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Oakland's Sugar-Sweetened Beverage Tax: Impacts on Prices, Purchases and Consumption by Adults and Children

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ABSTRACT

Several cities in the U.S. have implemented taxes on sugar-sweetened beverages (SSBs) in an attempt to improve public health and raise revenue. On July 1, 2017, Oakland California introduced a tax of one cent per ounce on SSBs. In this paper, we estimate the impact of the tax on retail prices, product availability, purchases, and child and adult consumption of taxed beverages in Oakland, as well as of potential substitute beverages. We collected data from Oakland stores and their customers and a matched group of stores in surrounding counties and their customers. We collected information in the months prior to the implementation of the tax and again a year later on: (1) prices, (2) purchase information from customers exiting the stores, and (3) a follow-up household survey of adults and child beverage purchases and consumption. We use a difference-in-differences identification strategy to estimate the impact of the tax on prices, purchases, and consumption of taxed beverages. We find that roughly 60 percent of the tax was passed on to consumers in the form of higher prices. There was a slight decrease in the volume of SSBs purchased per shopping trip in Oakland and a small increase in purchases at stores outside of the city, and we find some evidence of increased shopping by Oakland residents at stores outside of the city. We do not find evidence of substantial changes in the overall consumption of SSBs or of added sugars consumed through beverages for either adults or children after the tax.

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I. Introduction

Taxes on goods that impose external costs on society have been a focus of economics from the beginning of the discipline; even Adam Smith's Wealth of Nations specified that sugar, rum, and tobacco were "extremely proper subjects of taxation" (Smith, 1776). Historically, countries have tended to focus such taxes on tobacco and alcohol rather than sugar. However, in recent decades, there has been increasing recognition of the role of sugar-sweetened beverages (SSBs) in causing diabetes and obesity (Johnson, Appel, Brands, et al., 2009; Malik and Hu, 2011). In the past ten years, numerous countries, including France, India, Mexico, and the U.K., have begun taxing SSBs (Cawley, Thow, Wen, and Frisvold, 2019). Such taxes have also been implemented by several U.S. cities in the past five years, including Berkeley, California (2015); Albany, California (2017); Oakland, California (2017); Boulder, Colorado (2017); Cook County, Illinois (August-December 2017); Philadelphia, Pennsylvania (2017); San Francisco, California (2018); and Seattle, Washington (2018).

The effects of these city-level taxes on SSBs are of great interest, but the evidence base is relatively new and data are scarce; thus, information from each city is valuable and contributes to the evidence base. The purpose of this paper is to estimate the effect of the SSB tax in Oakland, California, which is equal to one cent per ounce and was first levied on July 1, 2017. The tax is levied on caloric SSBs, including regular soda, energy drinks, sweetened iced tea, and juice drinks; beverages such as water, milk, unsweetened iced tea, and 100% fruit juice are exempt. Using original hand-collected data of store prices, store exit interviews with customers, and surveys of households, this paper reports the first evidence of the effect of Oakland's SSB tax on a wide range of relevant outcomes, including retail prices, purchases, and consumption.

This study contributes to the evidence that is based on the experience of cities that adopted such taxes before Oakland. The impact of SSB taxes on retail prices varies across cities, from less than 50 percent in Berkeley (Cawley and Frisvold, 2017; Falbe, Rojas, Grummon, and Madsen, 2015), to greater than 50 percent but less than complete in Boulder (Cawley, Crain, Frisvold, and Jones, 2018), to essentially complete in both Philadelphia (Cawley, Frisvold, Hill, and Jones, 2018a; Cawley, Willage, and Frisvold, 2018; Seiler, Tuchman, and Yao, 2019) and Cook County (Leider, Pipito, and Powell, 2018). The impact of SSB taxes on purchases or sales also varies considerably, not just across cities but also within cities across different studies. For example, in Berkeley, two studies using retail scanner data find a substantial reduction in SSB

sales of roughly 7 to 12 percent in supermarkets (Silver, Ng, Ryan-Ibarra, et al., 2017; Bollinger and Sexton, 2018), while another finds no reduction in sales in supermarkets (Rojas and Wang, 2017), and one finds no reduction in sales in pharmacies (Bollinger and Sexton, 2018). In Philadelphia, one study that conducted store exit interviews found a relative reduction in purchases in the city of 8.9 ounces per shopping trip (Cawley, Frisvold, Hill and Jones, 2018b), while another found a 38 percent reduction in sales at large chain retailers one year after the tax (Roberto et al., 2019). Both studies find evidence of substantial increases in cross-border shopping, and the former estimate of 8.9 ounces per shopping trip is inclusive of increases in shopping outside of the city.

There is also mixed evidence regarding the impact of SSB taxes on consumption. For Berkeley, researchers found a 24 percent reduction in adults' SSB consumption and a 37 percent increase in water consumption, 6 months after the tax (Falbe, Thompson, Becker, Rojas, and McCulloch, 2016). The reduction in SSB consumption grew over time, averaging over 50 percent three years after the tax (Lee, Falbe, Schillinger et al., 2019). Results are more mixed for Philadelphia. Repeated cross-sectional phone surveys conducted shortly before and after the tax suggest that the probability of being a daily consumer of soda fell 40 percent after the tax, but there was no substantial change in consumption by several other measures, such as being a daily consumer of any SSBs; the daily volume consumed of SSBs or any category of SSBs also did not substantially change (Zhong, Auchincloss, Lee, and Kanter, 2018). Another study of Philadelphia uses longitudinal household surveys and finds no detectable impact of the Philadelphia SSB tax on the overall SSB consumption of adults or children; however, they do find a reduction in soda consumption for adults and substantial reductions among adults and children that were high consumers of SSBs prior to the tax (Cawley et al., 2018b).

The evidence base on city-level SSB taxes is still being formed. In this paper, we present comprehensive evidence of how the SSB tax in Oakland influenced all of the outcomes described above: retail prices, purchases, and consumption. In brief, we find that roughly 60 percent of the tax was passed on to consumers in the form of higher prices. There was a slight decrease in the volume of SSBs purchased per shopping trip in Oakland and a small increase in the volume of purchases at stores outside of the city, and we find some evidence of increased shopping by Oakland residents at stores outside of the city. We do not find evidence of substantial changes in overall consumption of SSBs or untaxed beverages for adults or children after the tax.

II. Data

To examine the beverage tax's influence on prices, purchases, and consumption, we collected data from three sources following a nested design: 1) longitudinal data on beverage prices at stores in Oakland and comparison communities prior to and after implementation of the tax, 2) cross-sectional data from consumers at stores in Oakland and comparison communities about their beverage purchases prior to and after implementation of the tax, and 3) a longitudinal household survey of beverage consumption prior to and after implementation of the tax among adults and children living in Oakland and the comparison communities. We used the same data collection methods as Cawley et al. (2018a, b), which estimated the impact of the beverage tax in Philadelphia.

We selected a representative set of stores, based on sales volume, in Oakland and a matched comparison group of stores in areas without SSB taxes in the Oakland MSA (Alameda and Contra Costa counties, excluding Oakland and Berkeley). The primary advantage of selecting stores in the same geographic area as stores in Oakland is that consumers in this area are subject to similar local economic conditions, similar state policies, and similar media markets; thus, the estimates are likely to reflect the impact of the tax as opposed to the impact of information campaigns surrounding the tax or local economic fluctuations. A disadvantage of selecting stores in the same geographic area is that these stores could be influenced by cross-border shopping, in which residents of Oakland evade the tax by purchasing SSBs at stores outside of the city. We selected stores from varying distances to the city border and investigate the potential magnitude of cross-border shopping in the analysis.

We matched each store in the Oakland sample to a store of the same type (large grocery store, small grocery store, pharmacy, convenience store, and gas station with a convenience store) in the comparison communities with the closest score on a composite measure of the three local population characteristics (percentage African-American, percentage Hispanic, and percentage of households in poverty in the neighborhood where the store is located). The approach also led to a pool of possible consumers and households for the purchases and consumption analyses who shop at the same types of stores and have similar percentages who are African-American, Hispanic, and in households below the federal poverty level (FPL).

To select the stores in Oakland, we stratified retailers listed in the ReferenceUSA database by store type and allocated the stores proportionally. We then selected stores within each store type stratum that had a probability proportional to sales (as reported in the ReferenceUSA database).[6] We collected data from stand-alone convenience stores [10 stores in Oakland and 15 in the comparison area], gas stations with convenience stores [6 stores in Oakland and 8 in the comparison area], small grocery stores [13 stores in Oakland and 14 in the comparison area], pharmacies [14 stores in Oakland and 19 in the comparison area], and large grocery stores [18 stores in Oakland and 19 in the comparison area].

a. Store observations (price and availability data)

From each store in our sample, we collected data on the posted shelf prices of 23 taxed and 23 untaxed products across a range of beverage types, manufacturers, and container sizes. To ensure comparability across stores and over time, we collected the prices of the commonly-sold sizes of commonly-sold items, such as Coke, Diet Coke, Arizona Iced Tea, Minute Maid Lemonade, Tropicana 100% Orange Juice, and Dasani bottled water.[7] We collected the information at two points in time one year apart: April to June 2017 (pre-tax) and April to June 2018 (post-tax).[8] We recorded prices in the same months in both years because beverage prices may be seasonal.[9]

Before the tax, the sample includes 70 stores in Oakland with prices for 918 taxed beverages and 616 untaxed beverages. After the tax, the sample includes 61 stores with prices for 773 taxed beverages and 497 untaxed beverages. In the comparison areas, the sample includes 87

[6] We included a slight oversample of small store types to facilitate subgroup analysis by store type (these results are discussed in the results section and presented in an appendix). We account for the oversample by adjusting the impact estimates using survey weights to be representative of sales at retailers in Oakland.

[7] Appendix Table A1 includes a complete list of all products, the average price per ounce before and after the implementation of the tax in Oakland and the comparison area, and the number of stores selling each product in each time period and each location.

[8] In all of the analyses reported in this paper, we used the listed price for a single item. However, we also collected information on whether the store was offering any multi-buy promotions (e.g., two for the price of one) or offered a discount for loyalty club members only.

[9] Besides recording a large number of posted (or shelf) prices in each store, we also purchased a taxed beverage from each store and reviewed the receipt to determine whether the tax was being applied at the register and thus would not be reflected in the posted or shelf prices. Two of the stores we visited applied the tax at the register. Cawley et al. (2018c) observed a similar pattern following the SSB tax in Boulder, Colorado. This is relevant because taxes tend to have a greater impact on consumer behavior when they are more salient (e.g., Chetty, Looney, and Kroft, 2009). We adjusted the posted prices for taxed beverages sold at these stores to add the amount of the tax and reflect the final price paid by shoppers, excluding sales tax.

stores with prices for 1,067 taxed beverages and 774 untaxed beverages in before the tax and 75 stores, and prices for 996 taxed beverages and 739 untaxed beverages after the tax. The loss of stores at follow-up was due to a mixture of store closures and cases in which the store managers or owners did not allow field interviewers to collect price data.

b. Exit interviews (repeated cross-sectional data on purchases)

We also collected information from consumers as they exited stores. We selected the time of the day (defined as blocks of time within the stores' operating hours) and day of the week at random to visit stores for interviews, and we interviewed consumers at all times of the day and every day of the week to capture the range of consumers visiting the stores.[10]

Children's beverage consumption is of particular policy interest, so we asked consumers several screener questions to identify adults age 18 and older who lived in a household with at least one child between 2 and 17 years of age, located in Oakland or one of the comparison areas.[11] As a result, the cross-sectional sample is representative of consumers in with children shopping at the stores in the sample, after applying survey weights, but it is not a representative sample of all consumers in Oakland. For consumers meeting these criteria, we recorded: (1) the quantity, size, and name of each beverage they purchased on that trip; (2) basic demographic information (age, gender, race, ethnicity, household size, and income); (3) whether they lived in Oakland; and (4) whether the store at which they were interviewed was their usual source of beverage purchases.[12] The main outcomes for the analysis of purchases are the volume of taxed and untaxed beverages purchased by consumers per shopping trip.[13] We collected the information from cross-sections of consumers visiting the stores at two points in time, one year

[10] We interviewed as many customers as possible during the blocks of time. Thus, the completed interviews during a block of time are roughly proportional to the volume of shoppers during the block of time, and in aggregate, the completed interviews should be representative of shoppers with children overall at the stores in our sample.
[11] In Oakland, 899 out of 3,532 individuals (25.5 percent%) screened met the eligibility criteria in 2017 prior to the tax; 955 out of 4,002 individuals (23.9 percent) who we screened did so in 2018 after the tax was implemented. At stores in the Oakland MSA but outside of the city, 952 out of 2,990 individuals (31.8 percent) screened in 2017 and 1,027 out of 3880 individuals (26.5 percent) screened in 2018 met the eligibility criteria.
[12] We collected information on all beverages that consumers purchased from out-of-pocket expenditures, SNAP benefits, and WIC benefits.
[13] We coded beverages as taxed or untaxed based on a manual review of the beverage names that were directly observed by interviewers or self-reported by consumers. If we were not able identify the volume for all beverages purchased by a consumer, then we recorded the value for the volume of purchases for that shopping trip as missing.

apart: April to June 2017 (pre-tax) and April to June 2018 (post-tax). We interviewed consumers in the same months in both years because beverage purchases may be seasonal.

For Oakland, the exit interview sample includes 785 consumers before the tax (25.12 percent purchased a taxed beverage and 20.37 percent purchased an untaxed beverage) and 786 consumers after the tax (22.72 percent purchased a taxed beverage and 21.12 percent purchased an untaxed beverage).[14] In the comparison areas, the exit interview sample includes 741 consumers before the tax (21.23 percent purchased a taxed beverage and 18.95 percent purchased an untaxed beverage) and 766 consumers after the tax (19.44 percent purchased a taxed beverage and 13.34 percent purchased an untaxed beverage). We successfully collected information from over 70 percent of consumers we approached at stores in Oakland and at comparison stores in both time periods who met the eligibility criteria described above (87.3 percent and 77.8 percent in Oakland and comparison stores at baseline, respectively, and 82.3 percent and 74.6 percent at follow-up).

We report the characteristics of shoppers participating in the exit interviews in Appendix Table A2. Age, gender, and the household size of shoppers in Oakland are similar to those shopping at comparison stores before and after the tax. The racial and ethnic composition of the shoppers at Oakland and comparison stores varies. A greater percentage of shoppers at Oakland stores are African American, and comparison stores have higher percentages of Hispanic, white, and other race or multi-racial shoppers. Oakland stores also have higher percentages of families below 185 percent of the FPL, although the difference is only statistically significant at the 5 percent level for shoppers after the implementation of the tax.[15]

c. Household survey (longitudinal data on consumption)

In the period before the implementation of the tax, we contacted the consumers who completed an exit interview and who agreed to provide their contact information.[16] Among Oakland residents, 42.6 percent also completed the household survey; among residents of the

[14] Throughout the paper, "taxed beverage" refers to a beverage that was subject to the SSB tax in Oakland after July 1, 2017. Thus, when we refer to "taxed beverages" for Oakland before the tax or in the comparison communities in any time period, it was not taxed at that time or place, but was taxed in Oakland after July 1, 2017. Likewise, "untaxed beverage" means it was exempt from Oakland's SSB tax after July 1, 2017.
[15] We used 185 percent of the FPL because it is a cutoff used for many federal programs (e.g., the Special Supplemental Nutrition Program for Women, Infants, and Children [WIC] and the National School Lunch Program).
[16] This contact included 773 individuals in Oakland and 738 individuals in the comparison areas in the Oakland MSA.

comparison communities, 48.9 percent completed the household survey. We surveyed these same households one year later, after the implementation of the Oakland SSB tax. We collected the information on the same timeline as the exit interviews, April to June 2017 (pre-tax) and April to June 2018 (post-tax). The number of households that responded to both waves of the survey was 193 in Oakland (58.7 percent of those that responded at baseline) and 218 in the nearby comparison communities (60.4 percent of those that responded at baseline) for an overall completion rate of 26.9 percent of households in all areas who completed the exit interview and also completed both waves of the household survey.[17] We classified households according to their original location; eleven households moved out of, and four households moved into, Oakland.

Through the survey, which was administered online with follow-up by telephone for those who could not complete it online, we collected detailed information on beverage consumption for the adult respondent and a randomly chosen child within the household. We surveyed children over 12 years of age directly; parents responded for younger children and any older children who could not be reached directly.[18] In addition, we collected information on beverage shopping patterns, attitudes toward the tax and SSBs, and individual and household characteristics. We measured beverage consumption using the National Health and Nutrition Examination Survey (NHANES) Dietary Screener Questionnaire (DSQ), which has been validated for adults and children two years of age and older. We used the responses in the survey to measure the frequency of beverage consumption for a range of taxed and untaxed beverage types over the past 30 days. We then constructed the total amount of added sugars consumed from beverages as a summary measure of consumption, using the National Cancer Institute (NCI) algorithm developed for the DSQ.[19]

[17] The percentage of those approached for exit interviews that were eligible and ultimately completed both waves of the household survey is roughly 20 percent in Oakland and comparison areas. The percentage of those completing exit interviews that completed both waves of the household survey is 24.6 percent in Oakland and 29.4 percent in the comparison areas.

[18] For households living in Oakland, 82.6 percent of child responses were conducted by the adult respondent; in the households in comparison communities, 85.6 percent of child responses were conducted by the adult respondent. For children over 12 years of age, roughly one-half of the responses were ultimately conducted by the adult respondent in Oakland and comparison communities.

[19] The algorithm uses age, gender, and the self-reported frequency of consumption of SSBs to estimate the daily intake of added sugars from beverages for both adults and children two years of age and older. The parameters in the algorithm are based on estimates of the amount of each serving size consumed for each beverage type (e.g., regular soda) in a given consumption period, which are based on responses to the What We Eat in America 24-hour dietary recall module from the 2009-2010 NHANES (National Cancer Institute, 2009–2010).

We report the characteristics of the household survey respondents for those living in Oakland and comparison areas in Appendix Table A3. The respondents are similar in terms of age (adult and child – note, the average age of children in the sample is between 8 and 9), gender (adult and child), education (adult), receipt of Supplemental Nutrition Assistance Program (SNAP) and Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) benefits, and receipt of free or reduced-price lunch. Similar to the exit interviews, respondents differ somewhat by race and ethnicity; in particular, 49 percent of respondents in Oakland are African American compared to 39 percent in comparison areas. The average household size is also lower in Oakland, 3.97 compared to 4.59 in comparison areas.

III. Methods

a. Analysis of beverage prices and availability

The methods used in our analyses closely follow those used in Cawley et al. (2018a, b) to study the beverage tax in Philadelphia. We estimate the effects of the Oakland tax using a difference-in-differences (DiD) design, which compares the change in outcomes in stores in Oakland to those in stores in comparison (or control) communities. We estimate the impact on two outcomes, the price and availability of beverages by type of beverage. The DiD equations are of the general form:

$$Y_{bst} = \alpha_0 + \alpha_1 Post_t + \alpha_2 Oakland_s * Post_t + \delta_b + \lambda_s + \varepsilon_{bst}, \quad (1)$$

where Y_{bst} is either the price per ounce or availability of the beverage *b* in store *s* in time period *t*. *Oakland* is a binary variable equal to 1 if the store is in Oakland and equal to 0 if the store is in a comparison area. *Post* indicates that an observation occurred after the Oakland tax took effect. δ_b is a vector of product fixed effects and λ_s is a vector of store fixed effects. α_2 is the coefficient of interest; it represents the change in the outcome (price per ounce or percentage of a beverage type sold in stores) before the tax to after the tax in Oakland relative to the comparison communities. The regression is estimated using ordinary least squares when the outcome is price; it is estimated by logistic regression when the outcome is an indicator variable for product

availability. In all cases, we cluster standard errors at the store level to account for correlations between observations within stores.[20]

We estimate the impact of the Oakland tax on the prices of all taxed beverages and all untaxed beverages separately. The elasticities of supply and demand may vary by product and store characteristics. Thus, we estimate regressions separately for both taxed beverages (regular soda, energy drinks, sports drinks, sweetened iced teas, and sweetened juice drinks) and untaxed beverages (diet soda, other diet drinks such as sugar free energy drinks, 100% fruit juice, and bottled water). We also estimate the differential impacts of the tax by store type, chain versus independent stores, product size, characteristics of the local population, and travel time to the closest untaxed competitor. See Appendix B for more details about how we tested for heterogeneity in the impact of the tax on prices and availability.

To establish that the observed changes in prices are in fact due to the SSB tax in Oakland, we examine whether the trends in prices at Oakland and comparison stores were parallel prior to the implementation of the tax. We do not have information on beverage prices at the stores in our sample prior to our pre-tax data collection. Instead, we used Nielsen Retail Scanner Data and provide supporting evidence that the trends in prices are parallel for retailers in Oakland and the area outside of Oakland but still in the Oakland MSA (Figure 1).[21] The trends in the average weekly price per ounce of regular soda are parallel in the 18 months prior to the tax. The price is consistently about 0.3 to 0.4 cents per ounce higher in retail stores in the Oakland MSA than in retail stores in Oakland in the year prior to the tax.[22] The parallel trends in beverage prices in Oakland and the Oakland MSA are consistent with our identifying assumption that the treated and comparison stores had parallel trends prior to the tax and the prices in stores in the Oakland

[20] With only two geographic regions, standard errors that are clustered at the geographic level would be degenerate (Donald and Lang, 2007). As a result, we cluster standard errors at the store level, following Cawley and Frisvold (2017).

[21] Using the Nielsen data, we examined the average weekly price per ounce and sales volume (in ounces) of regular soda for all retailers in Oakland and the Oakland MSA (outside of Oakland and Berkeley). Each retailer in the dataset reports the weekly price and sales volume for every UPC code with any sales volume during the week. Based on the UPC code, Nielsen categorizes beverage types. Sports drinks, energy drinks, and sweetened teas are not defined separately in the data. The Nielsen data include the three-digit zip code and the FIPS county code of each store, so we were able to approximately determine which retailers are located in the city of Oakland (Alameda County with a three-digit zip code of 946; this area also includes the cities of Emeryville and Piedmont) and in the Oakland MSA outside of Oakland and Berkeley (Contra Costa County, excluding the three-digit zip code of 947 [Berkeley] and Alameda County with a three-digit zip code of 945).

[22] The conclusions drawn from the Nielsen data are those of the researchers and do not reflect the views of Nielsen. Nielsen is not responsible for, had no role in, and was not involved in analyzing and preparing the results reported herein.

MSA are a valid counterfactual for the prices in stores in Oakland in the absence of the tax. Because there are still differences in the price *levels* in the Nielsen data and in the demographic characteristics of residents in Oakland and the Oakland MSA, we matched comparison stores to stores within the city based on store type and the population characteristics of the surrounding neighborhood to help minimize these differences.

b. Analysis of beverage purchases and cross-border shopping

We use the information collected on beverage purchases at stores in Oakland and comparison communities to examine how consumers changed the volume of their purchases per shopping trip and the location of their purchases. First, we estimate the changes in the mean volume of taxed and untaxed purchases in Oakland stores relative to the changes in the matched stores in communities adjacent to Oakland. We then control for the characteristics of the consumers and stores in a regression framework. However, if a consumer switched from purchasing SSBs in Oakland to outside of Oakland, the DiD estimate would double-count the impact of the tax by adding the decrease in purchases within Oakland to the increase in purchases outside of the city. Thus, cross-border shopping would amplify the estimate of the relative change in purchases per shopping trip by consumers in Oakland. We estimate the extent of cross-border shopping using self-reported responses about where Oakland residents shopped before and after the tax.

Changes in purchases

We estimate the relative change in beverage purchases in Oakland using a DiD design, which compares the change in purchases at stores in Oakland to those in stores in comparison (or control) communities. The DiD equations are of the general form:

$$Y_{ist} = \beta_0 + \beta_1 Post_t + \beta_2 Oakland_s + \beta_3 Oakland_s * Post_t + \beta_4 S_s + \beta_5 X_{it} + \varepsilon_{ist}, \quad (2)$$

where Y_{ist} is the volume in ounces of taxed or untaxed beverages for individual *i* in store *s* in time period *t*. *Oakland* is a binary variable equal to 1 if the store is in Oakland and equal to 0 if the store is in a comparison area. This variable is defined based on the location of the store where the consumer was interviewed; it is not based on the residence of the consumer. *Post* indicates that an observation occurred after the tax took effect. S_s is a vector of indicators for store type: stand-

alone convenience stores, gas stations with convenience stores, small grocery stores, and pharmacies; large grocery stores are the reference store type and, therefore, omitted from the model.[23] X_{it} is a vector of consumer and interview characteristics: age, indicator for female, indicator for African-American, indicator for Hispanic, household size, indicator for the household being below 185 percent of the FPL, indicators for day of the week, indicators for the time of the day of the interview (morning, afternoon, evening), indicators for the day of the study, and an indicator for whether the household is in Oakland. β_3 is the coefficient of interest; it represents the change in the volume of beverages purchased per shopping trip before the tax to after the tax, in Oakland relative to the comparison communities. The regressions are estimated using two-part models in which the first part is a logistic model for the indicator variable for any purchase and the second part is a generalized linear model (GLM) with a Poisson distribution for the amount (in ounces) purchased conditional on any beverage purchases. We selected a two-part model to address the large number of observations with zero beverage purchases, which skews the distribution of our main outcome (ounces purchased).[24] Impact estimates generated using ordinary least squares (OLS) were similar to the marginal effects obtained using the two-part model results, but the two part model resulted in improved precision of those estimates. We cluster the standard errors at the store level to account for correlations between observations within stores.[25] All regressions are estimated using survey weights at the consumer level, which account for sample design, oversampling, and nonresponse.[26]

[23] We define store types using NAICS codes: convenience stores (445120); gas stations with convenience stores (447110); pharmacies and drug stores (446110); large grocery stores (445110), which are supermarkets and other grocery stores with annual sales equal to or greater than $750,000; small grocery stores (445110), which are supermarkets and other grocery stores with annual sales less than $750,000. Note that we restricted pharmacies to three chains (CVS, Rite Aid, and Walgreens) due to the difficulty of identifying pharmacies that sold beverages.
[24] A lower percentage of shoppers purchased taxed beverages than in Philadelphia. Roughly 20 to 25 percent of shoppers purchased a tax beverage in Oakland compared to 25 to 30 percent in Philadelphia (Cawley et al., 2018b).
[25] With only two geographic regions, standard errors that are clustered at the geographic level would be degenerate (Donald and Lang, 2007). We cluster standard errors at the store level to account for the sampling design, which we described in Section II, but we acknowledge the possibility that these standard errors overstate the precision of the estimates.
[26] The weights take into account the multistage sample design, which begins with the selection of stores. We randomly selected stores and then randomly selected consumers within stores. The weights reflect the probability that the store was selected for our sample (thus accounting for the small oversample of smaller store types) and the probability that the consumer was selected within each sampled store. The selection of consumers occurred during a random time window on a random day of the week, which is also accounted for in the weights. Moreover, the weights take into account nonresponse for both stores and consumers. The store nonresponse occurs if a store refuses to allow us to talk with consumers, and consumer nonresponse occurs if the consumer refuses the interview request.

We estimate the relative change in purchases separately for beverages subject to, and exempt from, the Oakland beverage tax. Consumers may treat untaxed beverages as substitutes for the taxed beverages, leading to a shift in demand for the untaxed beverages and increased purchases. The elasticity of demand may vary by consumer characteristics, so we also estimate regressions separately by consumer demographics. See Appendix B for more details regarding the approach to estimating the impacts of the tax on purchases by consumer characteristics.

Similar to equation (1) for prices, the identifying assumption in equation (2) is that the purchases of consumers of stores in the Oakland MSA in our sample are a valid counterfactual for the purchases of consumers of stores in Oakland if that tax was not implemented. Parallel trends in purchases in the treated and comparison stores prior to the tax would be consistent with this assumption. Again, we examine the trends using the Nielsen data and find evidence consistent with the identifying assumption. In Figure 2, the trends in the average weekly sales volume of regular soda for retailers in Oakland and in the MSA (but outside of the city) were generally parallel during the 18 months prior to the tax.[27] The observed parallel trends give us some confidence that the pre-tax trends in purchases were likely similar between the stores in our sample in Oakland and the matched untaxed stores in comparison communities.

There is a difference in the *level* of sales in the Nielsen data, with average sales volume consistently higher at Oakland stores. By collecting data from stores in comparison areas that were matched (based on store type and population characteristics) to those Oakland, we sought to minimize differences in purchases at baseline and differences in the population characteristics of the two areas.

Cross-border shopping

We also examine more directly the extent to which there was a change in cross-border shopping—in particular, an increase in Oakland residents shopping for beverages outside of Oakland. We estimate the change in self-reported frequency of shopping across the city border among those interviewed as they exited Oakland and comparison stores. We asked consumers exiting stores how frequently they shopped for beverages across the city border (never, less than once a week, once a week, or more than once a week). We created an indicator variable for

[27] The conclusions drawn from the Nielsen data are those of the researchers and do not reflect the views of Nielsen. Nielsen is not responsible for, had no role in, and was not involved in analyzing and preparing the results reported herein.

whether the respondent shops in the given location once or more per week. We estimate the changes separately for Oakland residents and those living outside of the city. For example, we estimate the change in the likelihood that Oakland residents interviewed at a store in Oakland responded that they shop for beverages one or more times per week outside of Oakland.[28] The equations take the form of equation (2), excluding the indicator variable $Oakland_s$ and the interaction ($Oakland_s * Post_t$), and are estimated using logistic regression.

In addition, we examine changes in shopping behavior related to possible cross-border shopping reported through the household survey. We examine changes in: (1) any beverage shopping outside of Oakland, (2) having a usual source of beverage purchases that is outside of Oakland, (3) price as the primary factor in determining where to purchase beverages, and (4) travel time to purchase beverages. The first two variables are direct indications of increased shopping outside of the city. The third and fourth variables could be indirect indications of cross-border shopping if households travel greater distances to seek lower prices at untaxed stores. To estimate the impacts of the tax on these shopping behaviors, we use the method described below for analyzing the household survey data (see equation 3).

c. Analysis of beverage consumption

We use the responses to the longitudinal household survey to estimate the impact of the tax on beverage consumption among adults and children. The general framework is analogous to the DiD framework discussed above; however, the approach estimates the impact of the tax on within-person changes in consumption conditional on baseline consumption and covariates, which requires a different identifying assumption than DiD. Controlling for the lagged outcome (i.e., consumption before the tax) requires the assumption of unconfoundedness conditional on the lagged outcome. In a panel setting, for which we have an observation of the pre-treatment outcome, and given that we observe differences in mean consumption levels between the treatment and comparison groups before the tax (discussed later in this section), this approach is preferred over a DiD approach (Imbens and Wooldridge, 2009).

We estimate the impact of the tax on continuous outcomes for adults and children. First, we examine the effects on the daily intake of added sugars (in grams) from SSBs. In addition, we

[28] Note, we did not ask consumers at comparison stores how frequently they shopped outside of Oakland, nor did we as consumers at stores in Oakland how frequently they shopping for beverages in Oakland.

examine the effects on monthly frequency of consumption of all taxed beverages, specific categories of taxed beverages (regular soda and sweetened fruit drinks)[29], all untaxed beverages, and specific categories of untaxed beverages (diet soda, coffee, milk, water, and 100% fruit juice).[30] To estimate the effects of the tax on these outcomes, we estimated regressions of the form:

$$Y_{1i} - Y_{0i} = \gamma_0 + \gamma_1 Oak + \gamma_2 Y_{0i} + \gamma_3 X_i + \epsilon_i, \quad (3)$$

where $Y_{1i} - Y_{0i}$ is the change in consumption between baseline data collection (pre-tax) and follow-up (post-tax) for person i. Oak is a binary variable equal to 1 if the respondent lives in Oakland and equal to 0 if the respondent lives in a comparison area. For the consumption analysis, we define this variable based on the location of residence, as opposed to the location of the store for equations (1) and (2). Y_{0i} is the baseline consumption level reported by person i. X_i is a vector of individual-level characteristics including age, race, gender, ethnicity, education level of the sample adult, and household income. γ_1 is the coefficient of interest; it represents the effect of the tax on consumption. We estimate the regression above using OLS and cluster standard errors at the store level to account for correlations between observations within stores, which was how respondents for the survey were originally identified.[31] All results are estimated using survey weights at the household level, which account for sample design, oversampling, and nonresponse.[32]

[29] We received five survey responses to the questions about monthly frequency of consumption that we determined to be implausible. We removed records from the analysis that reported daily intake of any given individual beverage greater than 10 per day (or 300 per month). This approach is similar to the approach taken by NCI, in which they top code results for daily frequency at 7 or 8 per day depending on the beverage type.

[30] Most coffee drinks are untaxed. Any coffee drink sweetened by the consumer after the point of sale is untaxed and any beverage that is primarily milk is also untaxed.

[31] The distributions for monthly frequency of consumption and grams of sugars consumed are right-skewed with a small number of extreme values, and there are a large number of observations at or near zero. Thus, we tested the sensitivity of the results to estimation of nonlinear regression techniques to address the non-normality of the outcomes (e.g., zero-inflated count models and two-part models). The nonlinear models did not produce appreciably different estimates of the impacts of the tax compared to the results generated using OLS, and they did not result in improved precision. Moreover, the changes in the consumption outcomes, which are the primary outcomes, are approximately normally distributed; thus, we report the estimates from the OLS regressions for the analysis of consumption.

[32] We impute missing values of all covariates using multiple imputation. Because all of the covariates aside from age (for which we use OLS) are binary or categorical, we use logistic regressions to impute missing values in the sample. We estimated all regressions with and without multiple imputation, and the impacts of using imputed values for the models' covariates were small. We report the results for the regressions using multiple imputation.

We also estimate the impact of the tax on several binary outcomes, including any consumption of the beverage type during the month and daily consumption throughout the month. We use a framework similar to the framework we use for continuous outcomes, except that the outcome is a binary variable measured after the tax was implemented, instead of the change in the outcome over time. Thus, we regress the post-tax outcome on treatment status, baseline outcome, and a set of individual-level covariates (described above for equation 3). We use survey weights to account for the sampling design, and nonresponse and cluster standard errors at the store level to account for correlations between observations within stores.

The impact of the tax on consumption may be heterogeneous, and estimates of the average impact of the tax on our sample may mask important differences across key baseline characteristics. We examine heterogeneity in the impact of the tax on consumption by demographic characteristics, baseline attitudes about the tax and SSBs, and baseline shopping behavior. For more detail regarding the methods we use to examine possible differential impacts of the tax, see Appendix B.

IV. Results

a. Prices and availability

Stores in Oakland raised prices of taxed beverages by 1.00 cent per ounce on average after one year (from 7.95 to 8.94), which is exactly the amount of the tax (Table 1). Stores outside of the city in areas without a tax (i.e., the comparison communities) raised prices by 0.33 cents per ounce during the year after the tax, such that the net increase in Oakland was 0.66 cents per ounce (i.e., the unadjusted differences-in-differences estimate); however, the estimate of this net increase is not statistically different from zero. For untaxed beverages, stores in Oakland raised prices slightly, by 0.24 cents per ounce (from 9.92 to 10.16). In untaxed areas outside of the city, retailers kept prices fairly stable on average one year after the tax. The net increase in the average price in Oakland relative to comparison communities outside of the city was 0.27 cents per ounce, and this estimate is not statistically different from zero.[33]

[33] The changes in prices are larger, but qualitatively similar, when restricting the sample to stores in the sample during both periods (Appendix Table A4). The average price of regular soda, which is the most common beverage type examined in the analysis, increased by roughly 0.93 cents per ounce (Appendix Table A5). The prices for other taxed beverages increased by 0.23 to 0.63 cents per ounce on average. For untaxed beverages, there is a substantial amount of variation in the price changes, ranging from decreases in prices for water and juice on average to a 0.49

In addition to the changes in prices, as shown in the sample sizes in Table 1, we observe a decline in the availability of the beverage types included in the analysis in Oakland stores. This decline in product availability could influence the estimate of the average price change for observed products. For example, the availability of energy drinks decreased the least (Appendix Table A5). Because energy drinks are substantially more expensive by ounce than the other beverages (27.74 cents per ounce compared to 7.94 for all beverages on average), the relatively low decrease in energy drinks causes the average price change to be higher than if we just examined beverages available in both periods (i.e., a balanced sample).[34] To account for the differences in availability on prices and examine a more comparable group of beverages between the two time periods, we focus on the balanced sample of products available at given stores in both time periods for most of the subsequent analysis. We also include product fixed effects in the regression analyses so that we are comparing price changes within items (i.e., a specific size of a specific product). An advantage of this analysis is that product-size items (such as a 20-ounce bottle of Coke) are perfectly homogenous; variation in price over time or geography is not due to differences in quality or other unobserved characteristics.

Comparing the changes in prices in Oakland to untaxed comparison communities outside the city in a difference-in-differences regression framework, we find that the impact of the tax was to increase prices in Oakland by 0.61 cents per ounce (estimated using the balanced panel of beverages – Table 2). This increase translates to a 61 percent pass-through rate (i.e., 0.61 of the 1.00 cent per ounce tax), which is 7.7 percent of the pre-tax average of stores in Oakland. The estimate using the full sample of beverages is similar, although slightly lower at 0.56 cents per ounce. The impacts vary somewhat by beverage type (Appendix Table A6). We find greater pass-through for regular soda and energy drinks (0.63 and 0.73, respectively) compared to sports drinks, juice drinks, and sweetened iced tea (0.44, 0.51, and 0.32, respectively).

We find a slight increase (0.21 cents per ounce) in the average price of untaxed beverages in Oakland relative to the untaxed comparison communities (Table 2). The change varies substantially by the type of beverage; however, the changes are not statistically significant with

cent per ounce increase for diet sodas and a large increase (although not precisely estimated) for other diet beverages (unsweetened sports drinks, energy drinks, and iced tea).

[34] The relative change in availability also causes the average price increase for all beverages to be higher than any of the individual beverage types.

the exception of the slight increase for diet soda, which is statistically significant at the 10 percent level (Appendix Table A6).

In addition, we find that there was a decrease in the availability of taxed and untaxed beverages on average (Table 2). The probability that Oakland stores carried the taxed beverages in our sample relative to the comparison stores decreased by 7.71 percentage points nearly one year after the tax. The largest decrease occurred for regular sodas, a 12.58 percentage point decrease (Appendix Table A6). We also find a 5.24 percentage point decrease in the availability of untaxed beverages.

Heterogeneity of impacts

We also examined whether the pass-through of the tax in Oakland varied by store type, the container size of the beverage, distance and time to the closest untaxed competitor, and the characteristics of the local populations living near the stores (Appendix Tables A7 and A8). Pharmacies increased prices the most, fully passing through the tax, on average (0.55 higher than large grocery stores, the reference group, which increased prices by 0.45). Chain stores passed through more of the tax than independent retailers (0.47 higher than independent retailers, which raised prices by 0.30, on average). This finding is consistent with the finding that pharmacies increased prices the most; all pharmacies in the sample are chain stores. Pass-through is lower at stores with high percentages of local residents living in poverty and high percentages of African-American (statistically significant at the 10 percent level). For example, the average price increase at a store located in an area with the average percentage of households living in poverty (17.45 percent) was 0.60 cents per ounce; a ten percentage point increase in the percentage in poverty is associated with a 0.17 cents per ounce lower increase. All other differences are not statistically significant.

Regarding availability of beverages, we find that the overall decline is concentrated in independent retailers (Appendix Table A9); the differences between independent retailers and chain stores are generally substantial in magnitude and statistically significant. In fact, we do not see declines in availability for chain stores. There are no statistically significant changes in the availability of beverages by container size, except for a large decrease in the availability of single-serving bottles of water.

We do not find a relationship between changes in product availability and the distance and time to the closest untaxed competitor, but there is some evidence of differential changes

based on the local population characteristics of stores (Appendix Table A10). Stores that are farther from their closest untaxed competitor did not change the availability of beverages by more than those closer to competitors. We find larger declines in the availability of untaxed beverages in stores with relatively high percentages of local households living in poverty. In addition, we find smaller declines in availability of taxed beverages (particularly regular soda) for stores with relatively high percentages of local residents that are African American and larger declines for water. Finally, we find larger declines in availability of taxed and untaxed (particularly among untaxed) beverages in stores with relatively high percentages of local residents that are Hispanic.

b. Purchases

In Table 3, we report the unadjusted changes in the average volume of beverage purchases by type of beverage in Oakland and comparison stores. At Oakland stores, the volume of taxed beverages purchased per shopping trip decreased by 5.51 ounces from 19.26 to 13.75 ounces. When we compare the change to the untaxed comparison stores outside of Oakland, which saw an increase of 4.64 ounces per shopping trip, the relative decrease in Oakland is larger at 10.15 ounces. Conversely, we find that the average purchase of untaxed beverages at stores in Oakland increased by 10.18 ounces, from 36.52 to 46.71 ounces, with almost no changes at the comparison stores outside of Oakland. Neither of these unconditional difference-in-differences estimates are statistically significant.

In Table 4, we report the estimated impact of the tax on purchases in a regression framework accounting for characteristics of the consumers and stores. We find that consumers at Oakland stores were slightly less likely to purchase taxed beverages after the tax relative to consumers at comparison stores outside of the city (4.2 percentage points compared to 25.1 percent of consumers purchasing taxed beverages before the tax), although the change is not statistically significant. They were 10.8 percentage points more likely to purchase untaxed beverages (compared to 20.4 percent of consumers purchasing untaxed beverages before the tax). The findings regarding the volume of beverages purchased are similar to those in the unadjusted estimates reported in Table 3. Consumers at Oakland stores purchased 11.33 fewer ounces of taxed beverages per trip after the tax relative to shoppers at the comparison stores outside of Oakland, although this estimate is not statistically significant. We estimate that shoppers

increased the average volume of untaxed beverages, although the change is not statistically significant.

We also estimated the change in purchases after the tax for three populations with relatively high rates of SSB consumption, African-American residents, Hispanic residents, and families living in poverty. We find larger reductions in purchases of taxed beverages for all three subgroups compared to all consumers, but only the estimate for African-Americans is statistically significant (Appendix Table A11). African-American consumers decreased purchases of SSBs in Oakland, relative to comparison stores outside of Oakland, by 28.18 ounces per shopping trip and increased purchases of other, untaxed beverages by 30.1 ounces per shopping trip.

Cross-border shopping

In Table 5, we report results from the store exit interviews and the household surveys that provide evidence regarding the level of cross-border shopping and changes in shopping behavior by Oakland residents.[35] First, we find that there was not much change in the percentage of Oakland residents who reported shopping outside of the city for beverages at least once a week. We estimate a 2.98 percentage point increase compared to 36.36 percent before the tax, but the change is not statistically significant. Similarly, respondents to the household survey reported a slight, although not statistically significant increase in any shopping outside of Oakland, a 4.65 percentage point increase compared to 58.27 percent before the tax. However, we find a 10.33 percentage point increase in reporting that their usual source of beverage purchases is outside of Oakland, compared to 24.59 percent before the tax. Finally, we find positive, but not statistically significant, changes in reporting that price is the primary factor in determining where to purchase beverages or travel time to purchase beverages, which could be indicators of cross-border shopping.

c. Consumption

In Table 6, we report the unadjusted changes in two key measures of consumption for adults and children in Oakland and comparison stores: (1) grams of added sugars consumed from beverages and (2) monthly frequency of consumption overall and for several beverage types. We

[35] We observe some Oakland residents shopping at comparison stores outside of the city, but the number is too small to estimate changes in the proportion that purchase any taxed beverages and the volume of taxed beverages. Unlike Cawley et al. (2018a, b), the comparison stores for this analysis are farther from the city border, and we observe fewer Oakland residents shopping there.

see very little change in added sugars consumed for adults living in Oakland. The average grams of sugar consumed from beverages increased from 18.10 to 19.25, and the change is not statistically significant. We see consistent results for the frequency of SSBs consumed; there is little change in Oakland. Because there was a slight increase among adults living outside of Oakland, the net change for Oakland residents is a decrease in the frequency of consumption, although the decrease is small and not statistically significant (1.44 fewer times per month compared to a mean before the tax of 36.91 times per month). We see a similar pattern for adults for regular soda consumption, which is the most commonly consumed type of taxed beverage in Oakland and the comparison areas (Appendix Table A12). Consumption of untaxed beverages is much more common than taxed beverages in Oakland and the comparison areas; for example, respondents reported consuming untaxed beverages roughly 180 times per month prior to the tax compared to taxed beverages roughly 23 times per month.[36] Unexpectedly, we find a fairly large decline in consumption of untaxed beverages in the comparison communities driven by a decline in frequency, which leads to a relative increase in consumption for Oakland residents, although the relative change in untaxed beverage consumption in Oakland (the DiD estimate) is not statistically significant.

For children, we do not find substantial changes in consumption of taxed or untaxed beverages (Table 6). There was a slight (although not precisely estimated) increase in the grams of sugar consumed from beverages in Oakland and comparison communities. There was little change in the frequency of taxed beverages overall or for specific types of SSBs (regular soda and sweetened fruit drinks – Appendix Table A12). Similarly, there was little change in consumption of untaxed beverages overall and for specific beverage types (e.g., bottled water and milk).

In Table 7, we report regression estimates of the impact of the tax on grams of added sugars consumed and frequency of consumption overall and for several beverage types for adults and children.[37] We find a small and not precisely estimated relationship between the tax and grams of added sugar consumed for adults and nearly no change for children. We find a fairly

[36] Bottled water is the most commonly consumed untaxed beverage and is consumed 60 times per month, on average. Cawley et al. (2018b) report similar patterns in Philadelphia; i.e., higher consumption of untaxed beverages and bottled water being the most commonly consumed untaxed beverage.

[37] The estimates are similar when we restrict the sample to respondents with complete records of all beverages consumed in both survey waves, as shown in Appendix Table A13.

substantial decline in the frequency of taxed beverages, 9.22 fewer times per month, which is roughly one fewer times every three days and is a large percentage decline compare to the mean before the tax of 22.63 times per month. However, the decline is not statistically significant, and as we see in Table 6, much of the DiD estimate is due to an increase in consumption among residents in the comparison areas, not a decline in consumption among Oakland residents. Among SSBs, the largest decline is for sweetened fruit drinks. Oakland residents consumed these beverages 7.14 fewer times per month after the tax compared to those living in the comparison areas. For untaxed beverages, we estimate that there was an increase in the frequency of consumption, although the increase is not statistically significant, and we see in Table 6 that this result is driven by a decline in consumption among residents living in the comparison areas.

We do not find a substantial change in beverage consumption for children. The estimated change in grams of added sugars consumed from beverages is close to zero (0.29 grams, on average). Similarly, the estimated change in the frequency of consumption of taxed beverages is small and not statistically significant (2.72 more grams of sugar consumed from beverages after the tax). In addition, we do not find a substantial change in the frequency of consumption of untaxed beverages for children overall and for individual beverage types. The one exception is that we find an increase in the frequency of milk consumption, an extra 10 beverages per month; however, from Appendix Table A12, this change is driven by a reduction in comparison communities.

In Table 8, we report the impact of the tax on whether adults and children consume taxed and untaxed beverages at all and whether they consume them daily. We find declines in consumption for some specific taxed beverage types, but they do not add to a substantial overall decline in consumption of taxed beverages. There were small and statistically insignificant reductions in the probabilities that adults consume taxed beverages overall (a 1.7 percentage point decline for any consumption and a 1.2 percentage point decline for daily consumption). The two types of SSBs (regular soda and sweetened fruit drinks) showed fairly sizable declines in any consumption, a 7.3 percentage point decline in the probability of any consumption of regular soda compared to 75.14 percent before the tax and a 12.0 percentage point decline for sweetened fruit drinks compared to 69.49 percent. There were also declines in daily consumption of regular soda and sweetened fruit drinks, but the declines were not statistically significant. We do not find substantial changes in any or daily consumption of untaxed beverages.

For children, we find negative relationships between the tax and consumption and some evidence of a decline in any and daily consumption overall. Reporting any consumption declined by 6.4 percentage points for all taxed beverages compared to 83.57 percent before the tax (statistically significant at the 10 percent level). We find a negative relationship between the tax and daily consumption, but the decline is not precisely estimated. We estimate negative relationships between specific taxed beverages, but the declines are generally not statistically significant, with the exception of regular soda. We find a fairly sizable decline in the probability of reporting any consumption of regular soda (11.0 percentage point decline compared to 64.83 percent before the tax, statistically significant at the 10 percent level). We do not find substantial changes in any or daily consumption of untaxed beverages overall or by beverage type, with the exception of a decline for any fruit juice consumption (11.8 percentage point decline compared to 87.44 percent before the tax).

Heterogeneity of impacts

We examined the impact of the tax on consumption among African-American and Hispanic adults and children, two populations that have relatively high rates of consumption and diet-related health conditions. We also examined the impact of the tax on older children (over age 10), who have higher consumption of SSBs before the tax. We do not find substantial changes in consumption for these populations for adults or children (Appendix Table A14). We find that children over age 10 increased consumption after the tax, although the changes are not precisely estimated.

We also examined the impact of the tax among various low-income populations. These populations are of particular interest because low incomes are associated with higher rates of SSB consumption and diet-related health conditions. In addition, the tax and resulting higher prices could have particularly large effects on budgets for these households, leading to larger declines in consumption. We do not find substantial changes in consumption based on whether the household lives below the federal poverty level or the adult respondent has a high school education or less. We find some evidence of reductions in consumption for those in households receiving SNAP or WIC benefits, particularly among children. Children reduced the frequency of consumption of taxed beverages by 6.42 (SNAP) and 9.98 times per month (WIC). Children also reduced grams of added sugars consumed from beverages by 8.12 (SNAP) and 9.87 (WIC), although the results are only marginally statistically significant. For adults, the changes are not as

consistently negative, large, or precisely estimated, but they mostly point to decreased consumption for adults living in households receiving SNAP or WIC benefits.

We examined potential differential impacts of the tax among subgroups that we hypothesized could be more likely to reduce consumption: (1) those with positive views of the tax and awareness of the health impacts of SSBs, (2) those less likely to shop outside of the city, and (3) those with high baseline consumption. We find consistently negative relationships between the tax and consumption (grams of sugar and frequency of consumption) for adults with positive views of the tax, awareness that SSBs are bad for your health, and trying to reduce consumption of SSBs; however, the changes are not statistically significant. We also find some evidence that adults reporting that they do not shop outside of Oakland and those living farther from the closest untaxed store reduced consumption, although the estimates are not consistently statistically significant across the two subgroups and outcomes. Finally, we do not find a relationship between consumption before the tax and changes in consumption after the tax for adults, and in fact, we find an increase in consumption after the tax for children with the highest levels of consumption before the tax (Appendix Figures A1-A4).

V. Discussion

In this paper, we provide important evidence on the impacts of SSB taxes on a variety of outcomes, including prices, purchases, and consumption. We contribute to the evidence base by providing the first evidence regarding the tax in Oakland, California. For Oakland, we find less than full pass-through (roughly 60 percent) of the SSB tax, some evidence of a moderate decline in sales of SSBs in Oakland, an increase in the volume of beverages bought through cross-border shopping, and little evidence of substantial changes in beverage consumption.

As the evidence base regarding the effects of SSB taxes grows, it is becoming evident that their effects tend to vary across cities. Some of the difference across cities may be due to differences in the design of the tax (e.g., the Philadelphia tax is larger and includes non-caloric sweetened beverages) or the characteristics of the cities (e.g., Philadelphia is much larger in area and population and had higher baseline consumption of SSBs). The SSB tax in Oakland provides an interesting point of comparison because its tax is similar to that in Berkeley (one-cent per ounce, excludes non-caloric sweetened beverages) but Oakland's population is much larger than that of Berkeley and is also more diverse in its racial and ethnic composition and

sociodemographic characteristics. In addition, Oakland is unique in that there were three other municipalities nearby that had SSB taxes at the time or shortly after its tax was implemented (Albany, Berkeley, and San Francisco, California), which limited residents' ability to shop for untaxed beverages outside of the city.

Roughly 60 percent of Oakland's one-cent per ounce tax was passed through to consumers in the form of higher retail prices. To put this in context, the price of a 20-ounce Coca Cola increased by 10.80 cents (0.54 cents per ounce) on average relative to comparison communities, which is a 5.76 percent increase in the pre-tax price in Oakland. The price of a 2-liter bottle of Coca Cola increased by 41.25 cents (0.61 cents per ounces) on average, which is a 17.53 percent increase in the pre-tax price, and the price of a 12-pack of 12-ounce Coca Cola cans increased by 99.36 cents (0.69 cents per ounce) on average, which is a 15.75 percent increase in the pre-tax price.

This pass-through rate in Oakland (60 percent) is greater than the 40 to 50 percent found in Berkeley (Cawley and Frisvold, 2017; Falbe et al., 2015). However, it is lower than the rates found in Boulder, Colorado (roughly 80 percent found in Cawley et al. [2018c]) and Philadelphia, where Cawley et al. (2018a) and Seiler, Tuchman, and Yao (2019) found full pass through of the tax, and Roberto et al. (2019) found full pass-through at pharmacies but less pass-through at supermarkets and mass merchandise stores among large chain stores. Factors that likely influence the degree of pass-through include households' access to untaxed options (including untaxed beverages and stores selling SSBs outside of the taxed area) and, more generally, the variation in the price elasticity of demand among households in these cities.

The lack of a decline in consumption in Oakland is in contrast with findings in Berkeley; Falbe et al. (2016) and Lee et al. (2019) found 24 percent and 50 percent reductions in consumption after six months and three years, respectively. Cawley et al. (2018b), which is the most directly comparable study in Philadelphia, found some evidence of declines in consumption for subgroups (particularly for regular soda) although not a substantial decline overall. Zhong et al. (2018) found a decrease in regular soda consumption among adults but not for other types of SSBs, and Roberto et al. (2019) found larger decreases in sales at large chain stores, respectively. Seiler, Tuchman, and Yao (2019) did not find substantial impact on calories and sugar intake. It is possible that the price increases in Oakland are not high enough to induce substantial changes

in consumption. This finding is consistent with Alcott, Lockwood, and Taubinsky (2018), in which the authors estimate that the optimal tax is between 1.5 and 2.5 cents per ounce.

Regarding cross-border shopping, Cawley et al. (2018b) found similar evidence that the tax induced Philadelphia residents to increase shopping for beverages outside of the city (a slight increase in ever shopping outside the city and a large increase in reporting a store outside the city is the usual source of beverage purchases). Although, the study in Philadelphia also provides direct evidence of increased purchases of SSBs at stores outside of Philadelphia, whereas this study does not provide similar evidence for Oakland. In addition, while other studies do not have directly comparable estimates, they find evidence of substantial cross-border shopping (Seiler et al., 2019; Roberto et al., 2019).

We also find a decline in the availability of SSBs at Oakland stores, which is another possible (non-price) mechanism by which the SSB tax could affect purchases, consumption and health. We find a decline in the probability that Oakland stores sell SSBs of 7.71 percentage points, or 13.56 percent. This finding is consistent with the decrease in availability of taxed beverages after Philadelphia implemented its tax (Cawley et al., 2018b). However, in contrast to Philadelphia, and our expectations, Oakland stores also carried fewer of the untaxed beverages after the tax. We found a decrease of 5.24 percentage points, which is a 12.79 percent decrease in the pre-tax value. The decline was concentrated in independent retailers and in small single-serving bottles of water. It is important to note that, although we record the price and availability of the most commonly-sold brands, we do not have data for all brands and sizes; it is possible that the tax caused a shift away from the type of beverages included in our study and toward other beverage brand and size combinations that we do not observe.

We observe a small decrease in SSB purchases in Oakland (of 5.51 fewer ounces per shopping trip), which translates to roughly 88.16 fewer ounces or just over four fewer 20-ounce bottles purchased per month.[38] We also found an increase of similar size in purchases outside the city (4.64 more ounces per shopping trip), which led to a somewhat sizable relative decrease in Oakland. This relative decline is potentially due in part to cross-border shopping; i.e., the estimate could reflect a spillover effect of the tax by causing shoppers in Oakland to shop more

[38] We assume an average of 16 trips per month (Ver Ploeg, Larimore, and Wilde, 2017). If we estimate the change relative to consumers in stores in the comparison areas, the decline is 10.15 fewer ounces per shopping trip and 162.40 fewer ounces purchased per month, which is more than a 12-pack of 12-ounce cans or two 2-liter bottles.

outside of the city rather than an impact estimate of the tax on changes in purchases. However, many of the comparison stores are fairly far away from Oakland; for example, 13 of the stores are in Richmond, California, which is separated from Oakland by Berkeley. Twenty of the stores are in Pittsburg or Antioch, which are over 30 miles from Oakland. In addition, we found very few Oakland residents shopping at these stores (32 before the tax and 40 after the tax, which is roughly 5 percent of all shoppers interviewed).

In addition to observing a small increase in SSB purchases outside of Oakland, responses by shoppers in exit interviews and households surveys provides some evidence of cross-border shopping. Oakland residents were much more likely to report that a store outside of the city is their usual source of beverage purchases after the tax, a 10.3 percentage point increase, which is a 42 percent increase on the pre-tax percentage of 24.6. In contrast, there was only a small increase in the percentage of households reporting that they ever shop for beverages outside of the city; roughly half of respondents reported shopping outside the city before the tax, which increased by roughly five percentage points after the tax. Similar to findings in Philadelphia, it could be that the tax did not induce households to start shopping for beverages across the border, but it induced some households already shopping across the border to purchase a higher proportion of their beverages outside of the city (Cawley et al., 2018b). The geography of the region and existence of SSB taxes in other nearby municipalities likely play a role in the degree of cross-border shopping in Oakland. For example, Oakland has San Francisco Bay to the west, large areas of park lands to the east, and Berkeley (which has an SSB tax) to the north. Thus, there are limited nearby untaxed options for Oakland residents to cross the border to avoid the tax. Conversely, Oakland is not a large city, and the average distance to an untaxed store from households in our sample is less than two miles, so there are nearby untaxed options for residents.

The estimated changes in consumption, in addition to not being statistically significant, are generally small. A 3 gram reduction for adults in sugar consumed from beverages is roughly 12 fewer calories per day; the 0.3 gram reduction for children is just over one fewer calorie per day. The one beverage where we find the most evidence of a change is regular soda, particularly in any and daily consumption; Cawley et al. (2018b) found in Philadelphia that the most substantial and precisely estimated changes in consumption were for regular soda. We find reductions in any regular soda consumption for adults and children. We caution that the results

for regular soda could in part be due to random chance given the number of outcomes and subgroups examined in this analysis (i.e., the multiple comparisons problem). However, this result is robust across cities. One possible explanation is that the popular press often refers to it as a "soda tax," which might make the tax particularly salient for regular soda and less associated in the public with other types of beverages.

The findings of incomplete pass-through, small changes in purchases, and evidence of greater cross-border shopping are consistent with negligible changes in overall consumption of SSBs for adults and children. In addition, consumption of SSBs was low before the tax was implemented; both adults and children consumed SSBs less than once per day on average and 16 percent did not consume SSBs at all. Thus, there was not a lot of room to reduce average consumption for many adults and children.

There are several limitations of the analysis to consider when examining the estimated impacts of the tax in Oakland. First, to estimate the impacts of the tax on price and consumption, we rely on the assumption that the pre-period trends in these variables in our Oakland and comparison stores were parallel. While we have indirect evidence that the trends were parallel before the tax for regular soda in stores in Oakland and those outside the city but in the same MSA (which is where we draw our matched comparison group from), we do not have direct evidence that the parallel trends assumption is satisfied in the stores or among the consumers in the study. The indirect evidence among all stores in the region plus the fact that we matched comparison to Oakland stores based on store type and local population characteristics give us more confidence that the parallel trends assumption is satisfied. Second, we estimate the impact of the tax on self-reported consumption, and although our ability to estimate impacts on consumption rather than just purchases is an advantage of the study, the reports are subject to the measurement error concerns inherent in all self-reported data. Because we estimate relative changes in consumption conditioned on consumption prior to the tax, measurement error from self reports is only a threat to estimation of the impacts if there is differential measurement error between Oakland and comparison households and between the pre-tax and post-tax periods. For example, if Oakland residents inflated their reported consumption in the pre-tax period because they knew the tax was coming and they would eventually reduce consumption, but those in comparison communities did not do the same, and Oakland residents did not do the same in the post-tax period. Third, we examine a host of outcomes and subgroups in the analysis, and the

few statistically significant estimates could be due to chance, particularly since much of the other evidence suggests that there was no substantial change in consumption. To minimize the risk of overstating the findings, we do not focus on individual results for specific outcomes and subgroups, but instead, we focus on consistent patterns across outcomes for individual subgroups and across subgroups. We also weigh the overall outcomes for all beverage types more heavily when interpreting the results, i.e., grams of sugar consumed from beverages, monthly frequency of SSB consumption, and any or daily consumption of SSBs. Finally, although using a matched group in the Oakland MSA of comparison stores and shoppers at these stores has the benefit of the same regional factors influencing prices and sales of beverages as the stores in Oakland, there is the risk that there is a spillover effect of the tax in comparison communities. For example, if comparison stores near the Oakland border raised prices somewhat because they compete against Oakland stores that raised their prices substantially, we would underestimate the impact of the tax on prices. Also, if households in comparison communities reduced their consumption because of the tax (e.g., due to the increased knowledge of the health effects of SSBs or because they shop for beverages in Oakland), we would underestimate the impact of the tax. However, as discussed above, the comparison stores included in the study are fairly far from Oakland, which decreases the likelihood of spillover effects, and in the case of prices, we did not find differential effects by the proximity of Oakland stores to their nearest untaxed competitor.

In this paper, we provide the first estimated impacts of the tax in Oakland, an important policy with the potential to change consumption and improve health. The approach to the analysis has several key features that distinguish it from much of the past literature on SSB taxes. Namely, we provide direct evidence on reported consumption. Consumption, although certainly correlated with purchases, is not the same, and it is the outcome that ultimately affects health. We also use longitudinal data on households to directly compare reported consumption and shopping behavior before and after the tax rather than comparing repeated cross-sections of different respondents. The study is also only the second study that provides evidence of SSB taxes on children's beverage consumption. The evidence generated from Oakland can be used to compare to SSB tax policies in other cities and assess the degree to which details impact the efficacy of the tax in reducing consumption and improving health. For example, the geography of the local area, the region covered by the tax (city, state, or nation), and the amount of the tax can contribute to its efficacy. By considering the findings in this study and the details of the

Oakland tax in the context of the literature on other city-level taxes and their details, policymakers can design effective policies that are more likely to achieve their aims.

References

Allcott, H., Lockwood, B. B., & Taubinsky, D. (2018). Regressive Sin Taxes, with an Application to the Optimal Soda Tax. Working Paper, https://site.stanford.edu/sites/g/files/sbiybj8706/f/4786-regressive_sin_taxes.pdf.

Bollinger, B. & Sexton, S. (2018). Local excise taxes, sticky prices, and spillovers: evidence from Berkeley's soda tax. Working Paper, SSRN, Rochester, N.Y.

Cawley, J., & Frisvold, D. E. (2017). The Pass-Through of Taxes on Sugar-Sweetened Beverages to Retail Prices: The Case of Berkeley, California. *Journal of Policy Analysis and Management*, *36*(2), 303–326.

Cawley, J., Willage, B., & Frisvold, D. (2018). Pass-Through of a Tax on Sugar-Sweetened Beverages at the Philadelphia International Airport. *Journal of the American Medical Association*, *319*(3), 305–306.

Cawley, J., Frisvold, D.E., Hill, A., & Jones, D.J. (2018a). The Impact of the Philadelphia Beverage Tax on Prices and Product Availability. NBER Working Paper #24990, https://www.nber.org/papers/w24990.

Cawley, J., Frisvold, D.E., Hill, A., & Jones, D. (2018b). The Impact of the Philadelphia Beverage Tax on Prices and Product Availability. Journal of Health Economics, forthcoming

Cawley, J., Crain, C., Frisvold, D., Jones, D. (2018c). The pass-through of the largest tax on sugar-sweetened beverages: the case of Boulder, Colorado. NBER Working Paper #25050, https://www.nber.org/papers/w25050.

Cawley, J., Thow, A.M., Wen, K., & Frisvold, D. (2019) The Economics of Taxes on Sugar-Sweetened Beverages: A Review of the Effects on Prices, Sales, Cross-Border Shopping, and Consumption. *Annual Review of Nutrition*, *39*.

Chetty, R., Looney, A., & Kroft, K. (2009). Salience and Taxation: Theory and Evidence. *American Economic Revie*w, 99(4), 1145–1177.

DellaVigna, S., & Gentzkow, M. (2017). Uniform Pricing in U.S. Retail Chains. NBER Working Paper #23996.

Donald, S. G., & Lang, K. (2007). Inference with Difference-in-Differences and Other Panel Data. *Review of Economics and Statistics*, *89*, 221–233.

Falbe, J., Rojas, N., Grummon, A. H., & Madsen, K. A. (2015). Higher Retail Prices of Sugar-Sweetened Beverages 3 Months After Implementation of an Excise Tax in Berkeley, California. *American Journal of Public* Health, 105, 2194–2201.

Falbe, J., Thompson, H.R., Becker, C.M., Rojas, N., McCulloch, C.E., & Madsen, K.A. (2016). Impact of the Berkeley Excise Tax on Sugar-Sweetened Beverage Consumption. *American Journal of Public Health*, *106*(10), 1865–1871.

Imbens, G.W., &. Wooldridge, J. M. (2009). Recent Developments in the Econometrics of Program Evaluation. *Journal of Economic Literature, 47*(1), 5–86.

Johnson R.K., Appel L.J., Brands M., Howard B.V., Lefevre M., Lustig, R.H., Sacks, F., Steffen, L.M., & Wylie-Rosett, J. (2009). Dietary sugars intake and cardiovascular health: a scientific statement from the American Heart Association. *Circulation, 120*, 1011–20.

Lee, M.M., Falbe, J., Schillinger, D., Basu, S., McCulloch, C.E., & Madsen, K.A. (2019). Sugar-Sweetened Beverage Consumption 3 Years After the Berkeley, California, Sugar-Sweetened Beverage Tax. *American Journal of Public Health, 109*, 637–639.

Leider J., Pipito, A., & Powell, L. (2018). The Impact of the Cook County, Illinois, sugar sweetened beverage tax on prices, 2017. Chicago: Illinois Prevention Research Center. University of Illinois at Chicago.

Lin, Biing-Hwan, Travis A. Smith, Jonq-Ying Lee, Kevin D. Hall. (2011). Measuring weight outcomes for obesity intervention strategies: The case of a sugar-sweetened beverage tax. *Economics & Human Biology, 9*(4), 329–341.

Malik, V.S., & Hu, F.B. (2011). Sugar-Sweetened Beverages and Health: Where Does the Evidence Stand? *American Journal of Clinical Nutrition*, *94*, 1161–1162.

National Cancer Institute. *Dietary Screener Questionnaire (DSQ) in the NHANES 2009–10: Data Processing & Scoring Procedures*. Retrieved from https://epi.grants.cancer.gov/nhanes/dietscreen/scoring.

Roberto, C.A., Lawman, H. G., LeVasseur, M.T., Mitra, N., Peterhans, A., Herring, B., & Bleich, S. (2019). Association of a Beverage Tax on Sugar-Sweetened and Artificially Sweetened Beverages With Changes in Beverage Prices and Sales at Chain Retailers in a Large Urban Setting. *JAMA, 321*(18), 1799-1810.

Rojas, C., & Wang, E. (2017). Do taxes for soda and sugary drinks work? Scanner data evidence from Berkeley and Washington. Working Paper, SSRN, Rochester, N.Y., https://dx.doi.org/10.2139/ssrn.3041989.

Seiler, S., Tuchman, A., & Yao, S. (2019). The Impact of Soda Taxes: Pass-through, Tax Avoidance, and Nutritional Effects. Working Paper #3752, Stanford Graduate School of Business, https://www.gsb.stanford.edu/faculty-research/working-papers/impact-soda-taxes-pass-through-tax-avoidance-nutritional-effects.

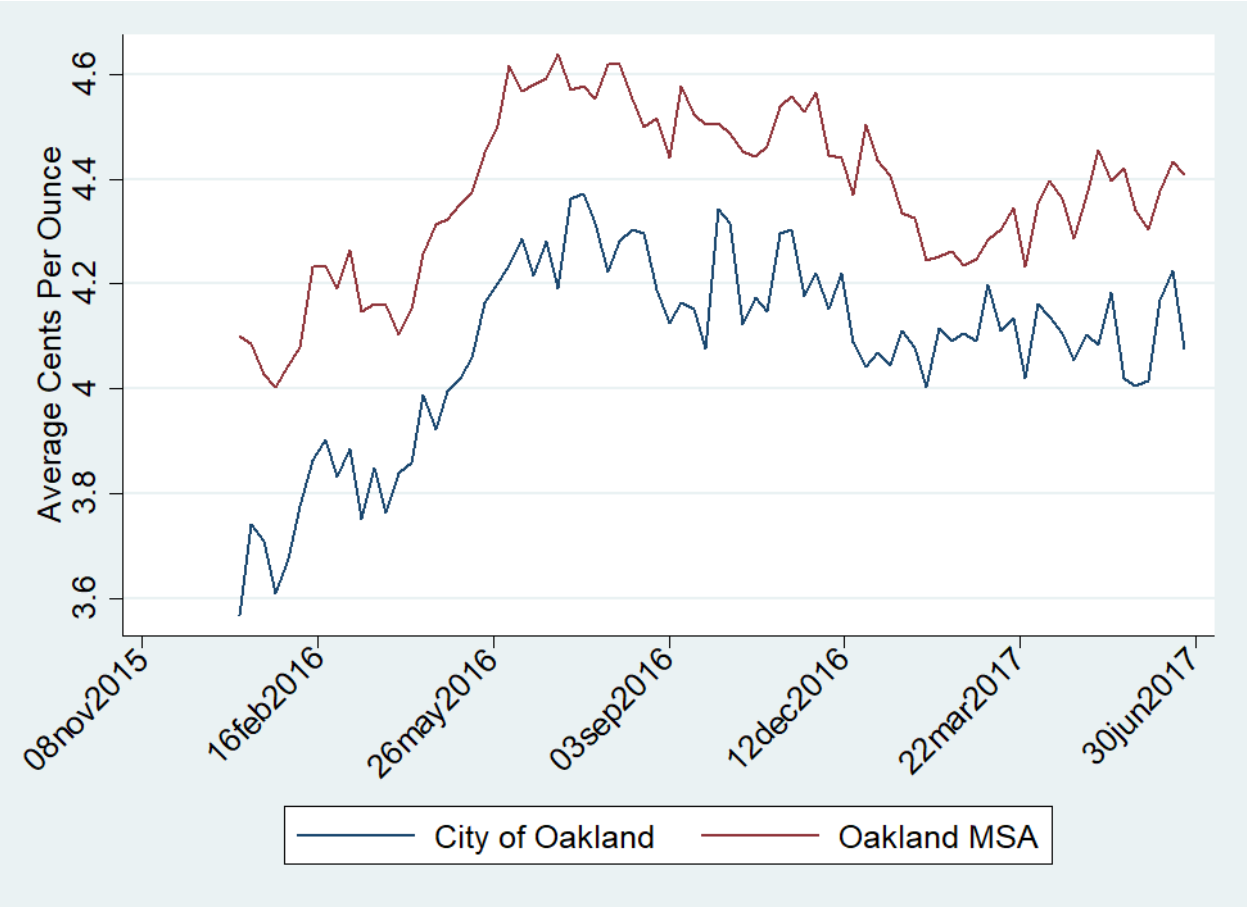
Silver, L.D., Ng, S.W., Ryan-Ibarra, S., Taillie, L.S., Induni, M., Miles, D.R., Poti, J.M., & Popkin, B.M. (2017). Changes in prices, sales, consumer spending, and beverage consumption one year after a tax on sugar-sweetened beverages in Berkeley, California, US: a before-and-after study. *PLOS Medicine*, 14:e1002283.

Smith, Adam. 1776. The Wealth of Nations. Book V, Chapter 3.

Ver Ploeg, Michele, Elizabeth Larimore, and Parke Wilde. (2017). *The Influence of Foodstore Access on Grocery Shopping and Food Spending*, EIB-180, U.S. Department of Agriculture, Economic Research Service, October 2017.

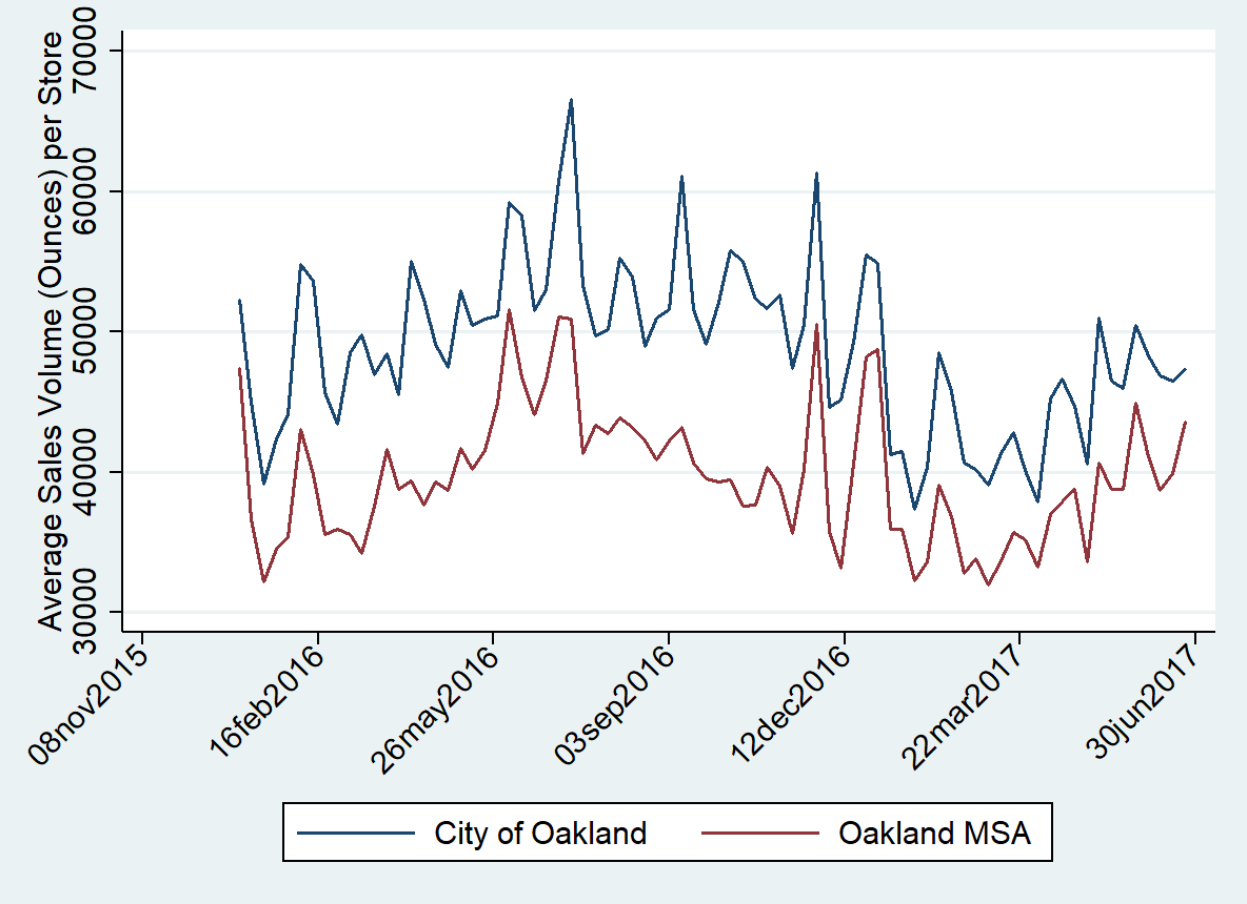
Zhong, Y., Auchincloss, A.H., Lee, B.K., & Kanter, G.P. (2018). The Short-Term Impacts of the Philadelphia Beverage Tax on Beverage Consumption. *American Journal of Preventive Medicine*, *55*(1), 26–34.

Figure 1: Average Weekly Price per Ounce of Regular Soda in the 18 Months Prior to the Oakland SSB Tax (January 2016 to June 2017)



Notes: This figure shows the average weekly price per ounce of regular soda in retail stores in Oakland and in the Oakland MSA in the 18 months leading up to the tax (January 2016 to June 2017). The conclusions drawn from the Nielsen data are those of the researchers and do not reflect the views of Nielsen. Nielsen is not responsible for, had no role in, and was not involved in analyzing and preparing the results reported herein.
Source: Researcher(s) own analyses calculated (or derived) based in part on data from The Nielsen Company (US), LLC and marketing databases provided through the Nielsen Datasets at the Kilts Center for Marketing Data Center at The University of Chicago Booth School of Business.

Figure 2. Average Weekly Sales Volume of Regular Soda per Store in the 18 Months Prior to the Oakland SSB Tax (January 2016 to June 2017)



Notes: This figure shows the average weekly sales volume of regular soda per retail stores in Oakland and in the Oakland MSA in the 18 months leading up to the tax (January 2016 to June 2017). The conclusions drawn from the Nielsen data are those of the researchers and do not reflect the views of Nielsen. Nielsen is not responsible for, had no role in, and was not involved in analyzing and preparing the results reported herein.
Source: Researcher(s) own analyses calculated (or derived) based in part on data from The Nielsen Company (US), LLC and marketing databases provided through the Nielsen Datasets at the Kilts Center for Marketing Data Center at The University of Chicago Booth School of Business.

Table 1: Average Price per Ounce of Beverages Before and After the Implementation of the SSB Tax (One Cent per Ounce) in Oakland

	Stores in Oakland			Comparison Stores			
	2017	2018	Difference	2017	2018	Difference	DiD
Taxed Beverages	7.95	8.94	1.00	7.91	8.24	0.33	0.66
	(0.22)	(0.25)	(0.33)	(0.22)	(0.22)	(0.31)	(0.46)
	[905]	[767]	[1,672]	[1,048]	[986]	[2,034]	[3,706]
Untaxed Beverages	9.92	10.16	0.24	9.51	9.49	-0.03	0.27
	(0.31)	(0.36)	(0.48)	(0.28)	(0.28)	(0.40)	(0.62)
	[608]	[493]	[1,101]	[762]	[732]	[1,494]	[2,595]

Notes: This table shows the mean price per ounce among beverages for the listed categories. Standard errors are in parentheses, and sample sizes are in brackets. The sample sizes are store-beverage combinations. In Oakland, there were 70 stores in April-June 2017 and 61 stores in April-June 2018. In the Oakland MSA, there were 87 comparison stores in April-June 2017 and 75 stores in April-June 2018. Taxed beverages include regular soda, sports drinks, energy drinks, juice drinks, and sweetened iced tea. Untaxed beverages include diet soda, other diet drinks (unsweetened sports drinks, energy drinks, and iced tea), 100% fruit juice, and bottled water). DiD = difference-in-differences.

Table 2: The Impact of the SSB Tax on Prices and Product Availability

	Price		
	Full Sample	Balanced Sample	Availability
Taxed Beverages	0.56	0.61	-7.71
	(0.11)	(0.11)	(2.13)
	[3,706]	[2,961]	[6,210]
Untaxed Beverages	0.26	0.21	-5.24
	(0.13)	(0.12)	(1.50)
	[2,595]	[1,928]	[6,256]

Notes: The first two columns show the DiD estimates in cents per ounce (full pass-through is 1.0 cent per ounce) for the beverage category in the row heading and the sample of stores in the column heading. The results in the third column represent the average percentage point change in the availability of beverages in Oakland within the given beverage type compared to the comparison stores. Standard errors, which are robust to clustering at the store level, are in parentheses, and sample sizes are in brackets. The sample sizes are store-beverage combinations. Each cell contains the results from a separate regression. Additional variables that are included, but not shown, are a binary variable indicating that the price or product availability is from after implementation of the tax, store fixed effects, and product fixed effects. Taxed beverages include regular soda, sports drinks, energy drinks, juice drinks, and sweetened iced tea. Untaxed beverages include diet soda, other diet drinks (unsweetened sports drinks, energy drinks, and iced tea), 100% fruit juice, and bottled water).

Table 3. Beverage Purchases (Ounces) Before and After the Implementation of the Beverage Tax in Oakland

	Consumers at Stores in Oakland			Consumers at Stores in Comparison Communities			
	Pre-tax	Post-tax	Diff.	Pre-tax	Post-tax	Diff.	DiD
Ounces purchased							
Taxed Beverages	19.26 (3.91)	13.75 (2.52)	-5.51 (4.65)	12.14 (-2.79)	16.78 (4.45)	4.64 (5.25)	-10.15 (7.01)
Untaxed Beverages	36.52 (7.12)	46.71 (9.31)	10.18 (11.72)	24.96 (6.78)	25.42 (10.47)	0.46 (12.48)	9.72 (17.12)
Observations	785	786	1,571	741	766	1,507	3,078

Notes: This table shows the mean ounces purchased among all beverages for the listed categories. Standard errors are in parentheses. The number of observations reported reflect the total number of exit interviews conducted (note, the actual number of observations varies slightly by beverage type based on a missing values for some beverage types). Taxed Beverages include regular soda, sports drinks, energy drinks, juice drinks, sweetened coffee and tea. Untaxed beverages include bottled water, diet soda, diet versions of sports and energy drinks, unsweetened coffee and tea, and 100% juice.
Diff. = Difference; DiD = difference-in-differences.

Table 4. The Impact of the Tax on Beverage Purchases (Any Purchases and Ounces Purchased)

	Any purchases	Ounces purchased
Taxed Beverages	-4.19	-11.33
	(6.10)	(8.36)
	[2,720]	[2,720]
Untaxed Beverages	10.76	10.07
	(4.49)	(15.65)
	[2,726]	[2,726]

Notes: This table shows the difference-in-differences estimates for any purchases and the ounces purchased for the product categories in the row headings. Standard errors, which are robust to clustering at the store level, are in parentheses, and sample sizes are in brackets. The rows contain the results of two-part regressions (logistic regressions in the first part estimating whether there was a beverage purchase and GLM with a Poisson distribution in the second part for the volume of beverages purchased). Additional variables that are included, but not shown, are age, gender (indicator for female), whether the respondent is African-American, whether the respondent is Hispanic, household size, whether household income is below the FPL, whether the respondent is an Oakland resident, indicators for days of the week, time of day, day of the study, whether the interview location is in Oakland, whether the interview occurred after implementation of the tax, and store-type indicators. Taxed Beverages include regular soda, sports drinks, energy drinks, juice drinks, sweetened coffee and tea. Untaxed beverages include bottled water, diet soda, diet versions of sports and energy drinks, unsweetened coffee and tea, and 100% juice.

Table 5. Estimates of Changes in Shopping Behavior Related to Cross-Border Shopping

Change in *Self-Reported* Cross Border Shopping from Exit Interviews	
Interviewed at Oakland store— Oakland residents (reported shopping outside Oakland one or more times per week)	2.98 (5.61) [1,302]
Change in *Self-Reported* Shopping from Household Survey	
Any beverage shopping outside of Oakland (asked only of Oakland residents)	4.65 (5.46) [210]
Usual source of beverage purchases is outside of Oakland	10.33 (3.85) [348]
Price is the primary factor in determining where to purchase beverages	6.54 (6.39) [375]
Travel time to purchase beverages (minutes)	0.79 (1.03) [374]

Notes: The results, with the exception of travel time, are percentage point changes. Standard errors, which are robust to clustering at the store level, are in parentheses, and sample sizes are in brackets. Each cell contains the results of a separate regression. Additional variables that are included, but not shown, are age, gender (indicator for female), whether the respondent is African-American, whether the respondent is Hispanic, household size, whether household income is below 185 percent of the federal poverty level, and whether the interview occurred after implementation of the tax. The regression used to generate the results in the top panel (from exit surveys) also include indicators for days of the week, time of day, day of the study, and store-type. The regressions used to generate the results in the bottom panel (from household surveys) also include an indicator for whether the respondent is an Oakland resident (with the exception of the regression for any shopping outside of Oakland, since the question was asked only of Oakland residents).

Table 6. Mean Consumption Before and After Implementation of the Beverage Tax in Oakland

	Residents of Oakland			Residents of Comparison Communities			
	Pre-tax	Post-tax	Diff.	Pre-tax	Post-tax	Diff.	DiD
Adults							
Added Sugars	18.10	19.25	1.15	28.04	28.17	0.13	1.02
	(2.38)	(2.78)	(2.14)	(6.21)	(5.41)	(3.99)	(4.53)
	[158]	[158]	[158]	[183]	[183]	[183]	[341]
Monthly Frequency							
Taxed Beverages	22.63	23.45	0.83	36.91	39.18	2.27	-1.44
	(3.11)	(3.36)	(3.03)	(9.21)	(7.75)	(6.84)	(7.48)
	[169]	[169]	[169]	[200]	[200]	[200]	[369]
Untaxed Beverages	179.94	170.52	-9.42	192.13	154.35	-37.78	28.37
	(15.19)	(12.15)	(20.13)	(14.70)	(12.81)	(12.99)	(23.95)
	[153]	[153]	[153]	[176]	[176]	[176]	[329]
Children							
Added Sugars	11.94	14.23	2.29	13.49	15.88	2.39	-0.10
	(1.72)	(2.84)	(2.06)	(1.87)	(2.64)	(2.37)	(3.14)
	[148]	[148]	[148]	[170]	[170]	[170]	[318]
Monthly Frequency							
Taxed Beverages	21.81	22.42	0.61	21.90	21.02	-0.87	1.48
	(3.52)	(3.82)	(3.23)	(3.65)	(3.05)	(3.16)	(4.52)
	[158]	[158]	[158]	[182]	[182]	[182]	[340]
Untaxed Beverages	162.47	152.11	-10.36	159.63	144.70	-14.93	4.57
	(11.95)	(10.76)	(14.78)	(9.67)	(8.91)	(11.07)	(18.47)
	[133]	[133]	[133]	[161]	[161]	[161]	[294]

Notes: The figures are the unconditional mean values for the outcome variables (grams of added sugars and frequency of consumption per month by beverage type) for adults and children by time and location. Standard errors are in parentheses. Sample sizes are in brackets. Added sugars are measured in grams, and beverage frequency is measured in times consumed per month. Taxed beverages include regular soda and sweetened fruit drinks, which include sports and energy drinks. Untaxed beverages include water (bottled and tap), diet soda, milk, coffee, and 100% juice.
Diff. = Difference; DiD = difference-in-differences.

Table 7. The Impact of the Beverage Tax on Consumption

	Adults	Children
Grams of Added Sugars	-3.08	0.29
	(3.67)	(3.10)
	[341]	[318]
	22.78	*12.67*
Frequency of Consumption (Times/Month)		
All Taxed Beverages	-9.22	2.72
	(6.18)	(3.96)
	[369]	[340]
	29.34	*21.85*
Regular Soda	-4.53	0.88
	(3.79)	(2.17)
	[383]	[369]
	16.4	*8.71*
Sweetened fruit drinks	-7.14	0.21
	(4.40)	(2.40)
	[386]	[345]
	13.35	*13.55*
Energy Drinks	n.a.	-1.752
		(4.03)
		[173]
		1.38
Untaxed Beverages	13.96	4.65
	(17.01)	(14.28)
	[329]	[294]
	185.6	*161.1*
Diet Soda	-0.73	0.03
	(1.40)	(0.38)
	[400]	[369]
	2.76	*1.08*
Bottled Water	-1.50	-5.08
	(8.14)	(5.37)
	[385]	[355]
	61.15	*46.86*
Coffee	2.22	n.a.
	(4.55)	
	[384]	
	30.97	

Juice	-2.31	-1.16
	(5.21)	(3.84)
	[382]	[354]
	21.92	*22.3*
Milk	2.19	10.12
	(5.85)	(4.88)
	[381]	[358]
	24.94	*36.75*
Tap Water	8.14	7.45
	(6.99)	(8.75)
	[379]	[346]
	55.35	*44.13*

Notes: The figures represent the change in the outcome for households in Oakland relative to those in the comparison communities. Standard errors are in parentheses. Sample sizes are in brackets. The mean values before implementation of the tax are reported in italics below the sample sizes. Added sugars are measured in grams, and beverage frequency is measured in times consumed per month. All regressions were estimated with sample weights and standard errors clustered at the store level.
n.a. = not applicable. We did not ask adults separate questions about consumption of energy drinks; energy drinks are included in the questions about sweetened fruit drinks. We collected information about coffee consumption among children, but very few responded that they drink any coffee.

Table 8. The Impact of the Beverage Tax on Any Consumption and Daily Consumption

	Adults		Children	
	Any	Daily	Any	Daily
All Taxed Beverages	-0.02	-0.01	-0.06	-0.07
	(0.03)	(0.06)	(0.04)	(0.05)
	[369]	[369]	[340]	[340]
	0.84	*0.31*	*0.84*	*0.23*
Regular Soda	-0.07	-0.04	-0.11	-0.02
	(0.04)	(0.04)	(0.07)	(0.04)
	[383]	[383]	[369]	[369]
	0.75	*0.19*	*0.65*	*0.12*
Sweetened fruit drinks	-0.12	-0.05	-0.06	-0.03
	(0.07)	(0.05)	(0.07)	(0.04)
	[386]	[386]	[345]	[345]
	0.69	*0.14*	*0.66*	*0.14*
Energy Drinks	n.a.	n.a.	-0.06	-0.03
			(0.05)	(0.05)
			[173]	[173]
			0.06	*0.02*
Untaxed Beverages	-0.01	-0.03	< 0.01	0.03
	(0.01)	(0.03)	(< 0.01)	(0.04)
	[329]	[329]	[294]	[294]
	1.00	*0.96*	*1.00*	*0.98*
Diet Soda	-0.09	-0.03	-0.07	< 0.01
	(0.06)	(0.03)	(0.05)	(< 0.01)
	[400]	[400]	[369]	[369]
	0.20	*0.04*	*0.12*	*0.01*
Bottled Water	0.02	0.04	-0.03	-0.09
	(0.04)	(0.06)	(0.05)	(0.06)
	[385]	[385]	[355]	[355]
	0.92	*0.62*	*0.84*	*0.52*
Coffee	0.01	0.04	n.a.	n.a.
	(0.05)	(0.07)		
	[384]	[384]		
	0.82	*0.48*		
Juice	-0.01	-0.01	-0.12	-0.02
	(0.05)	(0.05)	(0.04)	(0.05)
	[382]	[382]	[354]	[354]
	0.84	*0.26*	*0.87*	*0.24*
Milk	-0.01	0.01	-0.01	0.08
	(0.04)	(0.08)	(0.03)	(0.06)

	[381]	[381]	[358]	[358]
	0.83	*0.36*	*0.88*	*0.54*
Tap Water	0.03	0.12	0.05	0.10
	(0.07)	(0.06)	(0.05)	(0.06)
	[379]	[379]	[346]	[346]
	0.67	*0.61*	*0.47*	*0.46*

Notes: The outcomes are indicator variables for consuming any of the given beverage in the past month or daily consumption of the given beverage throughout the past month. For additional notes, see Table 7.

APPENDIX A

SUPPLEMENTAL TABLES AND FIGURES

Appendix Table A1: Average Price per Ounce of Beverages Before and After the Implementation of the SSB Tax in Oakland for All Products

	Oakland			Comparison Stores			
	2017	2018	Difference	2017	2018	Difference	DiD
Taxed Beverages							
7-Up, 20 ounces	6.87	9.13	2.26	7.61	8.73	1.12	1.14
	(0.31)	(0.31)	(0.44)	(0.29)	(0.22)	(0.36)	(0.56)
	[53]	[50]	[103]	[60]	[59]	[119]	[222]
7-up, 2 liter	3.42	3.85	0.43	3.02	3.32	0.31	0.13
	(0.08)	(0.12)	(0.14)	(0.10)	(0.17)	(0.19)	(0.24)
	[50]	[44]	[94]	[58]	[51]	[109]	[203]
Arizona Iced Tea,	2.61	3.36	0.75	2.48	2.54	0.05	0.70
1 gallon	(0.07)	(0.13)	(0.14)	(0.05)	(0.04)	(0.07)	(0.15)
	[19]	[18]	[37]	[22]	[25]	[47]	[84]
Arizona Iced Tea,	4.33	4.70	0.37	4.17	4.34	0.17	0.21
23 ounces	(0.13)	(0.15)	(0.20)	(0.07)	(0.04)	(0.09)	(0.21)
	[41]	[33]	[74]	[45]	[39]	[84]	[158]
Coke, 12-pack	4.38	5.01	0.63	4.29	4.22	-0.06	0.69
	(0.10)	(0.12)	(0.16)	(0.10)	(0.07)	(0.13)	(0.21)
	[36]	[29]	[65]	[55]	[52]	[107]	[172]
Coke, 20 ounces	9.37	10.25	0.87	9.13	9.47	0.33	0.54
	(0.10)	(0.15)	(0.18)	(0.11)	(0.20)	(0.22)	(0.30)
	[62]	[55]	[117]	[74]	[66]	[140]	[257]
Coke, 2 liter	3.48	4.09	0.61	3.35	3.36	0.00	0.61
	(0.07)	(0.08)	(0.10)	(0.10)	(0.08)	(0.13)	(0.17)
	[59]	[52]	[111]	[73]	[63]	[136]	[247]
Gatorade, 20	8.87	9.20	0.33	8.31	8.94	0.62	-0.29
ounces	(0.18)	(0.31)	(0.34)	(0.22)	(0.19)	(0.29)	(0.45)
	[56]	[43]	[99]	[59]	[55]	[114]	[213]
Gatorade, 8-pack	4.14	5.34	1.20	3.36	3.62	0.26	0.94
20 ounces	(0.48)	(0.43)	(0.65)	(0.30)	(0.24)	(0.41)	(0.79)
	[11]	[10]	[21]	[11]	[8]	[19]	[40]
Hawaiian Punch,	2.29	3.50	1.21	2.44	2.44	-0.01	1.22
1 gallon	(0.21)	(0.18)	(0.27)	(0.13)	(0.17)	(0.21)	(0.34)
	[11]	[12]	[23]	[16]	[13]	[29]	[52]
Hawaiian Punch,	6.08	5.76	-0.32	6.49	5.74	-0.74	0.42
20- ounces	(0.41)	(0.33)	(0.67)	(0.59)	(0.47)	(0.77)	(1.02)
	[22]	[9]	[31]	[14]	[12]	[26]	[57]
Minute Maid	8.93	9.78	0.86	8.68	8.81	0.13	0.73
Lemonade, 20	(0.25)	(0.29)	(0.39)	(0.41)	(0.31)	(0.50)	(0.64)
ounces	[31]	[27]	[58]	[24]	[35]	[59]	[117]
Minute Maid	2.93	3.39	0.46	2.86	2.91	0.05	0.41
Lemonade, 2 liter	(0.27)	(0.28)	(0.40)	(0.24)	(0.27)	(0.36)	(0.55)
	[12]	[9]	[21]	[15]	[13]	[28]	[49]
Lipton Iced Tea,	8.69	9.25	0.56	6.63	8.78	2.15	-1.59
20 ounces	(0.49)	(0.70)	(0.83)	(1.66)	(0.33)	(1.69)	(1.72)
	[12]	[7]	[19]	[3]	[3]	[6]	[25]
Mountain Dew,	9.34	10.10	0.76	9.11	9.24	0.13	0.63

20 ounces	(0.13)	(0.17)	(0.21)	(0.15)	(0.14)	(0.21)	(0.30)
	[53]	[46]	[99]	[59]	[60]	[119]	[218]
Mountain Dew, 2 liter	3.43	4.12	0.69	3.13	3.22	0.10	0.59
	(0.08)	(0.10)	(0.13)	(0.08)	(0.06)	(0.10)	(0.16)
	[47]	[36]	[83]	[49]	[52]	[101]	[184]
Pepsi,12-pack 12-ounces	4.14	4.98	0.84	4.18	4.16	-0.02	0.86
	(0.13)	(0.15)	(0.20)	(0.11)	(0.08)	(0.14)	(0.24)
	[32]	[26]	[58]	[49]	[41]	[90]	[148]
Pepsi, 20 ounces	9.36	10.21	0.85	9.04	9.27	0.23	0.62
	(0.10)	(0.16)	(0.18)	(0.14)	(0.12)	(0.18)	(0.26)
	[59]	[51]	[110]	[71]	[64]	[135]	[245]
Pepsi, 2 liter	3.45	4.11	0.66	3.15	3.27	0.12	0.54
	(0.08)	(0.08)	(0.11)	(0.07)	(0.06)	(0.09)	(0.14)
	[52]	[43]	[95]	[62]	[58]	[120]	[215]
Red Bull, 4-pack 8.4 ounces	23.44	25.27	1.83	23.78	24.16	0.39	1.45
	(0.45)	(0.85)	(0.94)	(0.37)	(0.35)	(0.51)	(1.00)
	[17]	[16]	[33]	[35]	[42]	[77]	[110]
Red Bull, 8.4 ounces	28.98	29.26	0.28	29.36	28.82	-0.54	0.82
	(0.36)	(0.40)	(0.54)	(0.39)	(0.29)	(0.50)	(0.73)
	[59]	[56]	[115]	[67]	[59]	[126]	[241]
Sprite, 20 ounces	9.32	10.22	0.90	9.14	9.54	0.40	0.50
	(0.12)	(0.15)	(0.19)	(0.12)	(0.20)	(0.23)	(0.30)
	[60]	[53]	[113]	[66]	[61]	[127]	[240]
Sprite, 2 liter	3.54	4.04	0.50	3.22	3.43	0.21	0.29
	(0.06)	(0.09)	(0.11)	(0.08)	(0.14)	(0.16)	(0.20)
	[51]	[42]	[93]	[61]	[55]	[116]	[209]
Untaxed Beverages							
Apple Juice, 10-pack boxes	7.65	7.32	-0.33	6.83	7.17	0.34	-0.67
	(0.51)	(0.28)	(0.55)	(1.22)	(0.62)	(1.65)	(1.85)
	[5]	[6]	[11]	[8]	[5]	[13]	[24]
Apple Juice, 15.2 ounces	13.00	15.07	2.06	13.28	12.49	-0.78	2.85
	(0.28)	(0.87)	(0.76)	(0.30)	(0.37)	(0.51)	(0.93)
	[34]	[6]	[40]	[41]	[18]	[59]	[99]
Aquafina, 20 ounces	8.53	8.85	0.32	7.87	7.79	-0.08	0.40
	(0.31)	(0.41)	(0.51)	(0.24)	(0.24)	(0.34)	(0.59)
	[36]	[23]	[59]	[47]	[50]	[97]	[156]
Aquafina, 24-pack 16.9 ounces	1.49	1.46	-0.03	1.39	1.42	0.03	-0.06
	(0.06)	(0.02)	(0.06)	(0.04)	(0.04)	(0.06)	(0.09)
	[16]	[17]	[33]	[19]	[22]	[41]	[74]
Coke Zero, 20 ounces	9.46	9.90	0.44	9.21	9.53	0.32	0.12
	(0.14)	(0.18)	(0.22)	(0.15)	(0.25)	(0.29)	(0.38)
	[43]	[41]	[84]	[57]	[52]	[109]	[193]
Coke Zero, 2 liter	3.73	3.36	-0.36	3.33	3.62	0.29	-0.65
	(0.33)	(0.15)	(0.40)	(0.21)	(0.31)	(0.37)	(0.56)
	[26]	[20]	[46]	[34]	[33]	[67]	[113]
Dasani, 20 ounces	8.45	8.68	0.23	8.05	8.20	0.14	0.09
	(0.33)	(0.32)	(0.47)	(0.28)	(0.26)	(0.38)	(0.60)
	[37]	[28]	[65]	[37]	[45]	[82]	[147]

Dasani,	1.44	1.49	0.05	1.38	1.46	0.08	-0.03
24-pack 16.9	(0.08)	(0.06)	(0.10)	(0.04)	(0.05)	(0.07)	(0.12)
ounces	[13]	[16]	[29]	[16]	[13]	[29]	[58]
Diet Arizona	6.45	8.02	1.57	6.39	6.33	-0.05	1.62
Iced Tea, 15.5	(0.00)	(1.63)	(2.11)	(0.00)	(0.14)	(0.34)	(1.36)
ounces	[2]	[3]	[5]	[2]	[11]	[13]	[18]
Diet Arizona	2.57	3.59	1.02	2.45	2.45	0.00	1.02
Iced Tea, 1 gallon	(0.00)	n.a.	n.a.	(0.12)	(0.04)	(0.10)	(0.18)
	[2]	[1]	[3]	[2]	[8]	[10]	[13]
Diet Coke,	4.42	4.63	0.21	4.14	4.22	0.08	0.12
12-pack 12	(0.09)	(0.17)	(0.18)	(0.12)	(0.07)	(0.15)	(0.24)
ounces	[31]	[26]	[57]	[47]	[44]	[91]	[148]
Diet Coke, 20	9.38	9.75	0.36	9.19	9.43	0.24	0.12
ounces	(0.11)	(0.18)	(0.21)	(0.12)	(0.21)	(0.24)	(0.33)
	[56]	[53]	[109]	[65]	[64]	[129]	[238]
Diet Coke, 2 liter	3.49	3.71	0.22	3.30	3.30	0.00	0.22
	(0.06)	(0.14)	(0.14)	(0.13)	(0.06)	(0.15)	(0.21)
	[46]	[36]	[82]	[63]	[55]	[118]	[200]
Diet Lipton	9.75	n.a.	n.a.	8.00	9.95	1.95	n.a.
Iced Tea, 20	0.25	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
ounces	[0]	[0]	[2]	[1]	[1]	[2]	[2]
Diet Pepsi,	4.27	4.67	0.40	4.00	4.14	0.14	0.26
12-pack 12	(0.10)	(0.15)	(0.18)	(0.13)	(0.10)	(0.17)	(0.25)
ounces	[30]	[25]	[55]	[39]	[34]	[73]	[128]
Diet Pepsi, 20	9.39	9.75	0.35	9.04	9.29	0.24	0.11
ounces	(0.11)	(0.19)	(0.21)	(0.14)	(0.12)	(0.19)	(0.28)
	[53]	[44]	[97]	[66]	[59]	[125]	[222]
Diet Pepsi, 2 liter	3.45	3.80	0.36	3.25	3.20	-0.05	0.41
	(0.09)	(0.15)	(0.17)	(0.13)	(0.06)	(0.15)	(0.23)
	[40]	[30]	[70]	[51]	[48]	[99]	[169]
Gatorade G2, 20	9.40	10.61	1.21	8.08	8.43	0.35	0.86
ounces	(0.25)	(1.09)	(0.73)	(0.49)	(0.55)	(0.73)	(1.16)
	[13]	[4]	[17]	[14]	[13]	[27]	[44]
Gatorade G2,	4.49	5.25	0.76	3.88	3.52	-0.36	1.12
8-pack 20 ounces	(0.33)	(0.45)	(0.62)	(0.31)	(0.11)	(0.29)	(0.65)
	[4]	[6]	[10]	[5]	[7]	[12]	[22]
Red Bull Sugar	23.51	24.38	0.87	23.97	23.98	0.01	0.86
Free, 4-pack	(0.47)	(0.71)	(0.83)	(0.44)	(0.38)	(0.58)	(1.03)
8.4 ounces	[14]	[12]	[26]	[26]	[34]	[60]	[86]
Red Bull Sugar	28.93	29.18	0.24	29.21	28.78	-0.43	0.68
Free, 8.4 ounces	(0.36)	(0.51)	(0.61)	(0.40)	(0.31)	(0.52)	(0.80)
	[58]	[52]	[110]	[63]	[57]	[120]	[230]
Tropicana 100%	16.65	17.49	0.84	16.18	17.06	0.88	-0.04
Orange Juice,	(0.39)	(0.88)	(0.90)	(0.33)	(0.89)	(0.91)	(1.31)
12 ounces	[26]	[21]	[47]	[34]	[30]	[64]	[111]
Tropicana 100%	8.43	8.55	0.11	8.18	8.45	0.27	-0.16
Orange Juice,	(0.23)	(0.30)	(0.38)	(0.28)	(0.17)	(0.32)	(0.49)
59 ounces	[21]	[23]	[44]	[25]	[29]	[54]	[98]

Notes: See Table 1 and Appendix Table 1. For a few products, there are not enough recorded prices to calculate standard errors and difference-in-differences estimates.

Appendix Table A2. Characteristics of Exit Interview Respondents

	Pre-tax			Post-tax		
	Oakland	Comparison	Difference	Oakland	Comparison	Difference
Age	40.20	41.34	-1.14	39.71	40.67	-0.97
	(0.62)	(0.79)	(1.00)	(0.68)	(0.58)	(0.89)
Female	64.54	66.80	2.26	60.08	65.48	5.40
	(3.07)	(2.69)	(4.08)	(2.97)	(3.03)	(4.24)
Hispanic	26.30	31.16	4.86	23.60	32.78	9.18
	(2.86)	(2.68)	(3.92)	(2.21)	(3.10)	(3.81)
African-American	49.22	30.32	18.89	53.96	30.19	23.77
	(3.65)	(2.69)	(4.54)	(2.91)	(2.61)	(3.90)
White	13.05	21.42	8.37	16.03	25.77	9.74
	(2.14)	(2.78)	(3.50)	(2.13)	(2.80)	(3.52)
Other Race or Multi-Racial	37.73	48.26	10.53	30.01	44.04	14.03
	(4.06)	(3.03)	(5.06)	(2.54)	(3.86)	(4.61)
Household Size	4.26	4.42	0.16	4.20	4.41	0.22
	(0.08)	(0.09)	(0.12)	(0.11)	(0.10)	(0.15)
Below 185% FPL	60.77	54.73	6.03	56.05	46.89	9.17
	(4.14)	(3.07)	(5.15)	(2.99)	(3.58)	(4.66)
Observations	785	797	1,582	741	767	1,508

Notes: The figures represent the mean characteristics of the exit interview respondents at Oakland stores and stores in comparison communities prior to the tax (April-June 2017) and after implementation of the tax (April-June 2018). Standard errors are in parentheses.

Appendix Table A3. Characteristics of Household Survey Respondents

	Oakland	Comparison Communities	Difference
Age (adult)	41.41	41.41	0.00
	(1.21)	(1.80)	(2.17)
Age (child)	8.52	8.66	-0.15
	(0.47)	(0.41)	(0.62)
Female (adult)	0.74	0.79	-0.04
	(0.04)	(0.04)	(0.06)
Female (child)	0.46	0.42	0.04
	(0.05)	(0.05)	(0.07)
Hispanic	0.23	0.29	-0.06
	(0.06)	(0.05)	(0.08)
African-American	0.49	0.39	0.10
	(0.05)	(0.05)	(0.07)
White	0.16	0.19	-0.03
	(0.04)	(0.04)	(0.05)
Other Race	0.35	0.42	-0.07
	(0.06)	(0.05)	(0.08)
Household Size	3.97	4.59	-0.62
	(0.13)	(0.21)	(0.24)
Household income below poverty level	0.41	0.36	0.05
	(0.05)	(0.05)	(0.07)
Household income below 185% poverty level	0.64	0.58	0.07
	(0.04)	(0.04)	(0.06)
High School Graduate	0.65	0.64	0.01
	(0.05)	(0.05)	(0.07)
SNAP Recipient	0.69	0.71	-0.02
	(0.06)	(0.08)	(0.10)
WIC Recipient	0.48	0.49	-0.01
	(0.08)	(0.09)	(0.12)
Free or Reduced-Price Lunch Recipient	0.76	0.73	0.03
	(0.06)	(0.07)	(0.09)
Observations	193	218	411

Notes: This table reports the mean characteristics of adults and children living in Oakland and in the comparison communities who responded to both waves of the household survey and the differences between the two groups. Standard errors are in parentheses.

Appendix Table A4: Average Price per Ounce of Beverages Before and After the Implementation of the SSB Tax (One Cent per Ounce) in Oakland among stores in the balanced panel

	Stores in Oakland			Comparison Stores			
	2017	2018	Difference	2017	2018	Difference	DiD
Taxed Beverages	7.92	9.01	1.09	7.59	8.06	0.47	0.62
	(0.27)	(0.31)	(0.42)	(0.28)	(0.29)	(0.40)	(0.58)
	[816]	[767]	[1583]	[932]	[986]	[1918]	[3501]
Untaxed Beverages	10.09	10.47	0.38	9.16	9.31	0.15	0.23
	(0.39)	(0.48)	(0.62)	(0.35)	(0.39)	(0.52)	(0.81)
	[560]	[493]	[1053]	[703]	[732]	[1435]	[2488]

Notes: This table shows the mean price per ounce among beverages for the listed categories. Standard errors are in parentheses, and sample sizes are in brackets. The sample sizes are store-beverage combinations. There were 61 stores in Oakland and 75 stores in the Oakland MSA. Taxed beverages include regular soda, sports drinks, energy drinks, juice drinks, and sweetened iced tea. Untaxed beverages include diet soda, other diet drinks (unsweetened sports drinks, energy drinks, and iced tea), 100% fruit juice, and bottled water).
DiD = difference-in-differences.

Appendix Table A5: Average Price per Ounce of Beverages by Type of Beverage Before and After the Implementation of the SSB Tax (One Cent per Ounce) in Oakland

	Stores in Oakland			Comparison Stores			
	2017	2018	Difference	2017	2018	Difference	DiD
Taxed Beverages	7.95	8.94	1.00	7.91	8.24	0.33	0.66
	(0.22)	(0.25)	(0.33)	(0.22)	(0.22)	(0.31)	(0.46)
	[905]	[767]	[1,672]	[1,048]	[986]	[2,034]	[3,706]
Regular Soda	6.09	7.02	0.93	5.86	6.14	0.28	0.65
	(0.12)	(0.13)	(0.18)	(0.11)	(0.12)	(0.16)	(0.24)
	[614]	[527]	[1,141]	[737]	[682]	[1,419]	[2,560]
Sports Drink	8.09	8.47	0.38	7.53	8.26	0.73	-0.35
	(0.28)	(0.33)	(0.43)	(0.29)	(0.28)	(0.40)	(0.59)
	[67]	[53]	[120]	[70]	[63]	[133]	[253]
Energy Drink	27.74	28.38	0.63	27.44	26.88	-0.56	1.19
	(0.40)	(0.41)	(0.57)	(0.39)	(0.32)	(0.50)	(0.77)
	[76]	[72]	[148]	[102]	[101]	[203]	[351]
Juice Drink	6.20	6.82	0.62	5.52	6.12	0.60	0.02
	(0.34)	(0.42)	(0.54)	(0.38)	(0.37)	(0.53)	(0.76)
	[76]	[57]	[133]	[69]	[73]	[142]	[275]
Sweet Tea	4.60	4.84	0.23	3.74	3.86	0.12	0.11
	(0.26)	(0.26)	(0.37)	(0.14)	(0.17)	(0.22)	(0.43)
	[72]	[58]	[130]	[70]	[67]	[137]	[267]
Untaxed Beverages	9.92	10.16	0.24	9.51	9.49	-0.03	0.27
	(0.31)	(0.36)	(0.48)	(0.28)	(0.28)	(0.40)	(0.62)
	[608]	[493]	[1,101]	[762]	[732]	[1,494]	[2,595]
Diet Soda	6.43	6.92	0.49	6.06	6.24	0.18	0.31
	(0.16)	(0.19)	(0.25)	(0.14)	(0.16)	(0.21)	(0.33)
	[325]	[275]	[600]	[422]	[389]	[811]	[1,411]
Other Diet	23.00	24.51	1.51	23.20	20.53	-2.67	4.18
	(0.95)	(1.01)	(1.39)	(0.88)	(0.90)	(1.26)	(1.91)
	[95]	[78]	[173]	[113]	[131]	[244]	[417]
Water	6.49	5.90	-0.60	6.02	6.22	0.20	-0.80
	(0.35)	(0.42)	(0.55)	(0.30)	(0.29)	(0.42)	(0.68)
	[102]	[84]	[186]	[119]	[130]	[249]	[435]
Juice	12.68	12.47	-0.21	12.53	12.41	-0.12	-0.09
	(0.39)	(0.69)	(0.74)	(0.37)	(0.55)	(0.64)	(0.98)
	[86]	[56]	[142]	[108]	[82]	[190]	[332]

Notes: This table shows the mean price per ounce among beverages for the listed categories. Standard errors are in parentheses, and sample sizes are in brackets. The sample sizes are store-beverage combinations. In Oakland, there were 70 stores in April-June 2017 and 61 stores in April-June 2018. In the Oakland MSA, there were 87 comparison stores in April-June 2017 and 75 stores in April-June 2018.

Appendix Table A6: The Impact of the SSB Tax on Prices and Product Availability by Beverage Type

	Price		
	Full Sample	Balanced Sample	Availability
All Taxed Beverages	0.56	0.61	-7.71
	(0.11)	(0.11)	(2.13)
	[3,706]	[2,961]	[6,210]
Regular Soda	0.57	0.63	-12.58
	(0.10)	(0.10)	(4.34)
	[2,560]	[2,149]	[2,568]
Sports Drink	0.49	0.44	-9.72
	(0.27)	(0.29)	(7.58)
	[253]	[205]	[432]
Energy Drink	0.86	0.73	-5.99
	(0.48)	(0.47)	(7.24)
	[351]	[290]	[356]
Juice Drink	0.65	0.51	-10.44
	(0.32)	(0.34)	(6.97)
	[275]	[140]	[912]
Sweet Tea	0.36	0.32	-8.40
	(0.15)	(0.15)	(6.64)
	[267]	[177]	[594]
All Untaxed Beverages	0.26	0.21	-5.24
	(0.13)	(0.12)	(1.50)
	[2,595]	[1,928]	[6,256]
Diet Soda	0.13	0.21	-6.80
	(0.13)	(0.12)	(4.51)
	[1,411]	[1,138]	[1,744]
Other Diet	0.70	0.69	-14.23
	(0.46)	(0.51)	(5.36)
	[417]	[271]	[1,792]
Water	-0.07	-0.17	-15.15
	(0.16)	(0.15)	(5.48)
	[435]	[330]	[792]
Juice	0.49	0.03	-3.47
	(0.76)	(0.63)	(5.28)
	[332]	[189]	[888]

Notes: The first two columns show the DiD estimates in cents per ounce (full pass-through is 1.0 cent per ounce) for the beverage category in the row heading and the sample of stores in the

column heading. The results in the third column represent the average percentage point change in the availability of beverages in Oakland within the given beverage type compared to the comparison stores. Standard errors, which are robust to clustering at the store level, are in parentheses, and sample sizes are in brackets. The sample sizes are store-beverage combinations. Each cell contains the results from a separate regression. Additional variables that are included, but not shown, are a binary variable indicating that the price or product availability is from after implementation of the tax, store fixed effects, and product fixed effects.

Appendix Table A7: Variation in Pass-Through Estimates by Subgroup (Binary Variables)

	All Taxed Beverages	Regular Soda
Store type		
Large grocery store (reference category)	0.45	0.36
	(0.27)	(0.27)
Pharmacy	0.55	0.65
	(0.28)	(0.28)
Small grocery	-0.48	-0.12
	(0.48)	(0.42)
Convenience store	-0.02	0.14
	(0.33)	(0.34)
Gas station	0.47	0.51
	(0.33)	(0.31)
Chain/independent stores		
Independent retailers (reference category)	0.30	0.41
	(0.20)	(0.18)
Chain stores	0.47	0.32
	(0.24)	(0.22)
Container size		
Small Single- Serving (reference category)	0.57	0.69
	(0.17)	(0.17)
Large Containers	0.01	-0.17
	(0.16)	(0.17)
Multi-Packs	0.20	-0.06
	(0.26)	(0.19)
Observations	2,961	2,149

Notes: The values for the reference groups are the impacts on prices for the groups (for example, pass-through for large grocery stores is 0.45 for taxed beverages). These groups serve as the comparison for the other columns. The values in the other columns represent the differential impacts for the store type compared to reference groups, estimated as the interaction between the store type indicators and the differences-in-differences interaction term. Standard errors, which are robust to clustering at the store level are in parentheses. The sample sizes are store-beverage combinations. Each row contains the results from a separate regression for the specified beverage category. Additional variables that are included, but not shown, are a binary variable indicating that the price is from after implementation of the tax, store fixed effects, and product fixed effects.

Appendix Table A8: Variation in Pass-Through Estimates by Subgroup (Continuous Variables)

	All Taxed Beverages	Regular Soda
Travel Time to Closest Untaxed Competitor		
Oakland x 2017	0.61	0.63
	(0.11)	(0.10)
Oakland x 2017 x Time	0.04	0.03
	(0.05)	(0.05)
Distance to Closest Untaxed Competitor		
Oakland x 2017	0.61	0.63
	(0.11)	(0.10)
Oakland x 2017 x Distance	0.16	0.13
	(0.12)	(0.11)
Percentage of Households in Poverty		
Oakland x 2017	0.60	0.62
	(0.11)	(0.10)
Oakland x 2017 x Population	-0.17	-0.17
	(0.07)	(0.07)
Percentage of Population African-American		
Oakland x 2017	0.62	0.64
	(0.11)	(0.10)
Oakland x 2017 x Population	-0.13	-0.11
	(0.08)	(0.07)
Percentage of Population Hispanic		
Oakland x 2017	0.61	0.63
	(0.11)	(0.10)
Oakland x 2017 x Population	-0.05	-0.07
	(0.05)	(0.05)
Observations	2,149	2,149

Notes: The triple interaction represents the change in the DiD estimate for a one-unit change in the subgroup variable: (1) one-minute increase in the travel time between stores and the closest untaxed competitor (excludes stores outside of Oakland but in other communities with a soda tax, i.e., Albany, Berkeley, and San Francisco), (2) one-mile increase in the travel time between stores and the closest untaxed competitor, (3) an increase of 10 percentage points in the local population characteristic. Given that the subgroup values are centered at the mean, Oakland x 2017 is estimated at the mean value for the subgroups, which are 6.63 minutes and 1.91 miles for all stores. The mean percentage of households in poverty is 17.45 percent. The mean percentage African-American is 24.37 percent. The mean percentage Hispanic is 27.17 percent. Standard errors, which are robust to clustering at the store level, are in parentheses. The sample sizes are store-beverage combinations. Additional variables that are included, but not shown, are a binary variable indicating that the price is from after implementation of the tax, store fixed effects, and product fixed effects.

Appendix Table A9: Variation in Impacts on Availability by Subgroup (Binary Variables)

	Taxed Beverages	Regular Soda	Untaxed Beverages	Diet Soda	Water
Store type					
Large grocery store (reference category)	-5.06	-8.67	-1.51	11.04	-15.16
	(4.93)	(10.26)	(3.24)	(9.92)	(9.33)
Pharmacy	3.50	8.86	1.07	6.35	16.33
	(3.50)	(21.31)	(3.83)	(17.47)	(13.20)
Small grocery	-13.61	-18.84	-11.06	-40.60	-31.44
	(13.61)	(15.46)	(6.86)	(16.28)	(15.70)
Convenience store	< 0.01	1.84	-8.31	-21.56	-6.04
	(8.78)	(17.86)	(6.28)	(16.40)	(15.38)
Gas station	-4.25	2.13	-7.37	-23.27	4.29
	(4.25)	(16.05)	(5.62)	(15.02)	(15.72)
Chain/independent stores					
Independent retailers (reference category)	-11.83	-13.93	-8.79	-13.89	-27.51
	(4.84)	(7.92)	(3.58)	(8.34)	(7.73)
Chain stores	9.19	4.68	6.71	19.97	20.51
	(5.58)	(12.77)	(3.98)	(11.95)	(10.22)
Container size					
Small Single-Serving (reference category)	-3.35	-7.36	-4.96	-1.03	-41.06
	(4.54)	(10.32)	(2.10)	(9.48)	(9.54)
Large Containers	-7.98	-9.03	1.50	-9.55	n.a.
	(5.31)	(11.15)	(2.60)	(9.08)	n.a.
Multi-Packs	-4.56	-3.11	-1.07	-7.11	41.29
	(4.89)	(10.76)	(3.64)	(9.00)	(9.74)
Observations	6,210	2,568	6,256	1,744	792

Notes: The values for the reference groups are the impacts on availability for the groups (for example, availability of taxed beverages declined by 5.06 percentage points in large grocery stores). These groups serve as the comparison for the other columns. The values in the other columns represent the differential impacts for the store type compared to reference groups, estimated as the interaction between the store type indicators and the differences-in-differences interaction term. Standard errors, which are robust to clustering at the store level, are in parentheses, and sample sizes are in brackets. The sample sizes are store-beverage combinations. Each row contains the results from a separate regression for the specified beverage category. Additional variables that are included, but not shown, are a binary variable indicating that the price is from after implementation of the tax, store fixed effects, and product fixed effects. Note, we did not collect price information for any large containers of water.

Appendix Table A10: Variation in Impacts on Availability by Subgroup (Continuous Variables)

	Taxed Beverages	Regular Soda	Untaxed Beverages	Diet Soda	Water
Travel Time to Closest Untaxed Competitor					
Oakland x 2017	-7.68	-12.69	-5.21	-6.83	-15.29
	(2.79)	(6.09)	(1.96)	(6.03)	(5.27)
Oakland x 2017 x Time	-0.83	-2.09	-0.41	0.20	-3.03
	(0.96)	(1.94)	(0.75)	(2.22)	(2.24)
Distance to Closest Untaxed Competitor					
Oakland x 2017	-7.71	-12.56	-5.22	-6.75	-15.70
	(2.80)	(6.16)	(1.95)	(6.10)	(5.26)
Oakland x 2017 x Distance	-0.27	-0.96	-1.78	-0.87	-13.15
	(2.65)	(6.10)	(1.82)	(6.01)	(6.40)
Percentage of Households in Poverty					
Oakland x 2017	-7.48	-12.84	-5.73	-8.19	-18.26
	(2.79)	(6.19)	(1.99)	(5.96)	(5.32)
Oakland x 2017 x Population	-0.36	-0.04	-1.96	-7.09	-7.26
	(1.89)	(3.95)	(1.36)	(4.04)	(3.15)
Percentage of Population African-American					
Oakland x 2017	-7.01	-12.03	-5.59	-8.09	-16.89
	(2.85)	(6.10)	(1.98)	(5.91)	(5.48)
Oakland x 2017 x Population	2.70	7.44	-1.07	-0.93	-5.37
	(1.85)	(3.90)	(1.16)	(3.63)	(3.02)
Percentage of Population Hispanic					
Oakland x 2017	-7.72	-11.50	-5.61	-6.00	-16.37
	(2.76)	(5.97)	(1.94)	(5.71)	(5.52)
Oakland x 2017 x Population	-2.05	-3.93	-2.25	-7.47	-2.50
	(1.34)	(2.66)	(0.99)	(2.72)	(2.39)
Observations	6,210	2,568	6,256	1,744	792

Notes: The triple interaction represents the change in the DiD estimate for a one-unit change in the subgroup variable: (1) one-minute increase in the travel time between stores and the closest untaxed competitor (excludes stores outside of Oakland but in other communities with a soda tax, i.e., Albany, Berkeley, and San Francisco), (2) one-mile increase in the travel time between stores and the closest untaxed competitor, (3) an increase of 10 percentage points in the local population characteristic. Given that the subgroup values are centered at the mean, Oakland x 2017 is estimated at the mean value for the subgroups, which are 6.63 minutes and 1.91 miles for all stores. The mean percentage of households in poverty is 17.45 percent. The mean percentage African-American is 24.37 percent. The mean percentage Hispanic is 27.17 percent. Standard errors, which are robust to clustering at the store level, are in parentheses. The sample sizes are store-beverage combinations. Additional variables that are included, but not shown, are a binary variable indicating that the price is from after implementation of the tax, store fixed effects, and product fixed effects.

Appendix Table A11. Variation in Impacts on Beverage Purchases (Ounces) by Subgroup

	Full Sample	African-American	Hispanic	Below 185% FPL
Taxed Beverages	-11.33	-28.18	-20.51	-14.26
	(8.36)	(14.59)	(17.20)	(10.80)
	[2,720]	[2,720]	[2,720]	[2,720]
Untaxed Beverages	10.07	30.09	-3.79	1.84
	(15.65)	(13.61)	(26.21)	(15.52)
	[2,726]	[2,726]	[2,726]	[2,726]

Notes: This table shows the difference-in-differences estimates for the ounces purchased for the subgroups in the column headings for the products in the row headings. Standard errors, which are robust to clustering at the store level, are in parentheses, and sample sizes are in brackets. The rows contain the results of the second part of two-part regressions (GLM with a Poisson distribution to estimate volume of beverages purchased). Additional variables that are included, but not shown, are age, gender (indicator for female), whether the respondent is African-American, whether the respondent is Hispanic, household size, whether household income is below 185% of the FPL, whether the respondent is an Oakland resident, indicators for days of the week, time of day, day of the study, whether the interview location is in Oakland, whether the interview occurred after implementation of the tax, and store-type indicators.

Appendix Table A12. Mean Consumption Before and After Implementation of the Beverage Tax in Oakland

	Residents of Oakland			Residents of Comparison Communities			
	Pre-tax	Post-tax	Diff.	Pre-tax	Post-tax	Diff.	DiD
Adults							
Added Sugars	18.10	19.25	1.15	28.04	28.17	0.13	1.02
	(2.38)	(2.78)	(2.14)	(6.21)	(5.41)	(3.99)	(4.53)
	[158]	[158]	[158]	[183]	[183]	[183]	[341]
Monthly Frequency							
Taxed Beverages	22.63	23.45	0.83	36.91	39.18	2.27	-1.44
	(3.11)	(3.36)	(3.03)	(9.21)	(7.75)	(6.84)	(7.48)
	[169]	[169]	[169]	[200]	[200]	[200]	[369]
Regular Soda	14.86	14.57	-0.29	18.19	20.58	2.39	-2.69
	(2.32)	(2.48)	(2.01)	(4.59)	(5.09)	(3.58)	(4.10)
	[178]	[178]	[178]	[205]	[205]	[205]	[383]
Sweetened Fruit Drinks	8.76	10.38	1.62	18.58	19.42	0.85	0.77
	(1.56)	(1.68)	(1.77)	(4.61)	(4.40)	(5.42)	(5.71)
	[179]	[179]	[179]	[207]	[207]	[207]	[386]
Untaxed Beverages	179.94	170.52	-9.42	192.13	154.35	-37.78	28.37
	(15.19)	(12.15)	(20.13)	(14.70)	(12.81)	(12.99)	(23.95)
	[153]	[153]	[153]	[176]	[176]	[176]	[329]
Diet Soda	2.34	2.72	0.38	3.24	4.03	0.80	-0.41
	(0.55)	(0.79)	(0.68)	(0.80)	(1.34)	(1.39)	(1.55)
	[187]	[187]	[187]	[213]	[213]	[213]	[400]
Bottled Water	59.51	56.21	-3.30	62.94	59.07	-3.87	0.57
	(5.71)	(5.78)	(5.02)	(6.92)	(7.42)	(7.34)	(8.89)
	[179]	[179]	[179]	[206]	[206]	[206]	[385]
Coffee	26.33	28.11	1.78	36.58	28.71	-7.87	9.65
	(2.25)	(2.97)	(2.91)	(5.19)	(3.55)	(5.19)	(5.95)
	[181]	[181]	[181]	[203]	[203]	[203]	[384]
Milk	28.42	32.49	4.07	35.33	31.69	-3.64	7.71
	(3.72)	(4.88)	(4.15)	(3.56)	(4.00)	(4.38)	(6.03)
	[179]	[179]	[179]	[202]	[202]	[202]	[381]
Juice	18.38	21.60	3.22	26.02	23.18	-2.84	6.06
	(2.44)	(3.75)	(3.03)	(3.73)	(4.22)	(4.39)	(5.34)
	[180]	[180]	[180]	[202]	[202]	[202]	[382]
Tap Water	60.47	47.80	-12.67	49.69	34.04	-15.65	2.98
	(15.23)	(5.35)	(16.16)	(6.89)	(4.51)	(6.06)	(17.26)
	[174]	[174]	[174]	[205]	[205]	[205]	[379]
Children							

Added Sugars	11.94 (1.72) [148]	14.23 (2.84) [148]	2.29 (2.06) [148]	13.49 (1.87) [170]	15.88 (2.64) [170]	2.39 (2.37) [170]	-0.10 (3.14) [318]
Monthly Frequency							
Taxed Beverages	21.81 (3.52) [158]	22.42 (3.82) [158]	0.61 (3.23) [158]	21.90 (3.65) [182]	21.02 (3.05) [182]	-0.87 (3.16) [182]	1.48 (4.52) [340]
Regular Soda	9.36 (1.70) [172]	10.76 (2.54) [172]	1.40 (2.42) [172]	7.96 (1.19) [197]	9.82 (1.28) [197]	1.86 (1.30) [197]	-0.46 (2.75) [369]
Sweetened Fruit drinks	12.82 (2.79) [160]	11.00 (2.10) [160]	-1.82 (1.70) [160]	14.39 (2.92) [185]	12.07 (2.23) [185]	-2.33 (2.44) [185]	0.50 (2.98) [345]
Untaxed Beverages	162.47 (11.95) [133]	152.11 (10.76) [133]	-10.36 (14.78) [133]	159.63 (9.67) [161]	144.70 (8.91) [161]	-14.93 (11.07) [161]	4.57 (18.47) [294]
Bottled water	42.33 (5.30) [164]	38.97 (4.26) [164]	-3.36 (4.71) [164]	52.10 (6.61) [191]	46.51 (4.51) [191]	-5.58 (7.34) [191]	2.22 (8.73) [355]
Coffee	3.70 (1.08) [165]	2.23 (0.60) [165]	-1.46 (1.08) [165]	5.47 (1.40) [194]	8.43 (2.98) [194]	2.96 (3.23) [194]	-4.42 (3.40) [359]
Milk	45.09 (4.83) [162]	47.91 (5.18) [162]	2.82 (4.28) [162]	46.37 (4.14) [196]	36.97 (2.99) [196]	-9.41 (3.62) [196]	12.23 (5.60) [358]
Juice	21.10 (2.60) [166]	23.35 (3.15) [166]	2.25 (2.68) [166]	23.66 (2.39) [188]	25.16 (3.00) [188]	1.50 (2.08) [188]	0.75 (3.39) [354]
Tap Water	51.73 (9.37) [162]	44.03 (6.53) [162]	-7.70 (10.10) [162]	34.86 (4.85) [184]	33.56 (4.67) [184]	-1.30 (5.05) [184]	-6.40 (11.29) [346]

Notes: The figures are the unconditional mean values for the outcome variables (grams of added sugars and frequency of consumption per month by beverage type) for adults and children by time and location. Standard errors are in parentheses. Sample sizes are in brackets. Added sugars are measured in grams, and beverage frequency is measured in times consumed per month. DiD = difference-in-differences.

Appendix Table A13. The Impact of the Beverage Tax on Consumption among Household Survey Participants with Complete Beverage Records Before and After the Tax was Implemented

	Adults	Children
Grams of Added Sugars	-3.20 (3.726) [341]	0.26 (3.105) [318]
Frequency of Consumption (Times/Month)		
All Taxed Beverages	-9.20 (6.513) [341]	1.70 (4.049) [318]
Regular Soda	-4.95 (4.122) [341]	1.48 (2.327) [318]
Sweetened fruit drinks	-6.75 (5.212) [341]	0.45 (2.582) [318]
Energy Drinks		-0.74 (3.518) [156]
Untaxed Beverages	13.86 (16.947) [329]	4.52 (14.312) [294]
Diet Soda	-0.38 (1.786) [329]	0.21 (0.443) [294]
Bottled Water	6.79 (8.713) [329]	-2.50 (6.509) [294]
Coffee	1.81 (4.923) [327]	

Juice	1.07	-2.85
	(4.967)	(3.819)
	[329]	[294]
Milk	4.62	7.63
	(5.833)	(5.269)
	[329]	[294]
Tap Water	2.83	3.70
	(6.545)	(10.144)
	[329]	[294]

Notes: The figures represent the change in the outcome for households in Oakland relative to those in the comparison communities. Standard errors are in parentheses. Sample sizes are in brackets. The mean values before implementation of the tax are reported in italics below the sample sizes. Added sugars are measured in grams, and beverage frequency is measured in times consumed per month. All regressions were estimated with sample weights and standard errors clustered at the store level.
n.a. = not applicable. We did not ask adults separate questions about consumption of energy drinks; energy drinks are included in the questions about sweetened fruit drinks. We collected information about coffee consumption among children, but very few responded that they drink any coffee.

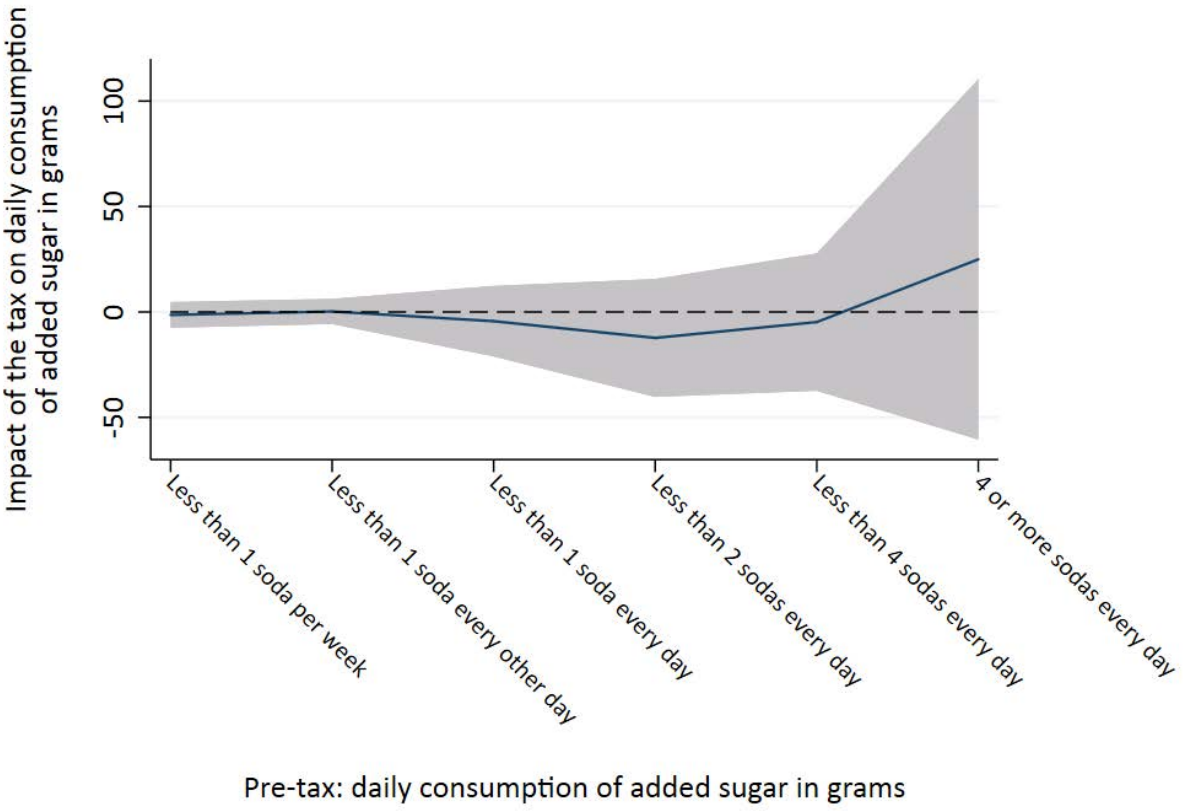
Appendix Table A14. Variation in Impacts on Consumption by Subgroups

	Grams of sugar per day		Times consumed regular soda per month	
	Adults	Children	Adults	Children
Individual Characteristics				
Male	2.43	-1.93	-2.33	0.74
	(7.98)	(4.83)	(7.29)	(3.46)
	[72]	[158]	[85]	[183]
	24.52	*12.48*	*16.30*	*8.38*
African-American	-1.89	6.31	-5.35	3.79
	(5.96)	(4.61)	(4.37)	(3.87)
	[160]	[144]	[181]	[175]
	23.70	*18.52*	*16.50*	*11.47*
Hispanic	2.01	1.22	-0.54	0.65
	(4.845)	(4.46)	(4.77)	(4.09)
	[84]	[76]	[89]	[81]
	18.10	*11.46*	*14.58*	*7.82*
Below FPL	5.63	4.73	0.79	3.15
	(6.61)	(3.99)	(5.17)	(4.35)
	[128]	[117]	[140]	[136]
	35.89	*16.07*	*23.40*	*10.05*
Below 185% of the FPL	3.57	4.92	0.03	1.52
	(4.58)	(2.96)	(3.50)	(2.97)
	[202]	[194]	[231]	[228]
	27.05	*12.88*	*18.65*	*9.02*
Household Member Receives SNAP Benefits	3.98	-8.12	-1.80	-6.42
	(6.83)	(5.52)	(7.47)	(2.90)
	[125]	[120]	[140]	[142]
	27.56	*12.30*	*20.27*	*10.79*
Household Member Receives WIC Benefits	-7.87	-9.87	-14.26	-9.98
	(10.29)	(7.44)	(11.92)	(4.55)
	[46]	[39]	[48]	[50]
	28.75	*9.73*	*19.26*	*5.65*
Sample Adults Have a High School Education or less	-2.87	1.73	-4.45	-0.34
	(6.84)	(3.12)	(5.71)	(2.89)
	128	122	148	142
	31.59	*14.84*	*24.74*	*12.28*
Child is Over Age 10	n.a.	9.45	n.a.	9.09
	n.a.	(7.48)	n.a.	(8.39)
	n.a.	[121]	n.a.	[142]
	n.a.	*22.27*	*n.a.*	*12.57*
Attitudes Toward the Tax and SSBs				
Sample Adult Supports Tax at Baseline	-4.17	n.a.	-2.35	n.a.
	(4.363)	n.a.	(3.01)	n.a.
	[159]	n.a.	[172]	n.a.

	14.47	n.a.	*9.45*	n.a.
Sample Adult Agrees that SSBs are Bad for Health	-4.37	n.a.	-4.43	n.a.
	(3.85)	n.a.	(4.10)	n.a.
	[324]	n.a.	[360]	n.a.
	20.05	n.a.	*14.51*	n.a.
Sample Adult is Trying to Drink Fewer SSBs	-4.70	n.a.	-5.57	n.a.
	(3.87)	n.a.	(4.31)	n.a.
	[303]	n.a.	[339]	n.a.
	22.66	n.a.	*15.91*	n.a.
Cross-border shopping				
Never Shops Outside Oakland	-5.31	n.a.	-15.30	n.a.
	(7.74)	n.a.	(7.20)	n.a.
	[87]	n.a.	[100]	n.a.
	20.52	n.a.	*13.63*	n.a.
Lives Far from nearest untaxed competitor (Top Quartile Based on Distance)	-4.65	2.89	-3.54	1.73
	(1.94)	(3.56)	(2.70)	(3.11)
	[40]	[39]	[46]	[46]
	21.37	*9.58*	*19.42*	*6.62*

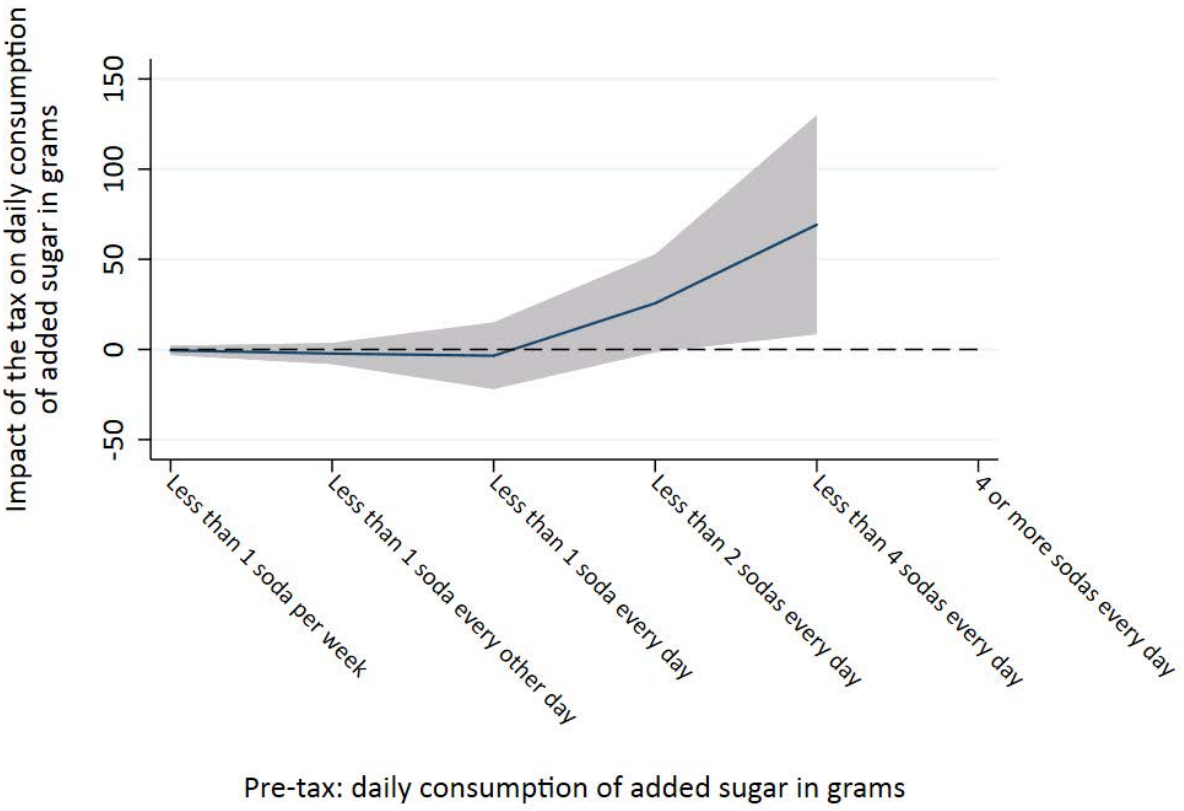
Notes: See Table 7.

Appendix Figure A1. Impact of the Tax on Consumption of Added Sugars from SSBs (Adults)



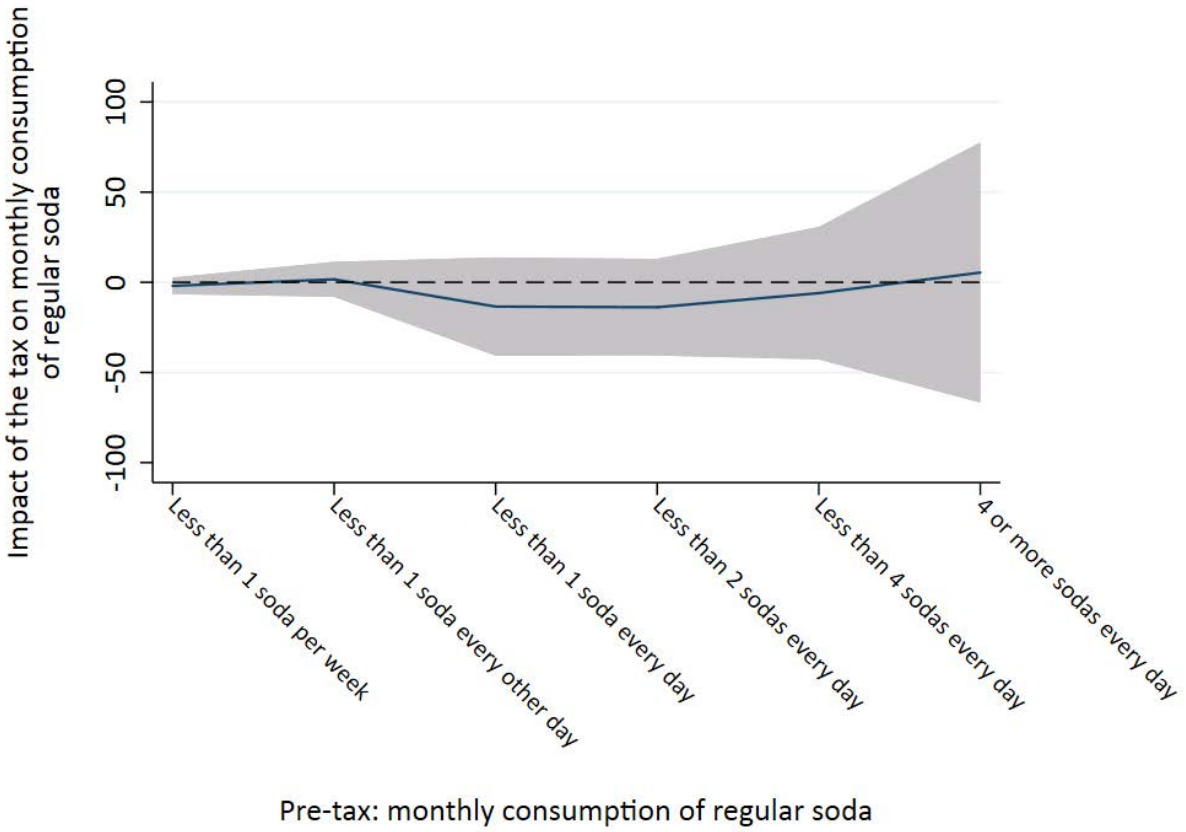
Notes: The solid line shows the impact of the tax for various levels of baseline consumption of added sugars. The shaded portion represents the 95 percent confidence interval for the impacts.

Appendix Figure A2. Impact of the Tax on Consumption of Added Sugars from SSBs (Children)



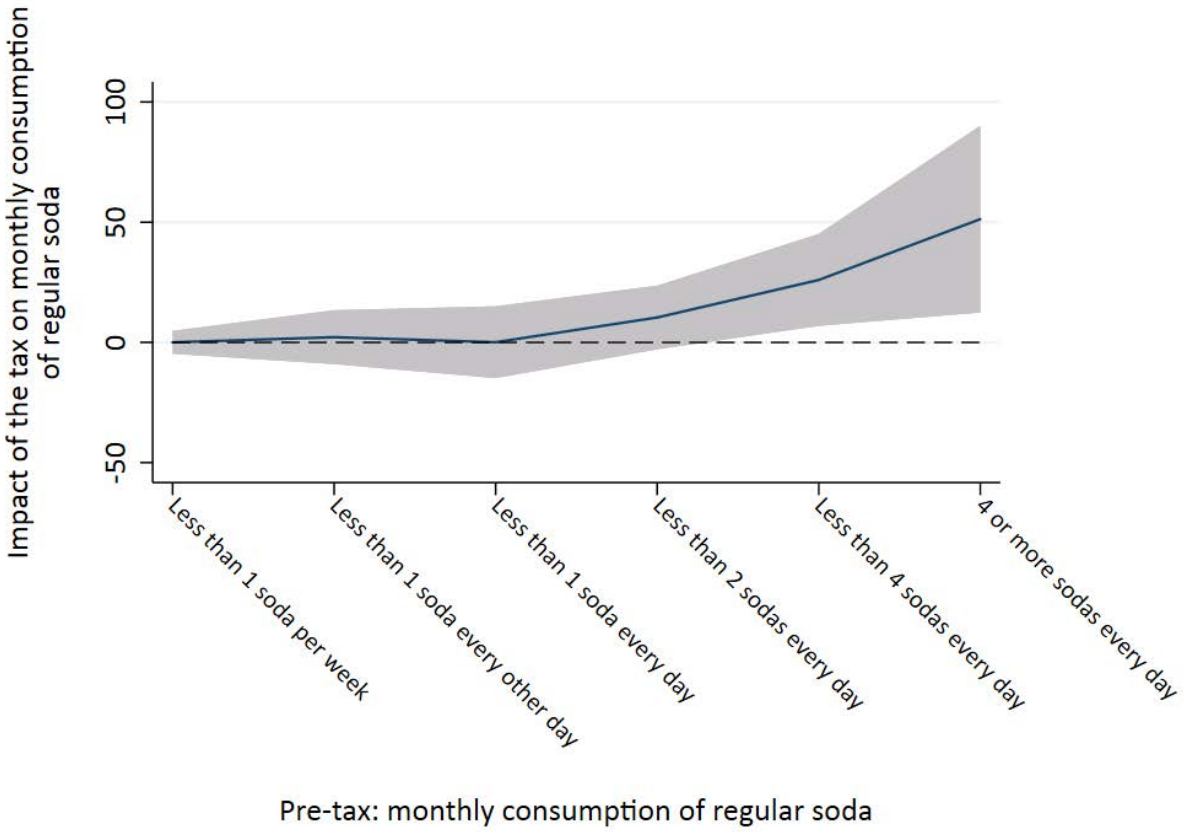
Notes: The solid line shows the impact of the tax for various levels of baseline consumption of added sugars. The shaded portion represents the 95 percent confidence interval for the impacts.

Appendix Figure A3. Impact of the Tax on Monthly Consumption of Regular Soda (Adults)



Notes: The solid line shows the impact of the tax for various levels of baseline monthly consumption of regular soda. The shaded portion represents the 95 percent confidence interval for the impacts.

Appendix Figure A4: Impact of the Tax on Monthly Consumption of Regular Soda (Children)



Notes: The solid line shows the impact of the tax for various levels of baseline monthly consumption of regular soda. The shaded portion represents the 95 percent confidence interval for the impacts.

APPENDIX B

METHODS FOR ESTIMATING HETEROGENEITY OF IMPACTS

I. Methods

a. Heterogeneity of the impact of the tax on prices and availability

We estimate the differential impacts of the tax on prices by store type, chain versus independent stores, product size, characteristics of the local population, and travel time to the closest untaxed competitor. We estimate these impacts by including interaction terms of the DiD term ($Oakland_s * Post_t$) and the given subgroup variable. For example, we estimate the differential impact of the tax for chain stores relative to independent retailers by interacting an indicator variable for chain stores with the DiD term in the model. We estimate the differential impact of the tax by travel time to the closest untaxed competitor by interacting the continuous travel time variable with the DiD term.[1]

We examine the differential impacts by type of store because they may have different elasticities of supply and face different elasticities of demand. For example, people may have relatively inelastic demand when shopping at a convenience store because they are not willing to walk several blocks to an alternative store for just a few items. Large supermarkets may face much more elastic demand because their customers are more likely to drive and can more easily visit a competing store that offers lower prices.

We also test whether pass-through differs for chain retailers versus independent retailers. Managers of chain stores may have less discretion to set prices than owners of small, independent stores if the chain stores require uniform pricing across stores (DellaVigna & Gentzkow, 2017).

We estimate the differential impact by product size, given that the elasticities of supply and demand may vary across them. Consumers may not be price elastic for a single serving (e.g., a 20-ounce bottle) but may be more price-sensitive regarding 2-liter bottles or multi-packs (e.g., 12-packs of 12-ounce cans), which may be purchased as part of a larger weekly trip for which they drive.

We also investigate the extent to which pass-through of the tax varies based on the distance of the taxed store from the closest rival store selling untaxed beverages. This distance

[1] In this case, we define travel time to the closest untaxed competitor (a continuous variable) as zero for the comparison stores in untaxed areas. Thus, we include the interaction between the DiD term and travel distance—but not the interactions between travel distance and Oakland and travel distance and the post period because they are identical to the travel time variable and the triple interaction, respectively.

estimates the ease to which that store's clientele can cross the border to evade the tax. Stores closer to rivals selling untaxed beverages may pass through less of the tax than stores farther from such competitors. Cawley and Frisvold (2017) and Cawley et al. (2018a) found evidence of such a pattern in Berkeley and Philadelphia, respectively, while Cawley et al. (2018c) did not find that the distance to the nearest untaxed competitor influenced the pass-through rate in Boulder. We measure the ease of cross-border shopping as the travel time (for a vehicle in minutes) from the store to the nearest untaxed competitor.

We further estimate whether the pass-through rate varies by the characteristics of the neighborhood surrounding the store. Given that individuals travel different distances, on average, to convenience stores compared with grocery stores, we define the area of the neighborhood differently for different store types. We focus on three characteristics of the local population: the percentage of households in poverty, the percentage of the population that is African-American, and the percentage of the population that is Hispanic. Whether the pass-through rate varies with the local poverty rate is of interest for two reasons. First, Lin et al. (2011) find that the elasticity of demand for regular soda is greater for individuals with greater incomes. Second, it sheds light on how the burden of the tax differs across neighborhoods and whether the tax could be regressive.

We also examine heterogeneity in the impacts of the tax on beverage availability to determine whether changes in availability might vary by store type, container size, time and distance to untaxed beverages, and local population characteristics.

b. Heterogeneity of the impact of the tax on purchases

We estimate whether the relative change in purchases varied by the characteristics of consumers. We focus on three characteristics: whether the consumer is African-American, Hispanic, and living in a household that is below 185 percent of the federal poverty level (FPL), a cutoff used for many federal program (e.g., the Supplemental Nutrition Assistance Program [SNAP] and the National School Lunch Program). We estimate the differential changes in purchases for these groups by including interaction terms of the DiD term ($Oak_s * Post_t$) and the given subgroup variable. For example, we estimate the change for households living below 185 percent of the FPL relative to those living above it by interacting an indicator variable for those living below with the DiD term in the model.

c. Heterogeneity of the impact of the tax on consumption

To examine heterogeneity on the impact of the tax on consumption for adults and children, we estimate the regressions for the consumption outcomes (equation 3) interacting Oak with the following indicators: Hispanic ethnicity, African-American, household is below 185 percent of the FPL, member of household receives SNAP benefits, member of household receives Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) benefits, adult has a high school education or less, adult never shops for beverages outside of Oakland at baseline, adult supports the tax at baseline, adult agrees that SSBs are bad for health at baseline, adult is trying to consume fewer SSBs at baseline, and child is over 10 years of age. We examine the impact of the tax by race, ethnicity, income, education, and public assistance to determine whether any subgroups changed their consumption as a result of the tax. We also examine the impact of the tax for those reporting that they do not shop outside of Oakland at baseline because cross-border shopping is one way that individuals can avoid the impact of the tax on their consumption of taxed beverages; thus, those not shopping for beverages outside of the city could be more likely to reduce consumption as a result of the tax. Similarly, those who supported the tax, who realized that SSBs are bad for their health, or who were trying to consume fewer SSBs might be more likely to reduce their consumption of taxed beverages. Finally, we are interested in whether older children, who are more likely to purchase beverages on their own (and many of whom directly responded to the survey) and consume more SSBs on average, changed their consumption of taxed and untaxed beverages.

We also split the sample of Oakland households into two groups based on how far they lived from the border. We estimate the impact of the tax separately for respondents whose address was in the top quartile by distance to the city border (in effect, those who lived in the middle of the city). Those living farther from the city border could have less opportunity to shop outside of the city at untaxed stores, and thus could be more likely to reduce their consumption of taxed beverages.

Finally, we estimate the relationship between the impact of the tax and baseline consumption level. Individuals who consume greater amounts of taxed beverages could be more likely to reduce their consumption because they have more to gain in terms of health effects or simply because they have more room to improve; conversely, they could be less likely to improve if their consumption patterns are more ingrained. We estimate the relationships between baseline consumption and the impact of the tax by adding spline terms for baseline consumption

with five knots to equation (3). We selected knots based on visual inspection of the distribution of baseline consumption for each outcome and to ensure that each spline term was supported by adequate numbers of observations.