesity prevention · Fiscal policies · Taxes · Subsidies · Cost-effectiveness · Economic evaluation · Price elasticity

## Introduction

The escalating global obesity epidemic [1] and its resultant huge disease burden have attracted enormous attention in recent decades as researchers, health promotion personnel, clinicians and policymakers alike scramble to find effective solutions [2, 3]. Some studies have suggested that the continued growth in obesity prevalence, together with the excess mortality attributable to it, may result in declining life expectancies in the future [4, 5]. There is thus an urgent need to seek coordinated, cost-effective and sustainable strategies [6] to put the brakes on what has been described as a ‘runaway train’ [7].

Governments have a major role to play in efforts to reverse the obesity epidemic. With the growing levels of obesity prevalence often viewed as a product of ‘market failure’ [2, 8], the onus is on governments to intervene and take action to counteract or break down obesogenic environments [9]. Governments operate at different levels (e.g. local, state, national), and offer the potential to deliver multi-sectoral responses, with a diversity of roles including leadership, advocacy, funding and policy [6]. In recent years, a growing focus has been placed on policy approaches as core components of government strategies to address the risk factors for obesity [9–11]. Governments have multiple policy instruments open to them, and economic policies are considered amongst the potentially ‘hard’ or politically stronger instruments which can be used to enhance the effectiveness of softer options such as health education or social marketing [10].

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M. Moodie (✉) · L. Sheppard · C. Keating · A. Flego  
Deakin Health Economics, Faculty of Health, Deakin University,  
221 Burwood Highway, Burwood, Victoria, Australia  
e-mail: marj.moodie@deakin.edu.au

L. Sheppard  
e-mail: lauren.sheppard@deakin.edu.au

C. Keating  
e-mail: catherine.keating@deakin.edu.au

A. Flego  
e-mail: anna.flego@deakin.edu.au

G. Sacks  
WHO Collaborating Centre for Obesity Prevention,  
Faculty of Health, Deakin University, 221 Burwood Highway,  
Burwood, Victoria, Australia  
e-mail: gary.sacks@deakin.edu.au

## Fiscal Policies for Obesity Prevention

Many key economic policies relevant to obesity prevention are of a fiscal nature. For governments, fiscal policy generally relates to its revenue collection and expenditure through instruments such as taxes, subsidies and changes in the level and composition of government spending (such as welfare benefits, tax benefits). However, fiscal policy can also be enacted by non-government entities in order to influence the prices of goods and services or the budgets which people have available to spend.

Given that price is one of the most important factors influencing food choice, pricing strategies are increasingly being proposed as measures to improve diets. Price manipulation to encourage consumers to purchase healthier foods or to discourage unhealthy choices operates primarily through the principles of demand—as the price of a product falls, the quantity demanded rises, and vice versa. To date, government fiscal policy in the area of food has been driven largely by government imperatives to raise revenue or increase demand or supply. Its use specifically for the purposes of improving population diets is still relatively untested [12••]. In a world of imperfect markets, governments have the opportunity to intervene and employ fiscal initiatives to alter consumer purchasing habits with a view to improving population health. Equally well, fiscal measures could potentially be used on the other side of the energy balance equation to promote physical activity.

This paper sets out to review the academic literature around fiscal policies to prevent obesity. After a brief summary of the current use of fiscal policy as obesity prevention initiatives, the paper assesses the evidence of the cost-effectiveness of fiscal policies for obesity prevention. The paper confines itself to the literature since 2010, and does not purport to be a systematic review but a snapshot in time which highlights key findings, and reflects on issues of current policy interest and gaps in the literature.

### Current Use of Fiscal Policy as Obesity Prevention Initiatives

A number of countries have either implemented or considered fiscal policies to encourage better nutrition. These are almost exclusively focused on targeted food taxes and subsidies, operating at the consumer-end. Recent summaries of the United States of America (US) situation by Powell et al. [13••] and Pomeranz [14] indicate that whilst there are no current federal taxes on foods or non-alcoholic beverages, low rates of sales taxes apply in many states (in the 3–7 % range), and seven states currently impose other types of taxes or levy fees on the sale of certain beverages. Whilst a number of programs, such as the Supplemental Nutrition Assistance Program (SNAP)

offer food subsidies via monthly monetary transfers to purchase food, they are essentially designed to alleviate food insecurity rather than change dietary habits. In recent years, a number of US states have proposed placing sizable excise taxes on sugar-sweetened beverages, although to date, no proposals have been enacted into law [13••]. A search of the legislation database on the Yale Rudd Centre website (accessed 3 March 2013) [15] indicates that there is currently legislation being debated in ten US states around the imposition of food and beverage taxes (with eight states proposing excise taxes on sugar-sweetened beverages).

Outside of the US, the most notable fiscal actions in response to the rising obesity prevalence have been the imposition of a ‘fat tax’ in 2011 by Denmark and Hungary. However, the Danish Fat Tax, which taxed all products containing more than 2.3 % saturated fat (at the rate of 16 kroner [~USD2.79] per kilogram of saturated fat) [16], was withdrawn 1 year after its introduction. The official explanation for the withdrawal of the tax was that it had resulted in undesirable losses of local sales and employment [16]; however, there have been suggestions that its withdrawal was largely the result of food industry pressure on the government [17]. Hungary imposed a 10 forint (~USD0.05) tax on foods high in salt, sugar or fat (levied on the producer or first distributor), in addition to a 10 % increase in the tax on liquor and soft drinks, making it the most comprehensive set of fiscal initiatives on unhealthy foods in the world to date [18]. As documented in a recent article by Jou et al., a number of countries (including the Pacific Islands of Samoa, Nauru and French Polynesia) have introduced either volume-based or price-based taxes on sugar-sweetened beverages [19].

### Cost-Effectiveness of Fiscal Measures as Obesity Prevention Measures

#### Evidence of Effectiveness

The starting point for cost-effectiveness evaluations is to establish the evidence base for the effectiveness of the initiative. The first prerequisite for a fiscal intervention to be cost-effective is that it is effective, in other words, it works. A very brief overview of the recent literature around the effectiveness of fiscal measures follows. It focuses on the strengths and weaknesses of this evidence base and its potential impact on the conclusions of the cost-effectiveness studies. This paper draws on a number of recent review articles [12••, 13••, 20, 21••, 22••, 23••, 24•, 25, 26•] (summarized in Table 1), which overlap in part, but differ in terms of scope, approach, study parameters and their place along the continuum of policy translation into obesity outcomes.

**Table 1** Recent relevant reviews of the effectiveness of fiscal policy for obesity prevention

Author, year	Setting	Aim and focus of review	Type and no. of studies reviewed	Search period stated by authors	Type of fiscal policy	Outcome measures	Key conclusions
Thow et al. 2010 [12••]	Global but mostly OECD countries	Reviewed the impact of fiscal policy on diet, obesity and chronic disease	8 empirical studies (actual tax) and 16 modelling studies (hypothetical tax/subsidy)	2000–2009	Food taxes and subsidies	Food consumption [9], weight [5], consumption & disease [4], body weight only [6]	-Taxes and subsidies generally influenced consumption, diet and health in the desired direction particularly when taxes/subsidies were large (>15 % of base price) -Quality of evidence overall low and a limitations due to high number of modelling studies
Andreyeva et al. 2010 [21••]	U.S.-based studies	Food prices on consumption by reviewing research on price elasticity of demand for food	160 observational studies on price purchase relationships for various food categories	1938–2007	Food taxes and subsidies	PE only	-Food away from home, soft drinks, and juice have own-PE estimates between -0.68 and -0.81 and fruit at -0.7 and veg at -0.58 -Taxes and subsidies likely to impact on consumption based on own-PE estimates
Faulkner et al. 2011 [24•]	Global	A scoping review of economic policies targeting diet, physical activity and obesity	38 observational or experimental studies	Dec 2009–May 2010	Food taxes, subsidies, tax credits for physical activity and active transport, income transfers, agricultural subsidies and rebalances	Food consumption, diet, physical activity and weight outcomes	- Food and beverage prices influence weight outcomes -Insufficient evidence for tax credits/ subsidies on physical activity
Lakdawalla and Zheng 2011 [25]	USA	Exploratory review of the literature assessing the relationship between food prices and body weight in both children and adults	14 studies –fixed effects, random effects and repeated cross sectional methods	Not specified	Not applicable	Body weight as measured by BMI and BMI categories	Children: Higher fast food prices depress body weight and higher fruit and vegetable prices may increase it Adults: some agreement that increases in food prices tends to reduce body weight
Eyles et al. 2012 [23••]	OECD countries	Food pricing strategies and (i) changes in purchasing or consumption, (ii) health outcomes and disease, (iii) whether outcomes are moderated by socio-economic status	Simulation studies only - 30 studies assessing purchasing and consumption -19 assessing health and disease outcomes	Jan 1990–October 2011	Food taxes, subsidies and combination of tax/subsidy	Majority of studies reported price elasticity but also body weight, mortality and specific measures/ risk factors of disease	-Pooled PE for soft drink -0.93 and fruit and veg at -0.35 -Taxes on carbonated soft drinks and saturated fat and subsidies on fruit and vegetables are associated with pro diet outcomes and potentially improved health -Level of evidence overall low to moderate quality with very few studies reviewed assessing compensatory purchasing through cross PE

Table 1 (continued)

Author, year	Setting	Aim and focus of review	Type and no. of studies reviewed	Search period stated by authors	Type of fiscal policy	Outcome measures	Key conclusions
Epstein et al. 2012 [22••]	Global	Reviewed experimental research conducted in laboratory or field investigating the relationship between food price changes and food purchasing patterns.	24 experimental studies only	January 1980–March 2011	Food taxes, subsidies and combination of tax/subsidy	Changes in food purchases, change in total energy and macronutrients purchased	-Price changes modify food purchases of targeted food but results on overall nutritional quality is mixed due to substitution effects -Individual characteristics may moderate the effects of pricing -19 out of 20 studies found that subsidies significantly increased the purchase and consumption of the subsidized product - Study limitations of reviewed literature include: small sample sizes, short intervention and follow up duration
An, 2012 [20]	Seven countries - USA, Canada, France, Germany, Netherlands, South Africa and UK	Reviewed evidence from field interventions on the effectiveness of monetary subsidies in promoting healthy food purchases/consumption	20 field intervention studies	1990–2012	Subsidies (price discounts/ vouchers) applied to fruits, vegetables and low fat snacks	Changes in food purchases and changes in food consumption	- PE for SSB –1.21, fast food –0.52 and fruit –0.49 and vegetables at –0.48 -No consistent direction of effect on weight outcomes from existing state taxes -Increasing number of longitudinal studies and evidence from these studies showed that association mostly but not always remained significant over time -More robust evidence needed to inform policy makers as to the health benefits of fiscal policy supporting active transport - Some positive effects of financial incentives on weight outcomes reported however results varied due to differences between studies in incentive size, schedule and context
Powell et al. 2013 [13••]	USA	Price elasticity of demand for SSBs, fast food, fruit and vegetables as well as direct associations between prices/taxes and body weight outcomes	-Modelled, cross sectional and longitudinal studies. -21 studies on price effects and consumption - 20 studies on prices and body weight outcomes	January 2007–March 2012	Taxes on fast food and sugar-sweetened beverages and subsidies on fruit and vegetables	-Sales, purchases and consumption of specific food items or food categories to determine PEs - BMI and BMI categories for studies assessing prices and body weight outcomes	
Martin et al. 2012 [26•]	Global	Financial incentives for modes of travel that encourage physical activity	5 relevant reviews and 20 primary studies (of which 9 were excluded)	Jan 1997–Jan 2012	Taxes to discourage car travel, subsidies to encourage public transport / active commuting	Travel mode, physical activity, BMI or weight	
Jeffery, 2012 [30]	Global	Exploratory review of studies evaluating the use of financial incentives to promote weight control	Number of studies reviewed not specified. Case studies, quasi-experimental and experimental studies reviewed	1972–2010	Not assessing taxes but financial incentives for weight loss	Body weight outcomes	

OECD Organisation for Economic Cooperation and Development; PE price elasticity; USA United States of America; BMI body mass index; UK United Kingdom

### *Relationship Between Changes in Food Prices and Consumption*

The already vast body of literature around price elasticity of demand for food and beverages has been supplemented in the past 3 years by several significant review articles. Powell et al. [13••], Andreyeva et al. [21••] and Eyles et al. [23••] focused on the relationship between food prices and consumption, given that the effectiveness of fiscal instruments in changing diets is dependent on the price sensitivity of food consumption. Whilst the specific price elasticities for different food groups varied across the three reviews, they reached similar conclusions: fiscal policies are likely to induce changes in consumption, the demand for less healthy items such as soft drinks, juice and meat is likely to be more price sensitive or elastic than the demand for healthier foods such as fruit and vegetables.

To date, many studies that evaluated the likely impact of consumer-end food taxes and subsidies were reliant on own-price elasticity data (which refers to the responsiveness of demand for a product to a change in price of that particular product) to estimate changes in consumer behaviour. These studies did not include cross-price elasticity (changes in demand for a product as a result of changes in the price of another product) data, and so did not consider the ramifications for the demand for other food or beverage groups. The absence of cross-price elasticity data challenges results, and a number of authors [13••, 22••, 23••] caution about compensatory purchasing behaviour which is likely to be complex, difficult to predict and not necessarily health-promoting. This is illustrated by the evaluation of a proposed tax on sugar sweetened beverages by Dharmasena and Capps [27•], which reported a resultant increase in consumption of fruit juices, low fat milk, tea and coffee. A very recent paper by Finkelstein et al. 2013 extends the analysis of cross price elasticity of a sugar sweetened beverages tax further to include not only impacts on the consumption of other related beverages, but on 12 major food categories (although no evidence was reported of substitution to other sugary foods) [28•].

### *Price of Food and Dietary Intake, Weight and Health Outcomes*

Studies which measure the impact of pricing strategies on dietary intake or weight outcomes provide more direct evidence of how interventions to change food prices are likely to impact on obesity prevalence. Epstein et al. [22••] reported that whilst some laboratory studies showed improvements in nutritional intake, field studies resulted in no overall nutritional improvements when fiscal measures were used in a supermarket or cafeteria.

Thow's systematic review [12••] of both empirical ('real world' studies) and modelled (outcomes predicted based on

hypothetical versions of taxes or subsidies) studies of fiscal policies on specific food products concluded that large taxes and subsidies (of the order of 20 % or more) could potentially influence dietary intake, weight and health outcomes, but even then the evidence was not definitive. The Eyles recent review of simulation studies [23••] supported Thow's conclusions but, overall this review reported smaller changes in diet, weight and health outcomes most likely as a result of the inclusion of more recent studies that assessed compensatory purchasing through cross-price elasticities. Powell et al. also reported that the evidence that changes in price significantly impact body weight was inconclusive, and highlighted the lack of consistency in direction of the effect of fiscal policies on weight outcomes [13••]. They did, however, hypothesize that this may be because of the low level of taxes reviewed in the studies. Very few studies in any of these reviews report longer term health outcomes, such as mortality and morbidity from obesity-related diseases. Where this has occurred (for instance, for cardiovascular disease outcomes), results are inconsistent in direction [12••, 23••, 29•].

### *Fiscal Measures to Promote Physical Activity*

On the other side of the energy balance equation, the evidence is even more limited around the use of fiscal policies to improve physical activity levels. Two recent reviews were identified. Martin et al. argues that financial incentives offer a potentially large, but as yet unexplored, role in promoting walking and cycling [26•]. Of the 20 primary studies included in this review, three were randomized controlled trials, whilst most were uncontrolled cross-sectional, pre-post analyses of population-level data, with travel behaviour or physical activity as outcome measures. The interventions covered both the use of positive financial incentives such as free bicycle schemes or subsidized public transport passes to promote active travel as well as negative incentives to reduce vehicle transport, such as road pricing, congestion charges, and car parking measures. However, the authors highlighted the lack of empirical evidence in this area which limited the conclusions that could be drawn about the likely effectiveness of interventions [26•].

The second review by Jeffery [30] focused on empirical studies between 1972 and 2010 which evaluated the use of financial incentives to promote weight control. The paper's focus on rewarding individuals for weight loss is likely to have less policy relevance than the population level active transport measures reviewed by Martin et al. [26•]. The research supports the notion that financial rewards can be a motivating factor for people wishing to lose weight, particularly in the short term, although the results vary widely given differences in size, frequency, source, temporal distribution over time and certainty. The data around the

use of financial incentives to promote weight maintenance is much less and unclear.

In its assessment of the evidence, a Canadian panel [24•] was not confident about the use of taxes and subsidies to promote physical activity at the population level. Whilst economic measures that penalized inactivity were considered unrealistic and ineffective, there was more support for, but still insufficient, evidence to recommend subsidized targeted physical activity programs.

#### *Summary of Effectiveness Evidence*

These recent reviews highlight the variability in the types of fiscal measures examined in the effectiveness literature. This makes it problematic to pool results together, conduct meta-analyses, or even to draw conclusions about the most effective fiscal strategies in this area. Studies vary highly in the methodologies employed, and there has been little attempt to replicate findings with other population groups or in other settings. To date, there is insufficient evidence on moderators of effect, but some evidence that measures may be more effective for specific subgroups. Many of the studies are based on modelling which has obvious limitations, whilst others are experimental or laboratory-based. The minimal number of studies in ‘real world’ settings collecting empirical data is an obvious gap in the evidence base. This parallels the development of policy in other public health areas such as tobacco control, where there was a reliance on modelling studies to simulate and test the impact of policies before they were implemented in the ‘real world’. There is a dearth of literature around the effectiveness of fiscal policies to promote physical activity. These inherent limitations of the evidence base around the effectiveness of fiscal policies to change food consumption behaviour and to prevent obesity necessarily have implications for the subsequent cost-effectiveness literature.

This paper does not purport to cover the literature around health insurance or employer-based incentives to change obesogenic behaviours. A recent overview of this literature is provided by Madison et al. [31], which concluded that appropriately structured financial incentives have the potential to improve health, but questions remain about their optimum size and duration, the relative merits of incentives versus disincentives, the sustainability of their effects long-term (after the incentives have ceased) and the potential for discrimination.

#### Evidence of Cost-effectiveness

##### *Key Study Parameters of the Economic Studies*

In addition to knowing whether fiscal policy measures to prevent obesity actually work, policymakers want to be confident about a potential policy’s ‘value for money’. Is

the fiscal policy likely to be cost-effective, in that the benefits accrued justify the funds allocated to it?

A search for cost-effectiveness literature was undertaken for the period 2010 to 2013 using Medline Complete and a combination of broad search terms including ‘tax’, ‘subsidy’, ‘obesity prevention’ and ‘cost-effectiveness’. This was supplemented by a targeted search of major health economics journals and searching the reference lists of review studies.

To date, and particularly since 2010, there have been very few economic evaluations of fiscal policies targeting obesity prevention. Of the eight papers identified (Table 2), three provided full economic evaluations in that they considered both costs and benefits of the intervention, with incremental analysis against a comparator [32••, 33••, 34••]. Five other papers [29•, 35•, 36•, 37•, 38•] are included in Table 2, but are not full economic evaluations according to the criteria set down by Drummond et al. [39]. Whilst labelled a cost-effectiveness study by the authors, Lin et al. [36•] essentially used econometrics to compare two alternate policy levers (one targeted, one non-targeted) within the US Supplemental Nutrition Assistance Program to increase the consumption of fruit, vegetables and dairy products. As their analysis did not incrementally compare these interventions nor assess the broader economic costs and cost-offsets attributable to each policy, this study is regarded to be an economic appraisal rather than a full economic evaluation. Two papers [29•, 35•] were cost-outcome studies with no comparator arm. Another econometric study [37•] sought to determine if a tax on sugary drinks could enhance individual consumer welfare using willingness to pay principles to derive findings. The final study applied a unique equilibrium displacement model to estimate the effects of a range of subsidy and taxation policies [38•]. All eight papers used modelling to calculate the intermediate and/or long term outcomes of the proposed fiscal policy, with two including children in their analysis of policy-induced effects [32••, 35•].

The magnitude and type of fiscal policy modelled varied as did the sources of data used to inform effectiveness. Five of the studies evaluated a tax to discourage consumption of unhealthy foods or sugar-sweetened beverages [29•, 34••, 35•, 37•, 38•], whilst four assessed a discount or subsidy to promote consumption of healthy foods or fruit and vegetables specifically [32••, 33••, 36•, 38•]. Both Chaloupka et al. [35•] and Wang et al. [29•] simulated a US nation-wide volume-based excise tax (as previously advocated by Brownell and colleagues [40]) rather than a comparable *ad valorem* (based on the value of the product and expressed as a proportion of its price) sales or excise tax given its easier administration, and likely greater impact on consumption as a consequence of being reflected in the product shelf price rather than just at the sales checkout. Lusk and Schroeter [37•] applied a 1 % increase in the price of sugary beverages based on the work of Dharmasena and Capps [27•]. Okrent and Alston [38•] selected a 5 cent per gram tax on fat and used this to derive a sugar tax and a calorie tax amount

**Table 2** Recent economic evaluations of fiscal measures for obesity prevention

Author	Setting	Population (age, years)	Type of study	Perspective	Time horizon, years	Economic measure		Source of effectiveness data	Main outcomes	Costs	Result, incremental cost-effectiveness ratio
						Intervention	Comparator				
Cecchini et al. 2010 [32••]	Brazil, China, India, Mexico, Russia, South Africa, UK	Whole of population (0–100)	CEA	Not stated	20; 50	Subsidies on fruit and vegetables and taxes on foods high in fat	No intervention	Demand elasticities: French Government report that reviewed results from 9 studies [55] Various sources of country-specific epidemiological data	DALYs	Personal use of health services and programme level costs attributable to the intervention. Revenue generated by tax excluded from cost analysis	Effective and cost saving
Cobiac et al. 2010 [33••]	Australia	Adults (15–100)	CEA	Health sector	Lifetime of cohort	Farmers market vouchers [53]; Supermarket vouchers [53]; Supermarket displays, flyers, discount coupons [54]	Current practice	Change in consumption of F&V taken from intervention studies [56, 57]	DALYs	Running costs of intervention to Government and patients (steady state conditions assumed)	Not cost-effective Farmers market vouchers AUD270,000/DALY Supermarket vouchers AUD660,000/DALY Supermarket displays, flyers discount coupons AUD2,500,000/DALY Vouchers used in 3 of 23 interventions evaluated Other 20 interventions used a range of strategies to increase fruit and vegetable intake, with only 5 estimated to be cost-effective
Sacks et al. 2011 [34••]	Australia	Adults (≥20)	CEA	Health sector	Lifetime of cohort	10 % tax on unhealthy foods	Current practice	Food consumption: Australian 1995 National Nutrition Survey Price elasticities: UK National Food Survey [58]	DALYs	Running programme costs attributable to intervention (steady state conditions assumed)	Effective and cost-saving
Lin et al. 2010 [36•]	USA	Adults	CEA	Not stated	10 % increase in overall food stamp benefits	10 % healthy food subsidy for food stamp recipients	10 % healthy food subsidy for food stamp recipients	Food consumption: 1999–2002 National Health and Nutrition Examination Survey Price and expenditure elasticities: Calculated by authors in paper	Narrowing consumption deficiencies of healthy foods (fruits, vegetables and dairy products)	Annual cost of policy implementation	ICER not reported An overall increase in food stamp benefits is estimated to reduce the consumption deficiency of fruits, vegetables and dairy products by 7–8 % at an annual cost of USD14 billion The healthy food subsidy is estimated to reduce the consumption deficiency of vegetables by 4.7 %

Table 2 (continued)

Author	Setting	Population (age, years)	Type of study	Perspective	Time horizon, years	Economic measure		Source of effectiveness data	Main outcomes	Costs	Result, incremental cost-effectiveness ratio
						Intervention	Comparator				
Chaloupka et al. 2011 [35]	Illinois, USA	Illinois population (≥2)	Health and cost impact	Not stated	1; 10	Four taxes on SSBs: one cent and two cent per ounce excise tax on SSBs and their diet versions; a one cent and two cent per ounce excise tax on SSBs only	SSB consumption: 2007–08 National Health and Nutrition Examination Survey Price elasticities: Taken from review by Andreyeva et al. [21] and Smith et al. [59] for tax on SSBs only	Reduced levels of obesity and related health care costs; reduced incidence of diabetes and related health care costs; and revenue generated by each tax	Health sector cost offsets arising from avoided obesity-related disease and tax revenue	The results presented are extensive and readers should consult the report for specific numbers The largest health improvements and health sector cost savings were estimated for the proposed tax on SSBs and their diet versions. Tax revenue is highest for the SSBs-only tax	fruits by 7 % and dairy products by 4.22 % at an annual cost of USD734 million
Wang et al. 2012 [29]	USA	Adults (25–64)	Health and cost impact	Not stated	10	Penny-per-ounce tax on SSBs	Demand elasticities: Taken from systematic review by Andreyeva et al. [21] SSB consumption: data taken from US National Health and Nutrition Examination Survey for 2003–06	Reduced incidence of obesity-related disease	Health sector cost offsets arising from avoided obesity-related disease	Over 10 years, reduction in the incidence of diabetes (2.6 %); coronary heart events (95,000); myocardial infarctions (30,000); strokes (8,000) and deaths (26,000) estimated USD17 billion in averted health sector costs calculated	
Lusk and Schroeter 2012 [37]	USA		Modelling			1 % price increase on sugary beverages	Weight effects of tax: Taken from Dharmasena and Capps [27] Annual household expenditure on sugary beverages: Taken from Zhen et al. [60]	Weight loss used as utility function	An average household would need to be willing to pay almost USD1500 for each pound of weight lost for the 1 % tax increase in price to be welfare-enhancing. This WTP amount is higher than what previous research has indicated individuals would be willing to spend on weight loss, suggesting that a SSB tax would not be welfare-enhancing at the individual level		
Okrent and Alston 2012 [38]	USA	Adults (≥18)	Modelling	Not stated	1	-All farm subsidies	Demand-elasticities: authors previous research [61]	Food consumption, body weight, social welfare (costs)	Benefits (costs) to consumers, producers and taxpayers measured	See paper for full results <sup>a</sup>	



**Table 2** (continued)

Author	Setting	Population (age, years)	Type of study	Perspective	Time horizon, years	Economic measure	Intervention	Comparator	Source of effectiveness data	Main outcomes	Costs	Result, incremental cost-effectiveness ratio
							-Farm grain subsidies only -10 % F&V product subsidy -16.24 % F&V farm commodity subsidy -Fat tax: USD0.005 per gram -Sugar tax: USD0.002637 per gram -Calorie tax: USD0.0001632 per calorie -5 % uniform tax on all foods		Elasticity of body weight with respect to food consumption: Authors calculations using US data (2003–04 National Health and Nutrition Examination Survey Data) and author assumptions that 3,500 kcal/year contributes one pound of body fat. Marginal increase in public health costs for body weight increase taken from previous research [62]	in terms of profit, tax-payer revenue and public health expenditure	-F&V retail and commodity subsidy had limited effect on calorie consumption with results suggesting a small increase consumption -Fat tax: Calorie consumption estimated to reduce by 19,642 or 20,901 kcal per adult per year under the two conditions modelled, saving USD0.15 or USD0.23 per pound of weight lost -Sugar tax: Calorie consumption estimated to reduce by 2,280 or 3,114 kcal per adult per year and would save USD1.67 or USD1.73 per pound of weight lost -Calorie tax: Calorie consumption estimated to reduce by 1,578 or 1,500 kcal per adult per year and would save USD1.77 per pound of weight lost -Uniform food tax: Calorie consumption estimated to reduce by 18–19,000 kcal per adult per year and would save USD1.28 or USD1.54 per pound of weight lost	

UK United Kingdom; CEA cost-effectiveness analysis; DALYs disability adjusted life years; F&V fruit and vegetables; AUD Australian dollars; USA United States of America; ICER incremental cost effectiveness ratio; USD US dollars; SSBs sugar-sweetened beverages; WTP willingness-to-pay

<sup>a</sup> Results presented by the authors according to two simulated conditions: upward sloping supply and perfectly elastic supply refer to full paper for details

that would yield an equivalent annual reduction in caloric intake. They also evaluated a fourth tax, a 5 % uniform tax on foods. Sacks et al. [34••] modelled an arbitrary 10 % tax on unhealthy foods with modelled changes in consumption based on aggregate own-price and cross-price elasticities. No recent cost-effectiveness appraisals of fiscal measures to improve physical activity were identified.

The three cost-effectiveness (or more correctly, cost-utility) studies reported outcomes as costs per Disability-Adjusted Life Year (DALY) averted, a common metric which facilitates comparison between studies and between different types of interventions and disease areas [32••, 33••, 34••]. In the case of Wang et al. [29•] and Chaloupka et al. [35•], results were reported as reductions in obesity-related diseases and health care costs averted. Lin et al. [36•] did not model outcomes over the life of the cohort, but adopted a prevalence approach and reported outcomes as reductions in the consumption deficiencies in healthy foods and the associated annual financial cost of implementing each subsidy policy. Lusk and Schroeter [37•] sought to estimate what an individual would need to be willing to pay per pound of weight loss in order for that tax to be welfare-enhancing, where welfare effects were determined by a trade-off between the disutility of paying a higher price and utility of weight lost. The effects of various food subsidies (applied to either food products or farm commodities used to produce food) and four nutrient-related food taxes on caloric intake, weight and social welfare (measured as costs) were assessed by Okrent and Alston [38•], with results reported as annual reductions in these outcomes of interest.

The uncertainty surrounding the effectiveness of the proposed taxes or subsidies was noted in several of the papers, as was the lack of definitive evidence around potential compensatory changes in food or beverages that were not taxed [29•, 32••, 33••, 34••]. Given the number of assumptions involved and the lack of definitive evidence around many parameters, probabilistic uncertainty analyses were predominantly used to report 95 % uncertainty intervals around key cost and epidemiological point estimates [29•, 33••, 34••]. One of the major assumptions in such long term modelling studies arises from the lack of data on the sustainability (or maintenance) of behavioural changes. Cobiac et al. [33••] assumed a 50 % exponential decay in effect each year following cessation of the intervention, whereas, in the Cecchini et al. study [32••], intervention effects were assumed to disappear once exposure to an intervention ceased. To allow for the inevitable uncertainty incorporated into the model, Sacks et al. [34••] conducted a threshold analysis to determine the degree to which the key parameters influencing the tax intervention would need to change in order for it to no longer be cost-effective.

The studies were generally quite crude in their assessment of the costs and did not always provide a clear rationale for including or excluding certain cost categories. The set-up costs associated with implementing or amending the new fiscal

policy were not assessed in any study and costs falling outside the health sector were appraised in two papers: Cobiac et al. [33••] included patient costs and Okrent and Alston [38•] quantified the policy-related net social gain to consumers, producers as well as taxpayers. With the exception of Lin et al. [36•], considerable focus was placed on the use of modelling to quantify the cost-offsets in terms of the averted savings to the health sector attributable to the resultant avoided cases of obesity-related disease [29•, 32••, 33••, 34••, 35•]. The narrowed focus on costs is likely due to the health sector perspective that was commonly adopted (although this was not always stated), and the assumption that interventions were operating under ‘steady state’ conditions [33••, 34••].

### *Key Results of the Economic Studies*

The small number of cost-effectiveness studies and the diversity of methods employed preclude pooling of results. The Sacks et al. [34••] and Cobiac et al. [33••] economic evaluations were conducted as part of the larger ACE (Assessing Cost-Effectiveness)-Prevention study in Australia which evaluated 150 preventive interventions targeting a range of chronic diseases [41]. The 10 % tax on unhealthy foods high in saturated fat, sugar and/or salt was one of 23 interventions classified as ‘dominant’ [34••] (both improved health and saved costs) which also included taxes on alcohol and tobacco. However, the analysis was considered somewhat speculative as it relied on relatively weak evidence of its effectiveness. None of the three fruit and vegetable interventions involving fiscal measures modelled by Cobiac et al. [33••] were cost-effective measured against the Australian benchmark of AUD50,000/DALY. The fiscal measures targeting obesity prevention modelled by Cecchini et al. [32••] were also part of a larger priority-setting exercise. Unspecified subsidies on fruit and vegetables and taxes on foods high in fats were the only measures amongst the six categories of interventions modelled to be ‘dominant’ in all seven Organisation for Economic Cooperation and Development (OECD) countries for which the modelling was conducted. The authors concluded that amongst the best value for money to address unhealthy diets and obesity was price manipulation using fiscal policies, which replicates the findings for other key chronic disease risk factors such as tobacco and alcohol [32••].

Chaloupka et al. [35•] considered four different tax combinations: one cent and two cent per ounce excise tax on sugar-sweetened beverages and their diet versions, and on sugar-sweetened beverages only. They concluded that the largest health improvements and health sector cost savings would stem from a tax on both sugar-sweetened beverages and the equivalent diet version. Both Chaloupka et al. [35•] and Wang et al. [29•] showed that, whilst resultant reductions in body weight may appear modest at the level of the individual, when translated to a population level, the savings in terms of long

term health consequences can be substantial. Wang et al.'s [29•] modelling showed that the modest net reduction of 0.9 pounds in mean weight resulting from the penny per ounce tax on sugar-sweetened beverages translated to a 1.5 % reduction in adult obesity prevalence (867,000 fewer cases) over a 10 year period in addition to a 2.6 % reduction in new cases of diabetes (1,541,000 fewer diabetes person-years). The savings to the health care sector were estimated at USD17.1 billion over the 10 year period. Lin et al. [36•] drew on data from three US nationally representative surveys to determine demand elasticities and the likelihood of spending on food out of food stamp benefits. They concluded that the demand for food was not particularly elastic and that price manipulations alone would not induce large consumer responses. A 10 % healthy food subsidy would curtail consumption deficiencies in fruit, vegetables and dairy foods amongst the US population eligible for food stamps by 4–7 % at an estimated cost of USD734 million per annum. Under their alternative non-targeted strategy of increasing food stamp benefits, a 10 % increase in spending would reduce consumption deficits by 7–8 %, but at a much higher cost of USD14 billion per annum.

The willingness to pay analysis by Lusk and Schroeter [37•] suggested that a 1 % increase in the price of sugary beverages would not be welfare-enhancing at the individual level. For an average household, the estimated USD1500 per pound of weight loss needed for the proposed tax to be welfare-enhancing was considerably higher than what (limited) previous work has indicated consumers would be willing to spend. Willingness to pay estimates were sensitive to both household expenditure on sugary beverages and effectiveness of the tax to reduce weight; however subgroup analysis demonstrated willingness to pay amounts remained consistently high across conditions (USD760–USD4655).

Subsidy and tax-induced effects evaluated by Okrent and Alston [38•] suggested that a subsidy on fruits and vegetables may potentially increase the consumption of calories and thus did not appear to be an efficient policy approach for preventing obesity. This finding was independent of whether the fruit and vegetable subsidy was introduced at a commodity level (i.e. applied to producers) or retail food level. In contrast, all four taxes modelled by the authors were found to be effective in reducing calorie consumption, with the most favorable result arising from a calorie tax which was estimated to yield a social welfare gain of USD2280 million, or, in other terms, a benefit of USD1.79 per pound of fat lost per adult.

#### Other Considerations of Benefit

Technical evidence on the cost-effectiveness of interventions is not in itself sufficient as a basis for priority setting in health [42, 43]. When making decisions around funding allocations to different priorities, policymakers need to take into account a

range of other important considerations [42]. Whilst a fiscal policy may be deemed cost-effective, as discussed earlier, the *strength of the evidence* underpinning its effectiveness is a major consideration [34••]. Economic evaluations necessitate the making of many assumptions given a lack of robust empirical studies and inconclusive evidence. As the section on effectiveness (above) illustrates, the evidence around consumer responses to price changes is not definitive, and there is a wide range of price elasticity estimates in the literature. Recent studies largely rely on own-price elasticity data as there is little known about substitutes, compensatory behaviour and cross-price elasticities. There is a need for more rigorous, high quality empirical studies to determine the 'real-world' impacts of fiscal policies on consumer purchasing behaviour and the sustainability of any consequent dietary improvements.

*Equity* considerations highlight the paucity of evidence around the differential impacts of taxes and subsidies on different socio-demographic or ethnic groups. Taxes on unhealthy foods or beverages are regressive in nature and, coupled with normal price rises in the cost of food, may further disadvantage consumers from lower socioeconomic groups who consequently spend a higher proportion of their income on the proposed tax [44–46].

The policy needs to be *feasible to implement* with buy-in from government enacting the legislative change. Contextual issues will be of relevance here including current obesity levels and consumption patterns, population profile and existing fiscal measures. Policymakers will need to weigh up the *acceptability* of fiscal policies to different stakeholder groups (consumers, manufacturers, retailers), and be in a position to counter potential resistance from industry, lobby groups or consumers. Engaging the private sector and civil society groups in policy processes is regarded as critical to advancing obesity prevention efforts [6].

*Potential side effects* (both positive and negative, intended and unintended) will be an important consideration [44]. The potential revenue raised by a tax would be considered a positive side-effect if it could be earmarked for obesity prevention programs. Andreyeva et al. [47] estimated that a US-wide penny per ounce tax on sugar-sweetened beverages would generate USD79 billion in revenue over a 5 year period. Chaloupka et al. [35•] concluded that taxes on all sugar-sweetened beverages were the most effective approach in terms of revenue generation with an estimated USD876.1 million being generated annually in Illinois alone via the proposed one cent tax. They and other authors [34••] highlight the opportunity to reinvest this revenue in obesity prevention programs, and cited this as a significant side-benefit of the fiscal measure which should be taken into account. If a higher share of the tax revenue was used to finance subsidies for low socio-economic groups, they would stand to gain proportionately more given their higher rates of obesity-related diseases such as diabetes.

Unintended side effects could also take the form of price-induced shifts to other (untaxed) unhealthy food or drink choices. Previous studies have highlighted an increase in the consumption of caffeine and fruit juice following the introduction of a sugar sweetened beverage tax [27•], which could undermine the policy's effectiveness from an obesity prevention perspective. In the broader public health literature, the introduction of a tobacco tax was accompanied by an increase in the illicit purchase of cigarettes [48]. Evidence of the potential impact on consumer behaviour of a 'black market' for unhealthy food or drink is needed as this may also undermine policy effectiveness. Finally, the response from industry to a tax or subsidy is largely unexplored and the potential impact of counteractive pricing strategies (e.g. the extent to which the actual price paid by the consumer is likely to change in response to a tax or subsidy) needs to be considered. Craven et al. [44] and Pratt [46], in recent commentary papers around the use of fiscal policies for obesity prevention, call for more careful attention to be focused on the possible unintended consequences and to their design, implementation and distributional impacts.

This does not purport to be an exhaustive list of other considerations of relevance to decision-makers but does serve to highlight some of the practical issues that should be taken into account when assessing the credentials of fiscal measures to deliver value for money as obesity prevention initiatives.

## Conclusions

To date, the literature on the cost-effectiveness of fiscal measures for obesity prevention is very limited, and more well-designed economic evaluation studies are required. Uncertainty in the effectiveness of fiscal policies for obesity prevention needs to be addressed first. There are obvious gaps in the evidence base, particularly around compensatory purchasing and likely changes to consumption patterns within a complete food demand system, moderators of effect, and sustainability of effects. Whilst there is some evidence to suggest that fiscal policies should cover a wide range of unhealthy foods rather than a narrow category to avoid compensatory behaviour, it is not definitive at this stage. Evidence is required from randomized controlled trials of longer duration and in 'real-world' settings, recognizing the inherent difficulties associated with conducting such studies. Nevertheless, in other areas of public health such as tobacco and alcohol control, taxes have been highly successful and a core part of strategies to prevent non-communicable diseases [49, 50]; this provides 'parallel' evidence of effectiveness for obesity prevention. On the basis of this parallel evidence, small pilot studies could be undertaken as an interim measure, whilst awaiting the outcome of large randomized controlled trials.

The question of what represents an acceptable level of taxation/subsidy and the most-effective fiscal policy or

combination of policies remains unanswered [51] and is likely to be context-dependent. Whilst previous authors such as Caraher and Cowburn [52], Steenhuis et al. [53] and more recently Mytton et al. [51] have recommended a combined approach of taxation and subsidies, Eyles et al. [23••] reports that the results for combined approaches were less clear (due to the variability in the tax/subsidy combinations being evaluated).

Industry is likely to be highly resistant to taxation (as was illustrated in New York with attempts to introduce soda taxes [54]) as might consumers. Clarification of the major cost drivers associated with implementing a new fiscal policy is needed. Fiscal policies have been considered inexpensive to implement, but little consideration has been given to the costs associated with countering industry or public opposition. Economic evaluations should adopt a societal perspective, enabling assessment of a tax or subsidy on other sectors outside health both in terms of costs and benefits (such as impacts on productivity and employment). Analysis of implementation filters should become a standard part of future economic evaluation work around fiscal policies, as there are other factors besides the technical cost-effectiveness results, which will impact on policymakers when making resource allocation decisions.

The paucity of recent cost-effectiveness studies of fiscal policies for obesity prevention is largely a product of the poor effectiveness data. Findings from recent cost-effectiveness work can only be regarded as preliminary and are not definitive. Whilst savings may appear modest at an individual level, when modelled to a population level, the results are more favorable suggesting that fiscal policies may not only be potentially effective but also cost saving. Whilst more evidence is needed, the introduction of fiscal policies as obesity prevention measures should be considered, not as stand-alone measures, but as part of a larger mix of strategies.

**Acknowledgments** No specific funding was obtained for the production of this paper. Moodie and Sacks are researchers in a NHMRC-funded Centre for Research Excellence on Obesity Policy and Food Systems. Sacks is funded by an Alfred Deakin Postdoctoral Research Fellowship.

## Compliance with Ethics Guidelines

**Conflict of Interest** Marj Moodie declares that she has no conflict of interest.

Lauren Sheppard declares that she has no conflict of interest.

Gary Sacks declares that he has no conflict of interest.

Catherine Keating declares that she has no conflict of interest.

Anna Flego declares that she has no conflict of interest.

**Human and Animal Rights and Informed Consent** This article does not contain any studies with human or animal subjects performed by any of the authors.

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- Of importance
- Of major importance

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