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A Review and Meta-analysis of the Impact of Local U.S. Sugar-sweetened Beverage Taxes on Demand

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Key Findings

- **Based on a meta-analysis of 26 estimates from 19 studies that evaluated U.S. local sugar-sweetened beverage (SSB) taxes implemented to date, this review found that, on average, following the implementation of local U.S. SSB taxes, the demand for SSBs fell by 20% with a corresponding price elasticity of demand of -1.5, with substantial heterogeneity across studies.**
- **Estimates of the tax impact on demand based on separate meta-analyses stratified by study demand measures (i.e., scanner data on store volume sold, purchase data and consumption data) all overlapped with the overall estimated 20% reduction in demand.**
- **Based on a subset of five studies that estimated the extent of cross-border shopping, this review found that, on average, approximately one quarter of the estimated reduction in demand was offset by cross-border shopping. After accounting for cross-border shopping, the average estimated price elasticity of demand was -1.1.**

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Introduction

Sugar-sweetened beverage (SSB) consumption is linked with obesity, type 2 diabetes, cardiovascular disease, and poor dental health[1-3] and SSBs are the leading source of added sugar intake in the U.S. diet.[4,5] A key objective and leading health indicator for Healthy People 2030 is to "reduce consumption of added sugars by people aged 2 years and over".[6] As part of a public health strategy to reduce the intake of added sugar and promote health, SSB taxes are used as a fiscal policy instrument aimed at reducing individuals' demand for SSBs. The key mechanism by which this occurs is through price increases faced by consumers for taxed products, known as tax pass-through. It is estimated that on average 70% of local U.S. SSB taxes are passed on to consumers in the form of higher prices.[7] Increases in the price of SSBs, all else constant, are expected to reduce demand. The extent of reductions in demand is determined by consumer price responsiveness, which is commonly measured by the price elasticity of demand: the percentage change in quantity demanded resulting from a one percent increase in price.

Since 2015, SSB taxes have been implemented in eight local (city/county) jurisdictions in the U.S. (Albany, Berkeley, Oakland, and San Francisco, California; Boulder, Colorado; Cook County, Illinois; Philadelphia, Pennsylvania; and Seattle, Washington), with one having since been repealed (Cook County). The taxes have ranged in terms of the products included in their tax bases (i.e., SSBs only versus both SSBs and artificially sweetened beverages (ASBs)), point of levy (i.e., distributor versus retail at the point-of-sale), and tax rate (i.e., from 1 to 2 cents per ounce).

This research brief reviews evaluation study findings on the impact of U.S. SSB taxes (referring hereafter to taxes levied on SSBs alone and on both SSBs and ASBs) on the demand for taxed beverages. The review includes peer-reviewed journal articles and governmental reports published between January 2015 and April 2021 that evaluated the impact of a U.S. SSB tax on quantity demanded of taxed beverages. A total of 26 estimates of change in demand from 19 studies were identified based on searches in four bibliographic electronic databases. The demand and elasticity estimates reported in this review represent evaluations conducted in five of the eight jurisdictions (including Berkeley, Cook County, Oakland, Philadelphia, and Seattle) implementing taxes since 2015. Estimates that account for cross-border shopping are represented for four jurisdictions (including Cook County, Oakland, Philadelphia, and Seattle).

Meta-analyses are conducted to provide an overall estimate of the impact on demand and an estimate of the price elasticity of demand. Additionally, separate analyses are undertaken to provide demand estimates stratified by studies' measure of quantity demanded (i.e., scanner data on volume sold in stores, purchase data, and consumption data). Finally, among a subset of studies that assessed cross-border shopping, meta-analyses are conducted of demand and elasticity estimates that do and do not account for potential cross-border shopping to understand the extent to which the impact of local SSB taxes is offset by cross-border shopping.

Methods

The current meta-analyses were conducted using estimates from peer-reviewed studies and governmental reports published between January 2015 and April 2021 that evaluated the impact of local U.S. SSB taxes on demand for taxed beverages. Searches were undertaken in the following four bibliographic electronic databases: PubMed, Web of Science, EconLit and Google Scholar. Studies were only included if the outcome was a measure of quantity; for example, studies that used sales in dollars as the outcome measure were excluded. Included studies required a reported measure of uncertainty; if unavailable, the author was contacted for this information, which occurred with one paper.

For each study, the broadest summary estimate of change in demand for taxed beverages was extracted. Estimated changes over the entire post-tax period were extracted where possible; otherwise, estimates for the latest post-tax period were extracted. Where estimates were reported from multiple models, the estimates from the authors' preferred model were extracted; where this was not specified, models with balanced data were selected over those with unbalanced data, weighted models were selected over unweighted models, and the most fully controlled models were chosen. Where multiple measures of demand were evaluated, measures of volume were selected over measures of frequency. Where possible, estimated relative changes were extracted; when only absolute changes were reported, they were converted into relative changes by dividing both the estimated change and confidence limits by baseline demand. Because adjustments for cross-border shopping were not applicable to some studies (e.g., those based on self-reported consumption) and were not always estimated for other studies, estimates of gross changes in demand were selected. In sensitivity analyses, we present demand estimates based on the subset of studies that accounted for cross-border shopping.

If a single study estimated impacts separately for children and adults or conducted analyses using multiple distinct datasets (e.g., purchase data and scanner data on volume sold), each estimate was extracted. If a study only provided estimates stratified by store or beverage type,[8-10] the highest-level estimates were extracted, and a sub-analysis was conducted to obtain a single estimate and confidence interval for taxed beverages overall from these stratified estimates. These sub-analyses were conducted using the same random-effects meta-analysis methodology used for the main analysis. Extractions were undertaken independently by two authors and coding differences were reviewed and resolved with a third author.

To estimate price elasticity of demand for taxed beverages, an overall measure of post-tax percentage change in price was calculated for each taxing jurisdiction. Baseline prices of taxed beverages and estimates of tax pass-through were extracted from peer-reviewed studies and governmental reports that evaluated tax impacts on prices. The inclusion criteria and extraction methods for tax pass-through are described elsewhere;[7] jurisdiction-specific pass-through rates were estimated using the same methodology described in that study. Percentage change in price for each jurisdiction was calculated by multiplying estimated pass-through by the tax rate and dividing by the median baseline price. Elasticities and their confidence intervals were then computed from relative changes in demand by dividing estimates of the percentage change in demand and corresponding confidence limits by the jurisdiction-level percentage change in price.

The final analytic sample included 26 estimates of change in demand from 19 studies. Pooled estimates of percentage change in demand and price elasticity of demand for taxed beverages were computed from inverse-variance weighted meta-analyses using random effects models. These models were used because true effect sizes were expected to vary across studies due to, for example, different store types, tax rates, and time periods.[11,12] Analyses were conducted based on extracted estimates and 95% confidence intervals for all studies; standard errors were computed from the confidence intervals under the assumption that they were from a standard normal distribution. We acknowledge as a limitation that this assumption only holds for confidence intervals derived from estimated absolute changes in demand, but not those from relative changes in demand. Given that our analysis is based on estimates derived from both absolute and relative changes in demand, we are unable to use a transformation to address this issue. Heterogeneity variance was estimated using the DerSimonian-Laird estimator, with the associated confidence interval computed using the Jackson method. For the main meta-analysis of percentage change in demand, the between-study heterogeneity variance was 0.008 (95% CI 0.003, 0.035) and the percentage of variation across studies due to heterogeneity (I^2) was 92.3% (95% CI 89.9%, 94.1%). For the meta-analysis of price elasticity of demand, the between-study heterogeneity variance was 1.697 (95% CI 0.692, 5.768) and I^2 was 98.3% (95% CI 98.0%, 98.6%). Stratified analyses of percentage change in demand were conducted by data source (scanner data on volume sold in stores, purchase data, and consumption data). Analyses were conducted in R version 4.1.0 using the *meta* package version 4.18-2.[13]

Results

Demand

- As shown in Figure 1, the meta-analysis of the impact of local U.S. SSB taxes on the demand for taxed beverages, based on 26 estimates from 19 studies, reveals that demand fell by 20% (-0.20, 95% CI -0.25, -0.14), on average, with substantial heterogeneity across studies.
- Figure 2 shows that the estimates of the impact on demand from separate meta-analyses stratified by study measures of scanner data on store volume sold, purchase data and consumption data all overlap with the overall estimate of a 20% reduction in demand.
  - Specifically, by study outcome measure, demand was estimated to fall by 20% (-0.20, 95% CI -0.26, -0.13) based on 10 estimates[8,15,16,18-20,22,27,28] that used store scanner data, by 28% (-0.28, 95% CI -0.45, -0.10) based on five estimates[21,23-26] that used purchase data, and by 15% (-0.15, 95% CI -0.26, -0.03) based on 11 estimates[9,10,14,15,17,21,23,29] that used consumption data.

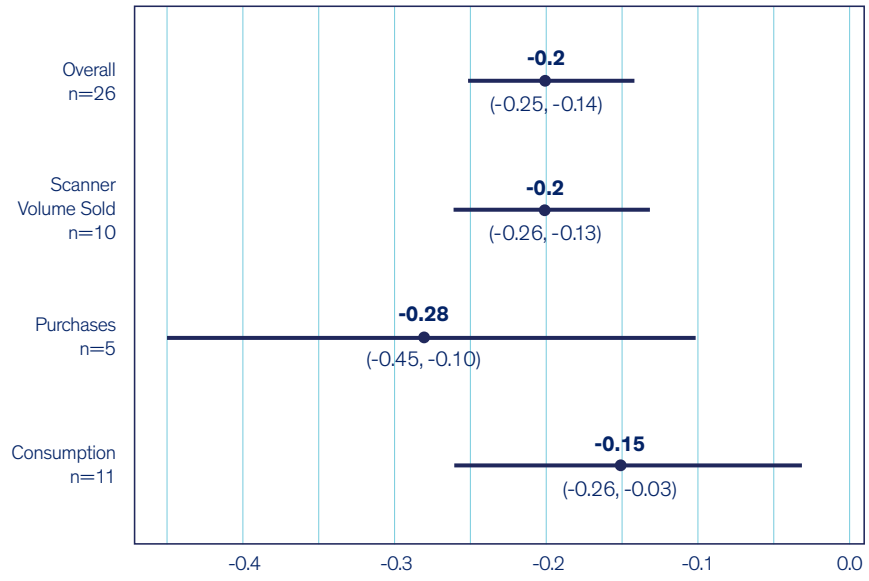
Elasticity

- The meta-analysis results shown in Figure 3 reveal, based on the same 26 estimates of change in demand and estimated changes in local taxing jurisdiction prices, that the price elasticity of demand was, on average, -1.47 (95% CI -2.11, -0.83). There was substantial heterogeneity across studies with some elasticity estimates that were particularly large in magnitude.

FIGURE 1 **Change in Demand Estimates and Meta-analysis Results**

Notes: Est: estimate
CI: confidence interval

FIGURE 2 **Demand Meta-analysis Results by Study Measure**

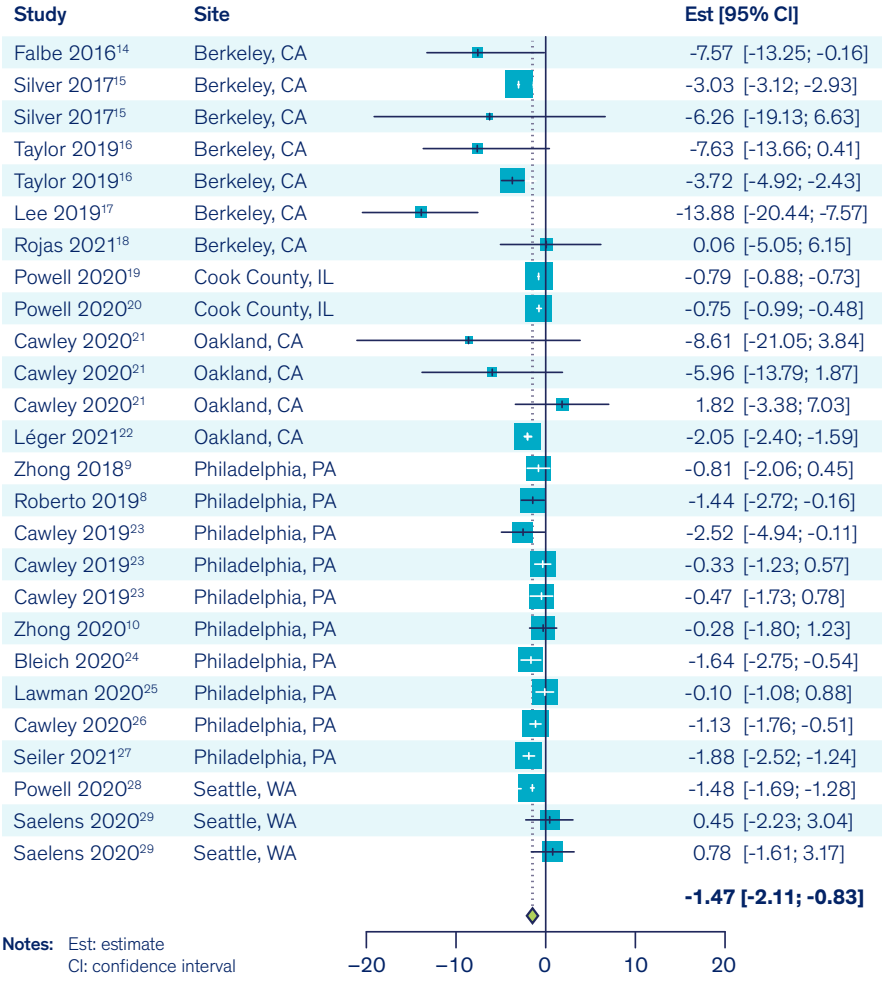


Notes: Estimates shown with 95% confidence intervals.

Cross-border shopping

- Based on the subset of five studies[8,19,22,27,28] that used store scanner data and provided estimates of the gross tax impact on demand and the net impact after accounting for cross-border shopping, the results show that, on average, approximately one quarter of the estimated reduction in demand was offset by cross-border shopping; however, it is worth noting that the confidence intervals with and without accounting for cross-border shopping overlap. Meta-analyses based on these studies find that:
  - Volume sold of taxed beverages fell on average by 25% (-0.25; 95% CI -0.32, -0.17) in the taxing jurisdiction; after accounting for cross-border shopping, it was estimated that volume sold fell by 18% (-0.18; 95% CI -0.27, -0.10).
  - The estimated price elasticity of demand was -1.51 (95% CI -2.07, -0.94) without accounting for cross-border shopping and -1.05 (95% CI -1.54, -0.57) after adjusting for cross-border shopping.

FIGURE 3 **Elasticity Estimates and Meta-analysis Results**



Notes: Est: estimate
CI: confidence interval

Conclusions

The results from this review and meta-analysis showed that, on average, demand for taxed beverages fell by 20% based on evidence (26 estimates from 19 studies) from evaluations of U.S. SSB taxes in five local jurisdictions. Separate meta-analyses found similar estimates of changes in demand based on whether demand was measured by volume sold in stores from scanner data, by purchase data or by consumption data. Based on estimated changes in demand and the changes in taxed beverage prices in the given taxing jurisdictions, the estimated price elasticity of demand was -1.47. There was substantial heterogeneity across studies in results for both percentage change in demand and price elasticity of demand. Based on a sub-group analysis of studies that estimated changes in volume sold in the border area, cross-border shopping was estimated, on average, to offset approximately one-quarter of the reduction in demand in the taxing jurisdiction, and there was a net 18% reduction in demand corresponding to a price elasticity of demand after accounting for cross-border shopping of -1.05. Overall, the results reveal that SSB taxes are a promising policy tool associated with significant reductions in the demand for SSBs.

SUGGESTED CITATION

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