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Impact of sugar-sweetened beverage taxes on purchases and dietary intake: Systematic review and meta-analysis

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Summary

The aim was to conduct a systematic review of real-world sugar-sweetened beverage (SSB) tax evaluations and examine the overall impact on beverage purchases and dietary intake by meta-analysis. Medline, EconLit, Google Scholar, and Scopus databases were searched up to June 2018. SSB tax evaluations from any formal jurisdiction from cities to national governments were eligible if there was a comparison between pre–post tax (n = 11) or taxed and untaxed jurisdiction(s) (n = 6). The consumption outcome comprised sales, purchasing, and intake (reported by volume, energy, or frequency). Taxed and untaxed beverage consumption outcomes were examined separately by meta-analysis with adjustment for the size of each tax. The study was registered at PROSPERO (CRD42018100620). The equivalent of a 10% SSB tax was associated with an average decline in beverage purchases and dietary intake of 10.0% (95% CI: −5.0% to −14.7%, n = 17 studies, 6 jurisdictions) with considerable heterogeneity between results (I^2 = 97%).The equivalent of a 10% SSB tax was also associated with a nonsignificant 1.9% increase in total untaxed beverage consumption (eg, water) (95% CI: −2.1% to 6.1%, n = 6 studies, 4 jurisdictions). Based on real-world evaluations, SSB taxes introduced in jurisdictions around the world appear to have been effective in reducing SSB purchases and dietary intake.

KEYWORDS
evaluation, excise, meta-analysis, natural experiment, tax, soft drinks

1 | INTRODUCTION

Many countries face a growing burden of obesity-related disease[1] and have experienced rapid trajectories of increased sugar-sweetened beverage (SSB) intake.[2,3] SSBs are associated with increased risk of type 2 diabetes,[4,5] cardiovascular disease,[6] dental caries,[7] excess weight gain,[8,9] and numerous other obesity-related diseases.[10] The World Health Organization (WHO) has recommended SSB taxation as a tool in the package of policy actions to tackle obesity and the non-communicable disease (NCD) crisis.[11,12] SSB taxes have become an increasingly popular fiscal policy implemented by governments,[13,14] and there has been an increasing number of real-world studies published evaluating the impact of these taxes on purchasing and dietary intake. At the same time, it is clear that beverage manufacturers and industry allies with plausible competing interests have tried to prevent SSB taxes by contesting scientific evidence and providing misinformation.[15-17] Systematic reviews and meta-analyses can combine review evidence across jurisdictions and identify common patterns.

Several systematic reviews have evaluated evidence for the impact of SSB taxes on consumption by combining results from simulation studies (eg, econometric studies of price elasticities), experimental studies, and real-world evaluations,[14,18-25] the most recent of which includes studies published up to December 2017.[26] However, there are only two meta-analyses that have examined the impact of SSB taxes.[27,28] The most recent study (searched conducted in June 2014) by Afshin et al examined the impact of price change on diet in interventional and prospective observational studies largely based in specific settings (eg, hospitals). The authors reported a pooled price elasticity of −0.67 (95% CI: −0.31 to −1.04),[27] ie, a 7% decrease in consumption for a 10% increase in price. Escobar et al examined the impact of SSB taxes and price changes (eg, in tax simulation modelling) on SSB consumption reporting a combined price elasticity of −1.30 (95% CI: −1.09 to −1.51).[28] Systematic reviews of published US simulation studies reported similar price elasticities of −0.79 (95% CI: −0.33 to −1.24)[29] and −1.21 (95% CI: −0.71 to −3.87).[30] Given the range of included study types within these meta-analyses, especially simulation studies, it remains unclear if the effects are similar to what happens in the real-world when SSB taxes are introduced. Also, there is little information available on the average impacts of a SSB tax on untaxed beverages, and whether purchases and dietary intake of potential substitute beverages such as water or other untaxed beverages are increased. It was expected that SSB taxes would result in greater consumption of untaxed beverages (eg, juice, water, milk, and diet soft drinks), as demonstrated in price elasticity modelling studies.[22] However, evidence from evaluation studies has not always been consistent [31-33] and further examination is warranted.

An updated meta-analysis is further required to take into account the recent growth in the number of SSB tax evaluations from around the world. Such a meta-analysis has the potential to provide even stronger epidemiological evidence on the impact of SSB taxes on purchases and dietary intake and can address some of the critiques of existing simulation and experimental studies.[34,35] Specifically, simulation studies have often relied on price elasticities, for example, from elasticity of demand estimates or experimental studies (that evaluate a change in behaviour in response to price) and pass through rates (the proportion of the tax passed through to the price seen by the consumer) may be assumed to be 100%. Furthermore, experimental studies based specific contexts (eg, airports, restaurants, or vending machines) or virtual supermarkets may not be generalizable to the wider jurisdiction. These studies usually do not account for supply side changes such as reformulation, and there is no signalling effect to the public as might be expected from a government introduced SSB tax. Real-world evaluation studies on the other hand examine the impact of a new SSB tax on purchases and dietary intake irrespective of the pathways via which the tax may have taken effect. For example, SSB taxes may reduce consumption via price changes; however, there may be further changes via other modes. The increased price can signal to the public the seriousness of the health concern from consuming a product, thus discouraging its consumption.[36] Taxation can encourage beverage companies to respond with measures such as reformulation of beverages to reduce sugar content[37,38] or, alternatively, by increasing marketing and discounting to reduce the impact of the tax. Evaluation studies are likely to have greater internal validity and provide stronger evidence for policymaking.

Given this background, the aim of this study was to systematically identify quantitative studies that evaluated the impact of real-world SSB taxes on SSB sales, purchases, and dietary intake before and after the tax, or in a taxed compared with an untaxed jurisdiction, and to combine results by meta-analysis. We account for the differences in study effects because of the size of SSB taxes, and we test for differences in impact by study quality, jurisdiction, and tax design. The secondary aim was to examine the impact of SSB taxes on the purchases and dietary intake of untaxed beverages.

2 | METHODS

The review was conducted in accordance with PRISMA guidelines. Title and abstract screening, data extraction, and risk of bias assessment were done independently by two investigators, and any conflicts arising were resolved by consensus. The full study protocol is registered with PROSPERO (CRD42018100620).

2.1 | Search strategy

Using a systematic approach, the databases Google Scholar, Medline, Scopus, and EconLit were searched for articles published in any language between database inception (<1980, except for EconLit, which was 1987) and June 8, 2018. Reference lists from eligible studies and systematic reviews were searched for additional relevant studies. Peer-reviewed publications and grey literature (reports and self-published research) were included. Authors were contacted when effect sizes and measures of uncertainty were not available or if information within the paper suggested that it was not a final version (eg, "not for citation").

The search terms aimed to identify two required domains: beverages and taxation (Appendix S1). For example, the search terms for Medline were as follows: ("beverages/ or exp carbonated beverages/ or coffee/ or exp drinking water/ or energy drinks/ or "fruit and vegetable juices"/ or milk/ or tea/ or kombucha tea/or teas, herbal/" OR "[drink* or beverage* or fizzy or sugar* or sweetened or soda or cola or coke or carbonated].mp.) AND (*taxes/OR [tariff* or tax or taxes or taxation or excise or excises or duty or duties or levy or levies].ti,kw.).

2.2 | Eligibility criteria

Studies eligible for inclusion were those that evaluated the impact of a real-world SSB tax introduced in a distinct local or central government jurisdiction (eg, city, region, or nation). Studies evaluating taxes that were applied within a limited setting such as supermarkets, airports, or schools were not eligible. A SSB tax was defined as a tax applied to at least one category of non-alcoholic beverages containing added sugars.[39] Taxes could comprise excise taxes, import tariffs, sales taxes, or any other taxes applied by a jurisdiction. SSB taxes were generally charged either at a local currency value per litre (ie, specific or volumetric tax) or as a proportion of the product's value (ie, ad valorem). Some taxes were based on the sugar content of SSBs and only apply above a defined threshold (eg, grams of sugar per litre).

Any quantitative study design that evaluated an actual SSB tax was eligible, thereby excluding simulation studies and experimental studies. Pre and postintervention comparisons were eligible, regardless of whether or not a control jurisdiction was used (ie, interrupted time series and before and after studies), as were comparisons between jurisdictions with and without a SSB tax (eg, cross-sectional study). Any length of follow-up was eligible, and a lack of statistical testing was not used to exclude studies at the systematic review stage. The primary outcome of interest was termed "consumption" and included any change in taxed beverage sales, purchases, or dietary intake following the implementation of a SSB tax and could be reported by volume, calories, or consumption frequency. The effect of SSB taxes could be reported as a ratio, difference, percentage change, or tax elasticity. Tax elasticity is the percentage change in consumption for a 1% change in tax. For example, a 10% tax with a 15% decline in consumption corresponds to a tax elasticity of −1.5. Changes in untaxed beverages were also examined, including water, 100% juice, milk, or untaxed diet beverages, and the sum of any untaxed beverages, as reported by study authors (termed here as "total untaxed beverages").

2.3 | Study selection

Titles and abstracts were screened to identify relevant articles, and then, full-text articles were screened against the eligibility criteria with the reasons for exclusion documented. Where multiple articles reported the results of the same study, a complete article with the longest duration of follow-up was selected as the primary article for reporting.

2.4 | Risk of bias assessment

For each eligible study outcome the risk of bias was assessed using a critical appraisal tool based on 12 study quality criteria: study design, inclusion of a control, untaxed beverage outcomes reported, representativeness of the taxed population, same outcome in comparison groups, objectivity of the outcome, correct classification of taxed and untaxed beverages, same individuals or stores over time, follow-up time points, adjustment for major confounders, accounts for changes in portion size, and reporting of any other health policies that were introduced with the SSB tax. The tool developed specifically for this review was informed by a previous systematic review,[25] the Grading of Recommendations Assessment, Development and Evaluation (GRADE) risk of bias questions, and the Critical Appraisal Skills Programme (CASP) appraisal checklist for cohort studies. A score of low, medium, or high quality was assigned to each consumption outcome according to the study design and control of major confounders (see Appendix S1). A bespoke tool was developed because an existing tool that would focus on all the major potential biases of SSB tax evaluation designs could not be identified in the literature.

2.5 | Data extraction

The study information and results were extracted into a data extraction form in Excel. There could be multiple primary outcomes from a study if there were separate analyses on unique data sets reported in the same article (eg, sales data and survey data). Data were extracted on jurisdiction, study population, SSB tax (introduction date; whether it was levied on price, volume or sugar content; level; rationale; included beverages; use of revenue; pass-through), outcome (sales, purchases, dietary intake), data source, risk of bias, results for taxed and untaxed beverages (magnitude, statistical test results), and funding. Effect sizes and confidence intervals (CIs) or *P* values and standard errors for eligible outcomes were extracted wherever available. In addition to effect sizes, reported standard errors were inputted into the Review Manager 5.3. If the standard error was not reported, it was calculated from *P* values or from CIs using the methods for "data extraction for estimates of effects" in the Cochrane Handbook.[40] *P* values reported as <.01 or <.05 in the articles were conservatively considered to equal .01 or .05, respectively.

2.6 | Analyses

Extracted data were analysed qualitatively and summarised in a narrative format. Eligible outcomes were then analysed by meta-analyses. If a study reported multiple eligible outcomes from the same data set analysis (eg, volume and calories), one outcome was selected for meta-analysis by prioritizing the most commonly evaluated measure across studies (volume was most common, followed by calories and frequency).

The summary measure was a risk ratio or rate ratio (RR) scaled for a 10% sized tax. The RR expresses the relative change in taxed beverage consumption for the taxed group compared with consumption before the tax and/or a control jurisdiction(s) with no tax. To obtain this measure, study effect sizes were extracted, converted to RRs if necessary (eg, $RR = 1 \pm \%\ change$) and then scaled to a 10% tax. When non-RR effect sizes were reported, two approaches were used to convert non-RR effect sizes to RRs, depending on the reported statistic. (a) For studies that reported a change in consumption as an absolute difference (n = 6 studies), then a RR was approximated by dividing the absolute change by the original level of consumption (ie, pretax level and/or control jurisdiction level). The 95% CIs were converted in the same manner (ie, by dividing the CI by this same level of consumption). (b) If a RR was reported per 1% tax change (tax elasticity), then this measure of effect was scaled to the size of the SSB tax to improve comparability. For example, if the SSB tax was 3% and it resulted in a tax elasticity of 1.03 times greater consumption for every 1% tax change, then the RR would be $1.03^3 = 1.09$.

Scaled RRs (and corresponding scaled upper and lower CIs) were then calculated to express the effect size of each study scaled to a 10% change in the level of SSB tax. This was done because we expected larger taxes to have a proportionately larger impact on the study outcomes. The calculation was done using this formula:

$$scaled\ RR = study\ RR^{(10\%/jurisdiction\ tax\ as\ a\ percentage\ of\ price)}.$$

For example, if the SSB tax was 8% and it resulted in 1.08 times greater consumption, then the scaled RR would be $1.08^{(10/8)}$ = 1.10. The calculation assumes a linear association between tax size and effect size, an assumption that we subsequently tested by plotting study RRs against the tax size. Calculating the scaled RR required a standardized ad valorem level of tax for each SSB tax intervention (ie, the SSB tax as a percentage of prices even if it was taxed per litre). For ad valorem taxes, this rate was used (or the average tax size when study results combined multiple US states). For each volumetric tax (expressed as tax per litre), an ad valorem equivalent (AVE) tax rate was calculated by first identifying the average pretax cost of 1 L of taxed beverage. This was done using the average import unit value for sweetened drinks from UN Comtrade data[41] (Harmonized code 22.20, US$/L, in the year of the tax) and converting taxes from local currency to US$ using official exchange rates.[42] This method has been used elsewhere for calculating AVEs in trade databases.[43] Results were very similar to the approximate ad valorem values reported by study authors (Table 1), with the exception of Philadelphia (AVE = 33.3%; approximate ad valorem rate = 20%), which was not eligible for meta-analysis because only odds ratios were reported. Using the study reported AVE of 10% for the 1 peso per litre Mexico tax was tested as a sensitivity test.

Scaled RRs were combined using a two-step meta-analysis. First, study outcomes from the same jurisdiction were combined using meta-analysis. Then, these jurisdiction-specific results (RRs and their CIs) were combined in a second meta-analysis. This process addresses the independence requirement of meta-analysis, whereby the contributing study results should be statistically independent from one another.

Subgroup analyses were performed according to preclassified variables: quality, peer review, funding, jurisdiction, tax design (ad valorem, volumetric, thresholds), study design (interrupted time series, before and after study, cross-sectional), outcome (dietary intake vs sales or purchases), and age (children, adults, both). Meta-analyses were performed on the secondary outcomes to evaluate any changes for the total untaxed beverage purchases and dietary intake and subcategories of water, milk, juice, and untaxed diet drinks if these outcomes were reported.

All analyses were conducted in the Review Manager Version 5.3 using the inverse variance method and a random effects model (Der Simonian-Laird's) because heterogeneity in outcomes was expected from the different SSB taxes introduced. Sensitivity analysis was conducted using fixed effects instead of random effects in the main overall meta-analysis. Risk of bias was assessed with a funnel plot. Heterogeneity between studies was assessed by the chi-squared heterogeneity test (I^2).

3 | RESULTS

A total of 1189 studies were identified by the search strategy, and of these, 18 studies met the study's inclusion criteria, and 15 studies (17 outcomes) were included in the meta-analyses (Figure 1). Eligible evaluations examined the impact of SSB taxes from 10 jurisdictions, with the addition of several other studies that compared tax levels between state jurisdictions in the United States (Table 1). Jurisdictions largely corresponded to the World Bank classified high-income countries and one "high–middle-income" country (Mexico). Based on the AVE tax rate, the highest taxes were in Philadelphia in the United States (33.3%), Berkeley in the United States (21.9%), and Catalonia in Spain (11.4%). See Appendix S2, Table C for further information.

3.1 | Summary of included studies

Table 2 summarizes the study outcomes that were eligible from the systematic review (n = 22). Two-thirds of studies measured sales or purchasing outcomes (n = 15) and one-third measured dietary intake (n = 7). Of the outcomes included in the meta-analysis, 11 out of 17 reported significant reductions in SSB sales, purchases, or dietary intake. For the remaining outcomes, no tests of statistical significance were reported.

Some studies assessed heterogeneity of study results by socioeconomic position (SEP) (Appendix S2, Table D). Results from Mexico reported significantly greater consumption declines in lower income households.[32,53] The two studies from Chile reported greater consumption declines in high-income groups, although this association was statistically significant in only one study.[31]

3.2 | Risk of bias within studies

The results of the risk of bias assessment are presented for the 18 included studies and the corresponding 22 outcomes (Table 3 and Appendix S3). There were eight high-quality, six medium-quality, and eight low-quality study outcomes. Interrupted time series analysis was the most common study design (15/22). The postintervention follow-up period varied from a few weeks to 3 years. Nearly half of studies (10/22) adjusted for major confounders such as time trends, seasonality, and differences in SEP. Studies generally scored well on measuring changes in portion sizes (eg, by measuring volume outcomes), reporting substitution to untaxed beverages and using consistent outcome measures before and after taxation or between tax and control jurisdictions.

Studies varied in correct classification of taxed beverages often because data sources were not able to precisely distinguish between taxed and untaxed beverage categories. Most studies scored poorly on how well they represented the taxed population (internal validity), because they used data based on a proportion of overall sales, had a low survey response rate, or were limited to a particular group such as children, urban dwellers, or neighbourhoods with higher or lower

TABLE 1 Legislated SSB taxes by jurisdiction, date of introduction and the legislated tax rates

Ad Valorem Taxes						
Jurisdiction	**Date of introduction**	**Legislated tax increase**	**Volumetric tax estimated from import unit value in US$/L[a]**		**Ad valorem tax rate, reported %**	**Ref**
Chile	Oct, 2014	Increased from 13% to 18% if ≥6.25 g sugar/100 mL	0.06		5	Caro et al and Nakamura et al[31,33]
US, state level analyses	Various	Average of 3%-5% sales tax	0.03		4	Sturm et al and Fletcher et al[44-47]
Cleveland, Ohio, US	2003	5% sales tax	0.04		5.0	Colantuoni and Rojas[48]
Portland, Maine, US	Aug, 1991	5.5% sales tax	0.05		5.5	Colantuoni and Rojas[48]
Volumetric Taxes						
Jurisdiction	**Date of introduction**	**Legislated tax increase**	**Volumetric tax rate, converted to US$/L[b]**	**AVE tax % reported by the study[c]**	**AVE tax as % of import unit value[d]**	**Ref**
Catalonia, Spain	May, 2016	€0.12/L if >8 g sugar/100 mL	0.13	5-23	11.4	Vall Castello[49]
France	Jan, 2012	€0.0716/L	0.09	7.1-8.4	9.7	Capacci et al and European Competitiveness and Sustainable Industrial Policy Consotium[50,51]
Finland	2011	Increased from €0.045/L to €0.075/L	0.04	-	3.7	European Competitiveness and Sustainable Industrial Policy Consotium[51]
Finland	2012	Increased from €0.075/L to €0.11/L	0.04	-	3.9	European Competitiveness and Sustainable Industrial Policy Consotium[51]
Hungary	2011	7 HUF/L	0.03	-	5.2	European Competitiveness and Sustainable Industrial Policy Consotium[51]
Mexico	Jan, 2014	1 peso/L	0.08	9-10	6.7	Colchero et al, Aguilar et al, and Andalón and Gibson[32,52-55]
Berkeley, California, US	Mar, 2015	US$ 0.01/oz (0.34/L)	0.34	12-34	21.9	Silver et al and Falbe et al[56,57]
Philadelphia, Pennsylvania, US	Jan, 2017	US$ 0.015/oz (0.51/L)	0.51	20	33.3	Zhong[58]

Note. Further information is available on how these figures were calculated from Table C in the Appendix S2.

Abbreviations: AVE, ad valorem equivalent; Ref, references; SSB, sugar-sweetened beverage.

[a]Ad valorem taxes were converted into volumetric rates in US$/L using the tax per litre on the average import unit value (US$/L, HS 22.02) of sweetened beverages from UN Comtrade data at the time the tax was introduced.

[b]Volumetric taxes corresponded to a specific price increase per unit volume in local currency and were converted to US$/L using the IMF official exchange rates in the year of the tax.

[c]Some studies did not report ad valorem equivalent tax rates.

[d]Volumetric taxes charged at a per volume value were transformed into an ad valorem equivalent (AVE, %). The value of the tax in LCU/L (year of the tax) was divided by the import unit value of sweetened beverage imports per litre (US$/L, HS 22.02) (transformed into local currency units (LCU) using the IMF official exchange rates in LCU/USD in the same year) to calculate a percentage figure, the ad valorem equivalent.

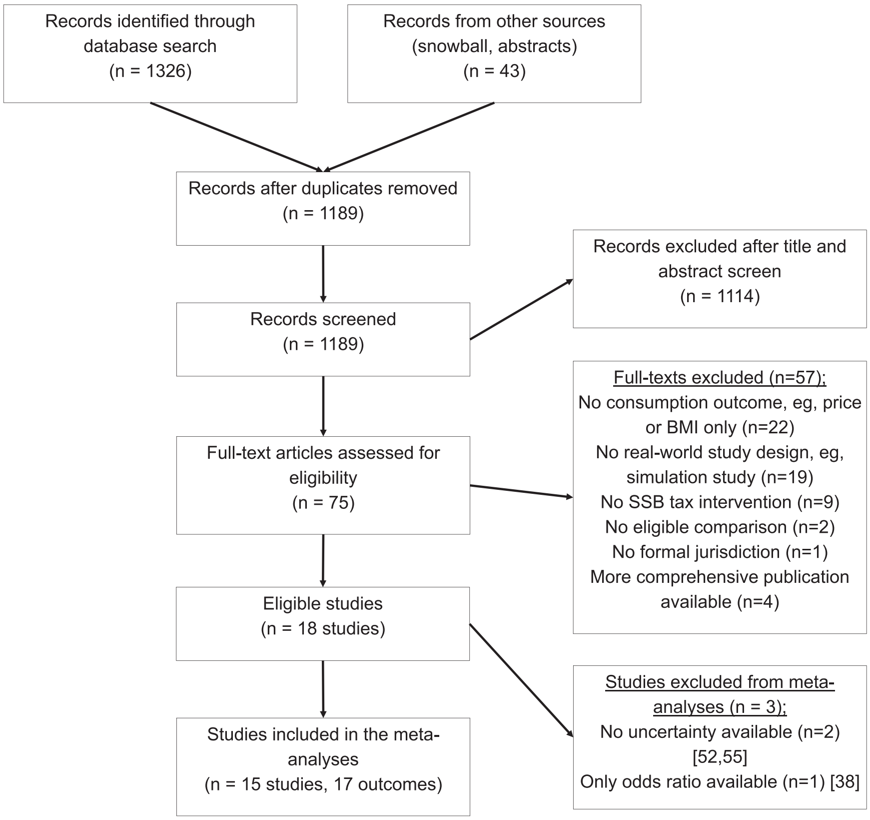

FIGURE 1 PRISMA flow diagram of the article selection process for studies evaluating real-world sugar-sweetened beverage taxes, June 2018. *Note*. Some studies contributed multiple outcomes if the study examined two different jurisdictions or used more than one unique data set

SEP. Studies were also generally poor at reporting other public health policies that were introduced concurrently with the SSB tax.

3.3 | Meta-analyses of taxed beverage outcomes

In the main meta-analysis, the equivalent of a 10% increase in SSB tax was associated with a decline in purchases and dietary intake of 10.0% (95% CI: −5.0% to −14.7%, n = 17 studies/6 jurisdictions, Figure 2B) based on pre–post intervention comparisons and/or comparisons to an untaxed control jurisdiction. This corresponded to a tax elasticity of −1.00 (95% CI: −0.50 to −1.47). There was a large amount of heterogeneity in results between jurisdictions (I^2 = 97%) but generally low levels of heterogeneity within jurisdictions ($I^2 \leq$ 25% in Mexico, Berkeley, and other US jurisdictions) with the exception of Chile (I^2 = 95%).

In a sensitivity test, adopting fixed effects rather than random effects resulted in a 13.3% (−12.7% to −13.8%) decline in purchases and dietary intake of taxed beverages for an equivalent of a 10% tax, largely weighted to results from France. A further sensitivity analysis was also done by using the frequently cited 10% AVE tax in Mexico, instead of the 6.7% tax size calculated in this review from import unit values. This resulted in an overall meta-analysis outcome of a 9.3% (−3.1% to −15.1%) decline in SSB purchases and dietary intake for a 10% tax.

There was little evidence of any major publication or reporting bias (Figure 3). Figure 4 plots study effects (unscaled and unweighted) with tax size and suggests a linear association. Larger taxes such as those in Catalonia and Berkeley tended to have the largest impacts on consumption (lowest risk ratios).

3.4 | Subgroup analyses

The impact of the equivalent of a 10% SSB tax varied significantly between jurisdictions (P < .001, Fig 2a). Meta-analysis results varied by study design with a 10.7% decline (95% CI: −5.3% to −15.8%) in consumption in interrupted time series, a 9.3% decline (−7.7% to −10.9%) in before and after studies and a 2.6% increase (−9.6% to 16.5%) in cross-sectional study designs from United States, but these differences were not statistically significant (test for heterogeneity P = 0.14). Similarly, results varied by tax type but not significantly (P = .11); with a 2.3% decline (−11.2% to 7.4%) in consumption for ad valorem taxes, a 10.2% decline (−4.1% to −15.9%) for volumetric taxes and a 14.0% decline (−7.5% to −20.1%) for taxes with a sugar concentration threshold. Furthermore, there was no statistical evidence that results varied by study quality (high vs medium/low declines: 11.3% vs 8.4%, P = .55), consumption measure (declines: self-reported intake 9.4%, sales or purchases 10.1%, P = 0.88), age group (declines: all ages 10.2%, adults 6.4%, children 7.7%, P = 0.91), peer review (declines: peer reviewed 6.8%, report only 12.9%, P = 0.08) or funding source (declines: NGO/public 6.3%, other/unclear 12.7%, industry 9.3%, P = 0.31), (Appendix S2, Figures D-J).

TABLE 2 Summary of study findings evaluating the impact of SSB taxes on sales, purchases and dietary intake, and transformation of results to a scaled rate ratio, search done in June 2018

Study	Jurisdiction	Outcome	n	Measure	Main Results	RR (95% CIs)	SE	Tax Size or AVE	RR Scaled for a 10% Tax (95% CIs)	SE, Scaled	% Change, Scaled
Falbe et al[57]	Berkeley	Intake	2679	% change compared with control	Consumption of SSBs decreased 21% in Berkeley and increased 4% in comparison cities, $P = .046$	0.760 (0.580-0.995)	0.138	21.9	0.883 (0.781-0.998)	0.063	-11.7
Silver et al[56]	Berkeley	Sales	10 152	% change	Posttax year 1 scanner data SSB sales (ounces/transaction) in Berkeley stores declined 9.6% ($P < .001$, volume sold per transaction) compared to estimates if the tax were not in place, but rose 6.9% ($P < .001$) for non-Berkeley stores.	0.904 (0.851-0.960)	0.031	21.9	0.955 (0.929-0.982)	0.014	−4.5
Silver et al[56]	Berkeley	Intake	1236	% change	Self-reported mean daily SSB intake in grams declined (−19.8%, $P = .49$) from baseline to posttax but was not statistically significant.	0.802 (0.429-1.501)	0.320	21.9	0.905 (0.68-1.203)	0.145	−9.5
Vall Castello[49]	Catalonia	Sales	284 464	Absolute difference	Purchases of SSBs are reduced by 4.7 L per product, establishment and week (standard error for absolute difference was 1.111), which implies a reduction by 15.42% with respect to the mean of SSB purchases before the reform (mean 30.48 L)	0.846 (0.774-0.917)	0.043	11.4	0.900 (0.852-0.947)	0.027	−10.0
Caro[31]	Chile	Purchases	1795	% change	Households decreased monthly per capita purchase volumes of (high sugar) SSBs by 3.4% (95% CI: −5.9% to −0.9%) and 4.0% by calories (95% CI: −6.3% to −1.9%)	0.966 (0.941-0.991)	0.013	5.0	0.933 (0.885-0.982)	0.026	−6.7
Nakamura[33]	Chile	Purchases	2836	% change	21.6% reduction in high tax soft drink volumes purchased, $P < .001$	0.784 (0.719-0.854)	0.044	5.0	0.615 (0.517-0.729)	0.088	−38.5
Capacci et al[50]	France	Purchases	416	% change, uncertainty reported for absolute difference	15.3% reduction for the average household of drinks for home consumption with a standard error for the 46 mL rate difference of 0.001 (regional calculation).	0.847 (0.841-0.854)	0.004	9.7	0.843 (0.836-0.85)	0.004	−15.7
Colchero et al[54] (PLoS One)	Mexico	Sales	57 164	% change	Pre vs both years posttax: decline of 7.3%, $P < .01$ (pre vs year 1 posttax: decline of 6.2%; pre vs year 2 posttax: decline of 8.7%)	0.927 (0.875-0.982)	0.029	6.7	0.893 (0.819-0.973)	0.044	−10.7

(Continues)

TABLE 2 (Continued)

Study	Jurisdiction	Outcome	n	Measure	Main Results	RR (95% CIs)	SE	Tax Size or AVE	RR Scaled for a 10% Tax (95% CIs)	SE, Scaled	% Change, Scaled
Colchero et al[32] (J Nutr)	Mexico	Purchases	75 954	% change	6.3% reduction ($P < 0.001$) in the observed purchases of SSBs in 2014 compared with the expected purchases in that same year based on trends from 2008 to 2012	0.937 (0.926-0.948)	0.006	6.7	0.907 (0.892-0.924)	0.009	−9.3
Colchero et al[53] (H Affairs)	Mexico	Purchases	6645	% change	Purchases of taxed beverages decreased 5.5% in 2014 and 9.7% in 2015, yielding an average reduction of 7.6% over the study period, $P < .01$	0.924 (0.870-0.981)	0.031	6.7	0.889 (0.812-0.972)	0.046	−11.1
Aguilar et al[52]	Mexico	Purchases	9953	% change	6.3% decrease in sugar drink consumption with a standard error of 0.006 (Table 2)	0.937 (0.926-0.948)	0.006	6.7	0.907 (0.892-0.924)	0.009	−9.3
Colantuoni and Rojas[48]	Cleveland, Ohio	Sales	720	% change	2% decline with a standard error of 0.04	0.980 (0.906-1.060)	0.040	5.0	0.960 (0.821-1.123)	0.080	−4.0
	Portland, Maine	Sales	576	% change	2% decline with a standard error of 0.04	0.980 (0.906-1.060)	0.040	5.5	0.964 (0.836-1.112)	0.073	−3.6
Fletcher et al[47] (J Public Econ)	United States	Intake	21 040	Absolute difference	1 percentage point increase in the soft drink tax rate reduces the amount of calories consumed by soda by nearly 6 cal, which is about 5% of the average calories from soda. Standard error for the −18 calorie rate difference was 7.333.	0.762 (0.607-0.947)	0.114	4.6	0.554 (0.337-0.889)	0.247	−44.6
Fletcher et al[46] (H Affairs)	United States	Intake	20 968	Absolute difference	319.671 g of soda consumed between states that have ever had a soft drink tax vs vs 312.091 in those without a soft drink tax, and $P = .569$ for a test of the difference	1.024 (0.941-1.108)	0.042	4.7	1.052 (0.878-1.244)	0.089	5.2
Fletcher et al[45]	United States	Intake	35 940	Absolute difference, per 1% tax	1.566 increase in calories from soda (only) for every 1% increase in tax, $P = .526$. The mean level of calories from soft drinks was 130. (Linear specification was preferred)	1.062 (0.882-1.269)	0.093	5.0	1.127 (0.778-1.610)	0.186	12.7
Sturm et al[44]	United States	Intake	7414	Absolute difference	Soda tax was associated with −0.006 less drinks per week (mean was 6.1 drinks per week), standard error for absolute difference was 0.201	0.999 (0.934-1.064)	0.033	3.5	0.997 (0.824-1.193)	0.094	−0.3

(Continues)

TABLE 2 (Continued)

Study	Jurisdiction	Outcome	n	Measure	Main Results	RR (95% CIs)	SE	Tax Size or AVE	RR Scaled for a 10% Tax (95% CIs)	SE, Scaled	% Change, Scaled
European Competitiveness and Sustainable Industrial Policy Consortium[51]	Finland	Sales		% change	Soft drinks: "slightly downward trend" between 1999 and 2013. Since 2007, demand in decline. Years following tax implementation demand declined at a faster pace: 2011: −0.7%, 2012: −3.1%, 2013: −0.9%. Uncertainty was not available so could not be included in meta-analysis.						
	France	Sales		% change	Cola 2012: −3.3%, 2013: −3.4%. Decrease in demand of 6.7% for regular cola for 2012 and 2013 combined. Demand for regular cola and low calorie cola has "steadily been increasing until 2011." After 2011, "both beverages show a decline in demand." Years following tax implementation: Regular cola: 2012: −3.3%, 2013: −3.4%. Uncertainty was not available so could not be included in meta-analysis.						
	Hungary	Sales		% change	Cola 2011: −2.7%, 2012: −7.5%, 2013: −6.0%. Demand for cola decreased by 10.2%. BUT, was already experiencing declining demand pretax, although decline appears to be accelerated by the tax. Uncertainty was not available so could not be included in meta-analysis.						
Andalón and Gibson[55]	Mexico	Purchases	17 404	% change	Average soda quantity acquired decreased by −4.6%. Uncertainty was not available and so could not be included in meta-analysis.	0.954		6.7	0.932		−6.8
Zhong[58]	Philadelphia	Intake	1777	Odds ratio	OR 0.84 (CI: 0.56-1.26), 30 day volume for SSBs was used as the primary outcome. Only odds ratio reported, so could not be included in meta-analysis.	0.840* (0.560-1.260)	0.207	33.3	0.949* (0.839-1.073)	0.062	−5.1

Note. Scaled RRs (and corresponding scaled upper and lower CIs) were calculated to express the effect size of each study according to a per 10% change in the level of SSB tax. The calculation was done by using this formula: ***scaled RR = study RR***$^{(10\ \%/\text{level of jurisdiction's tax as a percentage of price})}$. Absolute measures were divided the absolute change by the original level of consumption. Percentage change measures of effect were converted into a RR by adding one. If a RR was reported per 1% tax change (tax elasticity), then this measure of effect was scaled to the size of the SSB tax. If a volumetric tax was examined, the ad valorem equivalent of the jurisdiction's tax calculated from the volumetric tax and the import unit value of sweetened drinks. n = total individuals, households or sales data points analysed, eg, in the final model.

Abbreviations: AVE, ad valorem equivalent; RR, rate ratio; SE, standard error; SSB, sugar-sweetened beverage.

*This study reported ORs rather than rate ratio.

TABLE 3 Quality appraisal of study outcomes evaluating the impact of a SSB tax on beverage purchases and dietary intake, study results, and level of SSB

Study	Pop.	Study Design	Geographical Control	Reported Impact on Untaxed Beverages	Representative of the Taxed Population	Same Outcome Measure in Comparison Groups	Outcome Measure
Falbe[57]	Berkeley, California, US	Before and after study (with a control)	✓	✓	✗	✓	Intake
Silver[56] (sales)	Berkeley, CA, US	ITS	✓	✓	✗	✓	Sales
(survey)	Berkeley, CA, US	Before and after study	✗	✓	✗	✓	Intake
Vall Castello[49]	Catalonia, Spain	ITS	✗	✓	✗	✓	Sales
Caro[31]	Chile	ITS	✗	✓	✗	✓	Purchases
Nakamura[33]	Chile	ITS	✗	✓	✗	✓	Purchases
Capacci[50]	France	ITS	✓	✓	✗	✓	Purchases
Colchero[54]	Mexico	ITS	✗	✓	✗	✓	Sales
Colchero[32] (J Nutr)	Mexico	Before and after study	✗	✓	✓	✓	Purchases
Colchero[53] (H Affairs)	Mexico	ITS	✗	✓	✗	✓	Purchases
Aguilar[52]	Mexico	ITS	✗	✓	✗	✓	Purchases
Colantuoni and Rojas[48]	Portland, Maine, US Cleveland, Ohio, US	ITS ITS	✓ ✓	✗ ✗	✗ ✗	✓ ✓	Sales Sales
Fletcher[47] (J Public Econ)	US	ITS (repeated cross-sections)	✓	✓	Partially	✓	Intake
Fletcher[46] (H Affairs)	US	Cross-sectional study	✓	✗	Partially	✓	Intake
Fletcher[45]	US	ITS (repeated cross-sections)	✓	✓	Partially	✓	Intake
Sturm et al[44]	US	Cross-sectional study	✓	✗	Partially	✓	Intake
European Competitiveness and Sustainable Industrial Policy Consortium[51]	Finland France Hungary	Descriptive ITS Descriptive ITS Descriptive ITS	✗ ✗ ✗	✗ ✓ ✗	✓ ✓ ✓	✓ ✓ ✓	Sales Sales Sales
Andalón and Gibson[55]	Mexico	Before and after study	✗	✓	✗	✓	Purchases
Zhong[58]	Philadelphia, Pennsylvania, US	Before and after study (with a control)	✓	✓	✗	✓	Intake

Note. High quality studies were ITS with adjustment for key confounders; medium quality studies were ITS with poor or unclear adjustment for confounding or before and after studies with adjustment for key confounders; all other studies were considered low quality studies. Public funding was from government agencies such as the National Institutes of Health. NGO were non-government organization funders such as Bloomberg Philanthropies.

Abbreviations: ITS, interrupted time series analysis; mo, month; SEP, socio-economic position; SSB, sugar-sweetened beverage; w, week; y, year.

TABLE 3 (Continued)

Study	Correct Classification of Beverages as Taxed/ Untaxed	Same Individuals or Stores Overtime	Follow-up Time Before/ After	Controls for Major Confounders	Outcomes Account for Changes in Portion Size	Simultaneous Introduction of Other Public Health Policies	Quality Score
Falbe[57]	✓	✗	7- to 10-mo pretax/1- to 5-mo posttax	Partially	Partially	Not reported	Low
Silver[56] (sales)	✗	✓	24/12 mo	✓	✓	Not reported	High
(survey)	✓	✗	3- to 4-mo pretax/9- to 10-mo posttax	Partially	✓	Not reported	Low
Vall Castello[49]	✗	✓ Same stores	26 + 11/15 wk, comparing with same weeks of previous years	Partially	✓	Not reported	Medium
Caro[31]	Partially	Partially	21/15 mo	✓	✓	✓	High
Nakamura[33]	Partially	Partially	45/15 mo	✓	✓	✓	High
Capacci[50]	✗	✓	52/52 wk	✓	✓	Not reported	High
Colchero[54]	✗	Unclear	84/24 mo	✓	✓	Not reported	High
Colchero[32] (J Nutr)	✗	✗	3- and/or 2-y periods/1- and/or 2-y period	✓	✓	Not reported	Medium
Colchero[53] (H Affairs)	Partially	✓	24/24 mo	✓	✓	✓	High
Aguilar[52]	Partially	✓	52/52 wk	Partially	✓	✓	Medium
Colantuoni and Rojas[48]	✗ ✗	Partially Partially	3/3 quarters 3/3 quarters	✗ ✗	✓ ✓	✓ Not reported	Medium Medium
Fletcher[47] (J Public Econ)	✓	✗	Various, quarterly data 1989-1994,1999-2006	✓	✓	Not reported	High
Fletcher[46] (H Affairs)	✓	✗	Various, 1988-94 and 1999-06	✗	✓	Not reported	Low
Fletcher[45]	✓	✗ Repeated surveys	Various, quarterly data 1989-94, 1999-06	✓	✓	Not reported	High
Sturm et al[44]	✗	✗	NA, comparison in areas with and without tax	Partially	Partially	Not reported	Low
European Competitiveness and Sustainable Industrial Policy Consortium[51]	Unclear ✓ Unclear	✓ ✓ ✓	12/3 y 13/2 y 12/3 y	✗ ✗ ✗	✓ ✓ ✓	✓ Not reported ✓	Low Low Low
Andalón and Gibson[55]	✗	✗	14- to 17-mo pretax/8- to 11-mo posttax	✗	Partially	✓	Low
Zhong[58]	✓	✗	16-day period before/45-day period after	✓	Partially	Not reported	Medium

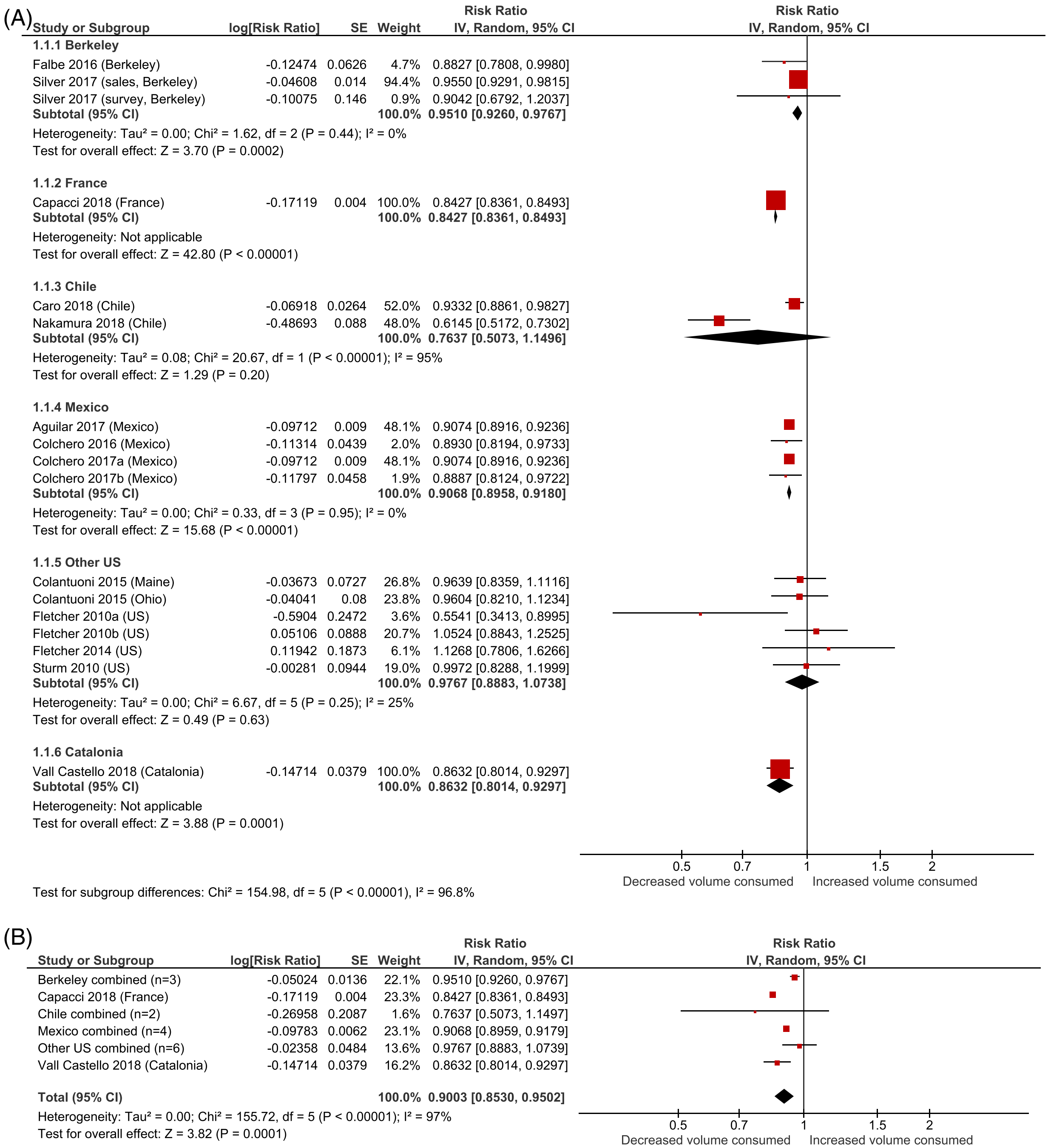

FIGURE 2 (A) Meta-analysis step 1: Jurisdiction specific results for the average impact a 10% sugar-sweetened beverage tax on consumption. (B) Meta-analysis step 2: combining jurisdiction results for the average impact a 10% sugar-sweetened beverage tax on consumption. *Note*. Meta-analysis with inverse-variance weights and random effects. Forest plot results were scaled to the expected effect of a 10% tax ($RR^{\text{tax rate(\%)/10\%}}$). SE is standard error on log scale; CI is confidence interval; IV is inverse variance. RR is the relative change in taxed SSB consumption in posttax vs pretax period, or for the taxed jurisdiction compared with the control jurisdiction. This is a two-step meta-analysis where results within each jurisdiction were combined in the first meta-analysis, and in the second step, these jurisdiction-specific results were combined across jurisdictions. A single study's results were used if there was only one eligible study in a jurisdiction [Colour figure can be viewed at wileyonlinelibrary.com]

3.5 | Meta-analyses of untaxed beverage outcomes

Studies differed in whether they reported total untaxed beverage consumption or if they did this for specific categories such as water, milk, juice, and diet drinks (Appendix S2, Figure A). There was no statistical evidence of an increase in total untaxed beverage consumption (1.9% increase, 95% CI: −2.1% to 6.1%, n = 6 studies/4 jurisdictions) nor for water (2.9% increase, CI: −6.2% to 12.7%, n = 6/4), juice (2.0% decline, CI: −10.5% to +7.2%, n = 3), milk (47.4% increase, CI: −35.5% to +237.1%, n = 2), or diet/zero and light beverage (4.5% increase, CI :

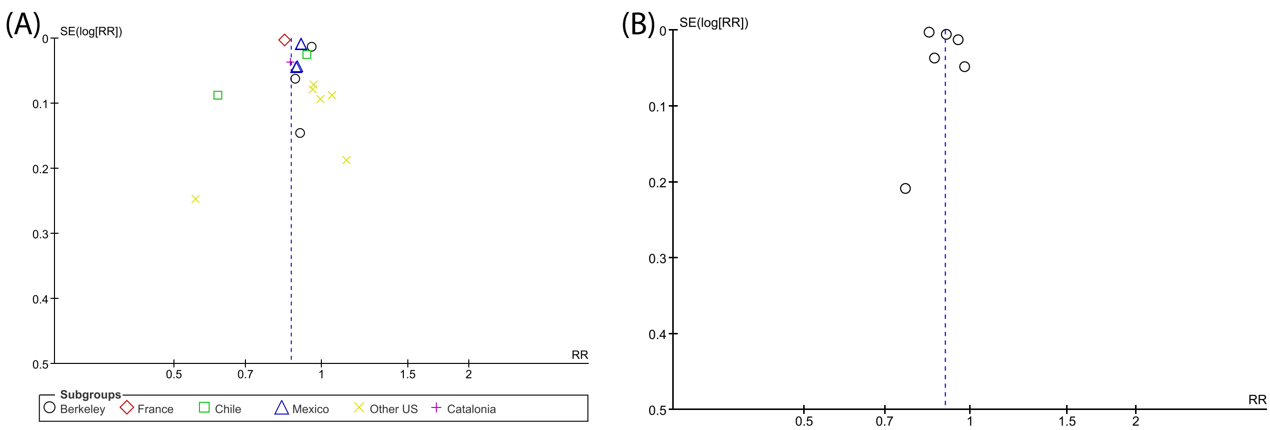

FIGURE 3 Funnel plot for examining publication bias in included studies on sugar-sweetened beverage taxes for step one (left) and step two (right) of the meta-analysis. *Note*. All results were scaled to the expected effect of a 10% tax. SE is standard error on log scale. RR is the relative change in taxed sugar-sweetened beverage consumption for posttax compared with pretax period or taxed jurisdiction compared to control jurisdiction. Each study result is indicated here coloured by jurisdiction [Colour figure can be viewed at wileyonlinelibrary.com]

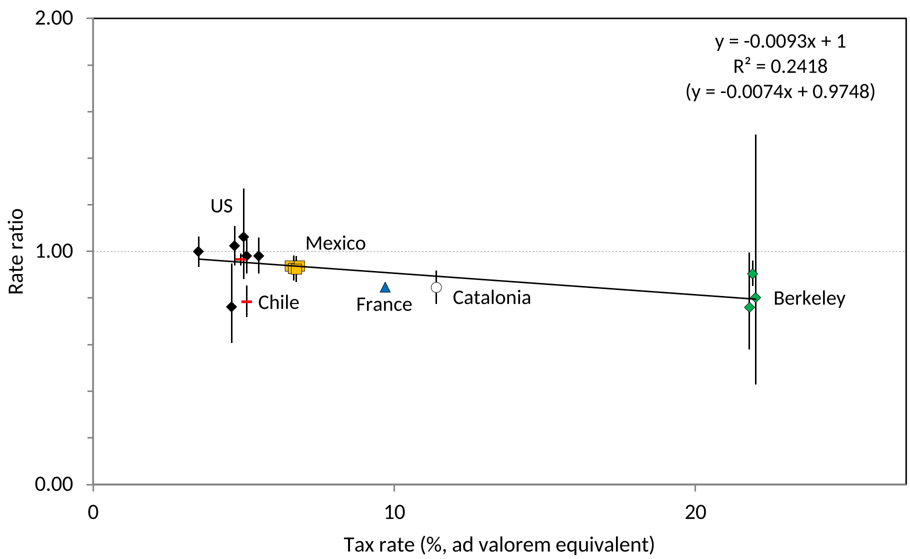

FIGURE 4 Impact of sugar-sweetened beverage taxes on consumption by the size of the tax in posttax compared with pretax period and/or taxed jurisdiction compared with a control jurisdiction. *Note*. Evaluations for the same tax were staggered to improve display of results. An alternative equation is presented in parentheses for a linear relationship (not displayed) that is allowed to vary from no effect when the tax is 0%. This analysis was not weighted and so Figure 2B should be used to give the best tax elasticity estimate. Chile results are indicated by a (red coloured) dash; other US results are indicated by black-coloured diamonds, Mexico by orange squares, France by a blue triangle, Catalonia by a white circle, and Berkeley by green diamonds [Colour figure can be viewed at wileyonlinelibrary.com]

−12.7% to +25.1%, n = 2) volumes. However, there were significant increases in untaxed beverage consumption in three of the four jurisdictions (Berkeley, Mexico, and other United States), with only the combined Chile studies showing a non-significant decrease.

4 | DISCUSSION

This examination of real-world SSB tax evaluations through meta-analysis presents compelling evidence that SSB taxes are associated with decreased sales, purchasing, and dietary intake of taxed beverages. For a 10% AVE SSB tax, SSB volumes declined an average 10.0%, equating to a tax elasticity of −1.00 (95% CI: −0.50 to −1.47, n = 17).

This meta-analysis included 17 study outcomes from real-world SSB tax evaluations, compared with just five in a recent systematic review[26] and three by a previous meta-analyses.[27] Tax elasticity results overlapped with elasticities reported by Afshin et al (−0.67, 95% CI: −0.31 to −1.04, n = 5), which relied on setting-specific experimental studies,[27] and by Escobar et al (−1.30, 95% CI: −1.09 to −1.51, n = 9), which relied largely on studies of price changes to simulate the effect of SSB taxes.[28] The addition of new data in this meta-analysis suggests the true average SSB tax elasticity may lie closer to an elasticity of −1 than the lower and higher results presented by these earlier studies.

A 10% SSB tax was also associated with a 1.9% non-significant increase in untaxed beverage purchases and dietary intake. In three of the four jurisdictions where this outcome was reported, there was a significant increase in untaxed beverage consumption. However, in the third jurisdiction, Chile, there was a non-significant decrease in untaxed beverage consumption. Notably, Chile was the only jurisdiction in which a modified price of "untaxed beverages" (low or no sugar category) was included within the tax policy (ie, the tax decreased from 13% to 10%). Accordingly, the untaxed beverage category includes beverages that were directly affected by tax changes, not just indirectly through changes in taxed beverages. It is unclear why Chile was the only jurisdiction in which untaxed beverage consumption did not significantly increase, even with a decrease in price (because of lower tax). The elasticity outcomes for untaxed beverages such as water, fruit juice, and milk had wide CIs and were based on a limited number of studies, suggesting a need for further reporting of these outcomes in future studies. Our results overlapped with previous meta-analysis results reporting an association between SSB taxes and increased consumption of fruit juice (cross-price elasticity: 0.39, 95% CI: 0.01-0.77) and milk (cross-price elasticity: 0.13, 95% CI: −0.09 to 0.34).[28]

Differences between local context and tax design appeared to influence meta-analysis results. There was some suggestion that taxes with sugar thresholds and volumetric taxes (per litre) had greater declines in taxed beverage consumption than ad valorem taxes as found in econometric studies of price elasticities;[59,60] however, the current results were not statistically significant ($P = .11$). Concurrent food and beverage pricing policies may have influenced the differences between jurisdictions, including the junk food tax in Mexico, the mandated 100% tax pass through in Catalonia, the decrease in tax on low sugar beverages in Chile, and the inclusion of diet soft drinks in the beverage tax in France; however, the extent of this effect is unclear. Part of the differences between jurisdictions may also be due to the nonprice mechanisms via which a tax influences consumption. For example, the health signalling pathway may occur even with low tax rates, whereby a tax signals to the public the seriousness of the health concern associated with consuming a product. This effect is likely to depend on the motivation for the tax, and public awareness about its purpose.[36] The policy process leading to the tax may also lead to differing levels of public awareness of the health hazards of SSBs. A SSB tax can also prompt manufacturers to reformulate sugar levels downward, as seen in the United Kingdom even before the SSB tax was introduced in April 2018.[37] Price elasticity results also suggest that differences in tax impact between jurisdictions may be influenced by country context including differences in consumer preferences, levels of wealth and baseline SSB consumption levels (higher consumers[61] and the less wealthy[59] tend to be more price responsive).

Previous reviews of simulation studies and experimental studies are unanimous in suggesting that low SEP groups were more likely to reduce consumption in line with economic theory for nonstaple goods.[59,62] Results in this meta-analysis from Mexico were consistent with this. However, a study of a 5% tax in Chile reported significantly greater declines in consumption among the highest SEP groups,[31] and a similar pattern was reported by the second Chile study.[33] The Chilean results may suggest that a signalling pathway where public health messaging discourages SSB consumption may work more effectively for high-income groups than low-income groups. There was no consistent evidence of this pattern of heterogeneity from settings outside of Chile.

4.1 | Strengths and limitations of included studies

Included studies were generally high quality observational studies for example using quasi-experimental study designs. The majority of studies accounted for substitution to different portion volumes after the SSB tax. Some studies measured consumption via sales or purchases. These are likely to be more objective measures than dietary recall; however, they may still depend on manufacturers reporting sales or households maintaining a diary of purchases. Studies of sales and purchases tended to only partially cover the taxed beverage categories (eg, sales and purchasing datasets excluded beverages bought and consumed outside the home, and some data sets were from supermarket sales only). Survey studies of dietary intake were better at comprehensively including taxed beverage categories but were predisposed to the recall bias found in dietary assessment tools such as 24-hour dietary recalls. Despite these differences, there was no evidence that results varied by consumption measure (Appendix S2, Figure G).

Many studies did not meet the threshold for being representative of the taxed jurisdiction. It is unknown whether individuals included in the studies had a different response to the tax than those excluded, eg, low socio-economic areas in Berkeley or high income areas in France. Furthermore, many studies could not universally distinguish between taxed and untaxed beverages, therefore introducing the potential for measurement bias and underestimation of tax impacts.

Some results may have been influenced by underlying declining trends in SSB consumption. However, the highest quality time-series analyses that did account for time trends demonstrated a greater impact than lower quality studies. Only two studies (both from US states) used cross-sectional designs, and together did not detect any impact on consumption. This is expected given the small taxes, sales tax design, and the potential biases from reverse causality where US states with the greatest SSB consumption may be more likely to introduce SSB taxes. Few studies reported simultaneous public health policies such as food taxes that may have affected results.[48,52,53] However, given that SSB taxes are often part of a broader obesity prevention package, results might be what we would expect from future SSB taxes introduced in the same way.

Lower quality studies could be improved by using longitudinal analyses, time-series data where possible, adjusting for major confounders including existing underlying time trends, selecting the specific taxed beverages categories, considering both purchasing, and dietary intake data-sources, maximising representativeness to the taxed jurisdiction and reporting simultaneous policy changes.

4.2 | Strengths and limitations of the review

This systematic review and meta-analysis captures the recent wave of real-world SSB tax evaluation studies published since 2016 and is the first to focus on real world SSB tax interventions to estimate tax elasticity. Evaluations are more robust than simulation studies based on experimental or elasticity of demand estimates. Evaluations allow for real-world variation in price pass-through, the signalling effect of a SSB tax about the seriousness of the health concern,[36] and any industry reformulation in response to the tax.[63] The inclusion of multiple subgroup analyses provides further information about the effects of study design, tax design, and study contexts.

There was substantial heterogeneity between studies (I^2 = 97%); however, heterogeneity between studies within jurisdictions was much lower. The variety of contexts in which SSB taxes are introduced, the different tax designs, and different study types could all account for these different impacts. A random effects model was used to allow for these differences, and effect sizes were scaled to a 10% tax to improve comparability. Major publication bias seems very unlikely given the shape of the funnel plot; however, numbers on which to base this were limited, and there is a risk that incomplete publications biased results towards a greater decline. Subgroup categories were largely decided in advance. The outcomes examined in this review were limited by outcomes reported in individual studies. More evidence is needed from low and medium-income countries and from studies reporting the effect of SSB taxes on total untaxed beverages and subcategories such as water.

The use of a bespoke quality appraisal tool limits comparison with other reviews of such evaluation studies. However, it enabled a thorough description of potential biases relevant to SSB tax evaluations, eg, presence of concurrent food and beverage pricing strategies, and a clear comparison between stronger and weaker types of study designs.

4.3 | Implications

For policymakers in jurisdictions considering SSB taxes, our results support the totality of the evidence that SSB taxes reduce SSB sales, purchases, and dietary intake. Larger taxes are recommended for greater declines in SSB consumption, but this is not the only characteristic that is important. Results in our study varied significantly between jurisdictions suggesting that country context and/or tax design may be important to SSB tax impact on purchasing and dietary intake. For jurisdictions that already have taxes, it is important to monitor and evaluate their impact using multiple data sources because there are many context and tax design factors that may need to be addressed and adjusted to maximize the impact of the SSB tax policy (eg, waning effects of a volumetric tax because of inflation). Also, additional increases in SSB tax are likely to be required if further declines in SSB consumption and associated health gains are to be achieved. Additional studies of oral health and overweight are desirable to determine the possible impact of SSB taxes on such outcomes. Future studies should also consider examining the impact of SSB taxes on tap water intake (where potable), substitution to untaxed beverages, food, and possibly alcohol (for which simulation results are mixed[64-66]).

SSB taxes have been reported to be extremely cost-effective[67] and can provide resource constrained governments with additional revenue that can be invested back into health and obesity prevention. Fiscal policies that encourage healthy eating have been endorsed by the World Health Assembly.[68] In particular, the WHO recommends a 20% tax on SSBs because the evidence for reduced consumption and meaningful health effects is currently strongest for this food category.[69]

5 | CONCLUSIONS

Evidence from real-world evaluation studies suggests that SSB taxes introduced in jurisdictions around the world have been effective in reducing SSB purchases and dietary intake. But jurisdiction context was identified as a likely important consideration and tax design (eg, applying tax by thresholds of sugar content rather than as a percentage of price) may be important in designing SSB taxes for maximum impact on purchasing and dietary intake. This evidence provides further support that SSB taxation is an effective tool to reduce SSB consumption and could be an effective component in policy to prevent obesity, prevent diabetes, and improve oral health.

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AUTHOR CONTRIBUTORS

AMT, LS, MG and NW contributed to the conceptualization and funding acquisition. LS, MG, and NW supervised the project. AMT contributed to data curation, methodology, formal analysis, visualization, and original draft preparation. ACJ, AM, and AMT did the investigation and validation (screening and extraction processes). ACJ, AM, AMT, LS, and NW reviewed and edited the manuscript, and all authors approved the final draft.

CONFLICTS OF INTEREST

All authors have completed the ICMJE uniform disclosure form at http://www.icmje.org/coi_disclosure.pdf and declared support from the Health Research Council of New Zealand for the submitted work. The authors declare no other financial relationships with any organizations that might have an interest in the submitted work in the previous

three years, and no other relationships or activities that could appear to have influenced the submitted work.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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