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Sustained Impact of the Philadelphia Beverage Tax on Beverage Prices and Sales Over 2 Years

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Abstract

Introduction: It is unclear if changes in beverage price and sales following beverage tax implementation can be sustained long term. This study aims to quantify changes in beverage prices and sales in large retailers 2 years after implementation of the 1.5 cents-per-ounce Philadelphia beverage tax.

Methods: Data on price and volume sales of beverages and potential food substitutes were collected from 109 supermarkets, 45 mass merchandisers, and 350 pharmacies in Philadelphia,

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CREDIT STATEMENT

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Baltimore (control), and Pennsylvania ZIP codes bordering Philadelphia (to investigate potential cross-border shopping for tax avoidance). Difference-in-differences analyses compared beverage prices and volume sales in the year before tax implementation (2016) to 2 years after (2018). Data were analyzed in 2020–2021.

Results: Difference-in-differences analyses found that, after tax implementation, taxed beverage prices in Philadelphia increased by 1.02 cents per ounce (95% CI=0.94, 1.11; 68% pass-through) and taxed beverage volume sales in stores decreased by 50% (95% CI=36%, 61%). After accounting for cross-border shopping, taxed beverage volume sales decreased in Philadelphia by 35% in 2018. Volume sales of nontaxed beverages did not change post-tax (difference-in-differences=4%, 95% CI= −3%, 12%). Volume sales of nontaxed beverage concentrates increased on average by 34% (95% CI=19%, 51%), but there was no evidence of substitution to high-calorie foods.

Conclusions: There was a large reduction in taxed beverage volume sales 2 years after Philadelphia tax implementation, even after accounting for cross-border shopping. Increases in nontaxed beverage concentrate sales likely partially offset this decline, but there was no evidence of post-tax food substitution.

INTRODUCTION

Several U.S. localities have implemented beverage taxes to raise revenue and discourage sugar-sweetened beverage (SSB) consumption, which is associated with chronic disease.[1–3] These taxes, which range from 1 to 2 cents per ounce, are generally partially or wholly passed through to prices.[4–8] Analyses of sales data have indicated short-term (≤1 year) post-tax declines in taxed beverage sales of 22% in Seattle,[7] 21% in Cook County during the 4-month period of the tax,[9] and 8% in Oakland[8] after accounting for increased shopping across the taxed jurisdiction border.

Philadelphia implemented a 1.5 cents-per-ounce sweetened beverage tax in 2017, making it the largest U.S. city with such a tax[10] and the only city that taxes both SSBs and artificially sweetened beverages (ASBs), which were included to broaden the tax base and distribute the tax burden across different income groups. One year after implementation, there was substantial (43%–104%) tax pass-through, a 38% decline in taxed beverage sales (accounting for cross-border shopping),[11] and no food or alcohol substitution except for an increase in beverage concentrate sales.[12] A separate study in Philadelphia also found a 22% decrease in taxed beverage sales after implementation.[4]

Post-tax decreases in beverage sales imply health benefits if they translate to reduced SSB intake,[13–15] but this requires longer-term changes in purchasing behavior. Effects of Mexico's SSB tax were sustained 2 years post-tax,[16] but in the U.S., effects of city taxes may attenuate over time owing to cross-border shopping. Additionally, consumers may substitute unhealthy foods and nontaxed sugary beverages (e.g., 100% juice, beverage concentrates) for SSBs, which may dilute health benefits from SSB reductions.

Because eating habits change gradually,[17] longer-term data are needed to examine whether post-tax reductions in SSB sales, without substitution to unhealthy foods, can be sustained.

This study examines whether the initial, large declines in taxed beverage sales, without food or alcohol substitution, persisted 2 years after Philadelphia beverage tax implementation.

METHODS

This study leveraged a natural experiment comparing beverage prices and volume sales in Philadelphia retailers pre-tax (2016) and 2 years post-tax (2018) to Baltimore, which was chosen as a control because it is near (but does not border) Philadelphia, and the 2 cities have similar demographics.[18,19] Analyses also examined changes in ZIP codes ≤6 miles outside of Philadelphia ("Pennsylvania border stores"), where people might have shopped to avoid the tax, compared with ZIP codes ≤6 miles outside of Baltimore ("Maryland border stores").

Study Sample

Item-level sales data from Information Resources, Inc. (IRI)[20] were obtained in 4-week periods for large, chain food retailers in Philadelphia, Baltimore, and their border areas from January 1, 2016 to December 30, 2018 (Appendix provides details on store selection). Stores that were continuously open between 2016 and 2018 were included. Stores were classified as supermarkets (n=109), mass merchandisers (n=45), or pharmacies (n=350).[21] These stores represent about 25% of taxed beverage volume sold in Philadelphia based on revenue data.[11] IRI data were also obtained from state-owned liquor stores that do not sell beer (n=110) in Philadelphia and non-bordering Pennsylvania ZIP codes (control for alcohol substitution analyses because Maryland has different liquor laws). The data had no missing values.

The beverage tax applies to nonalcoholic beverages with sugar-based or artificial sweeteners.[10] Beverages were identified by universal product code (UPC) and classified by tax status, sweetener status (sugar-sweetened/artificially sweetened), size (≤36 ounces vs >36 ounces), and beverage subtype (Appendix). Energy drinks were excluded from price change analyses because they had much higher prices per ounce. Beverages with price per ounce <1st percentile or >99th percentile (representing 8.7% of volume sales) were excluded from the main price change analysis to reduce the influence of extreme prices, but they were included in a sensitivity analysis.

Food and alcohol sales data were obtained to examine potential substitution to nontaxed high-calorie foods and beverages. Foods were classified as candy, sweet snacks (e.g., cookies), salty snacks (e.g., chips), beverage concentrates, or other using IRI subcategories.[12] Total beverage concentrates and sweetened beverage replacements (i.e., concentrates excluding coffee, tea, and milk mixes) were analyzed. Alcohol was classified as either wine or spirits.

Measures

The primary outcomes were weighted price per ounce and volume sales (ounces) of taxed and nontaxed beverages. For each UPC, IRI calculated the weighted price as the mean price customers paid over a 4-week period weighted by the number of units sold at that price. This was divided by volume (ounces) to calculate weighted price per ounce. The secondary

outcomes included beverage volume sales by size, sweetener status, and beverage type; food volume sales (grams); and alcohol volume sales (mL).

Statistical Analysis

Analyses used a difference-in-differences (DD) design,[22] which assumes pre-intervention parallel trends in outcomes between intervention and control locations. This assumption was tested by examining the *p*-value of city × time interaction terms in the pre-tax period, adjusted for multiple comparisons using the linear step-up method of Benjamini and Hochberg.[23] Price analyses excluded taxed family-sized beverages (Pennsylvania border versus Maryland border) because of a violation of parallel trends, but included 7 other outcomes with statistically significant *p*-values because the graphs suggested minor violations and the magnitude of the deviation was extremely small (Appendix) and likely detected because of the large sample size. Volume sales analyses excluded 6 secondary outcomes based on parallel trends violations, but included another 6 that had statistically significant interaction terms but appeared parallel graphically (Appendix).

Changes in weighted price per ounce of beverages (overall and by size and sweetener status) were estimated using UPC-within-store–level data. These analyses were weighted to reflect the pre-tax volume sold by UPC and store type so that prices reflected demand (Appendix). This required excluding 8,606 UPCs not sold in both tax periods. The remaining 7,603 UPCs accounted for 94.3% of volume sold. Generalized estimating equations clustered at the UPC level were used and robust empirical SEs were estimated. The model included variables for time (pre versus post), city (Philadelphia versus Baltimore), a time × city interaction, which represented the DD, beverage type, and size. Tax pass-through to prices was calculated as (DD/1.5 cents per ounce) × 100%. These analyses were repeated comparing Pennsylvania border to Maryland border stores.

Post-tax changes in store-level beverage volume sales were estimated using a generalized estimating equation clustered at the store level with robust empirical SEs and terms for city, time, and a time × city interaction. The model included a log link and percentage change was calculated as $(e^{DD-1}) \times 100\%$ because it was assumed the tax would be associated with relative changes in volume sales. These analyses were repeated comparing Pennsylvania border to Maryland border stores to examine potential cross-border shopping. The same model was used to calculate changes in volume sales of high-calorie foods and alcohol.

The DD percentage change estimates were multiplied by the mean pre-tax volume sold in Philadelphia and Pennsylvania border ZIP codes to estimate post-tax changes in volume sales for each location. These volume sales changes were summed and this “net effect” of the tax was divided by Philadelphia pre-tax volume sales to calculate the city-level percentage change in Philadelphia volume sales adjusted for cross-border shopping. The degree to which cross-border shopping offset the decreases in Philadelphia was also calculated (Appendix). This was repeated for each beverage type for which there was evidence of cross-border shopping.

Price and volume sales analyses were repeated by store type (except for mass merchandisers in Philadelphia because there was only 1 mass merchandiser in Baltimore). Price and

volume sales changes in 2017 were also calculated to determine whether associations changed over the post-tax period. Sensitivity analyses adjusted for fiscal quarter (approximately corresponding to season) and removed the month before implementation (December 2016), when consumers might have stockpiled beverages in anticipation of the tax.

All analyses were conducted in 2020–2021 using SAS, version 9.4. Analyses calculated 2-sided 95% CIs and *p*-values controlling the false discovery rate at q=0.05 using methods by Benjamini and Hochberg[23] (Appendix). The University of Pennsylvania IRB determined that this study did not meet criteria for human subjects research. All analyses were conducted by the authors, not IRI.

RESULTS

This study included 175 stores in Philadelphia (23 supermarkets, 12 mass merchandisers, and 140 pharmacies) (Appendix Table 1). In Philadelphia, taxed beverages had a mean price of 3.56 cents per ounce (SD=2.23) and stores sold a mean of 1.03 million ounces (SD=2.16) per 4-week period before tax implementation.

After implementation, Philadelphia taxed beverage prices increased on average by 1.02 cents per ounce (95% CI=0.94, 1.11) versus Baltimore, indicating a mean 68% tax pass-through (Table 1) and 29% increase in price (i.e., 1.02 cents per ounce/3.56 cents per ounce [mean pre-tax price per ounce]). Prices increased more for individual-sized beverages (DD=1.33 cents per ounce, 95% CI=1.23, 1.44) than family-sized beverages (DD=0.93 cents per ounce, 95% CI=0.83, 1.04), but were similar between SSBs and ASBs. Nontaxed beverage prices did not increase post-tax (DD= −0.08 cents per ounce, 95% CI= −0.16, 0.00). Border ZIP code taxed beverage prices increased by 0.03 cents per ounce (95% CI=0.01, 0.04). Tax pass-through was higher in pharmacies (95%) than supermarkets (48%) (Appendix Table 2). Results were similar when adjusting for fiscal quarter (Appendix Table 3), excluding December 2016 sales (Appendix Table 4), and including beverages with extreme price per ounce (Appendix Table 5). Tax pass-through in 2018 (68%) was slightly higher than in 2017 (63%) (Appendix Table 6).

After implementation, Philadelphia taxed beverage volume sales decreased on average by 50% (95% CI=36%, 61%) versus Baltimore (Table 2), which translates to an approximate 0.52 million–ounce decrease per 4-week period. In Pennsylvania border stores, taxed beverages sales increased on average by 16% (95% CI=9%, 24%) versus Maryland border stores (approximate 0.15 million–ounce increase per 4-week period). Philadelphia nontaxed beverage sales did not change post-tax (DD=4%, 95% CI= −3%, 12%). Philadelphia taxed beverage sales decreased in supermarkets on average by 62% (95% CI=42%, 75%), but did not change in pharmacies (Appendix Table 7). Border ZIP code volume sales increased most for mass merchandisers (DD=30%, 95% CI=16, 46). Results were similar when adjusting for fiscal quarter (Appendix Table 8) and excluding December 2016 sales (Appendix Table 9). Philadelphia volume sale changes were similar in 2017 (DD= −50%, 95% CI= −59%, −38%) and 2018 (DD= −50%, 95% CI= −61%, −36%) (Appendix Table 10). In

Pennsylvania border stores, the 16% increase in 2018 was slightly higher than the 13% increase (95% CI=6%, 19%) in 2017.

The DD estimate of a 50% decrease in taxed beverage volume sales in Philadelphia translated to an approximate decrease of 1,159 million ounces in 2018 versus 2016; in Pennsylvania border ZIP codes, the authors estimated a 359 million–ounce increase (Figure 1 and Appendix Table 11). After accounting for cross-border shopping, city-level taxed volume sales decreased by 35%. This represents a 30% offset compared with the DD estimate of −50% taxed volume sales.

Volume sales decreased similarly across taxed beverage types except coffee drinks, whose sales declined less (Appendix Table 12). After accounting for cross-border shopping, city-level volume sales declined by 24%–27% for all taxed beverage types except fruit drinks, whose sales declined by 41% (Appendix Table 11). Increased sales of 100% fruit juice in both Philadelphia and Pennsylvania border ZIP codes implied a net 21% increase in volume sales versus 2016 Philadelphia sales. Volume sales of other nontaxed beverage types did not change.

Volume sales of nontaxed potential food substitutes in Philadelphia decreased slightly post-tax (mean 4%–8% decreases across food categories) (Table 3). Beverage concentrates sales increased by 34% (95% CI=19%, 51%) post-tax versus Baltimore stores. Sweetened beverage replacements increased by 32% (95% CI=16%, 49%), which translated to an estimated 1.7 million–gram increase per store per 4-week period. Volume sales of alcoholic spirits did not change post-tax, but wine sales increased slightly (DD=7%, 95% CI=1%, 14%). Volume sales of food substitutes did not change in border ZIP codes. Food substitution results in Philadelphia were similar by year (Appendix Table 13).

DISCUSSION

This natural experiment indicates that the Philadelphia beverage tax was associated with substantial decreases in beverage volume sales, but increases in beverage concentrate sales, 2 years after implementation. DD analyses found that 68% of the 1.5 cents-per-ounce tax was passed through to prices (prices increased approximately 29%) and that volume sales of taxed beverages decreased 50% in Philadelphia stores post-tax. Volume sales in Pennsylvania border stores increased 16% post-tax, which implied a net 35% decrease in taxed beverage volume sold in Philadelphia in 2018. This decline is similar to that observed in 2017,[11] indicating a sustained effect of the tax, which can contribute to improved health and reduced chronic disease risk if it leads to an equally strong decline in SSB consumption.[13–15]

There was a 34% increase in volume sales of beverage concentrates, and a 32% increase specifically for sweetened beverage replacements, which likely partially offset the decline in taxed beverage sales, though it is difficult to know by how much. Because low quantities of liquid or powder concentrates (e.g., 20–30 grams) can create full-sized beverages, these post-tax increases could have substantially offset declines in taxed beverage sales if most increases were for sugar-sweetened concentrates. However, there was no information about

concentrates' sweetened status, making it difficult to know the exact degree of offset. Variability in the amount of liquid needed to reconstitute concentrates further makes it difficult to know how they offset taxed beverage sales declines. Including concentrates in future tax proposals, as done in several California beverage taxes,[24–26] may reduce substitution from taxed SSBs to sugary beverage concentrates.

There was overall little substitution to other unhealthy alternatives after tax implementation. There was no substitution to nontaxed beverages overall and snack food sales declined slightly post-tax. It is unclear why these declines occurred, though they were not offset by increased cross-border shopping of these foods. Volume sales of nontaxed 100% fruit juice increased 13% in Philadelphia and 8% in Pennsylvania border stores, indicating a net 21% increase, though these beverages only made up 7% of total Philadelphia pre-tax volume sales, implying overall little offset of taxed beverage sales declines. There was a 7% post-tax increase in wine sales, but Pennsylvania liquor laws changed in 2016 to allow sales of wine in grocery stores.[12,27] There could have been confounding if, for example, Philadelphia residents were less likely than suburban Pennsylvania residents to switch from liquor stores to grocery stores. The new law did not apply to spirits and investigators observed no post-tax changes in sales of spirits. To the authors' knowledge, there were no other major policies around the time of tax implementation that could have biased analyses of beverage or food sales.

This is one of the first studies demonstrating sustained 2-year declines in taxed beverage volume sales after a sweetened beverage tax, though taxes in other U.S. cities have been associated with large 1-year declines.[5–9] Seiler et al.[4] observed a smaller (but still substantial) 22% decline in sales 1 year and 8 months after Philadelphia tax implementation. Differences between that study and the present one may be due to Seiler and colleagues' inclusion of convenience and dollar stores and New Jersey border stores, though 88% of cross-border sales came from Pennsylvania stores. The present study may have therefore slightly underestimated cross-border shopping. Further, in Seiler et al., the control consisted of stores >6 miles outside of Philadelphia. The present study's control city of Baltimore may be more similar sociodemographically to Philadelphia, though it may not reflect regional demand shocks as well. Another study by Cawley and colleagues[28] found a 28% reduction in households' taxed beverage purchases in Philadelphia 6 months after implementation. These studies together point to a substantial decline in beverage sales after tax implementation.

Philadelphia's beverage tax included both SSBs and ASBs to increase city revenue for universal pre-kindergarten funding and to distribute the tax burden more equitably across racial/ethnic and socioeconomic groups. Although some have been concerned that this may discourage customers from reducing SSB purchases (less incentive to switch to ASBs), this study found very strong declines in SSB sales. It is possible that including ASBs in the tax led to increased substitution to beverage concentrates, but this is unknown from the data. Although this warrants further investigation, the results still suggest that including ASBs in beverage taxes can promote healthy behaviors while generating more revenue to invest in underserved communities. However, cross-border shopping offset an appreciable

amount of the tax's effects. Taxes applied to wider geographic jurisdictions (e.g., state- or national-level taxes), as adopted in other countries,[16,29] would likely limit this effect.[30]

Limitations

This study has limitations. First, the data did not include sales from independent stores or restaurants, though they represent a substantial proportion of Philadelphia sales.[11] Studies in independent stores in Philadelphia have indicated higher rates of tax pass-through (120%–138%) but similar declines in sales volume (39%–42%).[31,32] Second, the sample did not include New Jersey stores, though these likely accounted for a small proportion of cross-border shopping[4] because crossing that border requires a toll. Third, this study did not have information on consumption. Studies examining changes in beverage consumption in Philadelphia have been inconsistent[33,34] but have had small sample sizes. Fourth, city-level changes for energy drinks, sports drinks, or iced tea/lemonade could not be estimated because of parallel trends violations for those beverage types. Fifth, the proportion of Baltimore sales volume covered by the IRI data was unknown. If coverage were unequal between cities, the store-level analyses would likely be unbiased (because those estimate change in the average store, independent of the number of stores), though the city-level analyses could be biased by unequal coverage. Lastly, IRI captured more mass merchandisers (86%) than supermarkets (37%) or pharmacies (40%) in Philadelphia,[11] which could weight the findings toward mass merchandisers. However, IRI tends to capture more mass merchandisers than other store types generally,[20] and the same chains were included in all locations. If store type coverage in Baltimore and Pennsylvania border ZIP codes was similar to that in Philadelphia (which is unknown but likely), the city-level estimates are likely less affected by bias.

CONCLUSIONS

The 1.5 cents-per-ounce Philadelphia beverage tax was associated with higher beverage prices and a substantial decline in sales of taxed beverages 2 years after implementation. These declines were partially offset by cross-border shopping and increased purchases of beverage concentrates, which should be addressed by future policy proposals.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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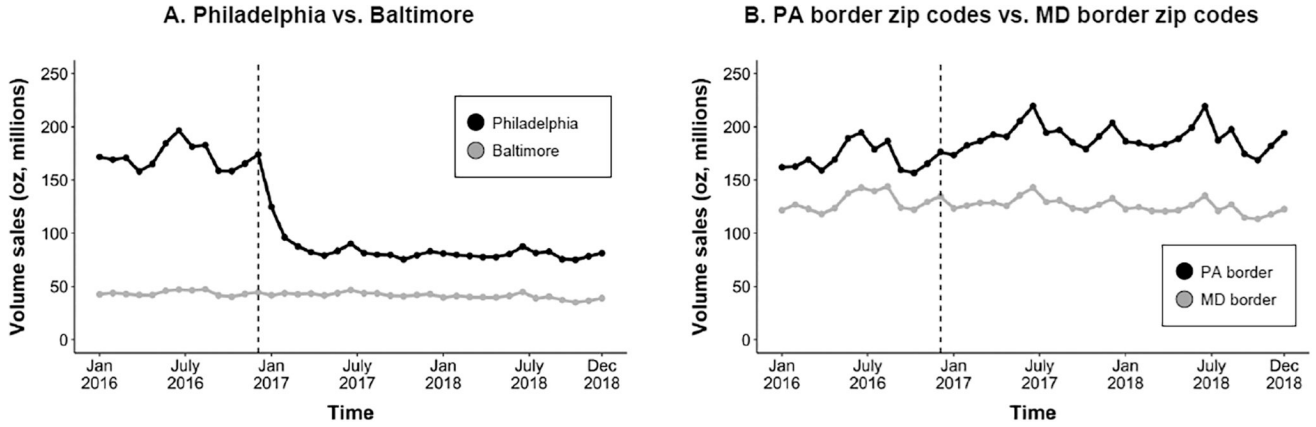

Figure 1.

Change in volume sales of taxed beverages (ounces, millions) in Philadelphia, Baltimore, Pennsylvania border ZIP codes, and Maryland border ZIP codes after tax implementation. *Notes*: Panel A: The graph shows total volume sales (ounces, millions) of taxed beverages over the study period for all store types in Philadelphia and Baltimore. The tax implementation date of January 1, 2017 is depicted as a dashed vertical line. Panel B: Similar to panel A but depicting volume sales in PA border ZIP codes and MD border ZIP codes.

Table 1.

Difference-in-Differences in Beverage Price per Ounce 2 Years After Philadelphia Beverage Tax Implementation

Outcome	Philadelphia vs Baltimore				PA border vs MD border		
	Mean (SD) pre-tax price per ounce in Philadelphia[a]	Difference-in-differences (95% CI)[b]	Adjusted *p*-value[c]	% pass-through[d]	Mean (SD) pre-tax price per ounce in PA border[a]	Difference-in-differences (95% CI)[b]	Adjusted *p*-value[c]
Taxed beverages							
All	3.56 (2.23)	1.02 (0.94, 1.11)	**<0.0001**	68%	3.38 (2.06)	0.03 (0.01, 0.04)	**0.003**
Individual-sized	6.56 (3.46)	1.33 (1.23, 1.44)	**<0.0001**	89%	6.51 (3.51)	−0.05 (−0.10, −0.01)	**0.03**
Family-sized[e]	2.91 (1.03)	0.93 (0.83, 1.04)	**<0.0001**	62%	–	–	–
Sugar-sweetened	3.57 (2.30)	1.04 (0.94, 1.13)	**<0.0001**	69%	3.41 (2.12)	0.02 (0.00, 0.04)	**0.02**
Artificially-sweetened	3.51 (1.94)	0.96 (0.79, 1.13)	**<0.0001**	64%	3.25 (1.79)	0.04 (0.01, 0.06)	**0.004**
Nontaxed beverages							
All	3.28 (2.63)	−0.08 (−0.16, 0.00)	0.08	–	3.38 (2.06)	0.16 (0.10, 0.22)	**<0.0001**
Individual-sized	7.91 (4.55)	0.04 (−0.12, 0.21)	0.62	–	7.97 (4.79)	−0.01 (−0.08, 0.05)	0.70
Family-sized	2.89 (1.94)	−0.07 (−0.15, 0.02)	0.15	–	3.15 (1.92)	0.16 (0.10, 0.22)	**<0.0001**

Note: Boldface indicates statistical significance ($p<0.05$).

[a] Per 4-week period; weighted by volume sales and store type.

[b] A generalized estimating equation was used with variables for intervention time (pre-intervention=0, post-intervention=1), city (Baltimore/MD border ZIP codes=0, Philadelphia/PA border ZIP codes=1), and an interaction term between the 2, which represents the difference-in-differences, as well as indicator variables for beverage type and beverage size. The UPCs were weighted by volume sales and store type.

[c] P-values controlled for the false discovery rate for 8 comparisons in Philadelphia and 7 in PA border ZIP codes.

[d] The percent pass-through was calculated for taxed beverages as the difference-in-differences point estimate divided by 1.50 cents/oz.

[e] Difference-in-differences not reported for PA border vs MD border because of a violation of pre-tax parallel trends.

Table 2.

Store-Level Difference-in-Differences in Beverage Volume Sales 2 Years After Philadelphia Beverage Tax Implementation

Outcome	Philadelphia vs Baltimore			PA border vs MD border		
	Mean (SD) pre-tax volume sales (ounces, millions) in Philadelphia[a]	Difference-in-differences (95% CI)[b]	Adjusted *p*-value[c]	Mean (SD) pre-tax volume sales (ounces, millions) in PA border[a]	Difference-in-differences (95% CI)[b]	Adjusted *p*-value[c]
Taxed beverages						
All	1.03 (2.16)	−50% (−61%, −36%)	**<0.0001**	0.96 (1.45)	16% (9%, 24%)	**<0.0001**
Individual-sized	0.13 (0.16)	−26% (−33%, −18%)	**<0.0001**	0.12 (0.14)	13% (8%, 17%)	**<0.0001**
Family-sized	0.90 (2.01)	−53% (−64%, −39%)	**<0.0001**	0.85 (1.32)	17% (9%, 25%)	**<0.0001**
Sugar-sweetened	0.88 (1.88)	−49% (−60%, −35%)	**<0.0001**	0.72 (1.10)	17% (9%, 25%)	**<0.0001**
Artificially-sweetened[d]	0.15 (0.32)	−55% (−63%, −44%)	**<0.0001**	–	–	–
Nontaxed beverages						
All	1.29 (2.70)	4% (−3%, 12%)	0.29	1.17 (1.76)	0% (−5%, 7%)	0.90
Individual-sized	0.07 (0.11)	1% (−4%, 6%)	0.67	0.08 (0.12)	2% (−2%, 6%)	0.50
Family-sized	1.21 (2.60)	4% (−3%, 13%)	0.29	1.09 (1.65)	0% (−6%, 7%)	0.90

Note: Boldface indicates statistical significance ($p<0.05$).

[a] Per 4-week period.

[b] A generalized estimating equation with a log link and gamma distribution was used with indicator variables for intervention time (pre-intervention=0, post-intervention=1), city (Baltimore/MD border ZIP codes=0, Philadelphia/PA border ZIP codes=1), and an interaction between them, which represents the difference-in-differences. Percent change was calculated as (exp(difference-in-differences)-1)*100%.

[c] P-values controlled for the false discovery rate for 8 comparisons in Philadelphia and 7 in PA border ZIP codes.

[d] Difference-in-differences not reported for PA border vs MD border because of a violation of pre-tax parallel trends.

Table 3.

Store-Level Difference-in-Difference in Food and Alcohol Volume Sales 2 Years After Philadelphia Beverage Tax Implementation

Outcome	Philadelphia vs control[a]			PA border vs MD border		
	Mean (SD) pre-tax volume sales in Philadelphia[b]	Difference-in-differences (95% CI)[c]	Adjusted *p*-value[d]	Mean (SD) pre-tax volume sales in PA border[b]	Difference-in-differences (95% CI)[c]	Adjusted *p*-value[d]
Food volume sales (g, millions)						
Candy	1.56 (2.13)	−4% (−8%, −1%)	**0.02**	1.93 (2.28)	2% (−2%, 6%)	0.92
Sweet snacks	4.55 (10.02)	−8% (−12%, −3%)	**0.003**	5.12 (8.27)	0% (−4%, 4%)	0.96
Salty snacks	2.70 (5.05)	−6% (−10%, −1%)	**0.02**	3.82 (5.85)	3% (−1%, 6%)	0.92
Beverage concentrates (total)	7.74 (19.04)	34% (19%, 51%)	**<0.0001**	5.97 (10.69)	2% (−6%, 9%)	0.92
Sweetened beverage replacements[e]	5.31 (12.55)	32% (16%, 49%)	**<0.0001**	4.54 (8.32)	1% (−7%, 10%)	0.92
Other foods	35.60 (85.53)	−8% (−12%, −3%)	**0.02**	39.80 (68.09)	−1% (−6%, 4%)	0.92
Alcohol sales (ml, thousands)						
Wine	11.54 (5.77)	7% (1%, 14%)	**0.03**	–	–	–
Spirits	9.50 (4.52)	−2% (−6%, 4%)	0.56	–	–	–

Note: Boldface indicates statistical significance ($p<0.05$).

[a] The control location for Philadelphia was Baltimore for food volume sales and PA non-border ZIP codes for alcohol sales.

[b] Per 4-week period.

[c] A generalized estimating equation with a log link and gamma distribution was used with indicator variables for intervention time (pre-intervention=0, post-intervention=1), city (control=0, Philadelphia=1), and an interaction between them, which represents the difference-in-differences. Percent change was calculated as (exp(difference-in-differences)-1)*100%.

[d] P-values controlled for the false discovery rate for 5 comparisons for food volume sales and 2 comparisons for alcohol sales.

[e] Excludes coffee, tea, and milk mixes.