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# Economic Evaluations of Obesity-Targeted Sugar-Sweetened Beverage (SSB) Taxes–A Review to Identify Methodological Issues

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ABSTRACT

*Introduction:* Economic evaluations of public health interventions like sugar-sweetened beverage (SSB) taxes face difficulties similar to those previously identified in other public health areas. This stems from challenges in accurately attributing effects, capturing outcomes and costs beyond health, and integrating equity effects. This review examines how these challenges were addressed in economic evaluations of SSB taxes.

*Methods:* A systematic review was conducted to identify economic evaluations of SSB taxes focused on addressing obesity in adults, published up to February 2021. The methodological challenges examined include measuring effects, valuing outcomes, assessing costs, and incorporating equity.

*Results:* Fourteen economic evaluations of SSB taxes were identified. Across these evaluations, estimating SSB tax effects was uncertain due to a reliance on indirect evidence that was less robust than evidence from randomised controlled trials. Health outcomes, like quality-adjusted life years, along with a healthcare system perspective for costs, dominated the evaluations of SSB taxes, with a limited focus on broader non-health consequences. Equity analyses were common but employed significantly different approaches and exhibited varying degrees of quality.

*Conclusion:* Addressing the methodological challenges remains an issue for economic evaluations of public health interventions like SSB taxes, suggesting the need for increased attention on those issues in future studies. Dedicated methodological guidelines, in particular addressing the measurement of effect and incorporation of equity impacts, are warranted.

## 1. Introduction

Fiscal policies, including taxation, have long been used in public health to address unhealthy behaviours [1]. Tax imposition potentially increases production costs, which may result in higher consumer prices and reduced consumption of targeted products. In recent years, sugar-sweetened beverage (SSB) taxes have gained prominence, with over 45 jurisdictions worldwide having implemented an SSB tax by 2021 [2]. These taxes are generally motivated by public health concerns, as SSBs are known for their high sugar levels, consumption of which can easily contribute to exceeding recommended daily sugar intake [3]. Overconsumption of SSBs has been shown to significantly contribute to the increasing global prevalence of obesity and related illnesses [4].

Economic evaluation is a crucial tool for assessing healthcare interventions, providing a systematic and transparent approach to allocate scarce resources across competing programs. This process is underpinned by explicit social value judgements, ensuring that the opportunity costs of a chosen intervention are assessed relative to that of potential alternatives [5]. Most often, economic evaluations in healthcare focus on 'clinical interventions' such as medicines and medical devices. In this context, cost-utility analysis (CUA), which focuses on health outcomes (most often, the quality adjusted life year; QALY), has become a standard approach [6].

Economic evaluations of public health interventions encounter additional methodological challenges compared to those facing clinical interventions [7]. These challenges were categorised in previous methodological studies into four domains [8–11]: (1) Measuring effects: Attributing observed effects directly to public health interventions can be difficult due to the typically long and complex causal pathways in public health; (2) Valuing outcomes: Many outcomes of public health

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interventions extend beyond health and the health sector; (3) Assessing costs: Public health interventions often involve multiple sectors, making it challenging to account for all relevant costs; and (4) Incorporating equity: Public health interventions aim to reduce health inequities, which traditional economic evaluations may not fully capture [11,12]. When exploring these domains within the context of a tax on SSBs, a range of challenges could emerge, as explored below.

### *1.1. Domain 1 – measuring effects*

Economic evaluations require an understanding of both the natural progression of the condition of interest in the absence of a given intervention (baseline clinical data) and how its progression is altered by that intervention (effectiveness or clinical effect sizes) [13]. In studying SSB taxes, weight is an important outcome for the focus of policymakers; however, high-quality evidence of the causal relationship between SSB consumption and weight is scarce [14] (e.g., costly, long-term experimental studies needed for gradual weight change observation [15]). Consequently, evaluations that rely on modelling approaches depend more on indirect evidence, such as using data on SSB consumption as a measure of caloric intake, and translating that into potential weight gain [16,17]. However, this approach is subject to additional uncertainties; for instance, individuals who consume SSBs often also consume other unhealthy foods, contributing to weight gain, or they might compensate[1] for their SSB consumption with other dietary behaviours, making the precise attribution of weight changes to SSB consumption difficult [16,18,19]. In terms of measuring effectiveness, the direct effects of SSB taxes on weight or related illnesses (e.g., diabetes) have rarely been studied [20], especially through a gold standard method like randomised controlled trials (RCTs) [21]. As a result, evaluations of SSB taxes may depend on alternative evidence, including observational studies of how responsive consumption is to price changes, i.e., price elasticity of demand, which has been extensively examined [21,22]. However, using this type of evidence to assess effectiveness can be challenging due to the presence of various moderators that affect intervention effects, often with limited evidence available [15]. For instance, the potential outcomes of SSB taxes, such as a reduction in weight, might be influenced by substitution behaviour (e.g., as indicated by cross-price elasticity of demand [23,24]’[2]), where individuals may switch to alternative products for consumption. This type of behaviour in the context of SSB consumption remains under-studied [24].

### *1.2. Domain 2 – valuing outcomes*

People eat not just for survival or health benefits, but also for various reasons such as enjoyment, social interaction, and emotional comfort [25]. In particular, foods containing sweetness, such as SSBs, are linked to activating a brain region responsible for releasing pleasure-inducing neurotransmitters, thus contributing to their consumption for pleasure [26]. Consequently, evaluations of interventions aimed at altering eating habits that solely rely on health outcomes like QALYs may overlook broader societal and individual impacts, including the welfare loss due to the reduction in consumption of SSBs [10]. Such effects can potentially be captured through the use of cost-benefit analysis (CBA) that offers a wider perspective than CUA in terms of outcomes assessment. Specifically, the National Institute for Health and Care Excellence (NICE) guideline suggests that *"a CBA is sometimes the most appropriate method of analysis for public health guidance"* [27]. Furthermore, cost-consequence analysis (CCA), a non-incremental form of economic evaluation, allows for a multidimensional evaluation of both health and non-health outcomes, providing a more complete understanding of the impacts of public interventions. Additionally, within CUA or CBA, emerging measurement approaches, like the capability approach, can allow for the assessment of non-health outcomes like empowerment and social participation [28]. However, the integration of non-health outcomes in economic evaluations is challenging given the limited exploration of how such outcomes, like productivity and employment, are affected by SSB taxes [21,29].

### *1.3. Domain 3 – assessing costs*

The implementation of SSB taxes involves various sectors, from policy planning to execution, and consequently, generates diverse costs [3,10]. Therefore, the intervention costs of SSB taxes have implications for both health-related and non-health-related sectors. In terms of health costs, SSB taxes may alter medical care expenses by decreasing illnesses associated with excess sugar consumption [30]. Additionally, non-health costs can emerge from implementation, potentially including expenses incurred by non-health government bodies, such as tax collection agencies. These costs may include those incurred for the hiring of additional administrative officers and inspectors to verify the sugar content in beverages for tax compliance [3]. Businesses may also face increased operational costs and the necessity for product reformulation within the industry [31]. Furthermore, non-financial costs, often referred to as 'deadweight loss' in economics [32],[3] can also be anticipated due to decreased SSB consumption. However, the extent to which these costs are included in economic evaluations often depends on the perspective adopted; evaluations from a societal perspective might consider economic costs relevant, while those adopting a healthcare system perspective may justifiably exclude these economic costs. The perspective adopted is often determined by existing health economic evaluation guidelines within the jurisdiction where the evaluation is conducted [33].

### *1.4. Domain 4 – incorporating equity*

Equity is relevant when evaluating public health policies like SSB taxes, given that SSB consumption is often concentrated among individuals with lower social status [34]; therefore, reducing their consumption could not only improve individual health outcomes but also potentially enhance health equity [35]. Nevertheless, while SSB taxes are generally viewed as beneficial from a public health perspective, from the perspective of taxes paid, they tend to be regressive, taking larger shares of income from lower-income populations compared to those on higher-incomes [1]. The concept of regressivity for SSB taxes is one of debate among proponents and opponents of such policies [36]. The equity implications of SSB taxes are complicated by several factors, such as the baseline health status (e.g., baseline weight and life expectancies) of those consuming SSBs, as well as the price elasticity of demand that may vary across subpopulations [35,37,38]. However, detailed data on these aspects, broken down by key equity criteria such as socioeconomic status, may not always be available, limiting the ability to accurately attribute the impacts of SSBs across socioeconomic groups. Additionally, the equity implication can also be affected by the choice of methodology for analysing health equity [37,38]. Equity analysis is a normative concept that generally demands complex analyses that may exceed the available time and resources of researchers [39]. A previous review in this field noted that while there is a growing use of equity-informed economic evaluations, the methods used show varying degrees of

[2] Caloric compensation is the circumstance where individuals make an adjustment for their intake of other foods to offset the calories consumed from a specific food or beverage.

[3] In economics, cross-price elasticity is the extent to which changes in the price of one product are likely to alter the consumption of other similar (or substitute) products.

[4] In economics, deadweight loss is an economic inefficiency resulting from taxes or other market distortions, where the decrease in supply and demand leads to a loss in total societal surplus.

complexity and quality [40]. Alternatively, evaluations may opt to incorporate analyses of health equalities, which involve less complex analysis than addressing health equities [41].

Given these methodological challenges, a comprehensive review of economic evaluations of SSBs would be invaluable in enhancing the quality of future evaluations in the area of SSB taxes. Thus, this review aims to conduct an overview of the methodological challenges faced in existing economic evaluations of SSB taxes as a strategy to combat obesity.

## 2. Methods

### 2.1. Literature search and study selection

Four databases, EconLit, Business Source Complete, Medline, and CINAHL, were searched via the EBSCOhost searching platform in February 2021 for literature published in English without specifying the date of publication. The search terms were defined based on the PICO(S) framework [42] and as detailed in the supplementary material. Hand-searching of references was performed to identify relevant literature not covered in the databases. The search and selection of evaluations was conducted by one reviewer (KT). The review included full economic evaluations which compare both the costs and consequences [5] of SSB taxes and their comparators, assessing their impact on obesity or obesity-related outcomes. Full details regarding the search terms and the study eligibility criteria are detailed in the supplementary material.

### 2.2. Data extraction and analysis method

A data extraction form was developed in Excel to collate the information extracted from the included evaluations. Data were extracted for the following parameters:

Overall characteristics of evaluations:

Authors and year of publication, country/setting, age of population, type of tax, rate of tax, comparator, modelling type, perspective, time horizon, discount rate, sensitivity analysis, and economic evaluation results.

Domains of methodological challenges:

Domain 1 – Measuring effects:

(i) Baseline clinical data: Approach used to evaluate weight outcomes from SSB consumption (e.g., direct or indirect approach; if indirect, details about adjustment for other sources of energy, e.g., consideration of other food consumption, physical activity or adjusting for caloric compensation effect), sources of evidence, details on effect size for SSB consumption and weight, and details on baseline consumption of SSBs.

(ii) Effectiveness: Types (e.g., price elasticity of demand); source of evidence, jurisdiction of evidence, details on effect size, substitution effect (e.g., if the price elasticity of demand was used), and persistence of effectiveness.

Domain 2 – Valuing outcomes: Types of weight outcomes, disease(s) evaluated, types of health-related outcomes, types of non-health outcomes, and results specific to these outcomes.

Domain 3 – Assessing costs: Types of health-related costs, types of non-health costs, and results specific to these costs.

Domain 4 – Incorporating equity: Approach, whether the method to assess equity was specified in the methods section of the evaluations (tool, outcomes of interest, and decision rule used to decide if a tax on SSBs improves equity), equity group of interest, equity-informative data, equity results (whether evaluations explicitly state if a tax on SSBs improves equity, and if so, how), and tax burden (regressive or progressive).

Data extraction, including the characteristics of evaluations and the identified methodological challenges, was performed by two reviewers (TK and KT); any disagreement on data extraction was resolved by discussion. The first author (KT) summarised the extracted data and presented it to the co-authors for discussion on potential issues.

The data obtained were analysed using a narrative synthesis approach [43]. This involved summarising the results by identifying, comparing, and synthesising findings across different evaluations. Results of costs in the included evaluations were converted to US dollars in 2021 values using an online web-based tool (CCEMG – EPPI-Centre Cost Converter) [44].

## 3. Results

A PRISMA diagram summarising the search results and selection of potential evaluations is presented in Fig. 1. The search identified 414 records; 407 were identified via database searches and seven through hand-searching of references. After removing duplicates, 407 were screened for title and abstract, and 19 of these were considered for full paper review. Of those 19, five were excluded: two did not focus on obesity [45,46], one did not have adults as the population [47], one evaluated only benefits [30], and one did not focus on the evaluation of SSB taxes [48]. A total of 14 published evaluations were thus included for assessment in the review.

### 3.1. Characteristics of evaluations

Characteristics of the 14 included economic evaluations are summarised in Table 1. The evaluations presented are predominantly concentrated in a few countries, with seven conducted in various regions of the United States [49–55], two in Australia [32,56], two in South Africa [57,58], and one each in Mexico [59], the Philippines [60], and Canada [61]. A majority of the studies (10/14; 71 %) assessed specific taxes [49–55,58–60] while the rest evaluated ad valorem taxes [32,56,57,61].[4] The most frequently used tax rate was US$0.01 per fluid ounce (equivalent to 29.6 mL), which was implemented in all evaluations conducted in the USA [49–55]. Most reported 'no SSB tax' as a comparator (13/14; 93 %) [32,49–54,56–61]. The minimum time horizon was ten years, used in six evaluations (6/14; 43 %) [49–52,55,59], while the maximum was a lifetime that was used in five evaluations (5/14; 36 %) [32,53,54,56,61]. Most of the included evaluations applied a discount rate (8/14; 57 %) [32,51–55,59,61] to both costs and outcomes, and two applied it to costs only (2/14; 14 %) [49,50]. The most common discount rate was 3 % applied to costs and outcomes in seven evaluations (7/14; 50 %) [32,51–55,59] and costs only in two evaluations (2/14; 14 %) [49,50]. Most evaluations used a cohort or Markov model (other non-individual models were classified into this type of model) (10/14; 71 %) [32,49–51,56–61] while four used micro-simulation modelling (4/10; 29 %) [52–55].

### 3.2. Measuring effects

#### 3.2.1. Baseline clinical data

Table 2 presents a summary of the baseline clinical data used in the 14 included evaluations. The evaluations were categorised based on whether they used direct or indirect evidence to assess the impact of SSB consumption on weight.

Nine evaluations estimated the impact of SSBs on weight indirectly by applying energy balance equations (9/14; 64 %) [32,49,50,55–58,60,

[5] SSB taxes are generally classified into two types: ad valorem taxes and specific taxes. Specific taxes can be levied as a monetary value per quantity (e.g., the sugar content of the beverage (such as a certain amount per gram of sugar) and the size of the beverage (like a fixed monetary amount per litre)). Ad valorem taxes are imposed as a percentage of the beverage's value.

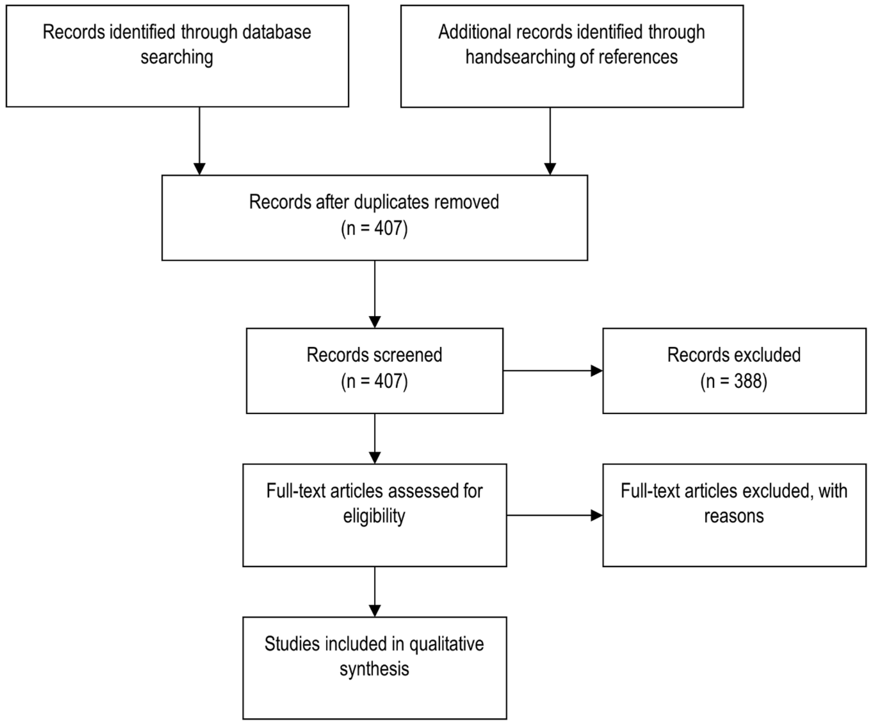


**Fig. 1.** PRISMA diagram illustrating the flow of studies through the review.

61]. Among them, six [32,49,55,56,58,60] used an equation developed by Hall et al., 2011 [63], two (2/14; 14 %) [57,61] used an equation developed by Swinburn et al., 2009 [64] and one (1/14; 7 %) [50] used a conventional rule of 3500 kcal per 1 pound (lb; 7700 kcal per 1 kilogram; kg) [65]. Caloric compensation effects were applied in two evaluations to consider the possibility that SSB consumption might reduce consumption of other products, thereby lessening the impact on weight. One included this in the base case analysis, assuming 40 % of SSB consumption would not result in weight change [49], and the other as a scenario analysis, applying a compensation effect of 39 % [50].

Five studies (5/14; 36 %) used direct evidence to demonstrate a relationship between SSB consumption and weight, either by combining data from RCTs and non-experimental studies [51,52], or by using data from non-experimental studies only [53,54,59]. Unlike evaluations that translate SSB consumption into weight gain using energy balance equations, these evaluations do not require additional adjustment for other sources of energy impacting weight, as this would be reflected in the direct effect evidence. To illustrate, it was explicitly stated by Long et al., 2015 and Basto-Abreu et al., 2019 that the evidence they used for weight change from SSB consumption already accounted for compensatory changes in diet or physical activity [51,59].

Only seven studies detailed the timeframe over which the effect of reduced consumption of SSBs on weight change would occur (7/14; 50 %): one year in Kao et al., 2020 [61]; two years in Basto-Abreu et al., 2019 [59]; three years in Wang et al., 2012 [49] and Lal et al., 2017 [32]; with the remaining studies using an unspecified, but not indefinite, period of time until a new equilibrium of energy balance was reached [49,55,57].

### 3.3. Effectiveness

A summary of the key evidence for the effectiveness of SSB taxes is presented in Table 3. Of the 14 evaluations, 13 (13/14; 93 %) [32, 49–54,56–58,60,61] used the own-price elasticity of demand of SSBs as a measure of the effectiveness of the taxes. Of the 13 evaluations, six [49-52,54,57] sourced data from published meta-analyses, six were based on a single non-experimental study [32,53,56,58,60,61] and one used survey data to estimate price elasticity of demand [55]. The published meta-analyses included three [66–68] that were based on non-experimental studies and a fourth [69] that was based on experimental and non-experimental studies. Data for own-price elasticity of demand were based on their own jurisdiction in nine evaluations (9/9; 100 %) [32,49–54,56,61]. The mean values of the own-price elasticity of demand ranged from −0.63 in an Australian evaluation by Veerman et al., 2016 [56] to −1.40 in a US evaluation by Basu et al., 2013 [55]. Only one evaluation took into account the impact of reformulating SSBs to have a lower sugar content on health outcomes as an additional effect of the tax [54].

Most of the evaluations using own-price elasticity of demand did not include the impact of cross-price elasticity of demand in their base case analysis (9/13; 69 %) [49-54,56,58,60] (although it was included in a scenario analysis in two evaluations [50,51]). Some evaluations provided justifications for the exclusion of cross-price elasticities, including a lack of evidence [49,58,60], that they assumed substitution effects would minimally impact weight [53], that those effects were already recognised in their risk model [54], or that they had assumed no cross-price effect [56]. Most of the included evaluations did not report the persistence of the effectiveness applied in their models (10/14, 71 %) [32,49,50,52–58,60], while two assumed that the effectiveness of the SSB tax remained constant throughout the defined time horizon [59,61].

### 3.4. Valuing outcomes

A summary of outcomes employed in the evaluations is presented in Table 4. Most evaluations utilised outcomes such as QALYs, disability-adjusted life years (DALYs) and health-adjusted life years (HALYs) (10/14; 71 %) [32,51–57,59,61]. The majority of evaluations (10/14; 71 %) [32,49,51,52,55–57,59–61] reported body weight outcomes following implementation of a tax, reporting metrics like a decrease in mean change in body mass index (BMI; weight in kilograms divided by height in metres squared) [51,52,55–57,60,61], mean weight change [49,56], or a reduction in obesity prevalence [49,51,52,56,57,59,61]. The reported decrease in obesity prevalence varied from 0.21 % [59] to 3.80 % [57], and the reduction in mean weight ranged from 0.23 kg[51] to

**Table 1**
Summary of characteristics of the included evaluations.

| Authors | Country | Target population | Type of tax | Tax rate | Comparator | Type of evaluation | Modelling type [a] | Perspective [b] | Time horizon | Discount rate (cost, outcome) | Uncertainty analysis |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Wang et al., 2012 [49] | US | 26–64 yrs | Specific (volumetric) | $0.01/oz | No tax | CEA | Cohort (Markov) | NS | 10 yrs | 3 %, NS | DSA |
| Basu et al., 2013 [55] | US | 25–64 yrs | Specific (volumetric) | $0.01/oz | SNAP | CUA | Microsimulation | Government | 10 yrs | 3 %, 3 % | DSA, PSA |
| Mekonnen et al., 2013 [50] | US (CA) | All ages | Specific (volumetric) | $0.01/oz | No tax | CEA | Cohort (Markov) | NS | 10 yrs | 3 %, NS | DSA, PSA |
| Long et al., 2015 [51] | US | ≥ 2 yrs | Specific (volumetric) | $0.01/oz | No tax | CUA | Cohort (Markov) | Societal | 10 yrs | 3 %, 3 % | DSA, PSA |
| Manyema et al., 2016 [57] | South Africa | ≥15 yrs | Ad valorem | 20 % | No tax | CUA | Cohort (Markov) | Health system | 20 yrs | No discounting | DSA |
| Veerman et al., 2016 [62] | Australia | ≥ 20 yrs | Ad valorem | 20 % | No tax | CUA | Proportional multi-state life table model (Markov) | Health system | Lifetime | No discounting | DSA, PSA |
| Lal et al., 2017 [32] | Australia | 2 to 100 yrs | Ad valorem | 20 % | No tax | CUA | Cohort (Markov) | Societal | Lifetime | 3 %, 3 % | DSA |
| Basto-Abreu et al., 2019 [59] | Mexico | 2 to 100 yrs | Specific (volumetric) | 1 peso/L | No tax | CUA | Cohort (Markov) | NS | 10 yrs | 3 %, 3 % | PSA |
| Long et al., 2019 [52] | US (Maine) | All ages | Specific (volumetric) | $0.01/oz | No tax | CUA | Microsimulation | NS | 10 yrs | 3 %, 3 % | PSA |
| Saxena et al., 2019 (pH) [60] | Philippines | All ages | Specific (volumetric) | ₱6/L | No tax | CEA | Cohort (Markov) | NS | 20 yrs | No discounting | DSA |
| Saxena et al., 2019 (SA) [58] | South Africa | ≥15 yrs | Specific (volumetric, sugar content) | 2.21 cents/g of sugar over four g/100mL | No tax | CEA | Cohort (Markov) | NS | 20 yrs | NS | DSA |
| Wilde et al., 2019 [53] | US | 35 to 85 yrs | Specific (volumetric) | $0.01/oz | No tax | CUA | Microsimulation | Societal | Lifetime | 3 %, 3 % | PSA |
| Lee et al., 2020 [54] | US | 35 to 85 yrs | Specific (volumetric, tier, sugar-Content) | (1) $0.01/oz (ii) (<5 g of added sugar/8 oz: no tax; 5–20 g/8 oz: $0.01/oz; and >20 g/8 oz: $0.02/oz (iii) ($0.01 per teaspoon added sugar | No tax | CUA | Microsimulation | Societal | Lifetime | 3 %, 3 % | DSA, PSA |
| Kao et al., 2020 [61] | Canada | ≥ 20 years | Ad valorem | 20 % | No tax | CUA | Cohort (Markov) | Health system | Lifetime | 1.5 %, 1.5 % | DSA, PSA |

Abbreviations: CA = California; CEA = cost-effectiveness analysis; CUA = cost-utility analysis; DSA = deterministic sensitivity analysis; *g* = gram; *L* = litre; mL = millilitre; NS = not stated; oz = ounce; pH = Philippines; PSA = probabilistic sensitivity analysis; SA = South Africa; SNAP = Supplemental Nutrition Assistance Program; US = United States; yrs = years.
Note:
[a] Unless stated otherwise, non-individual-based models have been classified into cohort (Markov).
[b] Societal perspective was chosen if a study adopted another perspective with societal
[c] as reported in this review but the evaluation also included other volumetric tax scenario including tiers (<5 g of added sugar/8 oz: no tax; 5–20 g/8 oz: $0.01/oz; and >20 g/8 oz: $0.02/oz) and (3) absolute sugar content ($0.01 per teaspoon added sugar).

**Table 2**
Evidence used to estimate weight change due to change in SSB consumption in the included evaluations.

| Evaluation | Baseline consumption of SSBs | Approaches used to estimate the impact of SSB consumption on weight | | | | |
|---|---|---|---|---|---|---|
| | SSB intake (min, max) | Source of data | Summary | Adjustment for other sources of energy | | |
| | | | | Caloric compensation effect | Overall other food intake | Physical activity |
| Wang et al., 2012 [49] | Mean by gender, age (33, 0.79 servings/d) | Equation (Hall et al.) | 100 kJ/d → 1 kg, 50 % in 1 yr, 90 % in 2 years, 100 % in 3 yrs [a] | Yes; 40 % (assumption) | - | – |
| Basu et al., 2013 [55] | Individual intake | Equation (Hall et al.) | 100 kJ/d → 1 kg, 50 % in 1 yr, 90 % in 2 yrs, 100 % in 3 yrs [b] | No | Likely | Unlikely |
| Mekonnen et al., 2013 [50] | Mean (value not reported) | 3500 kcal/lb eq. | 32,217 kJ → 1 kg | No, 39 % (RCT) in scenario analysis | Unlikely | Unlikely |
| Long et al., 2015 [51] | Mean varied by gender, age (29, 273 kcal/d) | RCT/non-experimental | 12 oz/d (~341 mL/d) (SSBs) → 0.39 BMI | Possibly reflected in the source of data | | |
| Manyema et al., 2016 [57] | Mean (value not reported) | Equation (Swinburn et al.) | 94 kJ/d → 1 kg [a] | Unlikely/No | Unlikely | Unlikely |
| Veerman et al., 2016 [56] | Mean by gender, age (71.0, 279.5 g/d) | Equation (Hall et al.) | 100 kJ/d → ~ 1 kg | Unlikely/No | Unlikely | Unlikely |
| Lal et al., 2017 [32] | Mean by types of SSBs, gender, age (2, 293.6 g/d) | Equation (Hall et al.) | 100 kJ/d → 1 kg, 100 % in 3 yrs | Unlikely/No | Unlikely | Unlikely |
| Basto-Abreu et al., 2019 [59] | Mean by gender, age (36.8, 183.1 kcal/d) | Non-experimental | 355 mL/d (soft drink) → 1.0 kg, in 2 yrs | Possibly reflected in the source of data | | |
| Long et al., 2019 [52] | Mean varied by gender, age reported (2.7, 23.9 fl oz/d) [b] | RCT/non-experimental | 12 oz/d (~341 mL/d) (SSBs) → 0.21 to 0.57 BMI | Possibly reflected in the source of data | | |
| Saxena et al., 2019 (pH) [60] | Mean intake by age, income (0.37, 11 mL/yr) | Equation (Hall et al.) | 94 kJ/d → 1 kg | Unlikely/No | Unlikely | Unlikely |
| Saxena et al., 2019 (SA) [58] | Mean by gender, age, income (1.26, 5.10 servings/d) | Equation (Hall et al.) | 94 kJ/d → 1 kg | Unlikely/No | Unlikely | Unlikely |
| Wilde et al., 2019 [53] | Likely to be based on individual data | Non-experimental | BMI<25: 8 oz/d (~237 mL/d) (SSBs) → 0.1 BMI<br>BMI ≥25: 8 oz/d (~237 mL/d) (SSBs) → 0.23 BMI | Possibly reflected in the source of data | | |
| Lee et al., 2020 [54] | Likely to be based on individual data | Non-experimental | 1 g (added sugar) → 0.005 BMI (baseline BMI<25)<br>1 g (added sugar) → 0.011 BMI (baseline BMI ≥25) | Possibly reflected in the source of data | | |
| Kao et al., 2020 [61] | Mean by types of SSBs, gender, age, income (6.86, 518.65 mL/yr) | Equation (Swinburn et al.) | 94 kJ/d of energy intake → 1 kg in weight, within 1 yr | Unlikely/No | Unlikely | Unlikely |

Abbreviations: BMI = body mass index; *d* = day, fl oz = fluid ounce; *g* = gram; kcal = kilocalorie, kg = kilogram; kJ = kilojoules; mL = millilitre; N/*A* = not applicable; pH = The Philippines; RCT = randomised controlled trial; SA = South Africa; SSBs = sugar-sweetened beverages; yr(s) =year(s).
Note: 'Unlikely' indicates that factor was unlikely to be considered in the model or that it could not be determined.
[a] Authors mentioned that weight loss ceases when energy intake once again reaches equilibrium with energy expenditures at a lower body weight.
[b] Unclear whether the model was based on individual data or mean.

1.33 kg[55]. The disease most frequently assessed in these evaluations was diabetes mellitus (either type 2 or unspecified type) (10/14; 71 %) [49–51,54–56,58–61].

Regarding non-health outcomes, increased tax revenue from SSBs was estimated by eight evaluations (8/14; 57 %) [32,49,51,54–56,58,60]. Improvements in productivity were estimated by two evaluations (2/14; 14 %) [53,54]. Additionally, two evaluations assessed the number of cases where catastrophic expenditure was averted (2/14; 14 %)[5], [58,60]. One evaluation assessed the food security score, suggesting that a tax on SSBs would increase low or very low food security among the Supplemental Nutrition Assistance Program (SNAP) participants in the US by 0.25 %, affecting about 69,000 individuals, due to the reallocation of disposable income and the tax burden [55].

### 3.5. Assessing costs

A summary of costs in the included evaluations is presented in Table 5. Among the evaluations reviewed, eight explicitly stated their analytical perspective (8/14; 57 %) [32,51,53–57,61]. Of these, four adopted a societal perspective [32,51,53,54], while three employed a health system perspective [56,57,61], and one was conducted from a government perspective [55]. For the remaining six evaluations (6/14; 43 %) that did not specify their perspective, the nature of the costs reported appears to indicate that three used a health system perspective [49,50,59] and three a societal perspective (including reporting of implementation costs to industry in one study [52] and out-of-pocket expenses (OOP) in two others [58,60]).

All the evaluations estimated healthcare costs (stated as medical costs in some evaluations) (14/14; 100 %) [32,49–54,56–61]. Other health-related costs included OOP expenses (3/14; 21 %) [32,58,60] and informal healthcare costs, such as travel expenses (2/14; 14 %) [53,54]. Non-health costs were estimated in half of the evaluations (7/14; 50 %) [32,51–56]. This included tax implementation costs in six evaluations (6/14; 43 %) [32,51–54,56], encompassing administrative costs for tax collection and legislative expenses related to enacting the tax bill. Five of these evaluations also considered implementation costs borne by the industry, assuming additional administrative burden, such as hiring more accountants (e.g., see Lal et al., 2017 [32]), due to the increased tax [32,51–54]. Two evaluations went further, assessing the economic impact of the increased SSB tax by estimating the deadweight loss (2/14; 7 %) [32,55].

There was a consistent finding across the included evaluations of reduced healthcare costs following the implementation of an SSB tax. The savings varied significantly, ranging from US$ 82.68 million [52] to US$ 75.24 billion [54], partly due to substantial variations in study population sizes. The relative costs of tax implementation were minor, representing 2 % [51] to 7 % [32] of the healthcare costs saved. The evaluation by Lal et al., 2017 [32], estimated the annual deadweight loss

[6] Health expenditures metric with illness-related expenditures exceeding 10% of total annual household expenditures.

**Table 3**
Evidence used for the effectiveness of SSB taxes in the included evaluations.

| Evaluation | Type | Data source | Evaluation setting vs source of data | Values | Substitution effect [a] | Effect duration |
|---|---|---|---|---|---|---|
| Wang et al., 2012 [49] | PED | Meta-analysis of non-experimental (Andreyeva et al., 2010) | US/US | −0.8 | No | NS |
| Basu et al., 2013 [55] | PED | Estimated based on non-experimental data | US/US | −1.40 (SNAP)<br>−1.00 (Non-SNAP) | Yes (e.g. juice) | NS |
| Mekonnen et al., 2013 [50] | PED | Meta-analysis of non-experimental (Andreyeva et al., 2010) | US/US | −0.79 to – 1.00 [b] | No (juice and milk in scenario analysis) | NS |
| Long et al., 2015 [51] | PED | Meta-analysis of non-experimental (Powell et al., 2013) | US/US | −1.22 | No (e.g. juice, provided as scenario analysis) | 2 years |
| Manyema et al., 2016 [57] | PED | Meta-analysis of non-experimental (Escobar et al., 2013) | South Africa/meta-analysis of multi-countries | −1.30 | Yes (e.g. juice) | NS |
| Veerman et al., 2016 [56] | PED | Non-experimental (Sharma et al., 2014) | Australia/Australia | −0.63 | N/A [c] | NS |
| Lal et al., 2017 [32] | PED | Non-experimental (Sharma et al., 2014) | Australia/Australia | −0.15 (juice, SES Q1) to −2.3 (cordial, SES Q1) | Yes (e.g. coffee) | NS |
| Basto-Abreu et al., 2019 [59] | Rate of decrease in purchase | Non-experimental (Colchero et al., 2017) | Mexico/Mexico | 7.6 % annually | No | = time horizon |
| Long et al., 2019 [52] | PED | Meta-analysis of non-experimental (Powell et al., 2013) | US/US | −1.22 | No | NS |
| Saxena et al., 2019 (pH) [60] | PED | Non-experimental (Colchero et al., 2015) | pH/Mexico | −0.97 (Q5 inc) to −1.12 (Q1 inc) | No | NS |
| Saxena et al., 2019 (SA) [58] | PED | Non-experimental (Colchero et al., 2015) | South Africa/Mexico | −0.98 (Q5 inc) to −1.26 (Q1 inc) | No | NS |
| Wilde et al., 2019 [53] | PED | Non-experimental (Wada et al., 2015) | US/US | −0.66 | NA | NS |
| Lee et al., 2020 [54] | PED, Reformulation [e] | Meta-analysis of experimental/ non-experimental (Afshin et al., 2017) | US/US | −0.67 | NA | NS |
| Kao et al., 2020 [61] | PED | Non-experimental (Lundy 2015) | Canada/Canada | −0.89 (Q5 inc) to −0.91 (Q1 inc) | Yes (diet, plain milk) | = time horizon |

Abbreviations: inc = income; NS = not stated; PED = price elasticity of demand; pH = Philippines; *Q* = quintile; SA = South Africa; SES = socioeconomic status; SNAP = Supplemental Nutrition Assistance Program; US = United States.
Note:
[a] Switching to other weight-unhealthy goods, e.g. juice. Substitution effect is most often represented by cross-price elasticity of demand.
[b] Unclear varied by which factors.
[c] Authors justified that no such effect in the studied setting.
[e] The evaluation assumed that, over ten years, half of SSBs in the highest tax rate (tier 3) would be reformulated to the next lowest tax rate (tier 2), and half of SSBs in the middle tax tier (tier 2) would be reformulated to the lowest tier (no tax). For the sugar content tax, SSBs would be reformulated to reduce overall sugar content by 25 % gradually over ten years.

at US$ 45.54 million. Basu et al., 2013 also included a deadweight loss in their analysis, but the specific estimate was not clearly reported [55]. Given the substantial healthcare cost savings and the relatively low implementation costs, SSB taxes were deemed cost-saving in all 14 evaluations.

### 3.6. Incorporating equity

More than half of the included evaluations (8/14; 57 %) [32,50,51,53,54,58,60,61] provided equity analyses alongside their economic evaluation, with the majority (5/8; 63 %) published between 2019 and 2020 [53,54,58,60,61]; see Table 6. Two used the concentration index (CI) [32,61], a tool developed in health economics for measuring socioeconomic inequalities in health [70]. Two evaluations employed an extended cost-effectiveness analysis (ECEA) [58,60], one of the earliest formal analytical frameworks to incorporate equity into economic evaluations [71]. Among the other evaluations, subgroup analyses were used to understand equity effects in three evaluations (3/8; 38 %) [50,53,54], while one (1/8; 13 %) [51] applied a qualitative evaluation to assess equity impacts. Four of the evaluations explicitly described their equity analysis in the methods section of their respective papers [32,58,60,61].

The main equity criteria considered in all eight evaluations was related to socioeconomic status. Equity impacts in the included evaluations were commonly investigated by examining health outcomes by socioeconomic group in the post-tax period. These included four evaluations that assessed QALYs, disability adjusted life years (DALYs), and health adjusted life years (HALYs) in their equity analyses [7,32,53,54,61], and three that assessed the reduction in diseases or death [50,58,60]. Six evaluations considered the distributional effects of the tax paid [32,53,54,58,60,61], while two evaluated OOP payments and catastrophic expenditure averted [58,60]. Most of the evaluations used specific consumption (7/8; 88 %) [32,50,53,54,58,60,61] and effectiveness data (6/8; 75 %) [32,53,54,58,60,61] tailored to their respective equity group of interest to investigate equity impacts.

Across the studies incorporating equity analyses, most (6/8; 75 %) [32,50,51,53,54,61] reported that the SSB tax mitigated inequity. For example, Lal et al., 2017 [32] demonstrated that the CI of HALYs gained post-tax implementation was negative,[6] which indicates that individuals in lower socioeconomic groups experienced greater health benefits from the tax compared to those in upper socioeconomic groups. However, the tax was found to be regressive in most evaluations (5/8; 63 %) [32,51,53,54,61], disproportionately impacting lower socioeconomic groups. A subset of evaluations did not explicitly draw a conclusion about equity (2/8; 25 %) [58,60]; their findings imply that while the health benefits

[7] A negative CI indicates that a studied outcome is less prevalent among those with higher socioeconomic status, while a positive CI suggests it is more prevalent among those with lower socioeconomic status.

**Table 4**
Outcomes in the included evaluations.

| Evaluation | Mean reduction in BMI (kg/m^2) | Mean reduction in weight (kg) | Reduction in prevalence of obesity (cases,%) | SSBs/obesity-related diseases | Major outcomes [a] | Non-health outcomes |
|---|---|---|---|---|---|---|
| Wang et al., 2012 [49] | NR | 0.41 (reported as 0.90 pounds) | 867,000, 1.5 % | CHD, stroke, DM2 | ↓26,000 death | Tax revenue ($13 billion/yr) |
| Basu et al., 2013 [55] | 0.46 | 1.33 [b] | NR | AHEI [c], MI, stroke, DM | ↑26,000 QALYs | Food security (−0.25 %; 69,000 persons), Tax revenue [d] |
| Mekonnen et al., 2013 [50] | NR | NR | NR | CHD, MI, DM2 | ↓1.8–3.4 % DM2 ↓0.5–1 % CHD ↓0.5–0.9 % MI (incidence) | No |
| Long et al., 2015 [51] | 0.08 (adult) | 0.23 (adult) [b] | 0.99 % (adults) | BC, CC, DM, EC, HHD, IHD, KC, OA, postmenopausal, stroke | ↓101,000 DALYs ↑871,000 QALYs | Tax revenue (12.5 billion/yr) |
| Manyema et al., 2016 [57] | 0.19; F 20–24yrs, 0.17; M 20–24yrs | 0.55; F 20–24yrs [b], 0.49; M 20–24yrs [b] | 220,000, 3.8% M, 2.4 % F | Stroke | ↓550,000 DALYs | No |
| Veerman et al., 2016 [56] | 0.10 M, 0.06 F | 0.36 M, 0.17 F | 2.7% M, and 1.2 % F | DM2 | ↑170,000 HALYs | Tax revenue (A$400 million/yr) |
| Lal et al., 2017 [32] | NR | 0.40 (55–64 yrs) to 1.10 (20–24 yrs) [e] | NR | BC, CC, DM2, IHD, KC, OA, stroke | ↑175,300 HALYs | Tax revenue (A$642.9 million/yr) |
| Basto-Abreu et al., 2019 [59] | NR | NR | 293,900, 0.21 % | BC, CC, DM, EC, HHD, IHD, KC, stroke | ↓5840 DALYs ↑55,300 QALYs | No |
| Long et al., 2019 [52] | 0.17 | 0.49 [b] | 10,400, 0.82 % | NR | ↑3560 QALYs | No |
| Saxena et al., 2019 (pH) [60] | 0.31 M 20–24yrs Q3 income 0.36 F 20–24yrs Q3 income | 0.90 M 20–24yrs Q3 [b] 1.04 F 20–24yrs Q3 [b] | NR | DM2, IHD, stroke | ↓5913 death | Tax revenue ($813 million/yr), catastrophic expenditure averted (13,890 cases) |
| Saxena et al., 2019 (SA) [58] | NR | NR | NR | DM2 | ↓8000 death | Tax revenue ($450 million/yr), Productivity ($ 2.32 M/yr), catastrophic expenditure averted (12,000 cases) |
| Wilde et al., 2019 [53] | NR | NR | NR | IHD, MI, stroke | ↑0.02 QALYs/person | No |
| Lee et al., 2020 [54] | NR | NR | NR | CVD, DM | ↑2470,000 QALYs | Tax revenue ($80.4 billion), productivity ($19.36 B) |
| Kao et al., 2020 [61] | 0.21 F Q5 income to 0.33 M Q1 income | 0.61 F Q5 [b] to 0.95 M Q1 [b] | 1.18 % F Q5 to 1.89% M Q5 | EC, CRC, LC, GBTC, PC, BC, UC, OC, KC, TC, leukaemia, IHD, stroke, HHD, DM2, CKD, OA, LBP | ↓690,000 DALYs | NE |

Abbreviations: AHEI = Alternative Healthy Eating Index; *B* = billion; BC = breast cancer; BMI = body mass index; CC = colorectal cancer; CHD = coronary heart disease; CKD = chronic kidney disease; CRC = colon & rectum cancer; CVD = cardiovascular disease; DALYs = disability-adjusted life years; DM = diabetes mellitus; DM2 = diabetes mellitus type 2; EC = oesophageal cancer; *F* = female; GBTC = gallbladder & biliary tract cancer; GN = glomerulonephritis; HALYs = health-adjusted life years; HHD = hypertensive heart disease; HT = hypertension; IHD = ischemic heart disease; KC = kidney cancer; LBP = low back pain; LC = liver cancer; *M* = male; MI = myocardial infarction; NR = not reported; OA = osteoarthritis; OC = ovarian cancer; PC = pancreatic cancer; pH = the Philippines; *Q* = quintile; QALYs = quality-adjusted life years; SA = South Africa; TC = thyroid cancer; UC = uterine cancer; US = United States; kg = kilogram; *m* = metre; yr(s) = year(s).
Note:
[a] Most of the evaluations reported more than one outcome. Major outcome in this review was prioritised as QALYs/DALYs/HALYs > LY > death > cases from diseases averted.
[b] Converted by reviewers from BMI assumed height of 1.7 m.
[c] Alternative Healthy Eating Index (AHEI) is a composite measure of nutritional quality that predicts long-term cardiovascular disease CVD mortality.
[d] The evaluation did not separately report results from tax revenue but included it as a part of the cost-saving results (see the respective evaluation in Table 5).
[e] Extracted from figure by reviewers.

of the tax were more pronounced for higher socioeconomic groups, the financial burden was also greater for those groups, indicating a progressive result of the tax.

## 4. Discussion

This review identified 14 economic evaluations examining the impact of SSB taxes as a strategy to combat obesity. Collectively, these evaluations demonstrated that SSB taxes may be effective at reducing obesity. Additionally, it appears that SSB taxes could potentially result in cost savings, as they may contribute to reducing illnesses associated with obesity, thus potentially helping to lower future healthcare costs. These evaluations also indicate a potential for SSB taxes to address health inequities. However, the review also found that these evaluations are subject to various methodological challenges inherent in economic evaluations of public health interventions. These challenges are related primarily to the approaches used to estimate the effects of SSB consumption and the impact of SSB taxes on body weight. The evaluations included in this review showed limited consideration of non-health consequences, both in terms of costs and outcomes. Most of the evaluations included equity analyses, but they displayed variation in the methods applied, with varying degrees of potential quality, in informing

**Table 5**
Costs in the included evaluations (US dollars in 2021).

| Evaluation | Perspectives[a] | Costs (health) | | Costs (non-health) | | Estimate inc. total costs |
|---|---|---|---|---|---|---|
| | | Type | Estimate (inc.) | Type | Estimate (inc.) | |
| Wang et al., 2012 [49] | NS | Medical costs | - $19.90 B | NE | N/A | - $19.90 B |
| Basu et al., 2013 [55] | Government | Medical costs | -$0.11 B | Tax costs [b], deadweight loss | -$15.23 B (subsidies and taxes costs [c]) Unclear for deadweight loss [d] | -$15.34 B |
| Mekonnen et al., 2013 [50] | NS | Direct medical costs | - $374.64 M to - $725.87 M | NE | N/A | - $374.64 M to - $725.87 M |
| Long et al., 2015 [51] | Societal | Healthcare costs | - $26.65 B | Implementation costs (government, industry) | $485.55 M | -$26.20 B |
| Manyema et al., 2016 [57] | Health system | Healthcare costs | - $1.13 B | NE | N/A | - $1.13 B |
| Veerman et al., 2016 [56] | Health system | Healthcare costs | - $504.23 M | Implementation costs (government) | $22.85 M | NR |
| Lal et al., 2017 [32] | Societal | Healthcare costs, OOP | - $1434.87 M (healthcare costs), -$249.63 M (OOP) | Implementation costs (government, industry), deadweight loss | $99.02 M (implementation costs), $45.54 M/yr (deadweight loss) | NR |
| Basto-Abreu et al., 2019 [59] | NS | Direct medical costs | - $103.46 M | NE | N/A | - $103.46 M |
| Long et al., 2019 [52] | NS | Healthcare costs | - $87.48 M | Implementation costs (government, industry) | $4.86 M | - $82.68 M |
| Saxena et al., 2019 (pH) [60] | NS | Medical costs, OOP | - $19.46 B (medical costs), - $1.15 B (OOP) | NE | N/A | NR |
| Saxena et al., 2019 (SA) [58] | NS | Medical costs, OOP | - $403 M (medical costs), - $ 261 M (OOP) [e] | NE | NE | NR |
| Wilde et al., 2019 [53] | Societal | Healthcare costs, informal healthcare costs | - $51.78 B (total) | Implementation costs (government, industry) | $2.12 B | -$49.66 B |
| Lee et al., 2020 [54] | Societal | Formal healthcare costs, informal healthcare costs | - $57.55 B (formal healthcare costs), -$0.04 (informal healthcare costs) | Implementation costs (government, industry) | $1.71 B | - $75.24 B |
| Kao et al., 2020 [61] | Health system | Healthcare costs | - $2.08 B to - $1.81 B | NE | N/A | - $2.08 B to - $1.81 B |

Abbreviations: *B* = billion; inc. = incremental; *M* = million; N/A not applicable; NE = not estimated; NS = not stated; OOP = out-of-pocket; pH = Philippines; SA = South Africa; US = United States; yr = year; ZAR = South African rand.
Note: Estimate reflects the incremental cost of tax policy vs comparator.
[a] Broadest perspective was stated in this review if there were more than one perspective included in evaluations.
[b] It is noted in the evaluation as the costs of taxes were estimated by multiplying the total demand by the cost of the tax per unit demanded.
[c] As stated in the evaluation, this reduction in costs included an increase in tax revenue. [d] the evaluation stated that deadweight loss was 32 % of the baseline cost of the subsidy scenarios (one scenario in the evaluation).
[e] extracted from the graph by reviewers.

equity outcomes of the taxes.

The review confirms the challenges inherent in estimating the effects of public health interventions [72]. It highlights the limited use of data from RCTs and emphasises the reliance on indirect evidence, through the application of analytic modelling approaches, both in terms of estimating the weight changes affected by SSB consumption and the impact of SSB taxes on weight. First, the review identifies the difficulty in accurately determining the effect size between SSB consumption and weight. This challenge arises from a dependence on indirect evidence, in which most of the evaluations use energy balance equations to infer weight change from SSB energy intake rather than direct evidence of SSB consumption's impact on weight. This indirect approach may introduce uncertainty to estimates of effect due to an inadequate accounting of factors that affect weight changes [72]. In particular, since alterations in SSB consumption often coincide with changes in other dietary habits, adjusting for the caloric compensation in overall energy intake associated with an SSB tax can lead to more precise predictions of weight change [19,63]. However, the review found that adjusting for caloric compensation was rarely considered in these evaluations. Second, the evaluations generally measured the effectiveness of SSB taxes on weight outcomes indirectly, by relying on estimates of reduced consumption indicated by the price elasticity of demand, which were predominantly derived from non-experimental studies. This reliance exemplified the constrained use of robust study designs like RCTs to evaluate long-term health outcomes in public health [12]. Further uncertainties arose, as the substitution behaviour associated with SSB taxes, which can negatively affect estimated weight outcomes, received little consideration from the evaluations. Additionally, the review found that another impact from the tax, such as product reformulation towards lower sugar content, was not generally considered in the evaluations included. However, this could be due to the types of tax assessed in most evaluations (value-based and volumetric-based taxes), which are unlikely to incentivise lower sugar content [73]. Other types of taxes that could potentially impact product reformation, such as those tiered by sugar content [3], might be worth considering in future evaluations alongside the more commonly assessed ones.

Similar to previous reviews examining public health interventions in alcohol and tobacco control [9,74], outcomes and costs related to health predominate in economic evaluations of SSB taxes. None of the included evaluations used CBA or CCA, which might reflect the general predominance of CUA in practice [9,10,75]. While some evaluations have tried to understand the wider effects of SSB taxes, they often only look at a limited set of consequences. For example, the most common non-health outcome assessed is the revenue from the SSB tax. Similarly,

**Table 6**
Equity analyses in the included studies.

| Authors | Setting | Key feature of methods | Equity group of interest | Method explained | Tool | Outcomes | Decision rule [b] | Use of equity-informative data | Suggest that tax improves equity? | …and how | Tax burden |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Mekonnen et al., 2013 [50] | US (CA) | Subgroup analysis | SES (low vs full population) | No | Subgroup analysis | Related-disease event, death | NS | Likely (consumption) | Yes | Lower SES gained more outcomes | No analysis |
| Long et al., 2015 [51] | US | Qualitative evaluation | SES | No | Group discussion | N/A | NS | N/A | Likely to favour the tax | 'substantial health benefits accrue to low-income consumers' | Regressive |
| Lal et al., 2017 [32] | Australia | Concentration index | SES (SES Indexes for Areas –5 levels) | Yes | Concentration index | Health gained including HALY (OOP healthcare costs saved, tax paid) | Yes | Yes (consumption, effectiveness) | Yes | CI < 0 (HALYs gained) | Regressive |
| Saxena et al., 2019 (pH) [60] | Philippines | ECEA | SES (income, 5 levels) | Yes/partly [a] | ECEA | Disease event, death, OOP, cases catastrophic expenditure averted, tax paid (revenues) | NS | Yes (consumption, effectiveness) | Did not say | Unlike improving the inequity in terms of health [c] | Progressive |
| Saxena et al., 2019 (SA) [58] | South Africa | ECEA | SES (income – 5 levels) | Yes/partly [a] | ECEA | Death, cases of poverty averted, cases catastrophic expenditure averted, tax paid (revenues) | NS | Yes (consumption, effectiveness) | Did not say/ unclear | Unlike improving the inequity in terms of health [c] | More tax burden in higher SES [c] |
| Wilde et al., 2019 [53] | US | Subgroup analysis | SES (reflected in 6 consumer categories) | No | Subgroup analysis | Health gained including QALY, tax paid | NS | Yes (consumption per microsimulation, effectiveness) | Yes | Health gains and overall healthcare cost reductions of the lower income were higher. | Regressive [c] |
| Lee et al., 2020 [54] | US | Subgroup analysis | SES (income-2 levels and race/ ethnicity) | No | Subgroup analysis | Health gained including QALY, tax paid | NS | Yes (consumption, effectiveness) | Yes | Lower SES gained greater health and economic benefits. | Regressive |
| Kao et al., 2020 [61] | Canada | Concentration index | SES (income – 5 levels) | Yes | Concentration index | Health gained including DALY, tax paid | No | Yes (consumption, effectiveness) | Yes | CI < 0 (DALYs averted) | Regressive |

Abbreviations; CA = California; CI = concentration index; DALYs = disability-adjusted life years; ECEA = extended cost-effectiveness analysis; HALYs = health-adjusted life years; N/*A* = not applicable; NS = not stated; OOP = out-of-pocket; pH = Philippines; QALYs = quality-adjusted life years; SA = South Africa; SES = socioeconomic status; US = United States.

[a] ECEA is a method specific to equity analysis in economic evaluations.

[b] Whether the evaluation explicitly states in the methods section what the results would imply if the tax contributes to improved health equity.

[c] Reviewers' judgement based on results presented.

many evaluations on SSB taxes did not consider non-health costs. However, this lack of consideration of non-health costs could be due to the limited adoption of the societal perspective. Moreover, the scant attention to non-health costs could also be due to the lack of a broader understanding of the costs of SSB taxes in the literature [21,76,77]. Even among the evaluations that used the societal perspective, only a few types of non-health costs were included, such as implementation costs narrowly focused on additional administrative burdens (e.g., human resources).

This review also found that one of the potential economic implications of SSB taxes, like the negative welfare effects associated with a reduction in consumption, was minimally explored, with a few of those evaluations claiming to use the societal perspective. This limited focus on economic costs could stem from the complexity of their valuation method, especially for those less familiar with economics [78]. It might also be due to differing viewpoints among researchers. For example, some researchers assumed welfare losses might not be present, citing potential biases in SSB consumer behaviour like lack of accurate foresight and stable time preferences [51]. However, regardless of these biases, it is likely that there will be welfare losses due to the reduced consumption among light or moderate SSB consumers who are unlikely to experience harmful impacts from SSB consumption [79]. Other potential economic costs, like the expenses of reformulating products or the effects on small businesses, were rarely covered in these evaluations. This omission might be because these non-health costs are not yet well-understood in the field of SSB taxes [21,76,77]. The prevalent focus on narrow health outcomes, such as QALYs, and a healthcare system perspective for costs generally adheres to the recommendations of many health technology assessment guidelines [6], suggesting that researchers might view SSB taxes similarly to clinical interventions. Finally, this lack of comprehensive evaluation of non-health consequences could also be due to the absence of guidelines for identifying and valuing these aspects in economic evaluations of public health interventions [80].

Equity is a key topic in health economics [7,39,81], and has increasingly been incorporated into economic evaluations [40]. This review suggests potential advances have occurred in integrating equity analyses into economic evaluations of public health interventions, as indicated in that over half of the included evaluations have incorporated equity analyses. All evaluations published post-2019 included equity analyses. This marks a significant shift from earlier periods, as highlighted by Hill et al., 2017 who found an absence of equity analysis in economic evaluations of alcohol taxes published up to 2016 [9] and Jain et al., 2020 who discovered that approximately one-third of economic evaluations of health taxes up to 2019 included equity [82]. Another significant observation from the review is that there is a variation in the method used to include equity impacts. The evaluations tended to focus more on health equalities, measuring the distribution of health outcomes across equity criteria like socioeconomic groups. Such approaches might be considered convenient for informally integrating equity into economic evaluations. While valuable in assessing distributional effects and providing an indirect measure of health equity, they might not fully capture the complex essence of equity [41]. For example, to more accurately represent the true impact of an intervention based on equity criteria (e.g., socioeconomic status), it is necessary to account for variances in baseline health (e.g., life expectancy) [83]. Such an approach was not undertaken in the evaluations reviewed.

That aside, of the evaluations which included equity analyses, we observed a need for greater transparency of the methods used. For instance, the review observed the absence of a clear decision rule to specify characteristics signalling an improvement in equity. As the interpretation of equity can be subjective, often resulting in a range of diverse conclusions [84,85] it is vital to establish predetermined criteria for assessing health equity outcomes. In addition, the review found a limited consideration of distributional data. Using distributional data is important for effective equity analysis, and this is particularly important for data like price elasticity of demand, which is likely to be different across equity criteria like socioeconomic status [22]. Techniques like microsimulation could enable thorough analysis of tax impacts on equity, allowing flexible aggregation of results by socioeconomic groups [39]. To further progress in this area, adopting a more refined approach underpinned by theoretical frameworks that more effectively integrate equity into economic evaluations is essential. For example, DCEA is an approach specifically developed to incorporate equity into economic evaluations. It offers analyses such as distributional breakdowns, identifying who gains most and who bears the largest burdens (opportunity costs) by equity-relevant social variables and disease categories, making it a viable choice [83]. Finally, the variation in approaches used and lack of transparency in the methods across the evaluations also indicate a need for clear guidelines on conducting equity analyses in economic evaluations.

This review has some limitations. First, this review was restricted to the evaluation of obesity outcomes, so it did not investigate other health outcomes arising from the consumption of SSBs. The findings, therefore, may not be fully generalisable to economic evaluations of SSB taxes focusing on other health problems (e.g., dental disease, or cancer) [45]. However, this review did find that there has been inadequate consideration of the likelihood that consumers of SSBs might switch to other sugary foods (substitution effects) potentially leading to an overestimation of the impact of SSB taxes. The absence of enquiry into such substitution effects serves as a caution for evaluations assessing the impact of SSB taxes on dental diseases, given the strong link between sugar consumption and dental problems [62]. Second, the review did not extensively examine variation among the non-experimental studies that could affect quality of the evaluations, particularly in the context of their effectiveness [10,11]. Lastly, there are other important moderators of the intervention effects of SSB taxes, including the pass-through of tax to consumers and cross-border shopping, which were not considered in this review [24]. Understanding how these aspects may contribute to the methodological challenges facing the conduct of economic evaluations of SSB taxes deserves more investigation.

## 5. Conclusion

Several areas for improvement were identified in the existing economic evaluations of SSB taxes. This is particularly evident in the techniques used to quantify effects. Most evaluations focused on health outcomes and health costs, with broader impacts, beyond health, being investigated less. Equity analyses of SSB taxes require more robust approaches than those applied currently. Theoretical approaches for the practical inclusion of equity into economic evaluations of SSB taxes are needed for future evaluations. These findings call for heightened attention to these challenges in future evaluations, which may include the necessity to develop dedicated guidelines for economic evaluations of public health interventions, like SSB taxes.

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## CRediT authorship contribution statement

**Kittiphong Thiboonboon:** Writing – original draft, Visualization, Validation, Methodology, Formal analysis, Data curation, Conceptualization. **Richard De Abreu Lourenco:** Writing – review & editing, Validation, Supervision, Conceptualization. **Paula Cronin:** Writing – review & editing, Supervision, Conceptualization. **Terence Khoo:** Writing – review & editing, Data curation. **Stephen Goodall:** Writing – review & editing, Validation, Supervision, Conceptualization.

## Declaration of interest statement

The authors of this manuscript declare that they have no potential conflicts of interest.

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## Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.healthpol.2024.105076.

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