

Beverage consumption and perceived healthfulness among parents, and investigation of spillover effects: Insights from the Seattle Sweetened Beverage Tax

Leah Neff Warner

A dissertation

submitted in partial fulfillment of the
requirements for the degree of

Doctor of Philosophy

University of Washington

2023

Reading Committee:

Jessica C. Jones-Smith, Chair

Amanda M. Fretts

Brian E. Saelens

Program Authorized to Offer Degree:

Department of Epidemiology

©Copyright 2023
Leah Neff Warner

University of Washington

Abstract

Beverage consumption and perceived healthfulness among parents, and investigation of spillover effects: Insights from the Seattle Sugar-Sweetened Beverage Tax

Leah Neff Warner

Chair of the Supervisory Committee:

Jessica C. Jones-Smith

Department of Epidemiology

Department of Health Systems and Population Health

Sugar-sweetened beverage (SSB) taxes are generally adopted with the goal of reducing SSB consumption and improving public health. Extensive research on local SSB excise taxes in the US shows that taxes consistently increase prices and decrease purchasing of taxed beverages in the taxed jurisdiction. Evidence of impacts on SSB consumption, however, is less consistent. In January 2018, Seattle implemented a 1.75-cent-per-ounce tax on the distribution of SSBs. While the tax was associated with fewer SSB purchases in Seattle, SSB consumption unexpectedly decreased in Seattle and the nearby nontaxed comparison area in King County in a cohort study of families with lower income. We hypothesized that the Seattle tax influenced comparison area

residents to reduce SSB consumption, known as spillover effects. We also hypothesized that parents responded differently to the SSB tax as compared to other adults as an alternative possible explanation for the cohort findings. Considering the essential role of parents in their child's dietary patterns and the limited evidence around tax spillover effects, the overall goal of this dissertation was to developing a better understanding of how perceived healthfulness and consumption of SSBs may have changed among families with lower income in Seattle and nearby areas. In Chapter 1, we conducted qualitative interviews with 35 former participants of the cohort study and learned that health was the primary reason that parents in Seattle and the comparison area decreased their SSB consumption one- and two-years post-tax. Parents said the tax had some influence on their SSB consumption as well, including some comparison area parents who were exposed to media coverage of the tax or beverage prices while shopping in Seattle. In Chapter 2, we analyzed a large panel of retail scanner data using linear difference-in-differences regression to investigate whether the tax influenced SSB purchasing in communities near Seattle as a form of spillover tax effects. We did not find evidence of spillover effects of the SSB tax in communities near Seattle relative to a matched comparison area, although we observed a 20% net decline in volume sold in Seattle relative to a matched comparison area. In Chapter 3, we analyzed repeated cross-sectional survey data from a Seattle tax evaluation study to examine whether associations between the SSB tax and perceived healthfulness and consumption of SSBs differed between adults with and without children in the home. Using linear and logistic difference-in-differences regression, we did not observe associations between the SSB tax and these outcomes among adults with or without children. Findings highlight the need to understand potentially unique experiences of tax spillover among households with lower income and strategies that support parents' motivations to reduce SSB consumption post-tax.

Table of Contents

List of Tables	6
List of Figures	8
Acknowledgments.....	9
Introduction.....	10
Chapter 1 Understanding changes in sweetened beverage consumption following implementation of the Seattle Sweetened Beverage Tax among parents in Seattle and nearby cities.....	15
Introduction.....	17
Methods	19
Results.....	24
Discussion.....	28
Conclusion	34
Supplemental Material	40
Chapter 2 Investigation of spillover effects of a sugar-sweetened beverage tax on beverage purchasing in a nearby, non-taxed area	42
Introduction.....	44
Methods	45
Results.....	50
Discussion.....	54
Conclusion	58
Supplemental Material	64
Chapter 3 Perceived healthfulness and consumption of sugar-sweetened beverages two years after the Seattle Sweetened Beverage Tax among adults with and without children in the household	72
Introduction.....	74
Methods	75
Results.....	81
Discussion.....	85
Conclusion	88
Supplemental Material	92
Conclusion	101
References.....	105
Appendix 1.1 Qualitative Interview Guide for Cohort Participants	115
Appendix 1.2 Qualitative Coding Framework and Protocol.....	123

List of Tables

Table 1.1. Sample of interview participants who were former participants in the Seattle Shopping and Wellness cohort study (N=35).	36
Table 1.2. Participant sample categorized by location and the change in consumption of sugar-sweetened beverages that were subject to the Seattle sugar-sweetened beverage tax from pre-tax to one-year post-tax in the Seattle Shopping and Wellness cohort study (N=35).	37
Table 1.3. Themes and illustrative quotes reflecting self-reported reasons for sweetened beverage consumption and influences on consumption among parents in Seattle and the comparison area whose consumption of sweetened beverages subject to the tax decreased from baseline (pre-tax) to 12 months post-tax.....	38
Supplemental Table 1.4. Themes and illustrative quotes reflecting self-reported reasons for and influences of sweetened beverage consumption among parents in Seattle and the comparison area whose consumption of beverages subject to the tax did not decrease from baseline (pre-tax) to 12 months post-tax.....	40
Table 2.1. Sample of beverages and mean volume sold (fluid oz.) by taxable status, type, and size in King County Excluding Seattle and its combined comparison area, 2016-2019.....	59
Table 2.2. Sample of beverages and mean volume sold (fluid oz.) by taxable status, type, and size in Seattle and its combined comparison area, 2016-2019.....	60
Table 2.3. Difference-in-differences in mean volume sold (fluid oz.) in Seattle and King County versus comparison areas, by taxed status, beverage size, and beverage type, comparing two years before to two years after the Seattle Sweetened Beverage Tax, 2016-2019.	63
Supplemental Table 2.4. Difference-in-differences in mean volume sold (fluid oz.) in Seattle and King County versus comparison areas, by taxed status, comparing one year before to one year after the Seattle SBT, 2017-2018.....	67
Supplemental Table 2.5. Difference-in-differences in mean volume sold (fluid oz.) in Seattle and King County versus comparison areas, by taxed status, comparing two years before to two years after the Seattle SBT in an unbalanced sample of UPCs, 2016-2019.	68
Table 3.1. Characteristics of the pre-tax and post-tax analytic sample in Seattle and the comparison area with and without at least one child in the home, 2017 and 2019.	89
Table 3.2. Changes in perceived health risks of sugar-sweetened beverages (SSBs) from before and after implementation of the Seattle SSB tax among adults with and without children in the home in Seattle and the comparison area, 2017 and 2019.....	90
Table 3.3. Changes in the odds of perceiving high consumption of sugar-sweetened beverages (SSBs) as healthful and reporting high consumption of SSBs from before and after implementation of the Seattle SSB tax among adults with and without children in the home in Seattle and the comparison area, 2017 and 2019.	91
Supplemental Table 3.4. Characteristics of the pre-tax and post-tax unweighted samples in Seattle and the comparison area among participants with and without at least one child in the household, 2017 and 2019.	95
Supplemental Table 3.5. Changes in perceived health risks of sugar-sweetened beverages (SSBs) and high SSB consumption in Seattle and the comparison area from before and after implementation of the Seattle SSB tax among participants with and without children in the household, 2017 and 2019.....	97

Supplemental Table 3.6. Changes in perceived health risks of sugar-sweetened beverages (SSBs) and high SSB consumption in Seattle and the comparison area from before and after implementation of the Seattle SSB tax among participants with children in the household and stratified by lower and higher household income (N=830), 2017 and 2019. 98

Supplemental Table 3.7. Differences-in-differences estimates from primary and stratified model variations in the use of propensity score weights and covariate adjustments in samples with and without children in the home..... 99

List of Figures

Figure 1.1. Conceptual model of potential factors influencing the pathways through which a sugar-sweetened beverage (SSB) tax affects SSB consumption among families living within and nearby the taxed jurisdiction.	35
Figure 2.1. Total weekly volume sold of beverages in King County excluding Seattle (KCES) and the comparison area, 2016-2019.	61
Figure 2.2. Total weekly volume sold of beverages in Seattle and the comparison area, 2016-2019.	62
Supplemental Figure 2.3. Map of the census tract-level population density in the treated areas in King County defined by the first three digits of the ZIP code.	69
Supplemental Figure 2.4. Differences in differences in annual mean volume sold of taxed and nontaxed beverages in King County excluding Seattle (KCES) relative to the comparison area from two years before and after implementation of the Seattle Sweetened Beverage Tax, 2016-2019.	70
Supplemental Figure 2.5. Differences in differences in annual mean volume sold of taxed and nontaxed beverages in Seattle relative to the comparison area from two years before and after implementation of the Seattle Sweetened Beverage Tax, 2016-2019.	71

Acknowledgments

To my Committee—Drs. Jessica Jones-Smith, Mandy Fretts, Brian Saelens, and Douglas Barthold—I feel incredibly lucky to have been able to learn from you and work together throughout my doctoral experience. This dissertation would not have been possible without your support and guidance. Thank you for your thoughtful feedback, expertise, and encouragement. A special thank you to my Chair, Dr. Jones-Smith, for your unwavering support, the immense amount of time you invested in my learning and growth as a researcher, and for believing I could do this even when I didn't.

To the SeaSAW research team at Seattle Children's Research Institute—Maya Rowland, Jonny Trujillo-Fernandez, Fahmo Abdulle, and Selam Kidane—Thank you for the incredible opportunity to work with you on the qualitative study. You made the qualitative study possible. I am forever grateful for the time and energy you devoted to making it a success.

I am extremely grateful for the time and contributions of all interview participants in the qualitative study. The qualitative study was funded by the City of Seattle as part of a five-year evaluation of the impacts of the Seattle Sweetened Beverage Tax led by researchers at UW School of Public Health, Seattle Children's Research Institute, and Public Health-Seattle & King County with oversight from the Sweetened Beverage Tax Community Advisory Board. City staff and elected officials did not influence the study design or interview questions, the data collection, or interpretation of findings.

Introduction

Background

Sugar-sweetened beverages (SSBs) are the largest source of added sugars in the diets of children and adults in the United States¹⁻³. Frequent intake of SSBs increases the risk of tooth decay, weight gain, obesity, diabetes, and cardiovascular disease,⁴⁻⁶ and consuming one additional SSB per day in the long-term is associated with a 10% increase in the risk of cardiovascular disease death⁶. Due to targeted marketing and long-standing structural and socioeconomic disparities in the food environment, populations with lower income and persons of color have disproportionately higher SSB intake and burden of disease^{1,7}. Moreover, while highly prevalent in the diet, SSBs contribute minimal nutritional value. There is a strong rationale for public health policies to help limit SSB consumption and improve health equity.

Sugar-sweetened beverage taxes show promise as an effective policy approach to reducing SSB consumption by increasing prices and reducing purchases of SSBs. Dietary behavior change is difficult to achieve with informational interventions alone.⁸ Fiscal policies can incentivize healthier decisions by changing the relative price of items at point of purchase, as well as generate revenue health promotion, and encourage product reformulation among beverage manufacturers.⁹ As such, SSB taxes are recommended by the World Health Organization to address a market failure of external costs linked to related health outcomes¹⁰ and incentivize behavior change.^{9,10} Further, excise taxes that reinvest tax revenue in community programs and public health like those in the US have been shown to have net benefits for populations disproportionately impacted by SSB-related health outcomes.¹¹

In the last decade, over 45 countries, regions, and cities have adopted SSB taxes.¹² In the US, rigorous evaluation studies of excise taxes in Berkeley,^{13,14} Philadelphia,¹⁵⁻¹⁸ Oakland,¹⁹

Seattle,^{20–23} and the repealed tax in Cook County²⁴ have established the majority of the evidence base showing that excise taxes on the distribution of SSBs increase the retail prices of SSBs (i.e., at least a portion of the tax is “passed through” to consumers) and reduce purchases in the taxed area relative to comparator non-taxed areas²⁵.

However, evidence of SSB tax impacts on consumption of SSBs has been less consistent. In general, reductions appear to be larger and most consistent for populations with lower income and for daily consumers of SSBs as compared to those with higher income and infrequent consumption, although other studies do not observe impacts in either group or overall^{13,17,19,26–31}. To date, only several studies have assessed tax impacts on health outcomes of SSB taxes. Evidence indicates positive impacts on weight gain^{32–34} and dental health particularly among lower income populations³⁵, suggesting that the taxes influence behavior despite the lack of consistency from SSB consumption data.

The Seattle Sweetened Beverage Tax

On January 1, 2018, the City of Seattle implemented a 1.75-cent-per-ounce tax on the distribution of SSBs. To assess the impact of the tax on SSB consumption, the Seattle Shopping and Wellness (SeaSAW) longitudinal cohort study enrolled children and their parents/caregivers from lower income households in Seattle and a non-bordering comparison area of South King County, Washington^{20,31}. Unexpectedly, SSB consumption decreased by similar amounts for families in Seattle and the comparison area after one and two years post-tax^{20,31}. This was unexpected because other studies observed significant tax impacts on SSB prices relative to the South King County comparison area²² and purchasing relative to Portland, Oregon²³.

In light of these findings and emerging evidence of health impacts^{33,34}, it is important to gain a better understanding of what led Seattle and South King County families to decrease SSB consumption, but not to a greater degree among Seattle families, in the SeaSAW cohort. More

broadly, examining how SSB taxes may influence behavior across different population groups can highlight implications for health equity. Parents/caregivers (henceforth, parents) are an important group in which to understand drivers of SSB consumption because their consumption and availability of SSBs in the household are the leading influences of their child's SSB consumption.^{36,37} In addition, individuals with lower income are more likely to be sensitive to beverage price increases than their higher income counterparts^{38,39}; this reinforces the need to investigate why differential change in SSB consumption was not observed among parents with low income in Seattle versus the comparison area.

Tax spillover effects in nearby areas

One hypothesis about the SeaSAW cohort findings is that of spillover effects, whereby Seattle and South King County parents were exposed to the SSB tax and this led parents in Seattle and some in South King County to decrease their SSB consumption. Mechanisms of this type of spillover include a signaling effect pathway and price sensitivity pathway of SSB taxes (**Figure 1.1**)

Signaling effects. Signaling effects, which can be understood through the theory of the expressive function of law^{40,41}, could change perceived healthfulness of SSBs or change social norms that lower the perceived appropriate intake of SSBs^{41,42}. The role of media coverage about the SSB tax can also be considered part of the tax signaling pathway. South King County and Seattle share a media market²⁰, thus potentially exposing both groups to information about the tax. There are several ways in which signaling effects could have manifested for South King County parents. Some people could have misunderstood the taxed jurisdiction and perceived the tax in their city as well. Evidence from other settings suggests that tax awareness is associated with reduced consumption⁴³ and framing higher prices as a SSB tax heightens its salience above the price alone^{44,45}. Even for South King County parents who understood the boundaries of the tax,

their awareness of the policy and the health rationale behind the policy may have also led to signaling effects.

Price sensitivity. The price sensitivity pathway is the primary way in which SSB taxes are thought to influence behavior in the taxed area^{10,14}. In the context of spillover, South King County parents may have been frequently exposed to high beverage prices due to the tax while shopping in Seattle and this led them to reduce purchasing and consumption. For example, commuting into Seattle regularly may have an influence on one's purchasing.

Differential impacts of SSB taxes for parents/caregivers versus other adults

A second hypothesis is that parents (with children in the home) were differentially responsive to the Seattle SSB tax as compared to other adults. To our knowledge this has not been examined in the SSB tax literature. Parents may be more responsive or less responsive to a SSB tax for several reasons. Marketing and health claims on beverages targeted towards children have been shown to mislead parents in perceiving certain SSBs are healthful^{47,49,109}. A tax may have a stronger signaling effect to parents than other adults if it makes clear which beverages are higher in sugar. Parents may in return modify their own consumption and their child's access to different beverages as they consider their health and their child's health. With relatively higher household costs, parents may be more price sensitive to the tax than other adults as well. On the other hand, parents may be less responsive to the tax if they have higher risk perceptions around SSBs to begin with or if child-directed marketing and demand for SSBs outweighs the potential burden of higher prices.^{53,54}

Aims

The overall goal of this dissertation is to develop a better understanding of how SSB consumption may have changed among families with lower income in Seattle in light of the unexpected findings from the SeaSAW cohort study. In the next three chapters, this work

investigates the hypotheses above to understand the extent to which the Seattle tax may have influenced health perceptions and consumption of SSBs in Seattle and nearby nontaxed communities, i.e., a form of spillover effects, and whether there is evidence of differential tax influences for parents with children in the home versus other adults.

Specifically, in Chapter 1, we collected qualitative data via semi-structured interviews with former participants of the SeaSAW cohort study to understand the experiences of parents who decreased their SSB consumption after implementation of the tax. We explored whether experiences and reasons for decreasing consumption differed between parents in Seattle and South King County to understand potential influences of the Seattle SSB tax and spillover. In Chapter 2, we conducted a quasi-experimental differences-in-differences analysis of retail scanner data to estimate changes in volume sold of SSBs in nontaxed areas of King County after implementation of Seattle's tax relative to a matched comparison area. This analysis used objective purchasing data to investigate whether tax spillover effects reduced SSB purchasing among shoppers in the nontaxed King County area. In Chapter 3, we analyzed data from the Seattle Sweetened Beverage Tax Norms and Attitudes survey, a repeated cross-sectional survey of adults in Seattle and a well matched comparison area, to estimate whether associations of the SSB tax and changes in health perceptions and SSB consumption differed between parents with versus without children in the home. We used linear and logistic triple differences regression models and propensity score weights to estimate associations and the extent to which they differed by having a child in the home.

Chapter 1 | Understanding changes in sweetened beverage consumption following implementation of the Seattle Sweetened Beverage Tax among parents in Seattle and nearby cities

Overview

Evaluation of Seattle's SSB tax showed that SSB prices increased and sales decreased in the two years post-tax, but in a community-based cohort study, SSB consumption unexpectedly decreased in both Seattle and nearby comparison areas. The objective of this qualitative study was to understand why parents in the cohort decreased or did not decrease their SSB consumption after implementation of the tax and whether reasons differed between Seattle and comparison area parents. We conducted semi-structured phone interviews with 35 participants who spoke English, Somali, or Spanish. Questions were based on socioecological influences on SSB consumption including price and non-price pathways of the SSB tax. Using thematic analysis, we compared themes between Seattle and the comparison area.

Most parents were primarily concerned about their health and the health of their families and this led them to decrease their SSB consumption. Other influences on SSB consumption were similar between Seattle and comparison area parents including beverage prices, media coverage, and participation in the cohort survey. Most Seattle parents and about half of comparison area parents who were aware of the SSB tax perceived some degree of influence of the tax on their SSB consumption. For some comparison area parents, media coverage about the SSB tax and exposure to taxed beverage prices while shopping in Seattle raised awareness of their consumption of sugary beverages. Some Seattle parents occasionally cross-border shopped for SSBs to avoid paying the tax.

Findings suggest that SSB taxes reinforce parents' health concerns about SSBs and support intentions to reduce consumption of SSBs. Pairing health messaging with SSB taxes may support

behavior change among families in the tax area and in nearby cities. Investigations of such spillover tax effects in other settings and with other data is warranted.

Note. A previous and extended version of this study was presented in a report to the Seattle Sweetened Beverage Tax Community Advisory Board and the City of Seattle in May 2022 as part of a suite of reports that finalized the five-year evaluation project on the tax, funded by the City of Seattle. The funder did not influence the study design, analysis, or results presented herein or in the above report.

Introduction

Sugar-sweetened beverages (SSBs) are the largest source of added sugars in the American diet and are a modifiable risk factor for diabetes, hypertension, heart disease, and dental caries^{3,5,6}. In the past decade, sugar-sweetened beverage taxes have been adopted in several US jurisdictions and many countries worldwide to disincentivize SSB consumption and generate revenue for public health¹². Rigorous evaluations of SSB excise taxes in the US in Berkely, Oakland, Philadelphia, Seattle, among others, have consistently found that these taxes are passed on to consumers in the form of higher retail prices and, in response, net SSB purchasing decreases in the taxed areas⁵⁵. Evidence of tax impacts on SSB consumption, however, is less consistent. Findings range from no change to moderate reductions in SSB consumption, mostly among populations with lower incomes or higher baseline levels of SSB consumption⁵⁵.

On January 1, 2018, the city of Seattle, Washington, implemented an excise tax of \$0.0175/ounce on the distribution of SSBs⁵⁶. To assess the impact of the tax on SSB consumption, the Seattle Shopping and Wellness (SeaSAW) longitudinal cohort study enrolled children and their parents/caregivers from lower income households in Seattle and a non-bordering comparison area of South King County, Washington^{20,31}. Unexpectedly, SSB consumption decreased by similar amounts for families in Seattle and families in the comparison area after one and two years post-tax^{20,31}. This finding was unexpected because other studies pointed to significant tax impacts on SSB prices relative to the South King County comparison area²² and purchasing relative to Portland, Oregon²³.

To begin investigating reasons for the discordance between the cohort findings and other Seattle tax findings, the research team held community event conversations with participants after the two-year study was completed³¹. Several potential explanations for the results were offered: a growing awareness of health effects of SSBs, high costs of SSBs in Seattle and the

comparison area even before the tax, differences in community resources for lower income families in Seattle versus the comparison area, and an increased awareness of beverage consumption after completing cohort surveys³¹. Because we could not analyze responses at the community events separately for participants from Seattle versus the comparison area or for participants who did versus did not decrease SSB consumption, it is unclear how the above experiences differ or relate across these groups and how the tax might have interacted with these experiences.

Further investigation can strengthen the field's understanding of SSB tax impacts beyond the Seattle context. Since taxes may influence beverage consumption through health risk signaling in addition to the main pathway of price sensitivity⁵⁷. This pathway may affect people in nearby areas outside of the taxed jurisdiction, known as spillover effects^{14,58}. Seattle and the comparison area in the cohort share a media market, whereas Seattle and Portland (the comparison area in the purchasing study mentioned above) do not⁵⁹. In addition, comparison area participants may have traveled into Seattle frequently enough to be exposed to the increased beverage prices due to the tax and leading to decreased consumption. Alternatively, the tax may have had little impact on cohort participants in either area. Questions remain about factors that lead individuals to change or not change beverage consumption in the context of a tax.

Objectives

Building on findings from the SeaSAW study community events, we sought to understand the experiences of parents in the SeaSAW cohort who decreased their SSB consumption after implementation of the tax and explore whether experiences and reasons for decreasing consumption differed between parents in Seattle and the comparison area. Secondly, we sought to understand the experiences of parents who did not decrease their SSB consumption after implementation of the tax and explore whether reasons differed between Seattle and comparison

area parents. Findings from this study offer important insights for future work on SSB taxes and other efforts to eliminate diet-related health inequities.

Methods

Design and population

We conducted semi-structured interviews with a sample of parents who were participants of the SeaSAW cohort. We interviewed parent participants instead of child participants because parents in the cohort were the primary grocery shoppers for their household and may have been more immediately exposed to the SSB tax, e.g., due to beverage price increases and media coverage. Participants were residents of Seattle or the nearby, non-taxed comparison area, comprised of cities in South King County, primarily Auburn, Federal Way, Kent, and Renton. Cohort participants who were eligible for the qualitative interviews must have completed all SeaSAW assessments (pre-tax, and 6-, 12-, and 24-month post-tax) and must not have moved out of their location group (Seattle or comparison area) during the study. At the time of cohort enrollment in 2017, cohort participants had a household income <312% of the Federal Poverty Level, with the majority having income <130% of the Federal Poverty Level. Detailed descriptions of eligibility and the baseline cohort population have been previously reported ²⁰. Interviews occurred between October 2022 and January 2023.

Sampling and recruitment

We used a stratified, convenience sampling scheme of four subgroups. The subgroups were based on whether participants lived in Seattle or the comparison area and whether their reported consumption of taxed SSBs decreased or did not decrease (i.e., increased or did not change) based on a modified beverage intake questionnaire⁶⁰ from baseline (pre-tax) to 12-months post-tax. We expected that participants who made large decreases in their SSB consumption may be more likely to remember what led to their change compared to participants with smaller decreases in SSB

consumption. Therefore, we used the midpoint between the mean changes in consumption for all Seattle parents and comparison area parents in the cohort after 12 months post-tax, 5.75 fluid ounces per day, as the cut point for the consumption change subgroups. This ensured that about half of the sample decreased their consumption by at least this amount.

We contacted individuals from a list of eligible cohort participants in a random order within each subgroup. Outreach was conducted in English, Spanish, and Somali, based on the language used in the cohort surveys. We contacted a larger proportion of Spanish-speaking participants because one of the interviewers primarily spoke Spanish, whereas the other interviewer spoke Somali and English. We made up to three contact attempts by text, phone, or email using following protocols similar to the cohort. Participants provided verbal informed consent after confirming eligibility criteria and were mailed a \$40 debit card after the interview. We closed recruitment when we reached our target sample size of 30-45 individuals within our timeline constraints.

Data collection

Theoretical framework. The interview questions were informed by our conceptual model depicting pathways through which a SSB tax may impact SSB consumption in the context of multilevel factors (Error! Reference source not found.). The model draws from previous work on socioecological determinants of SSB consumption⁸, community nutrition environments⁶¹, and multilevel influences on health behaviors⁶². The pathways involve exposures to 1) beverage prices (i.e., price pathway) and 2) health risk signaling of the tax (i.e., non-price pathway). Factors within individual, family, community, and regional domains influence one's experience with the tax pathways and SSB consumption over time. In this framework, we can identify factors that may lead tax effects to "spillover" in the comparison area for some individuals, and identify factors associated with little to no change in SSB consumption among parents in Seattle and the

comparison area. Finally, we include a pathway for the effects of participating in the SeaSAW cohort since this was a theme from community event discussions³¹. Different factors may be associated with the extent to which parents decreased their SSB consumption in response to participating in the study.

Interviews. Interview questions explored how parents' individual, family, community, and regional circumstances influenced their experiences with the pathways above. For example, we asked parents about SSB-related and tax-related information that they noticed and whether the information influenced their SSB consumption. When applicable, questions focused on the timeframe within the cohort study: from several months before the tax to one and two years after the tax was implemented. We also used parents' SSB consumption data from the cohort surveys to focus their recall of details around cohort study period. For example, we told parents whether their reported (taxed) SSB consumption decreased, did not change, or increased from baseline to one year and two years later. Among those whose SSB consumption decreased, we asked about the top reasons why about their top reasons why it decreased. To limit social desirability bias, the questions that mentioned the SSB tax were asked near the end of the interview. Finally, to explore the role of cohort participation, we asked participants directly if they thought any differently about the beverages they consumed after completing the surveys at each assessment and if this experience had an impact on their SSB consumption.

While we did not ask participants to describe their children's SSB consumption and reasons for changes over the same period, we asked participants about any changes in what they served to their children. We included these questions to understand household-level factors that may have influenced parental changes in SSB consumption. All questions incorporated input from the interviewers and were pilot-tested with two individuals not involved in the study. The interview guide is included in **Appendix 1.1**.

We offered interviews in English, Somali, and Spanish by phone, in person, and web-based video. Interviews were audio-recorded and professionally transcribed, and when applicable, translated to English. Interviewers also typed field notes following each interview to capture main points in the conversation. A subset of the research team met weekly with interviewers during data collection to assess interview quality, progress, and findings. Field notes and patient enrollment data were stored using REDCap electronic data capture tools^{63,64}. The study was approved by the Seattle Children's Institutional Review Board.

Research team. The interviewers, FA, and JFT, conducted recruitment and data collection. They each have extensive experience with community-based data collection, are native Somali- and Spanish-speakers, and identify as members of the local Somali and Hispanic/Latinx communities, respectively. Their community connections were essential to recruiting a diverse sample in the SeaSAW cohort and maintaining excellent retention over the two-year study. The interviewers were acquainted with many of the interview participants, as many recalled their involvement in the cohort study. The interviewers were also female, parents, and participants of the cohort study. Prior to data collection, each interviewer attended two trainings led by other team members on semi-structured interviewing techniques that included mock interviews. The interviewers worked for community public health and research programs at the time of this study.

Analysis

Method and code framework. We analyzed the transcripts using a thematic analysis approach, which is a method for identifying and interpreting patterns across individuals⁶⁵. Specifically, we tagged sections of text in transcripts with codes that described the basic meaning of the text in relation to our research objectives. We then examined coded text for patterns within each of the four analysis groups and iteratively developed themes within key topics relating to interview questions and the conceptual model. We additionally examined text that was not

patterned but meaningful to our understanding of diverse experiences. To compare themes between Seattle and comparison area groups, we created summary tables and further distillations of coded text, and to develop key findings, we interpreted thematic differences and similarities between the groups in the context of the conceptual model.

For our primary analysis, we compared themes between Seattle and comparison area parents who decreased their SSB consumption. Secondly, we compared themes among participants who did not decrease their consumption. We did this because the number of parents who did not decrease their SSB consumption was small and the participants had relatively low SSB consumption to begin with compared to participants in the groups that decreased consumption.

We employed a largely deductive approach to analysis in that we used the interview questions and conceptual model to inform the code framework. Codes were organized into two categories: 1) determinants of SSB consumption, which were organized within socioecological levels, and 2) indicators that either overlapped with determinants to provide context (e.g., timeframe, relating to the child versus the adult) or cataloged descriptive text (e.g., the number and ages of one's children). The code framework is included in **Appendix 1.2**.

Coding and theme development. Two members of the research team who were experienced with thematic analysis coded the transcripts. The coders first independently coded the same transcript, then discussed code applications. They adjusted the code framework to refine code definitions and adjusted code applications until all were in agreement. They repeated this process for each transcript until no further changes to the code framework were needed and they reached acceptable intercoder reliability (Cohen's kappa value of 0.78), which occurred after dual coding eight transcripts. Next, they separately coded the remaining interviews. Because interview questions asked about participants' beverage consumption data and city of residence, this

information was present in the transcripts and coders were aware of the subgroups in which participants belonged. Finally, one of the coders reviewed all coded text to develop themes and key findings. Throughout this process, early findings were shared with interviewers to gather feedback and obtain clarifications on sections of text. Dedoose Version 9.0.85 was used for coding and analysis⁶⁶.

Results

We received responses from 64 of the 201 participants who were contacted at least once for an interview invitation. Of those, six individuals declined to participate, 22 did not keep their scheduled appointment for an interview, one was lost to follow-up, and 35 agreed to participate and completed an interview. The participant sample included 16 individuals from Seattle and 19 from the comparison area. Participant demographic characteristics are described in **Table 1.1** and SSB consumption data from the cohort survey are presented in **Table 1.2**. All interviews were completed by phone and the average interview length was 40 minutes (range 22-68 minutes). One interview was repeated due to an audio recording failure; another was partially lost due to a recording failure and was not repeated.

Below, we describe five key findings from themes among participants whose sweetened beverage consumption decreased from baseline (pre-tax) to 12 months post-tax. Select illustrative quotes from participants are included below, and additional quotes are presented in **Table 1.3**.

1. Seattle and comparison area parents cited health as the top reason why they decreased their SSB consumption. Parents discussed motivations to improve their overall health as well as prevent weight gain, cavities, and diabetes which many parents linked to high consumption of sugary foods and beverages. Health concerns were discussed at the individual and household

level, as parents felt that modeling healthier behaviors and limited access to sugary drinks in the home was important for their children's health. Many parents also shared that having a recent medical diagnosis or a family history of diabetes and other conditions motivated them to change their SSB consumption, and this was slightly more common among comparison area parents than Seattle parents.

The main reasons I changed what I was consuming that period are, I understood what it's made of and what I was drinking. I got to know they were not good for the health of my children and mine. I planned to reduce its consumption as I couldn't stop consuming altogether. – Participant 29, Somali-speaker, Seattle

2. Parents in Seattle and the comparison area recalled information about the SSB tax in the media. While recollection of SSB tax media coverage was stronger among Seattle parents, many of those in the comparison area recalled hearing about the tax in the news. When asked about the information they remembered hearing or seeing about the tax, comparison area participants tended to comment on the health-related rationale of the tax in addition to the increased prices, while Seattle parents focused primarily on their personal experiences with noticing higher prices. This reinforces the idea that some comparison area participants were aware of the rationale for the tax which may have been communicated in the media coverage.

I remember once on Seattle Univision news; they were saying that they were going to charge a few cents more for people who consumed sugary drinks. But I didn't pay much attention because we don't consume that much. I only heard it on the news, on the Univision channel, from Latinos. But I don't remember hearing it anywhere else. Some friends were

also commenting on it. And well, it's good, so they don't buy sugary drinks anymore. – Participant 3, Spanish-speaker, Comparison area

3. Most Seattle parents felt that the higher beverage prices from the tax had some influence on their sweetened beverage consumption, and some parents occasionally cross-border shopped. Although health was the top reason for decreasing consumption sweetened beverages, many of the same parents in Seattle said the higher prices from the tax also had an influence on their consumption. Beverages became expensive and there was a strong motivation to limit purchasing. Some participants said they no longer bought SSBs in Seattle, and instead shopped outside the city to avoid the tax. Most conveyed that the cross-border shopping did not offset the amount they previously bought in Seattle.

That I've experienced it, I didn't need to hear about it. When you go it's like very evidenced that you are going to pay a big cut and nobody wants to pay it. So, I just walk away. When I think I need to buy it, I just walk away. As soon as it happened. And I was like, "Oh no, no, no," I was like no, I don't wanna be a part of this, water it is. [laughs]. In Seattle, I'm not gonna pay it. If I need it, I will yes, I will go to a different city and buy it and that will be the end of that. [...] But, it may not happen that day like I might go in Seattle and be like oh I forgot. But we don't need it that bad, we got bottles of water at home. Then like the next time when I'm going to another city, I remember like if I'm in Renton, I will go through that city and then I'll pick up whatever it is that I was gonna get. – Participant 34, English, Seattle

4. Some parents in the comparison area felt that the tax influenced their sweetened beverage consumption. When asked about the potential influence of the SSB tax on their SSB

consumption, about half of comparison area parents who were aware of the tax said that it had an influence on their consumption. Parents bought fewer beverages and limited their consumption to avoid paying higher prices. Some parents specified they did not buy SSBs while they were in Seattle, e.g., at work, while others did not specify where they noticed high prices of SSBs. For other parents, their awareness of the tax and its health rationale served as a reminder to limit consumption even when shopping elsewhere. Lack of clarity on the Seattle city boundaries of the tax did not surface as a theme (we introduced the Seattle SSB tax in the interview question).

Yes, yes, because I think, why should I spend on something that is not going to give me nutrition, that is not going to do me any good? [...] Yes, yes, everybody knows that, what I have heard is that the soda is so expensive, and we went to this place and a soda was about \$5. And with tax increase, people have stopped consuming so much of these sugary drinks. [...] Because I believe in the same thing. Me too. No, I don't buy a soda to save my money.

– Participant 13, Spanish-speaker, Comparison area

5. The experience of participating in the cohort and completing beverage surveys led some parents in Seattle and the comparison area to become more aware of the amount they consumed. Although many participants were already informed about health risks associated with excess SSB consumption, parents generally described a lack of awareness of the amount they and their household consumed prior to the cohort study. Most parents said the detailed cohort surveys helped increase this awareness. Both Seattle and comparison area participants mentioned that ubiquitous beverage industry marketing and promotions made it easy to buy and consume more than they intended, and the surveys brought clarity to this. Many parents attributed their increased awareness and ability to decrease consumption to participating in the cohort study.

Reinforcing these views, some comparison area parents discussed needs for more education and awareness efforts to expand beyond the study cohort and into their community.

So when I participated in the first survey, I started to see what I was consuming. I think, before that, I hadn't realized what my son and I consumed. And the study made me realize, "Wow, I'm eating too much sugar." – Participant 12, Spanish-speaker, Comparison area

Findings and illustrative quotes from the secondary analysis of participants whose SSB consumption did not decrease are presented in **Supplemental Table 1.1**. Briefly, we found that preferences for SSBs and habits were the top reasons offered for having not changed or increased their consumption in that period. Parents in both areas were generally aware of the Seattle SSB tax and had heard about it in the news or while shopping in Seattle. The Seattle SSB tax was perceived to have had little influence on SSB consumption patterns except for some comparison area participants when they shopped in Seattle. Parents recalled health clinics and the media as sources of health risk information about SSBs that motivated them to reduce consumption, but also mentioned beverage marketing and child's preferences for SSBs as barriers to doing so. Participating in the study increased some parents' awareness of their SSB consumption and prompted some to try to cut back. Other parents felt that the tax and cohort study had no influence on their consumption because they consumed few SSBs to begin with.

Discussion

In a racially/ethnically diverse sample of parents with lower incomes who reside within Seattle (taxed area) and nearby communities in South King County (non-taxed comparison area), this qualitative study identified factors that influenced SSB consumption following implementation of the Seattle SSB tax. We found that factors influencing declines in SSB

consumption were generally similar among participants in Seattle and the comparison group, including health concerns as the primary reason for change, as well as beverage prices, media coverage, and participation in the SeaSAW cohort study, with prices being a stronger influence among Seattle parents. Some parents in the comparison area were exposed to media coverage about the tax and this reinforced concerns about the health risks of SSBs, while others bought fewer beverages due to price increase when shopping in Seattle. Several parents in Seattle cross-border shopped to avoid paying the tax.

The finding of health as the primary reason for change among residents of the taxed and nontaxed areas aligns with other data from Seattle, Philadelphia, and Berkeley. In the SeaSAW cohort study, at two-years post-tax, participants reported whether they believed their sweetened beverage consumption changed in the previous two years, and if so, the primary reason for the change. Among those who believed their consumption decreased, most parents in Seattle (59%) and the comparison area (95%) selected health as their primary reason, whereas 26% of Seattle parents and 1% of comparison area parents selected SSB taxes or costs of beverages as their primary reason.³¹ A representative survey of Seattle adults two years post-tax with the same question found similar patterns as well⁶⁷. In addition, in Philadelphia and Berkeley, discussions with parents living in the taxed areas suggested that the tax supported parents' health-related motivations to reduce SSB consumption^{68,69}. Finally, there were subtle differences in the types of health reasons that parents described in the interviews. Relative to Seattle parents, comparison area parents more frequently discussed specific medical conditions that they or a family member were experiencing. This may point to differences in health status between Seattle and comparison area participants in the SeaSAW cohort. If such differences existed, this could have led to differential patterns of SSB consumption over the study period. However, while health status was not assessed

in the cohort study, many associated factors were controlled for in the analysis, including age, income, and race/ethnicity.³¹

Findings from the interviews support the hypothesis that a shared media market in the greater Seattle area raised parents' awareness of the SSB tax and health risks of SSBs in the comparison area. There was no publicly funded awareness campaign about the Seattle SSB tax, and while there were some grassroots community advocacy efforts to increase awareness about the tax and the health benefits of reducing SSB consumption prior to tax adoption, it is likely that news media was the main driver of public awareness about the tax in Seattle⁷⁰. A formal analysis of media coverage about the Seattle tax has not been conducted, but evidence from Boulder, CO, Oakland, CA, and elsewhere suggests that media more frequently framed SSB taxes in a neutral or positive manner than a negative manner, commonly citing health benefits of the tax⁷¹⁻⁷⁴. Evidence from a representative survey of Seattle adults indicated that a greater proportion of adults with low income recalled hearing or seeing positive messaging about the tax (32%) than adults with higher income (22%)⁶⁷, reinforcing the idea that parents in the SeaSAW cohort study from both Seattle and the comparison area may have been exposed to health risk messaging about SSBs in media coverage about the tax. It is worth noting from the interviews that two comparison area parents were unsure whether the tax had been up for a public vote (it was not; it was passed and enacted through vote of the Seattle City Council), suggesting potential confusion between the Seattle SSB tax and the 2018 Washington state ballot initiative 1634 (passed) to ban local grocery taxes and preempt any future SSB taxes in the state which generated substantial media attention⁷⁵.

In addition to media coverage, interviews suggested that some comparison area parents were exposed to high beverage prices that reinforced their intentions to decrease SSB consumption. Evidence from store audit studies indicate that SSB prices increased by a small

amount on average in the comparison area after implementation of the SSB tax, relative to larger price increases in Seattle as a result of the tax being applied to the distribution of SSBs in Seattle^{20,76}. This suggests that pricing in the comparison area did not increase dramatically post-tax and instead parents were probably exposed to the tax when shopping in Seattle. In addition, several comparison area parents described a signaling effect of the tax in that it served as a reminder to limit excess sugar intake even though they knew the tax was not in effect in the areas in which they lived. Confusion about the city boundaries of the tax did not emerge as a theme (we introduced the Seattle SSB tax in the interview question). However, this phenomenon may exist in the broader King County population, since a study in non-taxed communities in the Bay Area, CA, found that 15% of respondents incorrectly believed they lived in a taxed area⁷⁷.

From other studies of SSB taxes, there is mixed evidence about health risk signaling effects. Some natural and discrete choice experiments of SSB taxes suggest that awareness of the policy, apart from the higher prices themselves, has impacts on SSB purchasing or consumption^{43,45,78} and impacts may be greater when the tax is paired with health-related rationale⁴⁴. In contrast, after the repeal of the SSB tax in Cook County, IL, SSB purchasing quickly returned to pre-tax levels, indicating the tax did not have a signaling effect⁷⁹.

Responses from Seattle parents about the SSB tax align with previous evaluation work on this topic. Parents noticed higher beverage prices in stores and this motivated them to buy fewer taxed beverages. Some participants shopped outside of the city to avoid the tax, but most conveyed that this did not offset the amount they previously purchased. This finding is consistent with the one- and two-years studies of retail scanner data in Seattle compared to Portland that found there was minimal effect of cross-border shopping on tax-related decreases in volume sold in Seattle^{21,23}. We did not ask participants in the cohort study surveys if they cross-border shopped during the cohort study, so it is possible that this was a stronger theme than what surfaced here. In a separate

study, some parents with lower income in Philadelphia reported cross-border shopping to avoid the tax⁶⁸. In Seattle, it is unclear if cross-border shopping was more common for individuals with lower income than the retail scanner studies suggest since retail scanner data may underrepresent stores in lower-income neighborhoods⁸⁰. However, much of the literature suggests otherwise: tax impacts on SSB consumption and health outcomes are often greater in populations with lower income than higher income^{25,55}.

Finally, findings about the experience of participating in the SeaSAW cohort study is supported by literature on research participation effects on health behaviors^{81–83}. There is evidence that participation raises participants' awareness of unhealthy behaviors, and that intentions to change behavior may depend on perceived social acceptability as well as participants' relationship with the research study.⁸¹ In a systematic review, answering questions about alcohol consumption resulted in subsequent reductions in the amount consumed over time⁸². It is important to note that in the case of the SeaSAW cohort study, we would expect the influence of participation effects to be similar for parents in Seattle and parents in the comparison area because they completed the same surveys and received no intervention or health information about SSBs. The interviews suggested this, as participants from both areas described similar experiences of participating in study. Therefore, participation effects are an unlikely source of potential bias in the analysis of tax impacts on SSB consumption in the SeaSAW cohort. On the other hand, if there were differences between Seattle and comparison area participants with respect to health status or motivations for enrolling in the study, for example, participants effects may have been differential over time.

Limitations

First, this study relied on participant recall up to five years in the past, around the time of the baseline cohort assessment. Anticipating this, we designed our interview questions to prompt individuals to think thoroughly about their current SSB consumption to refresh their memories

before recalling past consumption and other life circumstances. We used evidence-based approaches to anchor one's memory to a point in time with the help of event-oriented prompts⁸⁴ and found it particularly effective to mention the baseline assessment itself. Nonetheless, some participants had difficulty remembering past details and their responses were brief. This limited our ability to compare them with those of participants who remembered more details.

Second, while our sampling approach oversampled people with large decreases in SSB consumption, which helped us explore potential tax spillover effects, the groups of individuals who did not decrease their consumption were substantially smaller in size. It was difficult to identify strong themes from the small groups of individuals who did not decrease consumption, so we described individual experiences to represent the variety of responses when appropriate. Several participants who did not decrease consumption had low consumption levels at baseline and thus had little room to decrease their consumption during the cohort study.

Third, whereas coding was conducted independently by two team members and found reliable, only one member of the study team analyzed the coded data and developed key findings; we did not have another team member try to independently reproduce findings. In addition, we were unable to share findings with interview participants during analysis. In light of these limitations, we use a relatively simple analytical framework and thematic analysis method so that our analytical process was more transparent than methods of greater complexity⁶⁵. We additionally checked our early findings with the interviewers and discussed the analytical approach with other study team members to find consensus on steps towards theme development and synthesis.

Fourth, when planning this study, we aimed to also interview peers of comparison area cohort participants who lived in the comparison area but did not participate in the cohort study. We wanted to understand the experience of living near the Seattle tax in the comparison area in the absence of cohort participation. Due to staffing and timeline limitations, we did not recruit

enough peers to be able to adequately synthesize and compare responses to those from cohort participants, and thus they were not included in this analysis.

Conclusion

This study revealed common threads between the experiences of Seattle and comparison area parents with lower income after SSB tax implementation in Seattle. Parents were primarily concerned about their health and the health of their families and this motivated them to reduced their SSB consumption. Most Seattle participants and about half of comparison area participants who decreased their SSB consumption and were aware of the SSB tax said the tax had some influence on their consumption. Findings provide insights on potential mechanisms of tax spillover among residents in the comparison area, including exposure to beverage prices while shopping in Seattle and media coverage of the tax. Future research investigating spillover of SSB tax signaling effects in other settings and with quantitative data is warranted.

Figure 1.1. Conceptual model of potential factors influencing the pathways through which a sugar-sweetened beverage (SSB) tax affects SSB consumption among families living within and nearby the taxed jurisdiction.

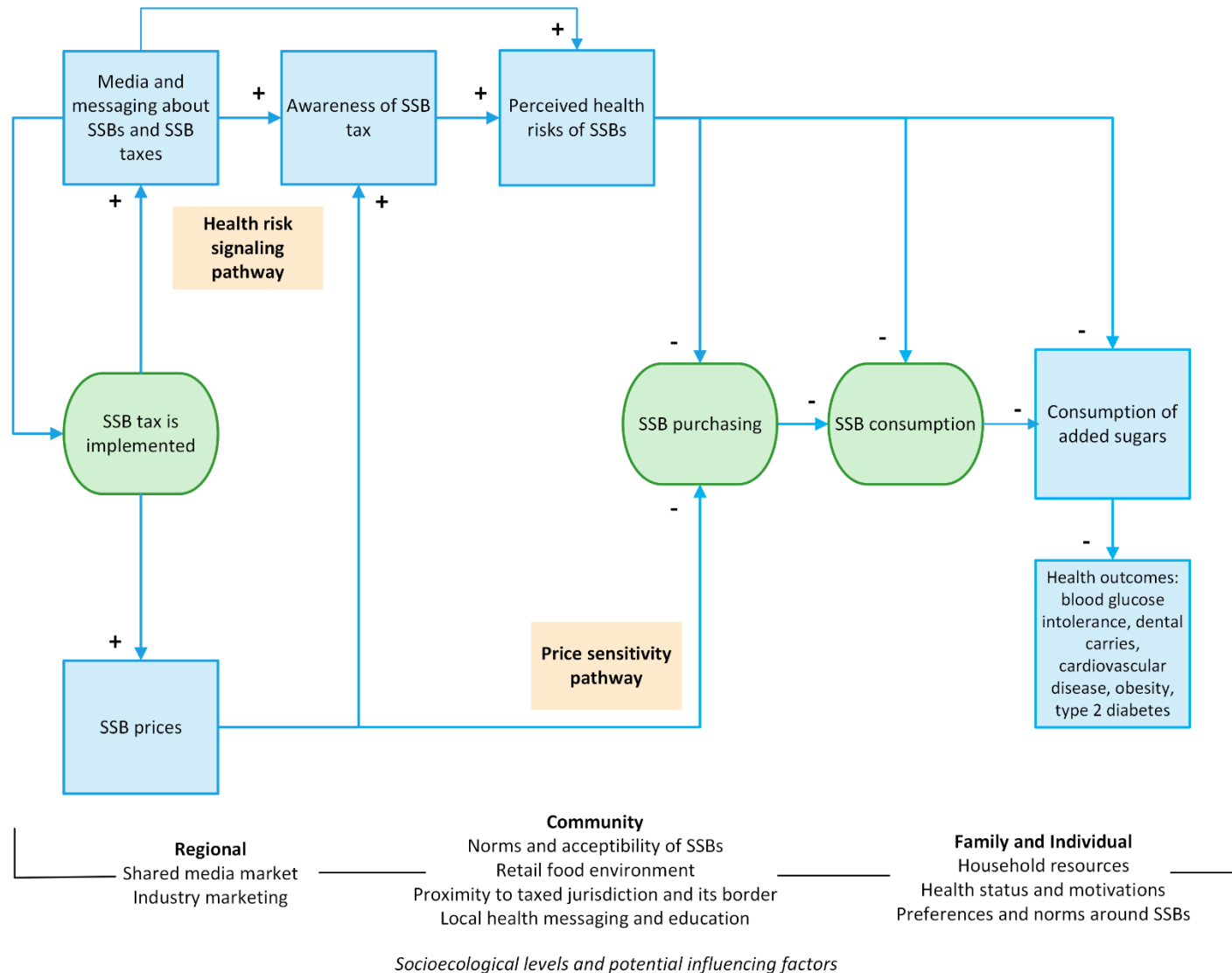


Table 1.1. Sample of interview participants who were former participants in the Seattle Shopping and Wellness cohort study (N=35).

	Seattle, n=16	Comparison, n=19	Total N (%)
<i>Language spoken</i>			
English	6	7	13 (37%)
Somali	7	0	7 (20%)
Spanish	3	12	15 (43%)
<i>Race/Ethnicity</i>			
Non-Hispanic African American/Black	8	5	13 (37%)
Non-Hispanic White	2	2	4 (11%)
Non-Hispanic other race ^a	2	0	2 (6%)
Hispanic	3	12	15 (43%)
Declined to answer	0	1	1 (3%)
Mean participant age, years (range)	46.0 (31-60)	41.4 (30-57)	43 (30-60)
Mean number of children (range)	3.3 (1-8)	2.7 (1-10)	3.0 (1-10)
Mean age of children, years (range)	13.9 (3-24)	12.3 (<1 – 27)	13.1 (<1 – 27)

^aTo protect participant confidentiality, this category combines two self-reported races that were each only reported once in the study sample. All participants but one identified as female.

Table 1.2. Participant sample categorized by location and the change in consumption of sugar-sweetened beverages that were subject to the Seattle sugar-sweetened beverage tax from pre-tax to one-year post-tax in the Seattle Shopping and Wellness cohort study (N=35).

Daily SSB consumption reported in the cohort study, fl.oz.	Decreased SSB consumption		Did not decrease SSB consumption ^a	
	Seattle n=10	Comparison area n=14	Seattle n=6	Comparison area n=5
Mean pre-tax SSB consumption (SD)	19.5 (19.4) Range: 1.1, 64.0	19.9 (21.5) Range: 2.9, 73.1	0.7 (1.2) Range: 0, 2.9	1.8 (2.5) Range: 0, 5.1
Mean change 1 year post-tax (SD)	-16.1 (19.3) Range: -62.3, -1.1	-16.7 (22.2) Range: -73.1, -1.4	2.8 (3.7) Range: 0, 9.14	2.9 (3.5) Range: 0, 7.1

^a Sweetened beverage consumption either did not change or increased. SSB: sugar-sweetened beverage; SD: standard deviation.

Table 1.3. Themes and illustrative quotes reflecting self-reported reasons for sweetened beverage consumption and influences on consumption among parents in Seattle and the comparison area whose consumption of sweetened beverages subject to the tax decreased from baseline (pre-tax) to 12 months post-tax.

Seattle parents (n=10)	Comparison area parents (n=14)
<p>1. Seattle and comparison area parents cited health as the top reason why they decreased their sugar-sweetened beverage consumption.</p>	
<p><i>There is no need to drink sugary sweets. Salty or sugary sweets are not good [for] health. Yes, I have cut down due to health reasons. – Participant 32, Somali-speaker</i></p> <p><i>The main reasons I changed what I was consuming that period are, I understood what it's made of and what I was drinking. I got to know they were not good for the health of my children and mine. I planned to reduce its consumption as I couldn't stop consuming altogether. – Participant 29, Somali-speaker</i></p>	<p><i>Well, it's also very much based on my family. One of my little sisters, the youngest one, she likes to eat a lot of sugar, a lot of sugar. So seeing that, she's gaining too much weight and it's affecting her breathing, she's getting like asthma. So that leads me to how to reduce the consumption of sugar even more. And if I do consume it, I'm trying not to consume it more than two or three times a week as I used to do in the past for the reason that on several occasions, whether it's part of my family, I'm also seeing many cases of people who are suffering or are being affected by the sugar. – Participant 11, Spanish-speaker</i></p>
<p>2. Parents in Seattle and the comparison area recalled information about the sugar-sweetened beverage tax in the media.</p>	
<p><i>I was like, are you kidding me? I was so upset, because it's not like I bought the stuff all the time. But even when I do buy it, I don't want to pay like double the amount. [...] All over the news. Everything. It was all over everywhere. – Participant 35, English-speaker</i></p> <p><i>Yeah, it was everywhere. They don't really talk about it much anymore. I guess everybody's used to it. – Participant 21, English-speaker</i></p>	<p><i>I remember once on Seattle Univision news; they were saying that they were going to charge a few cents more for people who consumed sugary drinks. But I didn't pay much attention because we don't consume that much. I only heard it on the news, on the Univision channel, from Latinos. But I don't remember hearing it anywhere else. Some friends were also commenting on it. And well, it's good, so they don't buy sugary drinks anymore. – Participant 3, Spanish-speaker</i></p> <p><i>There was just more information being pushed out about how sweetened drinks aren't healthy for your body. And that's why there's this sugar tax to decrease the consumption.- Participant 14, English-speaker</i></p>
<p>3. Most Seattle parents felt that the higher beverage prices from the tax had an influence on their sweetened beverage consumption, and some occasionally cross-border shopped.</p>	<p>4. Some parents in the comparison area felt that the tax influenced their sweetened beverage consumption.</p>

That I've experienced it, I didn't need to hear about it. When you go it's like very evidenced that you are going to pay a big cut and nobody wants to pay it. So, I just walk away. When I think I need to buy it, I just walk away. As soon as it happened. And I was like, "Oh no, no, no," I was like no, I don't wanna be a part of this, water it is. [laughs]. In Seattle, I'm not gonna pay it. If I need it, I will yes, I will go to a different city and buy it and that will be the end of that. [...] But, it may not happen that day like I might go in Seattle and be like oh I forgot. But we don't need it that bad, we got bottles of water at home. Then like the next time when I'm going to another city, I remember like if I'm in Renton, I will go through that city and then I'll pick up whatever it is that I was gonna get. – Participant 34, English

Yes, yes, because I think, why should I spend on something that is not going to give me nutrition, that is not going to do me any good? [...] Yes, yes, everybody knows that, what I have heard is that the soda is so expensive, and we went to this place and a soda was about \$5. And with tax increase, people have stopped consuming so much of these sugary drinks. [...] Because I believe in the same thing. Me too. No, I don't buy a soda to save my money. – Participant 13, Spanish-speaker

Well, I have thought about it more, although here where I live there is no tax, anyway it reminds me that if this tax exists, it is to remind us that sugar is not so good, that we should avoid consuming it. So, at least the tax will motivate us to stop buying so many sweetened beverages. – Participant 7, Spanish-speaker

5. The experience of participating in the cohort and completing beverage surveys led some parents in Seattle and the comparison area to become more aware of the amount they consumed

Yes, sometimes it gives me an idea like how to cut it. Even with my kids, even though I did it myself. Yes, whenever I did the survey with you guys, I used to slow it down with the sweet drinks. Participant 17, Somali-speaker

The truth is that I started to think about it when you started to investigate how much sugars I was drinking, and that was one of the reasons why I started to think "it is true that we are drinking a lot of sugars, my children are drinking" [...] And I said no, I have to start making the change. And then, since they have been doing the surveys I started to change a little bit, not completely like now, I don't buy them anymore, [...] but after the surveys I started to think about sugar, because my family suffers from diabetes, and I think it is a good step so that my children don't end up with diabetes, or me, who is older. – Participant 2, Spanish-speaker

Oh yeah, of course, made me think about how much sugary drinks I really did have. So yeah, just got me thinking, too much sugary drinks, need to cut back for sure. [...] We started to cut back less and less on juice and then eventually we don't even drink the juice anymore. – Participant 33, English-speaker

So when I participated in the first survey, I started to see what I was consuming. I think, before that, I hadn't realized what my son and I consumed. And the study made me realize, "Wow, I'm eating too much sugar." – Participant 12, Spanish-speaker

Supplemental Material

Supplemental Table 1.4. Themes and illustrative quotes reflecting self-reported reasons for and influences of sweetened beverage consumption among parents in Seattle and the comparison area whose consumption of beverages subject to the tax did not decrease from baseline (pre-tax) to 12 months post-tax.

Seattle parents (n=6)	Comparison area parents (n=5)
Preferences for sweetened beverages and habits were the top reasons participants reported for having not changed or increased their sweetened beverage consumption.	
<i>Because children liked it, that's why I used to buy them and drink with them, but now I noticed that it's not good for health. [...] I knew it was not healthy to drink those. Also, the more water you drink, the healthier your body will be. I knew this. [...] No, I just liked it with ice. – Participant 28, Somali-speaker</i>	<i>I think maybe just the time when I was struggling to not to drink too much coffee because coffee was the main problem. [...] That's the thing that when I tried to lower how much I drink then sometimes when I'm at work it's getting stressful and I say, "oh I need coffee," then I go get coffee. That's the only thing that I can say, that was hard to cut back. – Participant 25, English-speaker</i>
Participants had some awareness of the Seattle SSB tax and heard about it in the news or while shopping in Seattle.	
<i>I remember that too. If I bought any sweet drinks, I wouldn't buy them in Seattle. Sometimes I'd just do my grocery shopping outside of Seattle, just to limit. [When did you first hear about the tax?] I don't really know, but before it was about to roll out. I think it might be [from the] news. – Participant 19, English-speaker</i>	<i>Well, just that, that sugary drinks were going to have a tax increase, but I don't know how much, honestly. - Participant 1, Spanish-speaker</i>
The Seattle SSB tax was perceived to have had little influence on SSB consumption patterns except for some comparison area participants when they shopped in Seattle.	
<i>That's because if I wanted, I would just buy, if you have a habit of doing something, you don't look at the money, you just buy it. – Participant 31, Somali-speaker</i>	<i>If I lived in Seattle and I was on a budget knowing the fact that it has that high tax, that extra high tax, I probably wouldn't [buy taxed beverages]. My kids would probably be drinking water. – Participant 26, English-speaker</i>
Parents recalled health clinics and the media as common sources of SSB health risk messaging that motivated them to reduce consumption, but also mentioned beverage marketing and child's preferences for SSBs as barriers to doing so.	
<i>Well, yes, because before we used to drink more, almost every day and now it's not so much, it's not so much anymore. [...] Also, sharing information with the children, what you know, and also buying less so as not to be tempted. – Participant 16, Spanish-speaker</i>	<i>Well, it's always tempting to stop consuming, right? [...] Well, the truth is, I wouldn't want us to drink, neither them nor me. But sometimes I am not with my children all the time, so it's difficult. For example, the youngest sometimes drinks Sprite instead of Coca-Cola, which I think the only thing that changes is the color because I think it's the same amount of sugar. – Participant 1, Spanish-speaker</i>
Participating in the study increased parents' awareness of their own or their child's sweetened beverage consumption and prompted some to try to decrease their consumption.	
<i>Yeah. I understand even more better that it's not good for you. It can affect so many things and I also read some little bit more. [...] Definitely it</i>	<i>For example, I learned the amount, and I shared them with them so they could realize. [...] Yes, we reduced the quantity, immediately. [...] We</i>

helps. [...] Yeah. I understand more better than what is the difference between those regular concentrate juice or just normal fresh fruit? Which one is better? Definitely, yeah. In fact let me buy more fresh fruits than juice. – Participant 20, English-speaker

reduced the excessive consumption. [...] For example, some years ago, my answers were a lot of about sugar. Each day more and more. So. we have tried to moderated it, but there is still work to do. – Participant 5, Spanish-speaker

Chapter 2 | Investigation of spillover effects of a sugar-sweetened beverage tax on beverage purchasing in a nearby, non-taxed area

Overview

Growing research supports that excise taxes on sugar-sweetened beverages (SSBs) help reduce SSB purchasing and improve health outcomes in the taxed area. Some evidence suggests taxes influence behavior beyond price increases alone due to signaling effects and media messaging. It is unclear if these influences extend to non-taxed communities that share a media market. We assessed whether the 1.75 cent-per-ounce SSB tax in Seattle, WA (implemented in January 2018), influenced SSB purchasing in nearby communities within the same county and media market impacted SSB purchasing behaviors in surrounding non-taxed communities.

We used retail scanner data on weekly sales of 3,531 beverages at the Universal Product Code (UPC) level among 127 retailers in King County, Washington, excluding Seattle and its bordering area (KCES), and 243 retailers in a matched comparison area drawn from outside the regional media market. We estimated difference-in-differences in mean volume sold of taxed and nontaxed beverages comparing two years before (2016-2017) and after the tax (2018-2019) using linear regression with UPC fixed effects and robust standard errors clustered at the UPC level. We also estimated the DD among 87 retailers in Seattle versus 115 retailers in a matched comparison area outside the regional media market.

For taxed beverages, the mean difference in volume sold from pre-tax to post-tax in KCES was 5,811 fl. oz. (95% CI: -47,207, 58,828; $p=0.830$) above and beyond the change in the comparison area, reflecting a 1% change from the pre-tax mean in KCES. There was suggestive evidence of increased volume sold for regular and diet soda, and taxed multipack beverages in KCES relative to the comparison area. In Seattle, the mean difference from pre-tax to post-tax for taxed beverages was -122,677 fl. oz. (95% CI: -15,629, -89,064; $p<0.001$) above and beyond the change in the comparison area, translated to a 20% decrease in taxed volume sold associated with the tax.

This study did not find evidence of spillover effects in the form of reduced volume sold in communities near but not bordering the tax in Seattle. Studies in other SSB tax contexts are needed to investigate spillover on purchasing as well as possible changes to marketing in nearby areas that may explain observed increases in taxed and nontaxed soda.

Note. Researcher(s)' own analyses calculated (or derived) based in part on data from Nielsen Consumer LLC and marketing databases provided through the NielsenIQ Datasets at the Kilts Center for Marketing Data Center at The University of Chicago Booth School of Business. The conclusions drawn from the NielsenIQ data are those of the researcher(s) and do not reflect the views of NielsenIQ. NielsenIQ is not responsible for, had no role in, and was not involved in analyzing and preparing the results reported herein.

Introduction

Sugar-sweetened beverages (SSBs) are the largest source of added sugars in the American diet¹⁻³, contributing to high rates of obesity, diabetes, and cardiovascular diseases^{4,5}. To reduce SSB consumption and improve public health, more than 50 places worldwide have enacted SSB taxes over the past decade; this includes eight US jurisdictions¹².

There is consistent evidence that SSB taxes reduce purchasing of SSBs in the taxed area, suggesting a positive effect on public health⁵⁵. However, evidence of reduced SSB consumption is less clear. Drawing primarily from quasi-experimental studies in the US and Mexico, studies report moderate to no substantial reductions in reported SSB consumption or reductions only among high consumers of SSBs, populations with lower income, or within certain types of SSBs like soda^{25,55,85}.

The discrepancy between observed impacts on SSB purchasing and consumption raises questions about spillover effects of the tax in nearby comparison areas. A commonly studied form of spillover is tax avoidance, or cross-border shopping, whereby residents of the taxed area shop for SSBs outside of the taxed area and maintain their pre-tax SSB consumption levels¹⁰. While there is evidence of cross-border shopping in most SSB tax studies on SSB purchasing, the extent to which it occurs tends to vary by location, and it does not typically offset the net decreases in purchasing in the taxed areas^{25,55}.

Unlike cross-border shopping, a second form of tax spillover is thought to have positive implications for public health. In this case, a SSB tax may decrease SSB consumption not only among residents in the taxed area, but also in nearby nontaxed areas. A signaling effect of the tax about health risks of SSBs has been shown to influence behavior more than price increases alone in several^{41,45,86-88}, but not all studies⁷⁹. Residents living in nearby areas may be exposed to signaling effects through a shared media market or to messaging while spending time in the taxed area. While this type of spillover is a methodological consideration when selecting comparison areas for SSB tax evaluations²⁵, to our knowledge no studies have assessed SSB purchasing or consumption in nearby non-taxed areas beyond the immediate border areas prone to cross-border shopping. One study of four SSB taxes observed smaller tax effects on purchasing when compared to areas in the same media market as opposed to a national

comparison, offering some support for spillover effects⁵⁸. However, in a separate study, larger effects on purchasing were observed in Berkeley when compared to in-state versus out-of-state controls¹⁴.

On January 1, 2018, the City of Seattle implemented a 1.75-cent-per-ounce tax on the distribution of SSBs⁵⁶. Similar to other studies, extensive research on this tax has produced inconsistent findings. Prices of SSBs increased and purchasing of SSBs decreased, with little evidence of cross-border shopping.^{21–23} However, in a longitudinal cohort study of families with lower income in Seattle and nearby, non-bordering communities, SSB consumption decreased in both groups, but not differentially^{20,31}. These results leave open the possibility of tax spillover effects on nearby areas due to health risk signaling. To understand the scope and reach of the public health impact of SSB taxes, research on consumer behavior in nearby nontaxed areas is warranted.

Objective

This study investigated whether the Seattle Sweetened Beverage Tax influenced SSB purchasing in communities near Seattle as a form of spillover tax effects. We examined changes in volume sold of beverages before and after tax implementation among retailers in King County, Washington, that were not in Seattle or directly bordering Seattle, compared to changes in a matched comparison area drawn from outside of the Seattle media market. We also compared changes in volume sold among retailers within Seattle, relative to a matched comparison area outside of the media market. While tax effects on purchasing in Seattle have been observed^{21,23}, the comparison areas and statistical approach in the present study differ from previous studies. Moreover, it was important to assess whether our study detected a tax effect in Seattle to contextualize our assessment of spillover beyond Seattle.

Methods

Study design

We used a longitudinal, quasi-experimental difference-in-differences (DD) design to compare changes in the volume of taxable beverages sold in areas exposed to the Seattle Sweetened Beverage Tax—the treated areas—to comparison areas unexposed to the tax from two years before and after tax

implementation (2016-2017 vs. 2018-2019). We defined and examined separately two treated areas: 1) King County, Washington, excluding Seattle (KCES), which was not subject to the tax, but hypothesized to be subject to tax spillover effects, and 2) Seattle. We cannot directly estimate spillover effects by comparing KCES and Seattle to one another because we need comparison areas to represent trends we would expect in the absence of any tax and spillover effects. Further, due to demographic differences between the Seattle and KCES populations, SSB purchasing may trend differently over time in each area. Therefore, we estimated the DD for each treated area relative to comparison areas matched on demographic measures. The comparison area for KCES was the combination of Sacramento County, CA, and Oakland County, MI, and for Seattle, the combination of Dane County, WI, and Denver County, CO.

To select the comparison areas, we used a multi-step process that matched US counties with the treated areas on population-level variables thought to be associated with trends in SSB consumption⁸⁹. Steps are detailed in **Supplemental Material i**. We used Mahalanobis distance matching⁹⁰ based on pre-tax, county-level demographic measures from the American Community Survey⁹¹. From the list of matches, we excluded counties with a history of passing or proposing a SSB tax in or near the county because media coverage about a proposed tax may influence SSB purchasing behavior^{14,57,92} and we needed a comparison area unexposed to tax media coverage. We further narrowed the list by prioritizing counties with similar pre-tax political climates and SSB consumption levels to those in the treated areas. For the final comparison areas, we combined the top two county matches for each treated area and took the average of the volume sold; each county contributed equal weight to the outcome. We used combined comparison areas to smooth out potential violations of parallel trends that would be more problematic in a single county.

Data source and sample

We used retail scanner data from the NielsenIQ Datasets at the Kilts Center for Marketing Data Center at The University of Chicago Booth School of Business. Each observation represented the weekly total volume sold for a beverage item from each store in the dataset. Beverage items were defined at the Universal Product Code (UPC) level. The store types defined by NielsenIQ and present in the dataset were convenience, drug, food, and mass merchandizer stores.

The location of each store, and thus treatment assignment, was determined by the store's county and first three digits of the ZIP code. Within King County, WA, we assigned stores with a ZIP code starting with 980 to the KCES treated area and stores with a ZIP code starting with 981 to the Seattle treated area. Since this was the smallest geographic level at which we could assign treatment, some stores assigned to the Seattle area may have been located outside the border of the city and tax. Likewise, the KCES treated area may have included stores in King County that were located beyond the area most likely to experience tax spillover. For example, cities in South King County may be more sensitive to spillover effects than cities east of Seattle which extend over waterways and, further east, a mountain pass. Since the population density is highest in the areas we believe to be sensitive to spillover (**Supplemental Figure 2.3**), we assume stores are distributed similarly and that our sample largely reflects purchases in the areas sensitive to spillover. Importantly, all stores in the city of Seattle in the dataset were assigned to the Seattle treated area. In addition, stores in the immediate border around Seattle where cross-border shopping would likely occur are also grouped in the Seattle treated area. In the presence of cross-border shopping, a Seattle tax effect would be underestimated; however, previous studies found no evidence of cross-border shopping^{21,23}.

At the UPC level, we categorized beverages as taxed (i.e., would be subject to the tax) or nontaxed using product module and item descriptions in the dataset. The Seattle tax applies to beverages sweetened with caloric sweeteners, whereas beverages with artificial, non-caloric sweeteners (e.g., diet soda) are not taxed⁵⁶. We classified beverages by type, with taxed beverages including soda, fruit drinks, bottled coffee and tea, energy drinks, and sports drinks. Nontaxed beverages included diet soda, 100% juice/diet fruit drinks, milk, bottled water (plain, flavored, or sparkling), and diet/unsweetened bottled coffee, diet/unsweetened bottled tea, diet energy drinks, and diet sports drinks. We included nontaxed beverages because they serve as comparator to taxed beverages as we do not expect the tax or spillover of the tax to reduce purchasing of nontaxed beverages in the same way. Further, we wanted to understand whether nontaxed beverage purchasing increased as consumers may switch to nontaxed beverages in response to the tax. We additionally categorized beverages by size, including single serving (≤ 1 liter), family size (>1

liter), and multipack (>1 beverages of any size per package sold) because tax pass-through and purchasing are known to vary by beverage size^{22,23}.

Due to ambiguous tax status, we excluded from our sample: self-serve and fountain drink purchases, beverages in powder or syrup form, and beverages designated by NielsenIQ as mixers and additions to alcoholic beverages. We then excluded beverages for which we could not determine taxable status or beverage type after searching online for details, which accounted for 0.8-1.0% of volume sold in each of the treated and comparison areas. Finally, we omitted observations in the three months preceding the tax and in the first month after the tax due to potential effects of tax anticipation and implementation delays, as was suggested in previous studies of beverage purchasing and Seattle's tax^{21,23}.

To limit bias due to differences in the number of stores participating in the dataset over time and between the treated and comparison areas, we used a balanced sample of stores. This means we excluded stores that appeared only once in the dataset in either the pre- or post-tax period. We also restricted our sample to balanced UPCs, allowing us to compare changes in volume sold within the same beverages over time. We excluded UPCs that appeared only once in the pre- or post-tax periods, which amounted to excluding 5.5% of the total volume in our dataset for KCES, 4.2% for the KCES comparison area, 6.0% for Seattle, and 5.3% for the Seattle comparison area.

Statistical analysis

We aggregated the total volume sold for beverages each in the pre-tax and post-tax periods by multiplying the UPC unit size in fluid ounces by units sold. We then plotted weekly volume sold for beverages subject to the tax in the treated and comparison areas and performed event study analyses in the pre-tax period⁹³. Findings supported the parallel trends assumption in that pre-tax trends did not differ meaningfully between treated and comparison areas.

For the primary analysis, we estimated the DD in the volume sold of taxed beverages from the pre-tax to post-tax periods in KCES and the comparison area, and separately, in Seattle and the comparison area. We additionally estimated the DD for nontaxed beverages and for each beverage type and size

category among taxed and nontaxed beverages. We fit linear DD regression models with UPC fixed effects and robust standard errors clustered at the UPC level. The DD, or tax effect estimate, reflects the average amount by which volume sold changed in the two years post-tax compared to two years pre-tax for a typical beverage in the treated area above and beyond changes in the comparison area over the same period. Fixed effects adjust for time-invariant, unobserved factors at the UPC level that may otherwise bias the tax effect estimate. The statistical model is described in **Supplemental Material ii**.

In a secondary analysis, we estimated the DD in the first year post-tax because the tax may have influenced purchasing differently in the short-term. We balanced the sample on stores and UPCs present one year before and after the tax, and applied the same exclusion criteria and fixed effects model above. In a separate analysis, we fit a pooled ordinary least squares regression model to estimate DDs using an unbalanced sample of UPCs over the two years before and after the tax. This added back to our sample beverages with purchases reported in only one of the pre- or post-tax periods. We estimated the DDs for the same categories of beverages described above, with covariate adjustment for beverage type and/or size. Instead of estimating within-UPC changes in the primary balanced sample, this analysis estimated the average change per UPC across all beverages in the context of compositional shifts in product availability over time. Estimates may take on more bias since we cannot adjust for unobserved UPC-specific characteristics. Further, the number of UPCs in each area and each timepoint differ and therefore affect the outcome of mean volume sold per UPC.

Additionally, we fit a linear regression model to estimate the triple difference (DDD) in volume sold—the difference between the KCES DD and Seattle DDs—each for taxed and nontaxed beverages. This represented the amount by which the change in volume in Seattle that was attributed to the tax was different from any change in volume in KCES that was attributed to spillover of the tax⁹⁴. We used this model to test whether the DD in Seattle differed from the DD in KCES; if both DDs were negative and not statistically significantly different from other another, this suggests a similar effect of the tax in Seattle and KCES. We estimated the triple difference within each beverage type and size to examine differences in potential tax effects by beverage characteristics. We used the primary, balanced samples of UPCs and

adjusted for UPC-level fixed effects and clustered, robust standard errors. The statistical model is described in the **Supplemental Material iii**. A key assumption of a DDD analysis is that the relative differences between the pairs of treated and comparison areas trend similarly over time⁹⁴; we extend our assumption of parallel trends in the primary DD models to this case.

Finally, we assessed the robustness of our findings to different model specifications and sample inclusion criteria. First, we explored whether results from the primary analysis differed substantively when using fixed effects for store-type-specific UPCs. We considered a UPC sold at a drug store to be a unique observation from the UPC sold at a mass merchandizer store. With evidence of differential pass-through of the tax across store types²², this specification allowed changes in volume sold for a beverage product to vary by store type. Then, we examined whether results were materially different when using a more restrictive definition of a unique UPC. A beverage that changed its product size, brand, or description from one year to another was considered a separate beverage from its previous version and was thus less likely to be retained in the balanced sample. Results from both analyses were not materially different from those of the primary analysis (data not shown).

For all analyses in this study, we set α to 0.05. Due to known limitations of using the p -value to distinguish meaningful results, we did not correct for multiple comparisons and instead considered the magnitude of DD estimates, 95% confidence intervals, and p -values altogether to guide interpretation of results⁹⁵. All analyses were performed using Stata version 17.0 (College Station, TX).

Results

The analysis samples included 1,541 UPCs from 127 stores in KCES, 1,990 UPCs from 243 stores from the KCES comparison area, 1,439 UPCs from 87 stores in Seattle, and 2,135 UPCs from 115 stores from the Seattle comparison area between the years 2016 and 2019. **Tables 2.1 and 2.2** present mean volume sold for a typical UPC over time, by taxed status, beverage type, and size in each analysis sample. **Figures 2.1 and 2.2** show trends in volume sold by taxed status for each analysis sample.

Difference-in-differences in beverage volume sold in King County excluding Seattle

i. Taxed beverages

The estimate of the Seattle tax effect on mean taxed beverage volume sold over two years in KCES relative to the comparison area was 5,811 fl. oz. (95% CI: -47,207, 58,828; $p=0.830$) (**Table 2.3**). This translates to an approximate 1% change from the mean in the pre-tax period in KCES above and beyond changes in the comparison area and does not provide evidence of a tax effect. Estimates of tax effects by beverage type and size similarly reflected little differential change from pre- to post-tax. There was suggestive evidence of small increases for soda (7%; $p=0.059$) and multipack beverages (10%; $p=0.076$), and a small decrease for sports drinks (-9%, $p=0.089$) in KCES relative to changes in the comparison area.

When restricting the sample to balanced UPCs sold in the last year preceding the tax and the first year after the tax, some tax effect estimates were more positive compared to the primary results over the four-year period (**Supplemental Table 2.4**). The effect of the tax on mean taxed beverage volume sold in the first year in KCES was 20,375 fl. oz. (95% CI: -4,524, 45,274; $p=0.109$), a 7% increase from the pre-tax period relative to the change in the comparison area. There was some evidence of increased volume sold for soda (15%; $p=0.028$), energy drinks (20%; $p=0.020$), and multipack beverages (26%; $p=0.004$) in association with the tax.

In the unbalanced sample of UPCs, we retained UPCs that were present only in one of the pre- or post-tax periods and we adjusted for beverage type and size. Several tax effect estimates differed from those in the primary balanced sample (**Supplemental Table 2.5**). The tax effect for an average UPC among taxed beverages was more positive, at 74,795 fl. oz. (95% CI 22,841, 126,749; $p=0.005$), reflecting an approximate 16% increase in taxed beverages sold in KCES relative to the comparison area. We also observed increases for soda (44%; $p=0.003$) and multipack beverages (17%; $p=0.011$) in association with the tax.

ii. Nontaxed beverages.

The estimate of the Seattle tax on mean volume sold of nontaxed beverages in KCES was 65,241 fl. oz. (95% CI: -55,044, 185,525; $p=0.288$), a 3% increase in KCES from the pre-tax period after accounting for changes in the comparison area (**Table 2.3**). Tax effect estimates were generally small across nontaxed beverage types and sizes except for increases in volume sold of diet soda (12%; $p=0.008$) and diet/unsweetened bottled coffee (41%; $p=0.043$) relative to changes in the comparison area.

In the analysis restricted to one year before and after tax implementation, tax effect estimates were generally more positive than in the primary analysis (**Supplemental Table 2.4**). The effect of the tax on volume sold in KCES was 69,956 fl. oz. (95% CI: 8,028, 131,885; $p=0.027$) for nontaxed beverages overall, a 13% increase relative to the comparison area. We also observed increases for diet soda (24%; $p=0.003$), milk (26%; $p=0.033$), diet/unsweetened bottled coffee (70%; $p=0.008$), and nontaxed single serving sizes (23%; $p<0.001$) in association with the tax.

When we estimated the tax effect estimate in the unbalanced sample of UPCs, the tax effect in KCES was more positive than the balanced sample estimate (**Supplemental Table 2.5**). We observed an increase of 103,612 fl. oz. (95% CI: 4,384, 202,839; $p=0.041$) for nontaxed beverages overall in KCES above and beyond the change in the comparison area, which suggested a 31% increase from the pre-tax period. We observed increases for milk (35%; $p=0.024$), diet/unsweetened bottled coffee (61%; $p=0.068$), and nontaxed family size beverages (10%; $p=0.080$) as well.

Difference-in-differences in beverage volume sold in Seattle

i. Taxed beverages.

Among taxed beverages overall, the effect of the tax on mean volume sold in Seattle was -122,677 fl. oz. (95% CI: -156,290, -89,064; $p<0.001$) within the two years post-tax (**Table 2.3**). This amounts to a 20% decrease in taxed volume sold in Seattle above and beyond the change in the comparison area. Tax effect estimates were similarly negative and large across beverage types and sizes, with notable decreases for soda (-18%; $p<0.001$), fruit drinks (-30%; $p<0.001$), sports drinks (-23%; $p<0.001$), and family size

beverages (-29%; $p < 0.001$) in Seattle relative to the comparison area. No change was observed for bottled coffee (-1%; $p = 0.844$) and energy drinks (0%; $p = 0.999$).

In analyses restricted to one year before and after tax implementation, tax effect estimates for overall taxed beverages and by beverage type and size were similar to those in the primary analysis (**Supplemental Table 2.4**). In the unbalanced sample of UPCs, estimates of the tax effect were also generally negative and similar to those in primary analysis (**Supplemental Table 2.5**). For overall taxed beverages, we observed a mean decrease of -52,580 fl. oz. (95% CI: -82,557, -22,603; $p = 0.001$), or 14% from pre-tax levels, in Seattle relative to the change in the comparison area. The greatest reduction was observed for soda (-25%; $p = 0.002$), while no change was observed for bottled coffee (1%; $p = 0.971$), energy drinks (-9%; $p = 0.276$), and single serving beverages (-5%; $p = 0.252$).

ii. Nontaxed beverages.

The effect of the tax on the mean volume sold of nontaxed beverages in Seattle was 1,572 fl. oz. (95% CI: -65,948, 69,091; $p = 0.964$), approximating 0% change in volume sold in the two years post-tax (**Table 2.3**). Across beverage types and sizes, tax effect estimates were generally small and suggested minimal change associated with the tax. An exception was a decrease in volume sold for 100% fruit juices/diet fruit drinks (-14%; $p = 0.024$) relative to the comparison area.

When we restricted the sample to purchases in the one year preceding and one year following tax implementation, tax effect estimates suggested an increase in nontaxed volume sold in Seattle (**Supplemental Table 2.4**). The effect of the tax for nontaxed beverages overall was 44,313 fl. oz. (95% CI: 13,065, 75,561; $p = 0.005$), a 14% increase from the pre-tax period in Seattle. Estimates suggested increases for diet soda (15%; $p = 0.034$), milk (19%; $p = 0.064$), and diet/unsweetened bottled coffee (60%; $p = 0.059$), as well as increases for nontaxed single serving sizes (18%; $p < 0.001$) and nontaxed multipack sizes (15%; $p = 0.077$).

In the unbalanced sample of UPCs, estimates of the tax effect were similar to those in the balanced sample (**Supplemental Table 2.5**). For nontaxed beverages overall, the tax effect estimate on mean volume

sold in Seattle was 10,136 fl. oz. (95% CI: -46,488, 66,759; $p=0.726$), a 2% change from the pre-tax period. Estimates for beverage types and sizes were similarly small, except for a large increase for diet/unsweetened bottled coffee (82%; $p=0.057$).

Triple difference in beverage volume sold in Seattle relative to King County excluding Seattle

For taxed beverages overall, the triple difference estimate suggests that the effect of the tax on mean volume sold in Seattle was more negative than the effect of the tax in KCES by -128,487 fl. oz. (95% CI -191,247, -65,727; $p<0.001$), on average, in the two years post-tax. (**Table 2.3**). Since we observed evidence of a tax-related decrease in volume sold in Seattle from the DD analyses, but not in KCES, the triple difference estimate is similar in magnitude to the Seattle DD estimate. Among specific beverage types and sizes, there were larger tax-related decreases in Seattle relative to KCES for taxed soda (DDD: -204,856 fl. oz., 95% CI: -297,948, -111,763; $p<0.001$), taxed single serving sizes (DDD: -31,696 fl. oz., 95% CI: -59,793, -3,600; $p=0.027$), taxed multipack sizes (DDD: -212,305 fl. oz., 95% CI: -355,404, -69,206; $p=0.004$), and taxed family sizes (DDD: -288,097 fl. oz., 95% CI: -546,165, -30,030; $p=0.029$). Among nontaxed beverages, triple difference estimates were generally negative and small in magnitude; altogether, there was no evidence that the tax effect for nontaxed beverages in Seattle differed from the tax effect in KCES.

Discussion

In this quasi-experimental study of the Seattle Sweetened Beverage Tax, we did not find evidence of spillover effects on sweetened beverage purchasing in communities nearby but not bordering Seattle after two years post-tax. Primarily, volume sold of taxed beverages in KCES over time did not differ meaningfully from volume sold in the matched comparison area over the same period. Unexpectedly, there was suggestive evidence of small increases in volume sold for taxed soda (7%) and multipack (10%) beverages in KCES that persisted and became statistically significant in analyses that examined changes one-year post-tax and in an unbalanced sample. In contrast, in Seattle we observed an approximate decrease of 20% in mean taxed beverage volume sold in association with the tax, relative to the comparison area. We observed this tax effect even though the defined Seattle area in this study included immediate bordering

cities. Our overall findings in Seattle align with the 22% reduction reported previously that used a similar dataset but different comparison area and model specifications²³.

Among nontaxed beverages in KCES, we observed tax effects on volume sold for diet soda in the first year (24%) and combined two years (12%) post tax. Estimates suggested a similar pattern in Seattle. Volume purchased of diet single serving size beverages increased in KCES (24%) and Seattle (15%) in the first year post tax, though not in the two years combined. A previous Seattle study reported small increases in volume sold for diet single serving soda and diet single serving juice drinks after two years post-tax²³. As a larger trend, recent systematic review and meta-analysis did not find evidence of substitution (from taxed beverages) to nontaxed beverages or water in association with SSB taxes⁵⁵.

The overall null finding for spillover effects on purchasing has mixed support from other Seattle SSB tax studies with comparison areas in or containing KCES. First, two recent studies observed significant tax impacts on BMI change in Seattle relative to nearby counties^{33,34,96}. This suggests spillover was not present to the extent that it masked observable tax impacts in Seattle. On the other hand, a study of SSB consumption among families with lower income in Seattle and South King County found no evidence of a tax impact, and instead found SSB consumption to decrease in both areas^{20,31}. In the context of known tax impacts on price and purchasing in Seattle^{22,23}, the SSB consumption results support the idea of spillover on purchasing and consumption in KCES. Moreover, in follow-up interviews with parents with lower income, some comparison area parents reported decreasing their SSB consumption in part due to exposure to the price and messaging of the tax⁹⁷. If spillover effects were experienced among lower but not higher income households, this may explain our different findings. Small, independent stores (e.g., corner stores) are underrepresented in scanner data used in the present analysis⁸⁰, and they tend to be the primary source for SSB purchases among residents of lower-income neighborhoods^{80,98,99}. Alternatively, it is possible that tax spillover effects were indeed negligible, and that the consumption data were influenced by self-reporting biases.

There is little research from other SSB tax settings on spillover effects in nearby areas. However, the potential for spillover on nearby comparison areas is a known methodological consideration when

selecting comparison areas.²⁵ There is some evidence that nearby versus distal comparison areas tend to estimate smaller tax impacts¹⁰, though this has not been systematically evaluated across the SSB tax impact literature. One study of Berkeley's tax observed decreases in SSB purchasing post-tax when compared to in-state controls but not to out-of-state controls.¹⁴ The finding contrasts with the hypothesis that areas near a tax may trend more similarly than distal areas, but since this study omitted the Bay Area from the analysis—home to Berkeley and two other local SSB taxes—the findings say more about state-level secular trends than spillover within a shared media market. Findings from the repealed tax in Cook County offer some evidence against spillover effects. Since beverage purchasing returned to pre-tax levels soon after the repeal,⁷⁹ it is unlikely that the tax had a health risk signaling effect, i.e., consumers did not continue to purchase less due to the tax conveying health risk information about SSBs. Thus, it is unlikely that signaling effects spilled over into nearby areas.

Much of the literature instead examines cross-border shopping, which is also important to understanding the public health impact of SSB taxes. Unlike our study, these studies examined areas directly bordering the taxed area with the hypothesis that purchasing increased because shoppers avoided the tax. While moderate cross-border shopping has been observed outside of most local-level tax settings, such as Oakland and Philadelphia, it was not observed in the Seattle context^{17,19,23,100,101}. In this study, however, we observed small increases in volume sold for soda and multipack beverages in KCES relative to the comparison area, which could indicate cross-border shopping. The increases were larger within the first year post-tax; shoppers may have been more motivated early on to travel to non-bordering cities to avoid the tax. However, we also observed increases for diet soda in KCES, which would be inconsistent with cross-border shopping as an explanation for these results. In a post-hoc analysis, we performed an event study by year to explore changes within the first- and second-years post-tax. Relative to the comparison area, results suggested that volume sold of taxed and nontaxed beverages increased slightly in KCES in the first year and decreased slightly in the second year, but these were not statistically significant (**Supplemental Figure 2.4**). The Seattle event study is presented in **Supplemental Figure 4.5**.

Unlike previous studies of tax impacts on purchasing in Seattle, we additionally estimated difference-in-differences using an unbalanced sample of beverages. We observed increases in volume sold for overall taxed beverages (16%), taxed soda (44%), taxed multipack beverages (17%) as well as overall nontaxed beverages (31%) in KCES relative to the comparison area. Results appear to be largely driven by products new to the market in the post-tax period, suggesting shoppers purchased more new beverage products within the same stores over time. Cross-border shopping is an unlikely explanation because we would instead expect to observe increases in volume sold of taxed beverages previously on the market (i.e., in the balanced sample). It is possible that in-store promotions and marketing changed in response to the tax and contributed to this finding. For instance, in-store SSB advertising tends to decrease in the taxed area as producers attempt to reduce costs^{96,102-104}. Consequently, in-store advertising may have increased in stores beyond Seattle to offset losses. In a study of supermarket interior marketing displays before and after Seattle's tax, non-statistically significant increases for taxed and nontaxed SSBs were observed in the South King County comparison area relative to Seattle⁹⁶. The extent to which such advertising applies to new products is unclear and warrants further study.

Limitations

First, treatment assignment of stores in Seattle and KCES involved some amount of misclassification because we were limited to the store's county and three digits ZIP code as geographic identifiers which do not perfectly align with Seattle city boundaries. As noted earlier, this type of misclassification would bias estimates toward the null, producing underestimates of a tax or spillover effect. Second, the store sample is not representative of all retailers in the treated and comparison areas; therefore, we examine within-UPC changes in volume sold within the same stores over time to minimize bias related to store participation and product availability. Convenience stores and other small/independent stores are underrepresented in the scanner data, and dollar stores are absent from the data. Further, we are unable to analyze volume sold in food service establishments or vending machines. Third, we cannot control for potential bias due to time-varying, market-specific factors because we selected comparison areas in different media markets from the treated areas. While a synthetic control study design with many weighted

comparison areas would have diminished this concern, the burden of classifying thousands of unique beverages in each comparison area was too high to justify this approach. Instead, we examined weekly trends in the two years pre-tax to assess plausibility of parallel trends. Finally, with the small number of treated and comparison areas in the study, as is the case for most SSB tax studies, we were unable to adjust for clustering at the level of treatment and thus standard errors may be underestimated¹⁰⁵.

Conclusion

This quasi-experimental study is among the first to directly assess the extent to which SSB tax spillover effects may occur for beverage purchasing in communities beyond cross-border shopping. We did not find evidence of spillover effects in the form of reduced volume sold in communities near but not bordering the taxed city. Suggestive evidence of increased volume sold for regular and diet soda, as well as regular multipack beverages, raise questions about intensified beverage marketing in nearby areas post-tax. Studies are needed from other SSB tax contexts to investigate spillover effects on purchasing as well as marketing exposure in nearby areas. In the absence of additional evidence, this study supports efforts towards adopting state or national SSB taxes to increase the public health benefit of this policy.

Table 2.1. Sample of beverages and mean volume sold (fluid oz.) by taxable status, type, and size in King County Excluding Seattle and its combined comparison area, 2016-2019.

	KCES (N stores = 127)							Comparison (N stores = 243)						
	N, UPCs	Mean Volume	Pre-tax Lower 95% CI	Pre-tax Upper 95% CI	Post-tax Mean Volume	Post-tax Lower 95% CI	Post-tax Upper 95% CI	N, UPCs	Mean Volume	Pre-tax Lower 95% CI	Pre-tax Upper 95% CI	Post-tax Mean Volume	Post-tax Lower 95% CI	Post-tax Upper 95% CI
Taxed Beverages														
Overall	1,541	923,942	806,816	1,041,069	872,394	757,521	987,268	1,990	652,308	551,128	753,488	594,949	504,362	685,537
<i>Beverage Type</i>														
Soda	614	1,034,827	798,306	1,271,347	1,067,468	827,478	1,307,457	817	789,489	567,440	1,011,538	746,930	549,432	944,427
Fruit Drinks	393	821,338	643,254	999,421	629,483	497,160	761,806	592	519,825	414,950	624,701	409,061	326,279	491,842
Bottled Coffee	67	417,806	250,801	584,811	434,391	246,749	622,034	77	186,875	114,887	258,864	192,404	112,596	272,212
Bottled Tea	228	538,226	377,574	698,878	495,630	335,927	655,333	246	426,676	292,164	561,188	394,009	254,969	533,049
Energy Drinks	79	844,348	488,147	1,200,550	918,887	545,037	1,292,738	81	394,811	191,473	598,150	419,636	196,716	642,556
Sports Drinks	95	1,834,736	1,242,906	2,426,566	1,571,429	990,075	2,152,784	106	1,397,326	993,009	1,801,642	1,291,290	887,252	1,695,327
<i>Beverage Size</i>														
Single Serving (≤ 1 liter)	913	474,888	390,073	559,702	468,554	384,003	553,105	1,066	269,972	216,675	323,269	269,654	214,664	324,644
Multi-pack	342	1,155,589	881,933	1,429,245	1,252,254	971,877	1,532,630	466	800,020	597,065	1,002,976	783,178	608,443	957,912
Family Size (> 1 liter)	286	2,080,459	1,640,941	2,519,977	1,707,341	1,280,866	2,133,815	458	1,391,906	1,033,297	1,750,515	1,160,562	840,149	1,480,974
Nontaxed Beverages														
Overall	3,594	1,990,609	1,577,823	2,403,394	2,076,426	1,647,029	2,505,822	4,313	1,210,400	899,529	1,521,270	1,230,976	903,061	1,558,891
<i>Beverage Type</i>														
Diet Soda	858	1,981,544	1,568,906	2,394,182	2,233,312	1,732,417	2,734,207	995	1,055,686	812,546	1,298,825	1,075,403	818,664	1,332,142
100% Juice/Diet Fruit Drinks	1,014	640,026	540,482	739,569	511,226	406,831	615,622	1,209	341,685	282,667	400,704	259,067	206,855	311,278
Milk	594	3,860,876	1,946,737	5,775,016	3,916,127	2,032,001	5,800,253	820	1,588,904	574,161	2,603,648	1,514,471	603,077	2,425,865
Bottled Coffee	72	221,892	110,466	333,318	354,394	192,231	516,557	75	98,129	51,758	144,499	139,972	75,555	204,390
Bottled Tea	193	617,048	435,365	798,731	610,191	418,761	801,621	226	390,615	238,673	542,556	379,380	234,629	524,132
Plain/Sparkling/Flavored Water	578	3,673,496	2,171,508	5,175,484	3,969,732	2,319,119	5,620,345	643	3,413,598	1,836,460	4,990,737	3,773,591	1,962,853	5,584,329
Diet Energy Drinks	53	749,693	433,015	1,066,370	766,424	399,331	1,133,518	57	325,828	191,657	459,999	313,668	168,730	458,606
Diet Sports Drinks	70	2,152,670	1,525,851	2,779,489	2,085,366	1,425,309	2,745,423	81	1,328,091	910,375	1,745,807	1,267,311	858,672	1,675,949
<i>Beverage Size</i>														
Single Serving (≤ 1 liter)	1,970	455,406	405,326	505,487	469,673	416,525	522,820	2,312	185,941	163,573	208,308	190,071	166,021	214,121
Multi-pack	832	3,488,689	2,423,218	4,554,160	3,948,748	2,754,254	5,143,241	1,000	2,604,974	1,585,538	3,624,410	2,813,780	1,654,058	3,973,502
Family Size (> 1 liter)	792	4,235,490	2,756,496	5,714,483	4,106,138	2,640,546	5,571,729	1,001	2,183,401	1,324,024	3,042,778	2,053,923	1,257,520	2,850,326

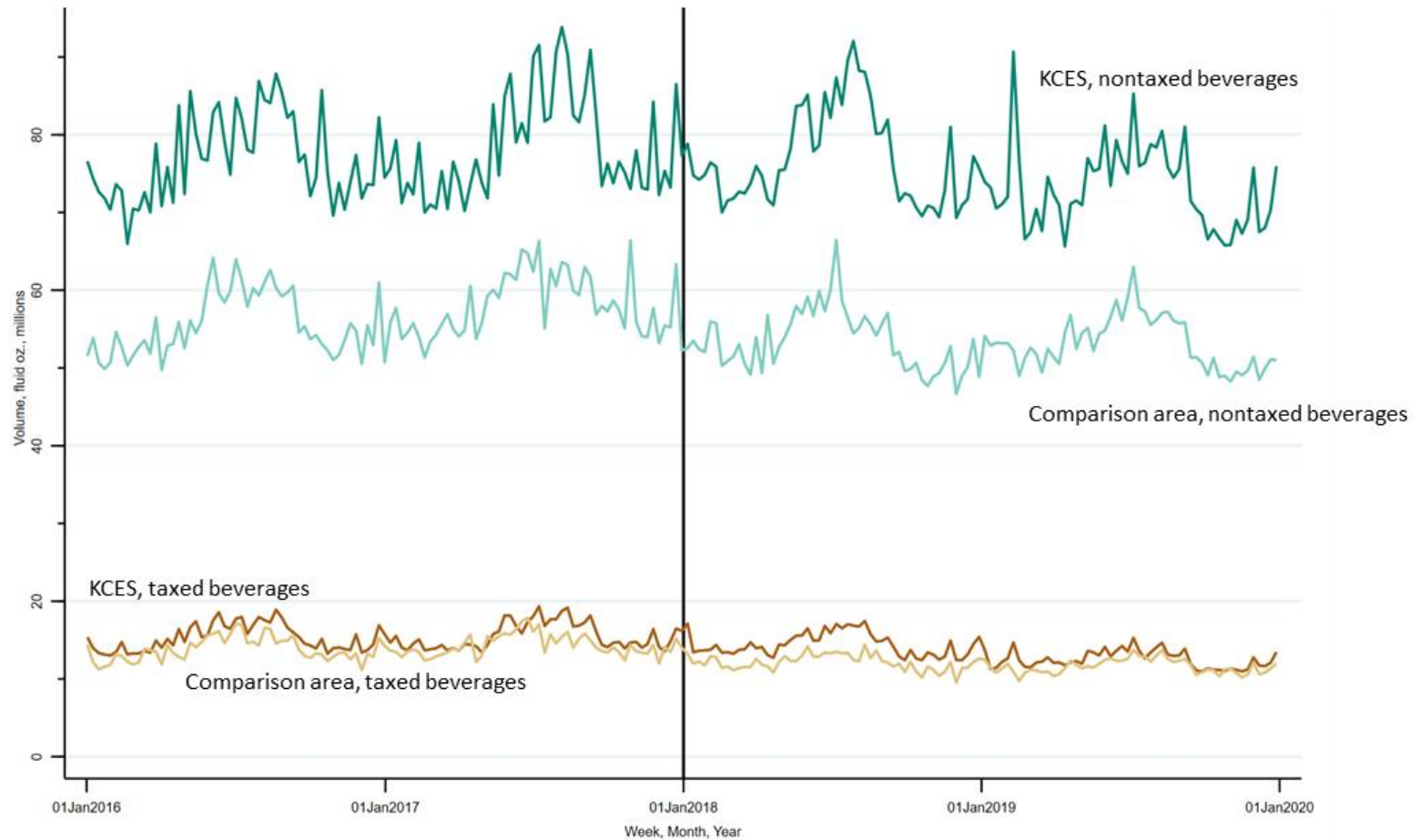
KCES: King County Excluding Seattle. UPC: Universal Product Code. CI: confidence interval. Sample is balanced on stores and beverages (defined by the UPC), meaning that unique stores and unique beverages that are present in both the pre and post periods are included in the sample. Mean estimates adjust for clustered standard errors at the UPC level. The combined comparison area includes Oakland County, MI, and Sacramento County, CA.

Table 2.2. Sample of beverages and mean volume sold (fluid oz.) by taxable status, type, and size in Seattle and its combined comparison area, 2016-2019.

	Seattle (N stores = 87)							Comparison (N stores = 115)						
	N, UPCs	Mean Volume	Pre-tax Lower 95% CI	Upper 95% CI	Mean Volume	Post-tax Lower 95% CI	Upper 95% CI	N, UPCs	Mean Volume	Pre-tax Lower 95% CI	Upper 95% CI	Mean Volume	Post-tax Lower 95% CI	Upper 95% CI
Taxed Beverages														
Overall	1,439	623,748	545,545	701,951	496,579	434,351	558,807	2,135	267,646	232,536	302,756	263,153	228,469	297,838
<i>Beverage Type</i>														
Soda	565	709,278	551,015	867,542	593,034	462,865	723,203	895	317,397	244,439	390,354	330,808	258,438	403,178
Fruit Drinks	376	571,721	450,960	692,482	369,472	295,549	443,395	636	182,998	145,660	220,336	152,428	121,447	183,409
Bottled Coffee	63	293,744	182,798	404,690	298,507	180,587	416,427	75	133,914	83,965	183,863	142,973	84,755	201,191
Bottled Tea	214	379,800	275,980	483,620	311,898	226,806	396,989	260	216,162	156,873	275,450	217,230	151,386	283,074
Energy Drinks	74	518,133	304,395	731,871	529,408	319,081	739,735	74	236,587	131,392	341,781	247,872	137,475	358,269
Sports Drinks	84	1,313,664	849,960	1,777,367	953,560	596,210	1,310,910	114	583,858	412,200	755,516	526,322	352,752	699,892
<i>Beverage Size</i>														
Single Serving (≤ 1 liter)	871	339,795	279,510	400,080	305,801	254,211	357,391	1,153	127,014	102,203	151,825	130,732	105,379	156,085
Multi-pack	300	686,611	526,892	846,331	613,475	482,839	744,110	529	358,297	273,739	442,855	383,958	298,370	469,546
Family Size (> 1 liter)	268	1,476,227	1,171,251	1,781,203	985,753	745,707	1,225,799	453	519,730	406,934	632,525	459,127	350,300	567,954
Nontaxed Beverages, Overall														
Overall	3,409	1,318,999	1,073,135	1,564,863	1,352,112	1,105,096	1,599,127	4,859	568,521	443,330	693,712	600,063	467,877	732,249
<i>Beverage Type</i>														
Diet Soda	806	1,411,452	1,148,734	1,674,170	1,565,039	1,267,604	1,862,473	1,153	686,864	512,546	861,182	741,730	555,251	928,208
100% Juice/Diet Fruit Drinks	966	458,435	393,653	523,217	356,783	290,310	423,256	1,449	163,360	139,348	187,371	126,867	107,554	146,181
Milk	580	2,402,824	1,364,856	3,440,791	2,407,427	1,418,297	3,396,558	845	944,140	447,818	1,440,462	981,702	458,440	1,504,965
Bottled Coffee	71	181,877	84,465	279,289	296,696	145,935	447,457	74	83,597	44,672	122,523	131,917	68,613	195,221
Bottled Tea	190	342,963	251,804	434,122	324,389	229,221	419,558	245	209,085	150,848	267,322	201,398	140,198	262,597
Plain/Sparkling/Flavored Water	526	2,473,318	1,460,689	3,485,946	2,619,470	1,562,371	3,676,568	751	1,052,232	535,167	1,569,297	1,192,483	647,385	1,737,580
Diet Energy Drinks	50	488,236	280,269	696,203	498,908	266,359	731,456	46	225,524	146,381	304,666	226,278	132,406	320,151
Diet Sports Drinks	59	1,348,552	947,751	1,749,352	1,259,451	876,325	1,642,577	82	749,912	558,844	940,980	748,396	540,617	956,176
<i>Beverage Size</i>														
Single Serving (≤ 1 liter)	1,845	359,818	319,445	400,191	358,075	317,547	398,602	2,613	106,900	94,757	119,043	111,672	98,850	124,494
Multi-pack	790	2,199,760	1,523,900	2,875,620	2,479,697	1,760,266	3,199,129	1,122	1,145,091	764,286	1,525,896	1,257,988	859,903	1,656,073
Family Size (> 1 liter)	774	2,706,449	1,889,760	3,523,139	2,570,725	1,787,474	3,353,975	1,124	1,066,125	685,862	1,446,388	1,078,686	673,299	1,484,072

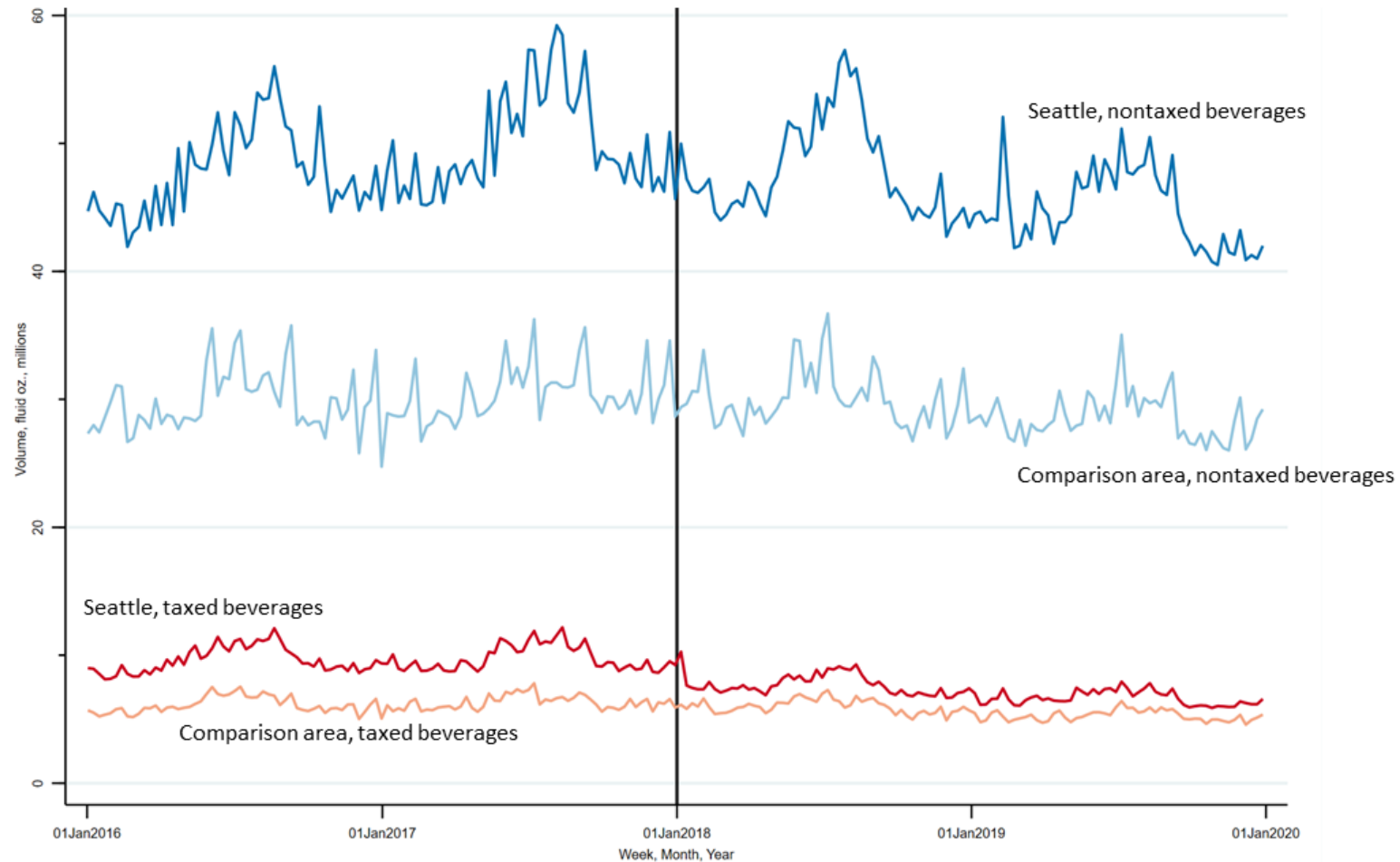
UPC: Universal Product Code. CI: confidence interval. Sample is balanced on stores and beverages (defined by the UPC), meaning that unique stores and unique beverages that are present in both the pre and post periods are included in the sample. Mean estimates adjust for clustered standard errors at the UPC level. The combined comparison area includes Dane County, WI, and Denver County, CO.

Figure 2.1. Total weekly volume sold of beverages in King County excluding Seattle (KCES) and the comparison area, 2016-2019.



Notes: Sample is balanced on stores and beverages (defined at the Universal Product Code level). KCES: King County excluding Seattle. The comparison area for KCES is the combined area of Sacramento County, CA, and Oakland County, MI, and the comparison area for Seattle is the combined area of Dane County, WI, and Denver County, CO. The average volume sold per county is presented for each comparison area (e.g., [total volume in Sacramento + total volume in Oakland] / 2).

Figure 2.2. Total weekly volume sold of beverages in Seattle and the comparison area, 2016-2019.



Notes: Sample is balanced on stores and beverages (defined at the Universal Product Code level). KCES: King County excluding Seattle. The comparison area for KCES is the combined area of Sacramento County, CA, and Oakland County, MI, and the comparison area for Seattle is the combined area of Dane County, WI, and Denver County, CO. The average volume sold per county is presented for each comparison area (e.g., [total volume in Sacramento + total volume in Oakland] / 2).

Table 2.3. Difference-in-differences in mean volume sold (fluid oz.) in Seattle and King County versus comparison areas, by taxed status, beverage size, and beverage type, comparing two years before to two years after the Seattle Sweetened Beverage Tax, 2016-2019.

	King County Excluding Seattle (KCES) vs. Comparison Area						Seattle vs. Comparison Area						Seattle DD v. KCES DD			
	Pre-tax Mean	DD Estimate	95% CI		P value	Percent change from pre-tax	Pre-tax Mean	DD Estimate	95% CI		P value	Percent change from pre-tax	DDD Estimate	95% CI		P value
Taxed Beverages																
Overall	923,942	5,811	-47,207	58,828	0.830	1%	623,748	-122,677	-156,290	-89,064	< 0.001	-20%	-128,487	-191,247	-65,727	< 0.001
<i>Beverage Type</i>																
Soda	1,034,827	75,201	-2,956	153,357	0.059	7%	709,278	-129,655	-180,332	-78,978	< 0.001	-18%	-204,856	-297,948	-111,763	< 0.001
Fruit Drinks	821,338	-81,090	-225,156	62,977	0.270	-10%	571,721	-171,679	-261,413	-81,945	< 0.001	-30%	-90,589	-260,168	78,990	0.295
Bottled Coffee	417,806	11,057	-58,499	80,612	0.754	3%	293,744	-4,296	-47,437	38,845	0.844	-1%	-15,353	-96,710	66,005	0.711
Bottled Tea	538,226	-9,929	-95,271	75,412	0.819	-2%	379,800	-68,971	-121,028	-16,913	0.010	-18%	-59,041	-158,826	40,743	0.246
Energy Drinks	844,348	49,714	-36,016	135,445	0.254	6%	518,133	-10	-48,237	48,218	0.999	0%	-49,724	-147,564	48,115	0.318
Sports Drinks	1,834,736	-157,270	-338,805	24,265	0.089	-9%	1,313,664	-302,568	-448,922	-156,214	< 0.001	-23%	-145,298	-377,478	86,882	0.219
<i>Beverage Size</i>																
Single Serving (≤ 1 liter)	474,888	-6,016	-27,734	15,702	0.587	-1%	339,795	-37,712	-55,557	-19,867	< 0.001	-11%	-31,696	-59,793	-3,600	0.027
Multi-pack	1,155,589	113,507	-11,717	238,731	0.076	10%	686,611	-98,798	-168,367	-29,228	0.005	-14%	-212,305	-355,404	-69,206	0.004
Family Size (> 1 liter)	2,080,459	-141,774	-357,368	73,820	0.197	-7%	1,476,227	-429,871	-572,250	-287,492	< 0.001	-29%	-288,097	-546,165	-30,030	0.029
Nontaxed Beverages																
Overall	1,990,609	65,241	-55,044	185,525	0.288	3%	1,318,999	1,572	-65,948	69,091	0.964	0%	-63,669	-201,593	74,256	0.366
<i>Beverage Type</i>																
Diet Soda	1,981,544	232,050	60,625	403,475	0.008	12%	1,411,452	98,721	-15,941	213,383	0.091	7%	-133,329	-339,472	72,814	0.205
100% Juice/Diet Fruit Drinks	640,026	-46,180	-131,845	39,484	0.291	-7%	458,435	-65,159	-121,899	-8,419	0.024	-14%	-18,979	-121,690	83,732	0.717
Milk	3,860,876	129,684	-215,329	474,696	0.461	3%	2,402,824	-32,959	-229,930	164,012	0.743	-1%	-162,643	-559,682	234,396	0.422
Bottled Coffee	221,892	90,659	2,738	178,579	0.043	41%	181,877	66,499	-26,133	159,131	0.158	37%	-24,160	-151,116	102,797	0.708
Bottled Tea	617,048	4,377	-87,723	96,478	0.926	1%	342,963	-10,886	-56,267	34,495	0.638	-3%	-15,263	-117,725	87,198	0.770
Plain/Sparkling/Flavored Water	3,673,496	-63,757	-661,633	534,119	0.834	-2%	2,473,318	5,901	-311,884	323,687	0.971	0%	69,658	-606,946	746,263	0.840
Diet Energy Drinks	749,693	28,892	-80,128	137,913	0.600	4%	488,236	9,917	-48,601	68,436	0.737	2%	-18,975	-141,754	103,804	0.761
Diet Sports Drinks	2,152,670	-6,524	-229,070	216,022	0.954	0%	1,348,552	-87,585	-258,044	82,875	0.311	-6%	-81,061	-359,761	197,639	0.567
<i>Beverage Size</i>																
Single Serving (≤ 1 liter)	455,406	10,136	-8,449	28,721	0.285	2%	359,818	-6,516	-20,221	7,189	0.351	-2%	-16,652	-39,740	6,435	0.157
Multi-pack	3,488,689	251,253	-164,997	667,504	0.237	7%	2,199,760	167,040	-57,058	391,138	0.144	8%	-84,213	-556,732	388,305	0.727
Family Size (> 1 liter)	4,235,489	126	-318,434	318,686	0.999	0%	2,706,449	-148,285	-334,626	38,056	0.119	-5%	-148,411	-517,291	220,468	0.430

DD: difference-in-differences. DDD: triple difference. CI: confidence interval. UPC: Universal Product Code.

Notes: Balanced sample of stores and beverages (defined by the UPC). Analyses use a linear DD regression model adjusted for UPC fixed effects and with standard errors clustered at the UPC level. Beverages with unknown taxed status or unknown beverage category are omitted.

Supplemental Material

METHODS

i. Comparison area selection.

To select the comparison areas, we first calculated the Mahalanobis distance⁹⁰ between each exposed area and nonrural US counties, using American Community Survey 2017 five-year estimates of county-level population size and density, age distribution, race and ethnicity distribution (non-Hispanic Asian, non-Hispanic Black, non-Hispanic white, and Hispanic), educational attainment, median household income, proportion living in poverty, and proportion of residents who rent¹⁰⁶.

Second, from the top 30 closest matched counties, we excluded those with a history of passing or proposing a sweetened beverage tax either in the county or in the county's Census-defined Core-Based Statistical Area during the study period. To align political contexts, we excluded counties in which Democratic votes were the minority for the 2016 Presidential Election.

Third, we estimated a proxy for pre-tax sweetened beverage consumption levels by calculating per capita volume sold of carbonated beverages in each area, using the data described below. We considered all these measures to select three top comparison area candidates for each treated area. Among the top three comparison area candidates for each treated area, we assessed evidence of pre-trends in the volume sold of taxed beverages. We found that two comparison areas trended similarly with each of the treated areas. Therefore, we decided to create a combined comparison area of the two counties for each exposed area.

ii. Difference-in-differences (DD) equations.

We used two linear DD regression models to estimate the mean difference in fluid ounces sold associated with the SSB tax from 2 years before and after implementation. The comparison areas are specific for each treated area: Sacramento and Oakland counties for King County excluding Seattle (KCES), and Dane and Denver counties for Seattle. The models will compare the changes in Seattle v. comparison area, and KCES v. comparison area:

$$1. Y_{KCES_it} = \beta_0 + \beta_1[Time]_t + \beta_2[KCES]_i + \beta_3[Time*KCES]_{it} + \varepsilon_{it},$$

$$2. Y_{Seattle_it} = \beta_0 + \beta_1[Time]_t + \beta_2[Seattle]_i + \beta_3[Time*Seattle]_{it} + \varepsilon_{it}$$

Where Y_{it} is the mean outcome i at time t , and $Time$ is set to a value of 1 for post-tax observations and 0 for pre-tax observations. $KCES$ is an indicator variable set to 1 for purchases in KCES and 0 for purchases in the comparison area. Likewise, $Seattle$ is set to 1 for purchases in Seattle and 0 for the comparison area. β_3 is the coefficient of interest in each model, representing the change in the mean volume purchased in the treated area above and beyond the change in the comparison area over the same time. Fixed effects at the UPC-level were used to adjust for time-invariant characteristics specific to each beverage.

iii. Triple difference equation.

The triple difference (DDD) estimates the degree to which Seattle experiences a larger effect of the tax than in KCES. The benefit of estimating this model is to be able to test whether the DDD coefficient is different from 0, meaning the effect of the tax in Seattle was different than the effect of the tax in KCES.

We fit the following linear regression model:

$$Y_{it} = \beta_0 + \beta_1[Time]_t + \beta_2[Group] + \beta_3[Treat] + \beta_4[Time*Group] + \beta_5[Time*Treat] + \beta_6[Group*Treat] + \beta_7[Time*Group*Treat] + \varepsilon,$$

Where Y_{it} is the mean outcome i at time t , and $Time$ is set to a value of 1 for post-tax observations and 0 for pre-tax observations. $Treat$ is a dummy variable set to 1 for Seattle and KCES areas, and 0 for comparison areas. Likewise, $Seattle$ is set to 1 for Seattle and its comparison area of Dane and Denver counties, 0 for KCES and its comparison area of Sacramento and Oakland counties. Fixed effects were applied as described in **ii**.

Supplemental Table 2.4. Difference-in-differences in mean volume sold (fluid oz.) in Seattle and King County versus comparison areas, by taxed status, comparing one year before to one year after the Seattle SBT, 2017-2018.

	King County Excluding Seattle (KCES) vs. Comparison Area					Percent change from pre-tax	Seattle vs. Comparison Area					Percent change from pre-tax
	Pre-tax mean	DD Estimate	95% CI		P value		Pre-tax mean	DD estimate	95% CI		P value	
Taxed Beverages												
Overall	276,327	20,375	-4,524	45,274	0.109	7%	153,920	-33,601	-46,184	-21,017	< 0.001	-22%
<i>Beverage Type</i>												
Soda	308,970	44,973	4,770	85,176	0.028	15%	170,658	-36,824	-52,688	-20,960	< 0.001	-22%
Fruit Drinks	238,527	-10,352	-73,275	52,570	0.747	-4%	128,539	-41,312	-78,179	-4,445	0.028	-32%
Bottled Coffee	97,960	18,041	-7,581	43,664	0.167	18%	71,582	-2,360	-17,718	12,999	0.762	-3%
Bottled Tea	178,839	2,924	-34,471	40,318	0.878	2%	112,648	-27,097	-47,675	-6,519	0.010	-24%
Energy Drinks	255,354	51,259	8,033	94,486	0.020	20%	155,029	7,559	-14,347	29,465	0.497	5%
Sports Drinks	615,151	-26,105	-107,813	55,604	0.530	-4%	357,480	-103,488	-145,326	-61,649	< 0.001	-29%
<i>Beverage Size</i>												
Single Serving (≤ 1 liter)	133,240	12,004	452	23,556	0.042	9%	79,748	-7,537	-13,906	-1,167	0.020	-9%
Multi-pack	325,024	83,449	27,415	139,483	0.004	26%	175,481	-26,350	-47,046	-5,654	0.013	-15%
Family Size (> 1 liter)	621,971	-18,373	-120,428	83,681	0.724	-3%	350,016	-118,956	-176,007	-61,905	< 0.001	-34%
Nontaxed Beverages												
Overall	549,666	69,956	8,028	131,885	0.027	13%	320,583	44,313	13,065	75,561	0.005	14%
<i>Beverage Type</i>												
Diet Soda	551,680	129,988	43,049	216,926	0.003	24%	372,387	56,506	4,180	108,831	0.034	15%
100% Juice/Diet Fruit Drinks	175,161	16,208	-21,957	54,372	0.405	9%	107,717	6,906	-18,751	32,563	0.598	6%
Milk	843,680	215,790	17,875	413,705	0.033	26%	532,721	101,184	-6,069	208,437	0.064	19%
Bottled Coffee	60,703	42,794	11,087	74,502	0.008	70%	50,288	30,386	-1,218	61,990	0.059	60%
Bottled Tea	184,497	13,611	-24,050	51,272	0.478	7%	103,309	3,078	-16,397	22,553	0.756	3%
Plain/Sparkling/Flavored Water	1,231,324	-58,686	-355,518	238,147	0.698	-5%	598,955	67,496	-68,323	203,315	0.330	11%
Diet Energy Drinks	201,494	45,482	-8,826	99,790	0.100	23%	138,232	22,476	-9,558	54,510	0.167	16%
Diet Sports Drinks	692,589	86,571	-9,567	182,708	0.077	12%	409,441	-19,448	-84,035	45,139	0.553	-5%
<i>Beverage Size</i>												
Single Serving (≤ 1 liter)	113,554	25,572	17,317	33,826	< 0.001	23%	77,287	13,991	8,041	19,941	< 0.001	18%
Multi-pack	1,081,013	111,763	-95,132	318,659	0.290	10%	599,840	87,125	-9,493	183,744	0.077	15%
Family Size (> 1 liter)	1,082,697	146,691	-25,296	318,677	0.095	14%	636,538	73,921	-20,457	168,298	0.125	12%

DD: difference-in-differences. CI: confidence interval. UPC: Universal Product Code. Sample is balanced on and UPCs, meaning stores and UPCs that were present in the year prior to the tax and year following the tax were included in the analysis. Model: linear DD regression with UPC fixed effects, with standard errors clustered at the UPC level. Beverages with unknown taxed status or unknown beverage category are omitted.

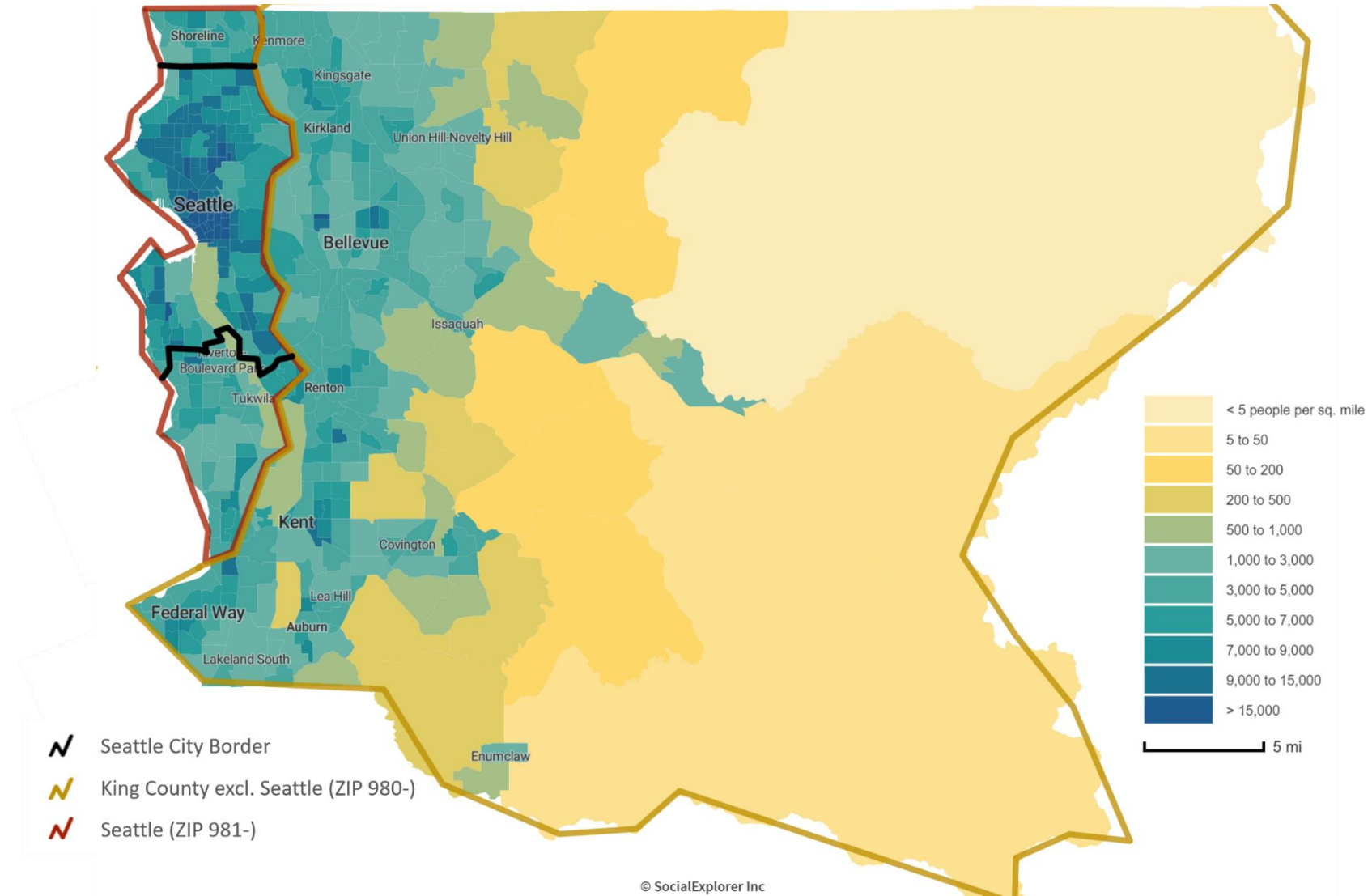
Supplemental Table 2.5. Difference-in-differences in mean volume sold (fluid oz.) in Seattle and King County versus comparison areas, by taxed status, comparing two years before to two years after the Seattle SBT in an unbalanced sample of UPCs, 2016-2019.

	King County Excluding Seattle (KCES) vs. Comparison Area					Percent change from pre-tax	Seattle vs. Comparison Area					Percent change from pre-tax
	Pre-tax mean	DD Estimate	95% CI		P value		Pre-tax mean	DD estimate	95% CI		P value	
			Lower	Upper				Lower	Upper			
Taxed Beverages												
Overall	458,638	74,795	22,841	126,749	0.005	16%	367,542	-52,580	-82,557	-22,603	0.001	-14%
<i>Beverage Type</i>												
Soda	268,791	118,877	41,810	195,943	0.003	44%	271,433	-67,636	-110,795	-24,477	0.002	-25%
Fruit Drinks	179,380	41,345	-84,779	167,468	0.520	23%	211,322	-51,763	-126,977	23,450	0.177	-24%
Bottled Coffee	230,641	27,760	-46,950	102,471	0.465	12%	165,615	931	-49,044	50,905	0.971	1%
Bottled Tea	267,600	40,583	-49,102	130,267	0.375	15%	224,122	-34,000	-87,053	19,053	0.209	-15%
Energy Drinks	807,765	-39,013	-156,880	78,853	0.515	-5%	460,867	-39,989	-112,176	32,197	0.276	-9%
Sports Drinks	1,588,323	-113,942	-362,208	134,323	0.367	-7%	1,118,023	-149,193	-294,782	-3,604	0.045	-13%
<i>Beverage Size</i>												
Single Serving (≤ 1 liter)	207,768	23,066	-1,965	48,098	0.071	11%	181,122	-9,267	-25,132	6,597	0.252	-5%
Multi-pack	856,318	141,800	32,833	250,766	0.011	17%	514,786	-62,749	-119,724	-5,774	0.031	-12%
Family Size (> 1 liter)	2,477,064	115,894	-121,829	353,617	0.339	5%	1,691,620	-197,109	-342,512	-51,706	0.008	-12%
Nontaxed Beverages												
Overall	335,798	103,612	4,384	202,839	0.041	31%	508,026	10,136	-46,488	66,759	0.726	2%
<i>Beverage Type</i>												
Diet Soda	763,208	58,681	-84,677	202,040	0.422	8%	517,738	24,265	-74,720	123,250	0.631	5%
100% Juice/Diet Fruit Drinks	211,127	9,106	-67,118	85,331	0.815	4%	194,995	-13,612	-64,471	37,248	0.600	-7%
Milk	1,089,552	377,341	48,939	705,742	0.024	35%	771,999	87,306	-85,394	260,006	0.322	11%
Bottled Coffee	102,299	62,007	-4,738	128,753	0.068	61%	80,402	65,963	-2,007	133,933	0.057	82%
Bottled Tea	191,749	46,422	-49,082	141,926	0.340	24%	139,243	26,882	-21,868	75,633	0.279	19%
Plain/Sparkling/Flavored Water	527,931	61,676	-431,566	554,917	0.806	12%	800,974	-73,963	-340,434	192,508	0.586	-9%
Diet Energy Drinks	614,296	93,601	-32,295	219,496	0.144	15%	387,423	36,094	-47,710	119,897	0.396	9%
Diet Sports Drinks	1,665,780	88,098	-214,761	390,958	0.567	5%	1,090,578	23,976	-181,055	229,007	0.818	2%
<i>Beverage Size</i>												
Single Serving (≤ 1 liter)	473,837	13,062	-7,374	33,498	0.210	3%	337,948	-242	-13,386	12,902	0.971	0%
Multi-pack	2,179,705	150,271	-181,104	481,647	0.374	7%	1,673,234	23,360	-168,654	215,375	0.811	1%
Family Size (> 1 liter)	2,804,260	278,437	-33,762	590,635	0.080	10%	1,886,317	-25,603	-199,496	148,290	0.773	-1%

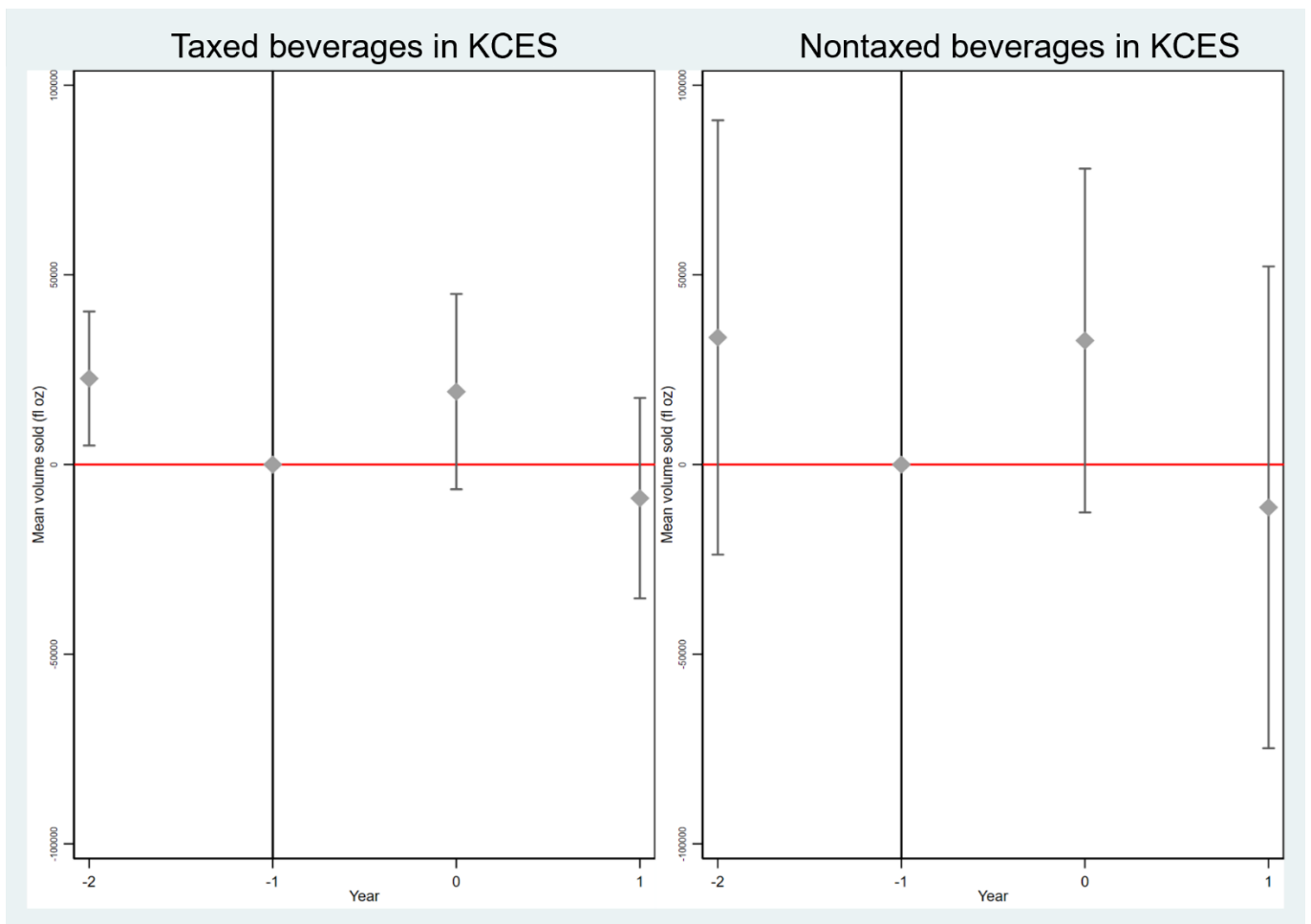
DD: difference-in-differences. CI: confidence interval. UPC: Universal Product Code.

Notes: Sample is balanced on stores but not beverages (defined by the UPC). This sample allows for any UPC to enter or leave the dataset from pre- to post-tax. Analysis uses a linear DD regression model adjusted for beverage type and size, with standard errors clustered at the UPC level. Beverages with unknown taxed status or unknown beverage category are omitted.

Supplemental Figure 2.3. Map of the census tract-level population density in the treated areas in King County defined by the first three digits of the ZIP code.

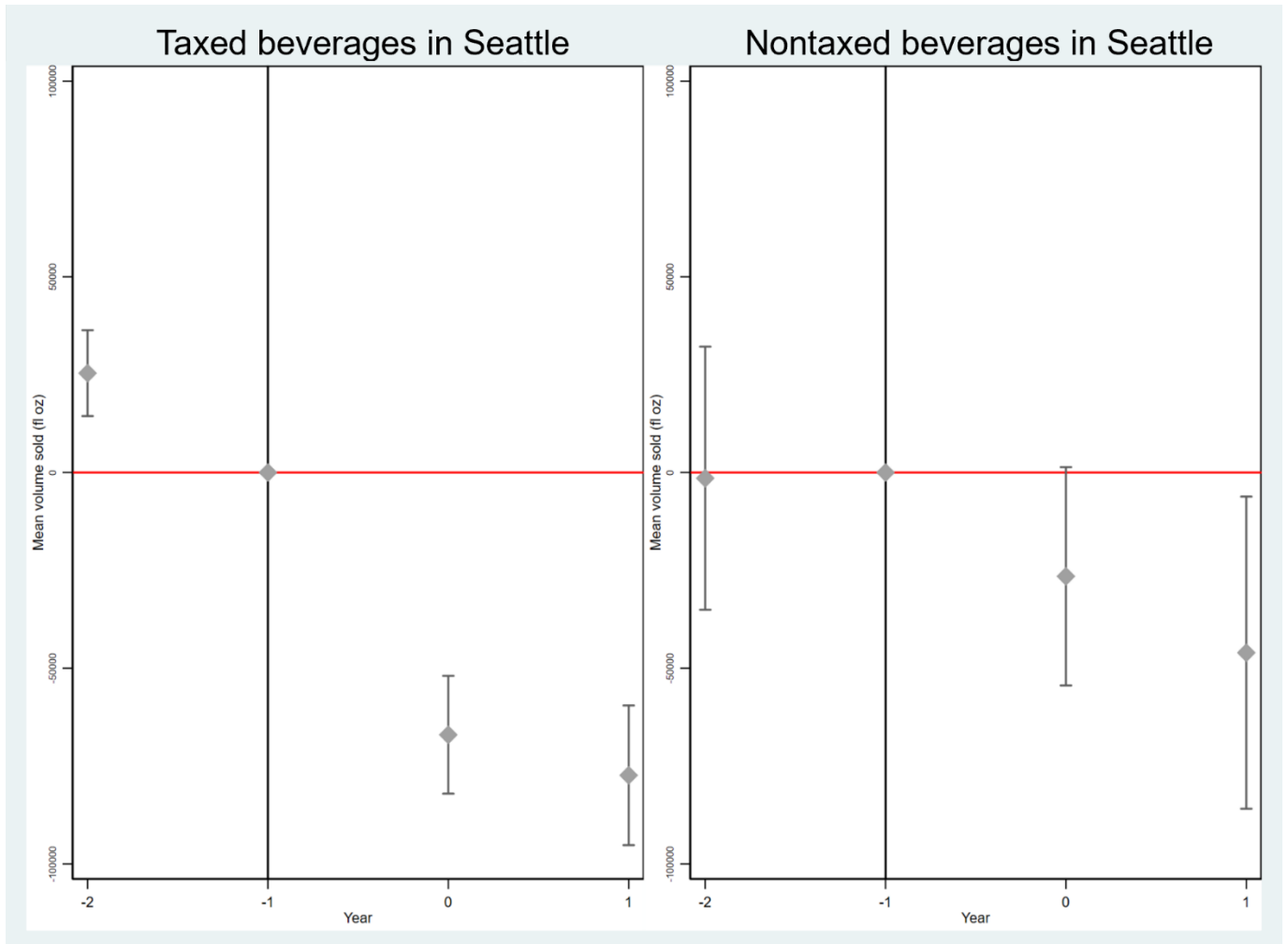


Supplemental Figure 2.4. Differences in differences in annual mean volume sold of taxed and nontaxed beverages in King County excluding Seattle (KCES) relative to the comparison area from two years before and after implementation of the Seattle Sweetened Beverage Tax, 2016-2019.



Note: Estimates are from a linear regression model with Universal Product Code (UPC) fixed effects and year fixed effects. Standard errors are clustered at the UPC level. The x axis refers to the year in which the SSB tax was implemented: 2018, i.e., Year = 0. Comparison areas: the combined area of Sacramento County, CA, and Oakland County, MI, for the KCES treated area, and the combined area of Dane County, WI, and Denver County, CO, for the Seattle treated area.

Supplemental Figure 2.5. Differences in differences in annual mean volume sold of taxed and nontaxed beverages in Seattle relative to the comparison area from two years before and after implementation of the Seattle Sweetened Beverage Tax, 2016-2019.



Note: Estimates are from a linear regression model with Universal Product Code (UPC) fixed effects and year fixed effects. Standard errors are clustered at the UPC level. The x axis refers to the year in which the SSB tax was implemented: 2018, i.e., Year = 0. Comparison areas: the combined area of Sacramento County, CA, and Oakland County, MI, for the KCES treated area, and the combined area of Dane County, WI, and Denver County, CO, for the Seattle treated area.

Chapter 3 | Perceived healthfulness and consumption of sugar-sweetened beverages two years after the Seattle Sweetened Beverage Tax among adults with and without children in the household

Overview

Parents and primary caregivers of children are an important population in which to understand impacts of a sugar-sweetened beverage (SSB) tax due to their influence on child SSB consumption. It is unclear whether parents with children in the home respond differently than other adults to SSB taxes.

We administered a repeated cross-sectional phone and online survey of adults in Seattle, WA, and a matched comparison area before and two years after implementation of the Seattle SSB tax. Adults reported living with (n=830) or without (n=2,398) children in the home. Using triple difference analyses (taking the difference between two difference-in-differences [DD]), we assessed whether net changes in a summary score of perceived health risks of SSBs, the probability of reporting that high SSB consumption (≥ 1 times/day) is a healthful amount, and the probability of reporting high SSB consumption were different after tax implementation in Seattle between adults with and without children in the home. Propensity score weights and covariate adjustment were used to improve comparability between samples over time.

Perceptions of health risks of SSBs were relatively high and did not change over time in association with the tax for adults with and without children in the home (DD with children: 0.54; [95% CI: -0.81, 1.89]; DD without children: -0.27; [95% CI: -1.06, 0.53]; triple difference: 0.81; [95% CI: -0.76, 2.38]; $p=0.31$). Self-reported high SSB consumption did not significantly change over time in Seattle or the comparison area, and we did not observe differential changes for adults with versus without children in the home. The ratio of odds ratios (ORs) for high SSB consumption was 0.88 (95% CI: 0.41, 1.88) among Seattle adults with children and 1.34 (95% CI: 0.79, 2.29) among Seattle adults without children (triple difference: 0.66 [95% CI: 0.26, 1.67]; $p=0.38$).

Results were similarly not significant for reporting that high SSB consumption was a healthful amount (triple difference: 0.80 [95% CI: 0.21, 3.05]; $p=0.74$).

We did not find evidence of associations between a SSB tax and changes in perceived healthfulness and high consumption of SSBs among adults living with and without children in the home. Identifying predictors of and barriers to parental behavior change in response to taxes is a direction for future research.

Introduction

Sugar-sweetened beverages (SSBs) are the largest source of added sugars in the diets of children and adults in the United States¹⁻³. While highly prevalent in the diet, SSBs contribute minimal nutritional value and are thus a recent target of tax policy to improve public health. In the past decade, eight US jurisdictions adopted excise taxes on the distribution of SSBs¹².

Evidence is clear from numerous evaluations that such taxes increase retail prices and reduce purchases of SSBs in the taxed areas²⁵. However, evidence of changes in reported SSB consumption is less consistent. Some studies observed reduced consumption in population subgroups such as those with low income and high consumers of SSBs, but other studies did not observe changes in these groups or overall^{13,17,19,26-31}. One reason for the inconsistent findings may be related to different pathways through which SSBs taxes influence behavior. In addition to the price sensitivity pathway, SSB taxes may also have health risk signaling effects which likely vary across local tax contexts and population subgroups^{41,42,45,70,107,108}.

Parents and primary caregivers of children are an important subgroup of the population in which to understand potential tax impacts and signaling effects. Marketing and health claims on beverages targeted towards children have been shown to mislead parents in perceiving certain SSBs are healthful^{47,49,109}. A tax may have a stronger signaling effect to parents than other adults if it makes clear which beverages are higher in sugar. Parents may in return modify their own consumption and their child's access to different beverages as they consider their health and their child's health. With relatively higher household costs, parents may be more price sensitive to the tax than other adults as well. On the other hand, parents may be less responsive to the tax if they have higher risk perceptions around SSBs to begin with or if child-directed marketing and demand for SSBs outweighs the potential burden of higher prices.

Previous studies that investigated SSB tax impacts among parents did not observe changes in SSB consumption, except for a reduction in soda in one study^{17,19,31}. To our knowledge, no previous work has assessed whether SSB tax impacts on health perceptions and consumption differ for parents versus other adults. Considering the essential role of parents in their child's dietary patterns,^{36,37,110} it is important to understand the extent to which parents may change beliefs and behavior in response to a SSB tax.

Objective

On January 1, 2018, the City of Seattle implemented a \$0.0175/ounce excise tax on the distribution of SSBs. In a repeated cross-sectional survey of adults in Seattle and a well matched comparison area, perceived health risks of SSBs increased and daily SSB consumption decreased in association with the Seattle SSB tax among adults with lower but not higher household income^{67,70}. In the present study, we analyzed the same survey data to estimate the degree to which associations between Seattle's tax and changes in perceived healthfulness and self-reported consumption of SSBs differed between adults with and without children in the home. We additionally explored whether associations with the tax differed by household income among adults with children in the home.

Methods

Design and sample

We used a repeated cross-sectional differences-in-differences design to compare changes in Seattle and a comparison area before and two years after tax implementation. We administered a population-based telephone and online survey in October-December 2017 (pre-tax) and again, with a different sample of individuals, in September-November 2019 (post-tax). Survey details have been previously described¹¹¹. In brief, the sample included 3,221 adults 18 years or older, of whom 1,621 had a home address in Seattle, WA, and 1,598 had a home address in the combined

comparison area of Minneapolis, MN, and the Washington, DC, Metro Area (Arlington, VA, Bethesda, MD, and Rockville, MD). The combined comparison area was selected because it shared similar demographic characteristics and political leanings with Seattle and did not have a history of proposing or adopting a SSB tax.

The overall sampling design achieved approximately representative racial/ethnic distributions in each city and oversampled participants who reported lower household income (<260% of the federal poverty level [FPL] based on 2017 federal poverty guidelines¹¹²). In the present study, we categorized adults based on whether they reported at least one child under 18 in their household (n=830) or no children in the household (n=2,389). Two participants were excluded because data was missing for this variable. Since we did not have information on parent/guardian status for the sample, we refer to participants as adults living with or without children in the home.

Survey questions assessed participants' perceptions about health risks of SSBs consumption, self-reported SSB consumption, and perceived impacts of SSB taxes. Participants also reported demographic and household information, such as the number of children and adults in their household and annual household income. The original study and the present analysis were determined to be exempt from review by the University of Washington Institutional Review Board because the researchers did not have access to identifiable information.

Outcomes

We examined three outcomes. The first two measured aspects of perceived healthfulness of SSBs: a summary score of perceived health risks, and perceived healthfulness of high SSB consumption. The third outcome was self-reported high SSB consumption. The survey referred to SSBs as "sugary drinks," and defined them as including regular soft drinks, soda or pop, fruit-flavored drinks, sports drinks, sweetened teas or coffees, and energy drinks. It further clarified that

SSBs do not include milk, 100% fruit juice, diet drinks, or artificially sweetened drinks. This was consistent with how the Seattle SSB tax defined SSBs⁵⁶.

Perceived health risks of SSBs. Participants were asked a total of 11 questions about whether consumption of SSBs increases risks for various serious health conditions. Participant response options included strongly agree, agree, don't know, disagree, and strongly disagree. The first five questions individually asked about risk of obesity, dental health problems, diabetes, heart disease, and serious health conditions in general. The next six questions separately asked whether consumption of added sugar, soda, fruit drinks, sports drinks, sweetened coffee/tea, and energy drinks increases risk of serious health conditions. To calculate the summary score, we combined and scored responses across all questions. A response of "strongly agree/agree" was given a score of 1, "strongly disagree/disagree" a score of -1, and "don't know" a score of 0. The summary score ranged from -11 to 11, with a higher score indicating greater perceived health risks of SSBs. We hypothesized that the summary score would increase in response to the Seattle SSB tax to a greater degree for adults with children in the home than adults without children in the home.

Perceived healthfulness of high SSB consumption. We created a binary outcome from responses to the following question: "Thinking about how sugary drinks affect health, what is the MOST people should drink them?" Response options included none or <1 time per week, weekly, 2-6 times per week, and daily or more. We defined high SSB consumption as daily or more. In association with the SSB tax, we hypothesized that the probability of reporting that daily (or more) SSB consumption was a healthful amount would decrease in Seattle to a greater degree among adults with children in the home than among adults without children in the home.

Self-reported high SSB consumption. Like the previous outcome, we defined a binary outcome of self-reported high SSB consumption as daily or more. Participants were asked, "during the past 30 days, did you drink sugary drinks never or less than 1 time per week, 1 time per week,

2-6 times per week, 1 time per day, or 2 or more times per day?” We hypothesized that the probability of reporting high SSB consumption would decrease in Seattle in response to the SSB tax to a greater degree among adults with children in the home than among adults without children in the home.

Covariates

We selected covariates based on hypothesized associations with each outcome and with the exposure of living in Seattle with the tax¹¹³⁻¹¹⁵. Covariates in the regression model and propensity score weights, described below, included self-reported age (18-30, 31-40, 41-50, and 51+), sex (male or female), race/ethnicity (non-Hispanic Asian, non-Hispanic Black or African American, non-Hispanic white, non-Hispanic other, and Hispanic), household income (<\$30,000, \$30,000-\$59,000, \$60,000-\$89,000, \$90,000-\$120,000, >\$120,000), education (some or completed high school, some or completed college, and completed graduate/professional degree), political affiliation (Democrat, Independent, Republican, other/don't know), marital status (married, widowed/divorced/separated, single and never married, and living with a partner), number of people living in the household (i.e., household size), and survey mode (phone or online).

Statistical analysis

To retain all participants in the analytical samples, we imputed missing data on all covariates and outcomes using multiple imputations by chained equations¹¹⁶. About 7% of participants were missing information on at least one covariate and 11% were missing information on at least one outcome. Missingness was no higher than 11% for any one variable (**Supplemental Table 3.4**). In addition to the imputed variables, predictors in the imputation model included a combined indicator for participants' location (Seattle or comparison area) and timepoint (pre- or post-tax) as well as survey mode and living with or without a child in the home. Imputed data were evaluated using trace plots and summary statistics comparisons with non-missing observations.

We then calculated propensity score weights that weighted observations so that each pre- and post-tax sample in each location resembled the distribution of covariates of the Seattle pre-tax sample¹¹⁷. The purpose of the propensity score weights was to minimize bias due to potential compositional changes in each pre- and post-tax sample in each location. Weights were winsorized to a value of 10 to limit the influence of extremes.

For the primary analysis, we fit adjusted difference-in-differences regression models for each of the three outcomes. We modeled the perceived health risks summary score using ordinary least squares regression and modeled the binary outcomes of perceived healthfulness of high SSB consumption and self-reported high SSB consumption using logistic regression. In addition to covariates, each model included indicator variables for location, timepoint, and living with or without a child in the home. The models included two-way interaction terms between each of the indicator variables and a three-way interaction term between all three indicator variables (see **Supplemental Materials** for details). All models included the covariates and propensity score weights, resulting in doubly-robust estimates that are robust to misspecifications of either the regression model or propensity score model¹¹⁸.

For the perceived health risk summary score, we used linear combinations of the model coefficients to calculate the difference-in-differences in the score among adults with children in the home, and separately, among adults without children in the home. Each difference-in-differences represented the average amount by which perceived health risks of SSBs changed in Seattle from pre-tax to post-tax above and beyond the change in the comparison area over the same period. The three-way interaction term in the model was the triple difference estimator, or the extent to which the difference-in-differences among adults with children in the home was different than the difference-in-differences among adults without children in the home. In other words, the

triple difference compared the tax impact on perceived health risks of SSBs in Seattle among adults with children to the tax impact in Seattle among adults without children.

For perceived healthfulness of high SSB consumption and self-reported high SSB consumption, we exponentiated the coefficients to interpret them in terms of odds of participants reporting each outcome. Using log-linear combinations of coefficients, we calculated the difference-in-differences for each outcome among adults with children, and separately, without children, interpreting each as a ratio of odds ratios (ORs). Each ratio of ORs compared the OR of the outcome in Seattle in the post-tax versus pre-tax period relative to the OR of the outcome in the comparison area over the same period. To support interpretation, we also calculated predicted probabilities of each outcome at each timepoint and location using postestimation calculations from the model. The three-way interaction term reflected the ratio of ratio of ORs, which compared the ratio of ORs of the outcome in association with the tax among adults with children in the home to the ratio of ORs of the outcome among adults without children in the home.

In a sensitivity analysis, we fit adjusted difference-in-differences models stratified by living with or without children in the home to assess whether the difference-in-differences estimates were materially different from the primary model. Unlike in the primary model, the covariate-outcome relationships can vary by the stratification variable in the stratified models. We imputed data and calculated propensity scores separately for each sample to maximize exchangeability between Seattle and comparison area participants within each sample.

In addition, we were interested in whether household income modified the association between the tax and changes in the three outcomes among adults with children in the home. To explore this, we fit a difference-in-differences regression model with two-way and three-way interaction terms between location, timepoint, and higher versus lower income ($\geq 260\%$ and $< 260\%$ FPL) in the sample of adults with children in the home. Previous analyses of the overall survey

sample observed tax impacts among participants with lower income, but not higher income^{67,70}, so this was important to explore within the sample with children in the home. We used household size information to define the binary household income variable coinciding with eligibility for state-subsidized health insurance.

Finally, in a post-hoc sensitivity analysis, we explored whether the variance of our difference-in-differences estimates were inflated due to the combination of propensity score weights and covariate adjustment. We compared estimates from the primary model to results from an unweighted model with covariate adjustment, a weighted model without covariate adjustment, and a weighted model with adjustment for covariates that remained unbalanced based on standardized mean differences, which were household income and education. Results did not substantially change across variations (**Supplemental Table 3.7**). All analyses set $\alpha = 0.05$ and were performed using Stata 17 software (StataCorp). We did not adjust for multiple comparisons.

Results

Characteristics of the weighted analytic sample within each timepoint, location, and group defined by living with or without a child in the home is presented in **Table 3.1**. The unweighted sample is presented in **Supplementary Table 3.4**.

Summary score of perceived health risks of SSBs.

Among adults with children in the home, the adjusted mean summary scores for perceived health risks of SSBs were relatively similar across the pre- and post-tax periods in Seattle and the comparison area (**Table 3.2**). In Seattle, the mean summary score was 6.05 in the pre-tax period and 6.45 in the post-tax period, reflecting an increase of 0.39 (95% CI: -0.54, 1.32) that was not statistically significant. In the comparison area, the mean score was 6.46 at pre-tax and 6.31 at post-tax, reflecting a decrease of -0.15 (95% CI: -1.12, 0.82) that was not statistically significant. Relative to the change in the comparison area, there was a net increase of 0.54 (95% CI: -0.81,

1.89]; $p=0.43$) in the mean score in Seattle from pre-tax to post-tax, which was not statistically significant.

Among adults without children in the home, the adjusted mean summary scores were similar in the pre- and post-tax periods in Seattle and the comparison area. In Seattle, the pre-tax mean score was 6.93 and the post-tax mean score was 6.68, which was a non-statistically significant decrease of -0.25 (95% CI: -0.76, 0.25). In the comparison area, the mean pre-tax score was 7.09 and the mean post-tax score was 7.10, reflecting a difference of 0.01 (95% CI: -0.60, 0.63). Relative to the change in the comparison area, the mean score in Seattle decreased by -0.27 (95% CI: -1.06, 0.53; $p=0.51$) from the pre-tax to post-tax period, but this was not statistically significant.

Comparing the net changes among Seattle adults with versus without children in the home, the triple difference estimate indicates that the net changes in perceived health risks of SSBs were not statistically significantly different from each other (0.81; [95% CI: -0.76, 2.38]; $p=0.31$).

Perceived healthfulness of high SSB consumption.

Among adults with children in the home in Seattle, the adjusted predicted probability of reporting that daily SSB consumption (or more) is a healthful amount was 9.9% in the pre-tax period and 10.4% in the post-tax period (**Table 3.3**). This translates to a non-statistically significant increase in the odds over time by 5% (OR: 1.05; [95% CI: 0.49, 2.25]). Among adults with children in the comparison area, the adjusted predicted probability decreased from 11.2% in the pre-tax period to 9.4% in the post-tax period, but this was also not statistically significant (OR: 0.82; [95% CI: 0.34, 1.97]). This suggests that relative to the change in the comparison area from pre- to post-tax, the odds of reporting that daily SSB consumption is a healthful amount increased in Seattle by 28% (ratio of ORs: 1.28; [95% CI: 0.41, 4.03]; $p=0.67$), though this was not statistically significant.

Among adults without children in the home in Seattle, the adjusted predicted probability of reporting that daily SSB consumption is a healthful amount was 6.5% in the pre-tax period and 8.4% in the post-tax period (OR: 1.33; [95% CI: 0.85, 2.07]). Among comparison area adults without children in the home, the pre-tax predicted probability was 9.7% and the post-tax predicted probability was 8.2% (OR: 0.83; [95% CI: 0.49, 1.41]). Relative to the change in the comparison area, there was a non-statistically significant increase of 60% (ratio of ORs: 1.60; [95% CI: 0.80, 3.20]; $p=0.18$) in the odds of reporting that daily SSB consumption is a healthful amount from pre-tax to post-tax in Seattle.

Finally, the triple difference indicates that the relative change in the odds in Seattle adults with children was not statistically significantly different from the relative change in the odds in Seattle adults without children in the home (0.80; [95% CI: 0.21, 3.05]; $p=0.74$).

Self-reported high SSB consumption.

Among adults with children in the home in Seattle, the adjusted predicted probability of reporting high SSB consumption was 19.0% in the pre-tax period and 22.6% in the post-tax period (**Table 3.3**). This amounts to 24% (OR: 1.24; [95% CI: 0.77, 1.99]) higher odds in the post-tax versus pre-tax period, which was not statistically significant. Among adults with children in the home in the comparison area, the pre-tax adjusted predicted probability was 18.5% and the post-tax probability was 24.1%, translating to 40% (OR: 1.40; [95% CI: 0.77, 2.56]) higher odds over time, which was also not statistically significant. Relative to the change in the odds in the comparison area, the odds of reporting high SSB consumption in Seattle decreased by 12% (ratio of ORs: 0.88; [95% CI: 0.41, 1.88]); $p=0.75$), though this was not statistically significant.

Among adults without children in the home in Seattle, the adjusted predicted probability of reporting high SSB consumption was 12.9% at pre-tax and 15.7% at post-tax, reflecting non-statistically significant higher odds by 26% (OR: 1.26; [95% CI: 0.90, 1.76]) over time. In the

comparison area, the adjusted predicted probability was 17.1% in the pre-tax period and 16.3% in the pre-tax period, translating to 6% lower odds of high SSB consumption over time (OR: 0.94; [95% CI: 0.62, 1.43]), which was not statistically significant. Relative to the change in the comparison area from pre-tax to post-tax, there was a non-statistically significant increase in the odds of reporting high SSB consumption in Seattle by 34% (ratio of ORs: 1.34; [95% CI: 0.79, 2.29]; $p=0.28$).

Lastly, comparing the ratios of ORs in Seattle adults with versus without children, the triple difference estimate suggests that the relative change in the odds of reporting high SSB consumption in Seattle was not statistically different for adults with children versus adults without children in the home (0.66; [95% CI: 0.26, 1.67]; $p=0.38$).

Sensitivity analysis stratified by living with or without a child in the home.

To understand whether the difference-in-differences results were materially different from those calculated from the primary models with three-way interaction terms, we performed stratified difference-in-differences analyses among adults with children in the home, and separately, adults without children in the home. Despite minor variations likely to due to stratified imputation and propensity scores, results are not materially different from the primary results **(Supplemental Table 3.5)**.

Exploratory analysis of effect modification by household income among adults with children in the home.

Among adults with children in the home, 49% (n=409) reported lower household income (< 260% FPL). In general, we did not observe significant associations between the Seattle tax and changes in the outcomes, and these did not differ for lower versus higher income households,

though power is limited due to smaller sample sizes within each timepoint and location, (Supplementary Table 3.6).

Discussion

In this repeated cross-sectional difference-in-differences study, we assessed changes in perceived healthfulness and self-reported consumption of SSBs in adults with children in the home relative to adults without children in the home before and after the Seattle SSB tax. We found that perceptions of health risks of SSBs were relatively high and did not change over the two years post-tax in either location among adults with or without children in the home. Additionally, we did not observe changes in the probabilities of reporting that daily SSB consumption was healthful and reporting daily SSB consumption in the past month, nor did we observe differential changes between adults with and without children in the home. Findings were not substantially different in stratified sensitivity analyses and across model variations of confounding control with covariate adjustment and propensity score weights.

While tax impacts on perceived healthfulness of SSBs among parents have not been quantitatively assessed elsewhere, surveys of overall adults and qualitative studies with parents provide some context. In a Philadelphia survey, perceived healthfulness of taxed beverages (artificially and sugar-sweetened) decreased after tax implementation, particularly among participants from low-income neighborhoods¹¹⁹. Similarly, in an analysis of all survey participants from the present study, perceived health risks of SSBs increased among participants with lower income, but not higher income⁷⁰. In qualitative studies with parents in Berkeley, and parents with lower income in Philadelphia and Seattle, parents generally were aware of health risks of SSBs prior to the tax, and some parents discussed health risk signaling of the tax in Seattle and Philadelphia^{68,69,97}. These qualitative findings support our observation that parents (as well as other adults) had a relatively high perception of health risks of SSBs prior to the tax. In addition, effect

modification by household income could be present, but we were unable to adequately investigate this due to limited power.

Studies have assessed tax-related changes in SSB consumption among parents in Oakland, Philadelphia, and Seattle in the two years post-tax^{17,19,31}. Like the present study, self-reported SSB consumption did not significantly change among Oakland parents after the tax, however, reductions in SSB purchasing were observed¹⁹. In Philadelphia, parents decreased their consumption of soda in particular, offering some support for a health risk signaling pathway since soda is most often associated with SSB taxes and health concerns^{17,41}. In Seattle, a longitudinal cohort of parents with lower income found that SSB consumption decreased significantly in Seattle as well as in the nearby comparison area³¹. We did not observe such decreases in Seattle, and reasons for the discordance may be due to sociodemographic differences between study populations.

In the broader SSB tax literature on all adults, high consumers of SSBs tended to reduce their consumption more so than other SSB consumers after tax implementation.²⁵ In our study, although the confidence intervals overlap, the adjusted proportion of high SSB consumers in Seattle prior to the tax was higher among adults with versus without children in the home (19% v. 13%). The direction of the relative change in reporting high SSB consumption in Seattle post-tax suggested a non-statistically significant decrease for adults with children relative to adults without children in the home (triple difference: 0.66; $p=0.38$). It is possible that if high SSB consumption is indeed more common among parents with children in the home versus other adults, which we were not able to detect, parents may be more sensitive to the tax for this reason than adults without children.

Finally, qualitative studies with parents have explored tax impacts on SSB consumption. Parents in the Berkeley, Philadelphia, and Seattle studies described the tax as supporting their goals

in reducing SSB consumption in the household, but also mentioned barriers to doing so such as heavy advertising and cross-border shopping^{68,69,97}. Altogether, our findings support this body of literature by advancing discussion of possible differential impacts of SSB taxes for parents and caregivers towards the broader goal of understanding barriers and facilitators to health behavior change.

Limitations. We note several limitations of this study. First, we were not able to evaluate the plausibility of the parallel trends assumption between Seattle and the comparison area because we had only one pre-tax time point. We used propensity score weights and covariate adjustment to strengthen this assumption by making the samples similar to one another on factors believed to be related to trends in the outcomes. Second, the sample size of adults with children in the home was relatively small compared to adults without children in the home. Considering the magnitude of some point estimates and substantial width of confidence intervals, we may have lacked power to detect potential associations and differences between groups. Third, the nature of the survey questions limited the range of possible answers related to SSB consumption and are subject to social desirability bias. Fourth, we did not have information on whether participants were parents or guardians of the children in their household, nor did we have information on the age of the children.

Strengths. This study explores a novel question of whether adults with children in the household respond differently to a SSB tax than adults without children in the household. In addition to SSB consumption, we investigate measures of perceived healthfulness of SSBs, which are relatively understudied tax impacts relevant to health and health risk signaling. Finally, we used multiple imputations to address missing data unlike previous analyses from this survey that omitted participants with missing data^{70,111}.

Conclusion

Adults with children in the household were similar to adults without children in the household with respect to perceived health risks of SSBs and high consumption of SSBs before and two years after the Seattle SSB tax. Directions for future work include exploring whether SSB tax impacts differ for parents with young children versus older children in the home and formally investigating household income as an effect modifier in studies among parents. Understanding how parents and caregivers respond to SSB taxes can inform public health efforts aiming to maximize health benefits of the taxes.

Table 3.1. Characteristics of the pre-tax and post-tax analytic sample in Seattle and the comparison area with and without at least one child in the home, 2017 and 2019.

	<i>n</i> =	Living with children in the home (N=830)				Living without children in the home (N=2,389)			
		Seattle		Comparison		Seattle		Comparison	
		Pre-tax	Post-tax	Pre-tax	Post-tax	Pre-tax	Post-tax	Pre-tax	Post-tax
<i>Age</i>		645	584	653	597				
18-30 years old		14%	18%	24%	17%	16%	15%	13%	17%
31-40 years old		31%	40%	34%	35%	15%	11%	15%	13%
41-50 years old		38%	28%	30%	30%	10%	11%	12%	10%
51+ years old		18%	15%	13%	18%	60%	63%	60%	60%
<i>Sex</i>									
Female		60%	52%	57%	60%	59%	62%	62%	59%
<i>Race/Ethnicity</i>									
Non Hispanic Asian		8%	8%	18%	23%	8%	7%	5%	5%
Non Hispanic Black/African American		6%	11%	9%	12%	7%	6%	7%	4%
Non Hispanic White		65%	63%	44%	46%	71%	74%	77%	76%
Non Hispanic Other		13%	8%	13%	11%	8%	9%	6%	11%
Hispanic		9%	11%	16%	8%	6%	4%	5%	4%
<i>Household Income relative to the FPL</i>									
< 260%		43%	45%	55%	52%	49%	49%	53%	48%
260-400%		27%	30%	30%	23%	24%	23%	22%	21%
> 400%		30%	25%	16%	25%	27%	28%	26%	31%
<i>Education</i>									
Completed high school or less		12%	12%	17%	11%	12%	11%	12%	12%
Some or completed college		56%	62%	52%	65%	60%	57%	67%	57%
Completed graduate/professional degree		32%	26%	32%	24%	28%	31%	21%	32%
<i>Political Affiliation</i>									
Democrat		52%	56%	45%	57%	58%	56%	61%	55%
Independent		28%	24%	31%	24%	29%	30%	26%	30%
Republican		14%	15%	12%	8%	7%	7%	7%	8%
Other/Don't Know		7%	5%	12%	10%	7%	7%	6%	7%
<i>Marital Status</i>									
Married		64%	66%	56%	59%	31%	29%	30%	31%
Widowed/divorced/separated		12%	8%	11%	11%	21%	23%	22%	22%
Single, never married		19%	18%	23%	22%	39%	40%	40%	38%
Living with partner		5%	8%	10%	8%	10%	9%	8%	9%
<i>Household Size</i>									
1 person		0%	0%	0%	0%	43%	49%	47%	42%
2-4 people		73%	75%	69%	66%	55%	49%	52%	56%
5 or more people		27%	25%	31%	34%	2%	2%	1%	1%
<i>Survey Mode</i>									
Online (versus phone)		56%	73%	64%	64%	49%	43%	49%	45%
<i>Summary score of perceived health harms of SSBs*</i>									
Score -11-0		10%	5%	5%	5%	6%	7%	5%	5%
Score 1-5		13%	19%	17%	16%	16%	17%	15%	14%
Score 6-11		77%	76%	78%	79%	79%	77%	79%	81%
<i>Considering how SSBs affect health, what is the MOST that people should drink them?</i>									
None or <1 times/week		35%	24%	26%	31%	35%	37%	30%	30%
1 time/week		34%	33%	38%	41%	35%	31%	39%	43%
2-6 times/week		21%	33%	26%	21%	23%	23%	19%	18%
1+ times/day		10%	10%	11%	7%	7%	9%	11%	10%
<i>Past 30-day consumption of SSBs</i>									
None or <1 times/week		39%	20%	16%	33%	51%	49%	41%	40%
1 time/week		11%	19%	24%	9%	17%	15%	20%	23%
2-6 times/week		27%	31%	36%	28%	18%	22%	22%	21%
1+ times/day		23%	30%	25%	30%	14%	15%	18%	16%

Note: Percentages are weighted based on propensity score weights that adjust the distribution of covariates in each pre-tax and post-tax sample in each location to look similar to the Seattle pre-tax sample. Percentages also reflect the final distribution of covariates in the analysis including those from observations initially missing and imputed using multiple imputations by chained equations (see Supplemental Table 1 for unweighted proportions and missingness for each variable in each sample).

FPL=Federal Poverty Level calculated from the 2017 Federal Poverty Guidelines.

*A higher score indicates a greater perceived health risk.

Table 3.2. Changes in perceived health risks of sugar-sweetened beverages (SSBs) from before and after implementation of the Seattle SSB tax among adults with and without children in the home in Seattle and the comparison area, 2017 and 2019.

	Seattle			Comparison Area			Difference-in-Differences	Triple Difference**
	Pre-tax Mean	Post-tax Mean	Difference	Pre-tax Mean	Post-tax Mean	Difference		
Perceived health risks of SSBs, mean summary score* (95% CI)								
Adults with children in the home (n=830)	6.05 (4.82, 7.29)	6.45 (5.27, 7.62)	0.39 (-0.54, 1.32)	6.46 (5.32, 7.6)	6.31 (4.99, 7.63)	-0.15 (-1.12, 0.82)	0.54 (-0.81, 1.89) <i>P</i> =0.43	0.81 (-0.76, 2.38) <i>P</i> =0.31
Adults without children in the home (n=2,389)	6.93 (5.94, 7.92)	6.68 (5.67, 7.68)	-0.25 (-0.76, 0.25)	7.09 (6.08, 8.09)	7.10 (6.10, 8.11)	0.01 (-0.60, 0.63)	-0.27 (-1.06, 0.53) <i>P</i> =0.51	

Note: We used adjusted difference-in-differences linear regression models with a three-way interaction term between variables for timepoint, location, and living with or without a child in the home. Models adjusted for age, sex, race/ethnicity, household income, education, political affiliation, marital status, household size, and survey mode and imputed missing observations using multiple imputations by chained equations. Models also used propensity score weights, based on the covariates, so that each pre- and post-tax sample in each location resembled the Seattle pre-tax sample¹¹⁷.
 *The summary score range of possible values is -11 to 11. A higher score reflects a greater perceived health risk of SSBs.
 **The triple difference estimates the amount by which the difference-in-differences in the outcome among adults with children in the home is larger or smaller than the difference-in-differences in the outcome among adults without children in the home.
 CI=confidence interval. *P*=p-value.

Table 3.3. Changes in the odds of perceiving high consumption of sugar-sweetened beverages (SSBs) as healthful and reporting high consumption of SSBs from before and after implementation of the Seattle SSB tax among adults with and without children in the home in Seattle and the comparison area, 2017 and 2019.

	Seattle			Comparison Area			Ratio of ORs	Triple Difference**
	Pre-tax Probability	Post-tax Probability	OR*	Pre-tax Probability	Post-tax Probability	OR*		
Reported high SSB consumption as healthful (95% CI)								
Adults with children in the home (n=830)	9.9% (4.8, 15.0)	10.4% (4.4, 16.4)	1.05 (0.49, 2.25)	11.2% (5.7, 16.6)	9.4% (3.0, 15.8)	0.82 (0.34, 1.97)	1.28 (0.41, 4.03) <i>P</i> =0.67	0.80 (0.21, 3.05) <i>P</i> =0.74
Adults without children in the home (n=2,389)	6.5% (4.5, 8.4)	8.4% (5.8, 11.1)	1.33 (0.85, 2.07)	9.7% (6.6, 12.8)	8.2% (5.0, 11.4)	0.83 (0.49, 1.41)	1.60 (0.80, 3.20) <i>P</i> =0.18	
Self-reported high SSB consumption in the past 30 days (95% CI)								
Adults with children in the home (n=830)	19.0% (12.9, 25.1)	22.6% (16.2, 28.9)	1.24 (0.77, 1.99)	18.5% (11.9, 25.0)	24.1% (15.0, 33.2)	1.40 (0.77, 2.56)	0.88 (0.41, 1.88) <i>P</i> =0.75	0.66 (0.26, 1.67) <i>P</i> =0.38
Adults without children in the home (n=2,389)	12.9% (10.2, 15.5)	15.7% (12.4, 18.9)	1.26 (0.9, 1.76)	17.1% (13.1, 21.2)	16.3% (11.8, 20.7)	0.94 (0.62, 1.43)	1.34 (0.79, 2.29) <i>P</i> =0.28	

Note: We used adjusted difference-in-differences logistic regression models with a three-way interaction term between variables for timepoint, location, and living with or without a child in the home. Models adjusted for age, sex, race/ethnicity, household income, education, political affiliation, marital status, household size, and survey mode and imputed missing observations using multiple imputations by chained equations. Models also used propensity score weights, based on the covariates, so that each pre- and post-tax sample in each location resembled the Seattle pre-tax sample¹¹⁷.

*Odds ratio (OR) of the outcome when comparing the odds of the outcome in the post-tax period to the odds in the pre-tax period. The ratio of ORs is the difference-in-difference estimator and reflects the relative change in the odds of the outcome in Seattle above and beyond the relative change in the odds of the outcome in the comparison area. Pre-tax and post-tax estimates in each city are presented as predicted probabilities calculated from the logistic regression model.

**The triple difference estimates the amount by which the difference-in-differences (or ratio of ORs) in the outcome among adults with children in the home is larger or smaller than the difference-in-differences (or ratio of ORs) in the outcome adults without children in the home. CI=confidence interval. *P*=p-value.

Supplemental Material

Linear Regression Model Equation

$$Y_{it} = \beta_0 + \beta_1[\text{Timepoint}]_t + \beta_2[\text{City}]_i + \beta_3[\text{HHchild}]_i + \beta_4[\text{Timepoint}*\text{City}]_{it} + \beta_5[\text{Timepoint}*\text{HHchild}]_{it} + \beta_6[\text{City}*\text{HHchild}]_i + \beta_7[\text{Timepoint}*\text{City}*\text{HHchild}]_{it} + \beta_8[X]_{it} \varepsilon_{it}$$

Where Y_{it} is the mean outcome for person i at time t . *Timepoint* is set to a value of 1 for post-tax observations and 0 for pre-tax observations. *City* is a dummy variable set to 1 for Seattle and 0 for comparison areas. Likewise, *HHchild* is set to 1 for adults with children in the home and 0 for adults without children in the home. X is a vector of person-level covariates. The coefficients are described and interpreted below:

	Time (T)	City (C)	HHchild (H)
β_0	0	0	0
$\beta_0 + \beta_1$	1	0	0
$\beta_0 + \beta_2$	0	1	0
$\beta_0 + \beta_3$	0	0	1
$\beta_0 + \beta_1 + \beta_2 + \beta_4$	1	1	0
$\beta_0 + \beta_1 + \beta_3 + \beta_5$	1	0	1
$\beta_0 + \beta_2 + \beta_3 + \beta_6$	0	1	1
$\beta_0 + \beta_1 + \beta_2 + \beta_3 + \beta_4 + \beta_5 + \beta_6 + \beta_7$	1	1	1

	Expected value	Interpretation
β_0	$E[Y T=0, C=0, H=0]$	Mean outcome in comparison area, no children, pre-tax
β_1	$E[Y T=1, C=0, H=0] - E[Y T=0, C=0, H=0]$	Difference in mean outcome in comparison area from pre- to post-tax, among adults without children
β_2	$E[Y T=0, C=1, H=0] - E[Y T=0, C=0, H=0]$	Difference in mean outcome comparing Seattle to comparison area, pre-tax, among adults without children
β_3	$E[Y T=0, C=0, H=1] - E[Y T=0, C=0, H=0]$	Difference in mean outcome comparing adults with children to adults without children in the comparison area, pre-tax
β_4	$(E[Y T=1, C=1, H=0] - E[Y T=1, C=0, H=0]) - (E[Y T=0, C=1, H=0] - E[Y T=0, C=0, H=0])$	Difference in differences in mean outcome comparing Seattle to comparison area from pre- to post-tax, among adults without children
β_5	$(E[Y T=1, C=0, H=1] - E[Y T=0, C=0, H=1]) - (E[Y T=1, C=0, H=0] - E[Y T=0, C=0, H=0])$	Difference in differences in mean outcome comparing adults with children to adults without children from pretax to post tax, in the comparison area
β_6	$(E[Y T=0, C=1, H=1] - E[Y T=0, C=1, H=0]) - (E[Y T=0, C=0, H=1] - E[Y T=0, C=0, H=0])$	Difference in difference in mean outcome comparing adults with children and adults

		without children in Seattle to comparison area, at pre-tax
β_7	$\{(E[Y T=1, C=1, H=1] - E[Y T=1, C=1, H=0]) - (E[Y T=0, C=1, H=1] - E[Y T=0, C=1, H=0])\} - \{(E[Y T=1, C=0, H=1] - E[Y T=1, C=0, H=0]) - (E[Y T=0, C=0, H=1] - E[Y T=0, C=0, H=0])\}$	Triple difference: the difference between the difference-in-differences comparing Seattle to comparison area from pre to post tax in adults with children versus adults without children
$\beta_4 + \beta_7$	$(E[Y T=1, C=1, H=1] - E[Y T=0, C=1, H=1]) - (E[Y T=1, C=0, H=1] - E[Y T=0, C=0, H=1])$	Difference in difference in mean outcome comparing Seattle to comparison area from pre tax to post tax among adults with children

Logistic Regression Model Equation

$$\ln(Y_i) = \beta_0 + \beta_1[\textit{Timepoint}]_i + \beta_2[\textit{City}]_i + \beta_3[\textit{HHchild}]_i + \beta_4[\textit{Timepoint*City}]_i + \beta_5[\textit{Timepoint*HHchild}]_i + \beta_6[\textit{City*HHchild}]_i + \beta_7[\textit{Timepoint*City*HHchild}]_i + \beta_8[X]_i \varepsilon_i$$

Where Y_{it} is the mean outcome for person i at time t . *Timepoint* is set to a value of 1 for post-tax observations and 0 for pre-tax observations. *City* is a dummy variable set to 1 for Seattle and 0 for comparison areas. Likewise, *HHchild* is set to 1 for adults with children in the home and 0 for adults without children in the home. X is a vector of person-level covariates. The coefficients are described and interpreted below:

	Time (T)	City (C)	HHchild (H)
β_0	0	0	0
$\beta_0 + \beta_1$	1	0	0
$\beta_0 + \beta_2$	0	1	0
$\beta_0 + \beta_3$	0	0	1
$\beta_0 + \beta_1 + \beta_2 + \beta_4$	1	1	0
$\beta_0 + \beta_1 + \beta_3 + \beta_5$	1	0	1
$\beta_0 + \beta_2 + \beta_3 + \beta_6$	0	1	1
$\beta_0 + \beta_1 + \beta_2 + \beta_3 + \beta_4 + \beta_5 + \beta_6 + \beta_7$	1	1	1

Exponentiated coefficient:	Expected value	Interpretation of exponentiated coefficient
β_0	$E[Y T=0, C=0, H=0]$	Odds in comparison area, no children, pre-tax
β_1	$E[Y T=1, C=0, H=0] - E[Y T=0, C=0, H=0]$	OR of outcome in comparison area from pre- to post-tax, among adults without children
β_2	$E[Y T=0, C=1, H=0] - E[Y T=0, C=0, H=0]$	OR of the outcome comparing Seattle to comparison area, pre-tax, among adults without children
β_3	$E[Y T=0, C=0, H=1] - E[Y T=0, C=0, H=0]$	OR of the outcome comparing adults with children to adults without children in the comparison area, pre-tax

β_4	$(E[Y T=1, C=1, H=0] - E[Y T=1, C=0, H=0]) - (E[Y T=0, C=1, H=0] - E[Y T=0, C=0, H=0])$	Ratio of ORs of the outcome comparing Seattle to comparison area from pre- to post-tax, among adults without children
β_5	$(E[Y T=1, C=0, H=1] - E[Y T=0, C=0, H=1]) - (E[Y T=1, C=0, H=0] - E[Y T=0, C=0, H=0])$	Ratio of ORs of the outcome comparing adults with children to adults without children from pretax to post tax, in the comparison area
β_6	$(E[Y T=0, C=1, H=1] - E[Y T=0, C=1, H=0]) - (E[Y T=0, C=0, H=1] - E[Y T=0, C=0, H=0])$	Ratio of ORs of the outcome comparing adults with children and adults without children in Seattle to comparison area, at pre-tax
β_7	$\{(E[Y T=1, C=1, H=1] - E[Y T=1, C=1, H=0]) - (E[Y T=0, C=1, H=1] - E[Y T=0, C=1, H=0])\} - \{(E[Y T=1, C=0, H=1] - E[Y T=1, C=0, H=0]) - (E[Y T=0, C=0, H=1] - E[Y T=0, C=0, H=0])\}$	Triple difference: Ratio of ratio of ORs of the outcome comparing Seattle to comparison area from pre to post tax in adults with children versus adults without children
$\beta_4 + \beta_7$	$(E[Y T=1, C=1, H=1] - E[Y T=0, C=1, H=1]) - (E[Y T=1, C=0, H=1] - E[Y T=0, C=0, H=1])$	Difference in difference in mean outcome comparing Seattle to comparison area from pre tax to post tax among adults with children

Supplemental Table 3.4. Characteristics of the pre-tax and post-tax unweighted samples in Seattle and the comparison area among participants with and without at least one child in the household, 2017 and 2019.

	Living with children in the home (N=830)				Living without children in the home (N=2,389)			
	Seattle n (%)		Comparison n (%)		Seattle n (%)		Comparison n (%)	
	Pre-tax	Post-tax	Pre-tax	Post-tax	Pre-tax	Post-tax	Pre-tax	Post-tax
<i>Age</i>								
18-30 years old	26 (14)	43 (21)	68 (28)	51 (26)	102 (16)	107 (18)	91 (16)	148 (25)
31-40 years old	57 (30)	79 (39)	90 (37)	79 (41)	92 (14)	75 (13)	88 (16)	83 (14)
41-50 years old	70 (37)	57 (28)	58 (24)	35 (18)	62 (10)	67 (11)	66 (12)	62 (10)
51+ years old	32 (17)	26 (13)	28 (11)	26 (13)	378 (59)	328 (56)	317 (56)	304 (51)
Missing	2 (1)	0 (0)	0 (0)	3 (2)	11 (2)	7 (1)	1 (0)	0 (0)
<i>Sex</i>								
Male	75 (40)	101 (49)	133 (55)	59 (30)	263 (41)	222 (38)	310 (55)	194 (32)
Female	112 (60)	103 (50)	111 (45)	134 (69)	379 (59)	354 (61)	251 (45)	402 (67)
Missing	0 (0)	1 (0)	0 (0)	1 (1)	3 (0)	8 (1)	2 (0)	1 (0)
<i>Race/Ethnicity</i>								
Non Hispanic Asian	14 (7)	21 (10)	42 (17)	27 (14)	51 (8)	54 (9)	33 (6)	43 (7)
Non Hispanic Black/African American	11 (6)	25 (12)	21 (9)	53 (27)	47 (7)	39 (7)	40 (7)	55 (9)
Non Hispanic White	120 (64)	120 (59)	102 (42)	73 (38)	458 (71)	414 (71)	408 (72)	421 (71)
Non Hispanic Other	24 (13)	12 (6)	11 (5)	17 (9)	51 (8)	50 (9)	23 (4)	39 (7)
Hispanic	17 (9)	27 (13)	64 (26)	23 (12)	36 (6)	27 (5)	55 (10)	34 (6)
Missing	1 (1)	0 (0)	4 (2)	1 (1)	2 (0)	0 (0)	4 (1)	5 (1)
<i>Household Income relative to FPL</i>								
< 260%	78 (42)	99 (48)	115 (47)	113 (58)	302 (47)	256 (44)	244 (43)	285 (48)
260-400%	48 (26)	61 (30)	78 (32)	51 (26)	146 (23)	159 (27)	117 (21)	160 (27)
> 400%	54 (29)	38 (19)	44 (18)	19 (10)	163 (25)	140 (24)	159 (28)	124 (21)
Missing	7 (4)	7 (3)	7 (3)	11 (6)	34 (5)	29 (5)	43 (8)	28 (5)
<i>Education</i>								
Completed high school or less	22 (12)	31 (15)	63 (26)	33 (17)	77 (12)	81 (14)	89 (16)	87 (15)
Some or completed college	103 (55)	133 (65)	95 (39)	132 (68)	381 (59)	356 (61)	329 (58)	380 (64)
Completed graduate/professional degree	60 (32)	41 (20)	81 (33)	29 (15)	175 (27)	143 (24)	129 (23)	130 (22)
Missing	2 (1)	0 (0)	5 (2)	0 (0)	12 (2)	4 (1)	16 (3)	0 (0)
<i>Political Affiliation</i>								
Democrat	96 (51)	108 (53)	77 (32)	104 (54)	359 (56)	317 (54)	256 (45)	300 (50)
Independent	52 (28)	47 (23)	74 (30)	39 (20)	180 (28)	169 (29)	158 (28)	151 (25)
Republican	25 (13)	33 (16)	47 (19)	18 (9)	41 (6)	38 (7)	80 (14)	76 (13)

Other/Don't Know	12 (6)	15 (7)	34 (14)	33 (17)	43 (7)	53 (9)	43 (8)	70 (12)
Missing	2 (1)	2 (1)	12 (5)	0 (0)	22 (3)	7 (1)	26 (5)	0 (0)
<i>Marital Status</i>								
Married	118 (63)	123 (60)	149 (61)	84 (43)	193 (30)	127 (22)	212 (38)	138 (23)
Widowed/divorced/separated	23 (12)	17 (8)	15 (6)	25 (13)	130 (20)	119 (20)	92 (16)	131 (22)
Single, never married	35 (19)	47 (23)	55 (23)	63 (32)	246 (38)	275 (47)	200 (36)	290 (49)
Living with partner	9 (5)	18 (9)	20 (8)	22 (11)	63 (10)	58 (10)	36 (6)	38 (6)
Missing	2 (1)	0 (0)	5 (2)	0 (0)	13 (2)	5 (1)	23 (4)	0 (0)
<i>Household Size</i>								
1 person	0 (0)	0 (0)	0 (0)	0 (0)	276 (43)	302 (52)	219 (39)	278 (47)
2-4 people	135 (72)	156 (76)	176 (72)	136 (70)	355 (55)	273 (47)	336 (60)	306 (51)
5 or more people	50 (27)	49 (24)	66 (27)	56 (29)	13 (2)	9 (2)	8 (1)	13 (2)
Missing	2 (1)	0 (0)	2 (1)	2 (1)	1 (0)	0 (0)	0 (0)	0 (0)
<i>Survey Mode</i>								
Online	105 (56)	171 (83)	188 (77)	171 (88)	317 (49)	356 (61)	378 (67)	471 (79)
Phone	82 (44)	34 (17)	56 (23)	23 (12)	328 (51)	228 (39)	185 (33)	126 (21)
<i>Summary score of perceived health harms of SSBs*</i>								
Score -11-0	18 (10)	10 (5)	21 (9)	13 (7)	38 (6)	36 (6)	38 (7)	26 (4)
Score 1-5	25 (13)	41 (20)	47 (19)	37 (19)	100 (16)	94 (16)	82 (15)	86 (14)
Score 6-11	144 (77)	154 (75)	176 (72)	144 (74)	503 (78)	454 (78)	442 (79)	485 (81)
Missing	0 (0)	0 (0)	0 (0)	0 (0)	4 (1)	0 (0)	1 (0)	0 (0)
<i>Considering how SSBs affect health, what is the MOST that people should drink them?</i>								
None or <1 times/week	62 (33)	45 (22)	51 (21)	47 (24)	203 (31)	195 (33)	157 (28)	192 (32)
1 time/week	61 (33)	57 (28)	76 (31)	64 (33)	208 (32)	163 (28)	177 (31)	211 (35)
2-6 times/week	38 (20)	66 (32)	63 (26)	41 (21)	137 (21)	118 (20)	102 (18)	96 (16)
1+ times/day	18 (10)	18 (9)	23 (9)	12 (6)	41 (6)	49 (8)	57 (10)	48 (8)
Missing	8 (4)	19 (9)	31 (13)	30 (15)	56 (9)	59 (10)	70 (12)	50 (8)
<i>Past 30-day consumption of SSBs</i>								
None or <1 times/week	72 (39)	31 (15)	40 (16)	49 (25)	328 (51)	252 (43)	208 (37)	204 (34)
1 time/week	21 (11)	36 (18)	47 (19)	23 (12)	109 (17)	93 (16)	114 (20)	127 (21)
2-6 times/week	49 (26)	67 (33)	85 (35)	72 (37)	116 (18)	138 (24)	129 (23)	161 (27)
1+ times/day	43 (23)	70 (34)	71 (29)	48 (25)	86 (13)	93 (16)	108 (19)	102 (17)
Missing	2 (1)	1 (0)	1 (0)	2 (1)	6 (1)	8 (1)	4 (1)	3 (1)

Note: All values are unweighted. Missing observations presented here were imputed in the primary analysis using multiple imputations by chained equations. FPL=Federal Poverty Level calculated from the 2017 Federal Poverty Guidelines.

*A higher score indicates a greater perceived health risk.

Supplemental Table 3.5. Changes in perceived health risks of sugar-sweetened beverages (SSBs) and high SSB consumption in Seattle and the comparison area from before and after implementation of the Seattle SSB tax among participants with and without children in the household, 2017 and 2019.

	Seattle	Comparison Area	Difference in Differences (95% CI)	P-value
Perceived health risks of SSBs, summary score	Difference in means (95% CI)	Difference in means (95% CI)		
Adults with children in the home (n=830)	0.29 (-0.67, 1.25)	-0.11 (-1.06, 0.84)	0.40 (-0.93, 1.73)	0.55
Adults without children in the home (n=2,389)	-0.22 (-0.72, 0.29)	0.11 (-0.50, 0.73)	-0.33 (-1.13, 0.46)	0.35
Reported high SSB consumption as healthful	OR (95% CI)*	OR (95% CI)*	Ratio of ORs (95% CI)	P value
Adults with children in the home (n=830)	1.24 (0.53, 2.89)	1.31 (0.49, 3.48)	0.94 (0.25, 3.61)	0.93
Adults without children in the home (n=2,389)	1.46 (0.91, 2.33)	0.81 (0.47, 1.40)	1.79 (0.87, 3.68)	0.11
Self-reported high SSB consumption in the past 30 days (%)	OR (95% CI)*	OR (95% CI)*	Ratio of ORs (95% CI)	P value
Adults with children in the home (n=830)	1.06 (0.61, 1.85)	1.33 (0.69, 2.58)	0.80 (0.34, 1.89)	0.60
Adults without children in the home (n=2,389)	1.27 (0.90, 1.78)	0.93 (0.61, 1.41)	1.36 (0.80, 2.33)	0.26

Note: We used stratified difference-in-differences regression based on whether participants were living with children. Linear regression models were used in the first outcome and logistic regression models were used for the second and third outcomes. All models adjusted for age, sex, race/ethnicity, household income, education, political affiliation, marital status, household size, and survey mode, and used propensity score weights, based on the covariates, so that each pre- and post-tax sample in each location resembled the Seattle pre-tax sample¹¹⁷. Missing observations for covariates and outcomes were imputed using multiply imputations by chained equations. For the first outcome, the difference-in-differences reflect the mean change in the score over time in Seattle above and beyond the change in outcome in the comparison. The summary score range of possible values is -11 to 11. A higher score reflects a greater perceived health risk of SSBs. *Odds ratio (OR) of the outcome when comparing the odds of the outcome in the post-tax period to the odds in the pre-tax period. The ratio of ORs is the difference-in-difference estimator and reflects the relative change in the odds of the outcome in Seattle above and beyond the relative change in the odds of the outcome in the comparison area. Pre-tax and post-tax estimates in each city are presented as predicted probabilities calculated from the logistic regression model. **Refers to testing whether the difference-in-differences are statistically significantly different between households with and without children, based on a pooled model with a three-way interaction term between variables for timepoint, location, and child in the household. CI=confidence interval.

Supplemental Table 3.6. Changes in perceived health risks of sugar-sweetened beverages (SSBs) and high SSB consumption in Seattle and the comparison area from before and after implementation of the Seattle SSB tax among participants with children in the household and stratified by lower and higher household income (N=830), 2017 and 2019.

	Seattle			Comparison Area			Difference in Differences	Triple difference
	Pre-tax mean	Post-tax mean	Difference in means	Pre-tax mean	Post-tax mean	Difference in means		
Perceived health risks of SSBs, summary score (95% CI)								
Lower household income (n=409)	7.09	6.84	-0.24 (-0.98, 0.49)	7.52	7.33	-0.18 (-1.16, 0.79)	-0.06 (-1.28, 1.16) P=0.93	0.57 (-1.08, 2.23) P=0.5
Higher household income (n=421)	7.33	7.13	-0.19 (-0.91, 0.52)	7.14	7.58	0.44 (-0.35, 1.23)	-0.63 (-1.70, 0.43) P=0.24	
	Pre-tax probability	Post-tax probability	OR*	Pre-tax probability	Post-tax probability	OR*	Ratio of ORs*	Triple difference**
Reported high SSB consumption as healthful (95% CI)								
Lower household income (n=409)	7%	10%	1.47 (0.78, 2.76)	10%	8%	0.74 (0.35, 1.54)	2.00 (0.75, 5.32) P=0.17	1.25 (0.75, 5.00) P=0.75
Higher household income (n=421)	5%	7%	1.44 (0.74, 2.80)	9%	8%	0.90 (0.42, 1.96)	1.60 (0.58, 4.39) P=0.36	
Self-reported high SSB consumption in the past 30 days (95% CI)								
Lower household income (n=409)	15%	18%	1.28 (0.82, 1.98)	16%	18%	1.19 (0.69, 2.07)	1.07 (0.54, 2.15) P=0.85	0.55 (0.17, 1.73) P=0.3
Higher household income (n=421)	9%	11%	1.27 (0.71, 2.28)	18%	12%	0.65 (0.33, 1.27)	1.97 (0.81, 4.80) P=0.14	

Note: Lower and higher household income refer to < 260% and ≥ 260% of the Federal Poverty Level, respectively. We used linear difference-in-differences regression to model the first outcome, and logistic difference-in-differences regression for the second and third outcomes. All models adjusted for age, sex, race/ethnicity, household income, education, political affiliation, marital status, household size, and survey mode, and used propensity score weights, based on the covariates, so that each pre- and post-tax sample in each location resembled the Seattle pre-tax sample¹¹⁷. For the first outcome, the difference-in-differences reflect the mean change in the score over time in Seattle above and beyond the change in outcome in the comparison. The summary score range of possible values is -11 to 11. *Odds ratio (OR) of the outcome when comparing the odds of the outcome in the post-tax period to the odds in the pre-tax period. The ratio of ORs is the difference-in-difference estimator and reflects the relative change in the odds of the outcome in Seattle above and beyond the relative change in the odds of the outcome in the comparison area. Pre-tax and post-tax estimates in each city are presented as predicted probabilities calculated from the logistic regression model. **Refers to testing whether the difference-in-differences are statistically significantly different between households with lower and higher income, based on a pooled model with a three-way interaction term between variables for timepoint, location, and household income below or above 260% of the Federal Poverty Level. CI=confidence interval.

Supplemental Table 3.7. Differences-in-differences estimates from primary and stratified model variations in the use of propensity score weights and covariate adjustments in samples with and without children in the home.

Model Variation	1. Primary Model: Covariates and propensity score weights	2. Covariate adjustment only	3. Propensity score weights only	4. Propensity score weights and adjustment for age, household income, political affiliation, mode*	5. Propensity score weights and adjustment for household income and education**
Pooled model: Adults with children					
DD in health risk summary score (95% CI)	0.54 (-0.81, 1.89)	0.24 (-0.97, 1.44)	0.25 (-1.17, 1.68)	0.43 (-0.94, 1.81)	0.38 (-0.98, 1.73)
ROR of reporting high SSB consumption is a healthful amount (95% CI)	1.28 (0.41, 4.03)	1.40 (0.52, 3.75)	1.36 (0.44, 4.19)	1.35 (0.44, 4.15)	1.28 (0.42, 3.91)
ROR of reporting high SSB consumption (95% CI)	0.88 (0.41, 1.88)	1.76 (0.92, 3.36)	1.12 (0.54, 2.30)	1.02 (0.49, 2.10)	1.06 (0.51, 2.20)
Stratified model: Adults with children					
DD in health risk summary score (95% CI)	0.40 (-0.93, 1.73)	0.43 (-0.92, 1.78)	0.33 (-1.10, 1.77)	0.40 (-0.96, 1.76)	0.42 (-0.92, 1.76)
ROR of reporting high SSB consumption is a healthful amount (95% CI)	0.94 (0.25, 3.61)	1.33 (0.47, 3.82)	0.87 (0.23, 3.38)	0.95 (0.25, 3.61)	0.91 (0.24, 3.44)
ROR of reporting high SSB consumption (95% CI)	0.80 (0.34, 1.89)	1.59 (0.82, 3.12)	0.77 (0.32, 1.86)	0.79 (0.43, 1.86)	0.76 (0.32, 1.78)
Pooled model: Adults without children					
DD in health risk summary score (95% CI)	-0.27 (-1.06, 0.53)	-0.16 (-0.86, 0.54)	-0.28 (-1.10, 0.55)	-0.24 (-1.05, 0.56)	-0.21 (-1.02, 0.60)
ROR of reporting high SSB consumption is a healthful amount (95% CI)	1.60 (0.80, 3.20)	1.63 (0.91, 2.94)	1.54 (0.77, 3.08)	1.57 (0.79, 3.15)	1.54 (0.77, 3.06)
ROR of reporting high SSB consumption (95% CI)	1.34 (0.79, 2.29)	1.40 (0.9, 2.19)	1.31 (0.77, 2.23)	1.30 (0.76, 2.23)	1.27 (0.34, 2.17)
Stratified model: Adults without children					
DD in health risk summary score (95% CI)	-0.33 (-1.13, 0.46)	-0.13 (-0.82, 0.55)	-0.36 (-1.19, 0.47)	-0.34 (-1.15, 0.46)	-0.31 (-1.12, 0.50)
ROR of reporting high SSB consumption is a healthful amount (95% CI)	1.79 (0.87, 3.68)	1.74 (0.93, 3.27)	1.75 (0.85, 3.61)	1.84 (0.89, 3.78)	1.72 (0.84, 3.55)
ROR of reporting high SSB consumption (95% CI)	1.36 (0.80, 2.33)	1.43 (0.91, 2.24)	1.41 (0.83, 2.39)	1.39 (0.82, 2.37)	1.38 (0.81, 2.36)

Notes: A higher health risk score indicates greater perceived risk of SSBs. We expect the score to increase and the odds of the two SSB consumption measures to decrease in association with the tax. DD = Difference-in-differences. ROR = ratio of odds ratios. CI = confidence interval. SSB = sugar-sweetened beverage. *The 4 covariates were selected after qualitatively assessing balance in the distribution of covariates in a propensity-score-weighted Table 1. **The 2 covariates were selected after assessing balance based on standardized mean difference calculations on the pooled, weighted sample.

Conclusion

The overall goal of this dissertation was to develop a better understanding of how SSB consumption may have changed among families with lower income in Seattle in light of the unexpected findings from the SeaSAW cohort study. Triangulating new data collected from Seattle-area parents, existing data from two evaluation studies of the Seattle SSB tax, and retail purchasing data, this work investigated different pathways through which SSB taxes influence behavior—namely, price sensitivity and health risk signaling—in the taxed area and nearby non-taxed areas. This generated new insights on whether parents/caregivers in the nontaxed comparison area were additionally impacted by the SSB tax via spillover effects and whether parents/caregivers as a population group are particularly affected (or unaffected) by SSB taxes more broadly. With emerging evidence of tax impacts on health outcomes in Seattle and elsewhere,^{32–35} there is a renewed importance to understanding how SSB taxes may influence behavior across different population groups with implications of health equity.

In Chapter 1, we conducted qualitative interviews with 35 former participants of the SeaSAW cohort study and learned that health was the primary reason for decreasing SSB consumption in the one- and two-years post-tax for parents in Seattle and the comparison area. Many parents also cited the tax as having some influence on their consumption, with some comparison area parents experiencing spillover effects of the tax through exposure to media coverage or beverage prices while shopping in Seattle. In Chapter 2, using retail scanner data and a difference-in-differences analysis of beverage volume sold in the two years before and after the tax, we did not find evidence of tax spillover effects in the form of reduced purchasing in the nontaxed King County area. Relative to matched comparison areas, volume sold of taxed beverages did not substantially change in King County, whereas a net decrease of -20% was

observed in Seattle, reinforcing previous findings of tax effects on purchasing in Seattle²³. In Chapter 3, we examined the question of whether parents/caregivers responded differently to the SSB tax than other adults. Using a difference-in-differences analysis of repeat cross-sectional survey data in Seattle and matched comparison areas, we did not find evidence of differential tax impacts on health perceptions or consumption of SSBs for adults with versus without children in the home. We also did not observe associations between the SSB tax and these outcomes among adults in either group, and power was limited to explore potential differences by household income among adults with children.

Within the Seattle SSB tax context, the findings provide more pieces to the puzzle of what happened with SSB consumption patterns following tax implementation. However, the findings are also discordant, and implications are not immediately clear. Specifically, there was no detection of tax spillover effects on purchasing in nearby nontaxed areas, although interviews with parents in the nearby nontaxed area suggested some experiences of tax spillover. It is possible that spillover effects in the comparison area were too subtle to detect in the retail scanner data over the large area of King County. Since retailers in lower income neighborhoods are underrepresented in retail scanner data⁸⁰, it is also possible that spillover affected lower income households to a greater degree than higher income households, and this was not captured well in the scanner data. Finally, it is possible that experiences of spillover effects were relatively unique to the SeaSAW cohort study population or the sample who participated in interviews. We also cannot rule out potential bias related to social desirability, recall, and selecting into the interviews.

Despite this, our findings have general implications for continued implementation and evaluation of Seattle's SSB tax with respect to potential health benefits for families with lower income. First, health concerns were the primary driver of SSB consumption change among parents/caregivers in Seattle, and risk perceptions of SSBs were high before and after the SSB tax

among adults with children in the home. This suggests that pairing health messaging with information about the SSB tax may reinforce parents'/caregivers' health motivations and support their efforts to reduce SSB consumption. Since there was no coordinated public education campaign when the tax was implemented,⁶⁷ incorporating new messaging in stores, clinics, and community centers years later may provide an additional nudge towards behavior change. Evaluating changes in awareness, purchasing, or consumption after the campaign would be informative as well.

Second, SSB taxes primarily influence behavior by increasing prices of taxed beverages, as evidenced by our finding of no substantial change in SSB purchasing in nearby nontaxed areas and studies elsewhere of price elasticity^{10,23,79}. As the cost of all beverages rises over time with inflation, the price differential between taxed and nontaxed beverages and thus the potential impact of the tax may diminish. In recent years, Washington and other states have adopted preemption laws, promoted heavily by the beverage industry,¹²⁰ that prevent local jurisdictions from adopting or increasing excise taxes on beverages and other grocery items. Seattle and other cities wanting to preserve the public health goal of the SSB tax may consider advocating for the adoption of state-level SSB taxes. In addition, cities may consider bolstering food subsidy programs that lower the relative cost of healthier food and beverages for eligible households and create a price differential that would disincentivize SSB purchasing¹²¹.

Finally, there are several directions for future research to build on and contextualize our findings. First, quantitative investigations of spillover effects in nearby nontaxed areas around other SSB tax locations are needed. It would be particularly informative to investigate spillover in a large sample of individuals with lower income as well as with objective purchasing data from stores in lower income neighborhoods. Second, SSB tax impact studies should increasingly assess for effect modification by household income or stratify the sample across income strata, and larger

studies among families with low income are needed. Third, there is little research on tax impacts among families with young and very young children. Parents with young or very young children may respond differently to SSB taxes than parents with older children in the home, and this has not been assessed. Further, additional qualitative and quantitative research on the experiences of parents with lower income in taxed areas can extend our findings to understand predictors and barriers to parental and child behavior change.

References

1. Bowman S, Clemens J, Friday J, Schroeder N, LaComb R. *Added Sugars in American Children's Diet: What We Eat in America, NHANES 2015-2016.*; 2019. Accessed June 11, 2021. https://www.ars.usda.gov/ARUserFiles/80400530/pdf/DBrief/26_Sources%20of%20Added%20Sugars%20in%20Children's%20Diet_1516.pdf
2. Bowman SA, Clemens JC, Friday JE, LaComb RP, Paudel D, Shimizu M. *Added Sugars in Adults' Diet: What We Eat in America.*; 2019. Accessed July 5, 2021. https://www.ars.usda.gov/ARUserFiles/80400530/pdf/DBrief/24_Sources_of_Added_Sugars_in_Adults'_Diet_2015-2016.pdf
3. Ricciuto L, Fulgoni VLI, Gaine PC, Scott MO, DiFrancesco L. Sources of Added Sugars Intake Among the U.S. Population: Analysis by Selected Sociodemographic Factors Using the National Health and Nutrition Examination Survey 2011–18. *Front Nutr.* 2021;0:316. doi:10.3389/FNUT.2021.687643
4. Bleich SN, Vercammen KA. The negative impact of sugar-sweetened beverages on children's health: An update of the literature. *BMC Obes.* 2018;5(1). doi:10.1186/s40608-017-0178-9
5. Malik VS, Popkin BM, Bray GA, Després JP, Hu FB. Sugar Sweetened Beverages, Obesity, Type 2 Diabetes and Cardiovascular Disease risk. *Circulation.* 2010;121(11):1356-1364. doi:10.1161/CIRCULATIONAHA.109.876185
6. Malik VS, Li Y, Pan A, et al. Long-Term Consumption of Sugar-Sweetened and Artificially Sweetened Beverages and Risk of Mortality in US Adults. *Circulation.* 2019;139(18):2113-2125. doi:10.1161/CIRCULATIONAHA.118.037401
7. van de Gaar VM, van Grieken A, Jansen W, Raat H. Children's sugar-sweetened beverages consumption: associations with family and home-related factors, differences within ethnic groups explored. *BMC Public Health.* 2017;17(1):1-11. doi:10.1186/s12889-017-4095-0
8. Von Philipsborn P, Stratil JM, Burns J, et al. Environmental Interventions to Reduce the Consumption of Sugar-Sweetened Beverages: Abridged Cochrane Systematic Review. *Obes Facts.* 2020;13(4):397-417. doi:10.1159/000508843
9. Waqanivalu T, Nederveen L, Oppong D, Sosa P. *Fiscal Policies for Diet and Prevention of Noncommunicable Diseases.*; 2015. Accessed July 5, 2021. https://www.who.int/docs/default-source/obesity/fiscal-policies-for-diet-and-the-prevention-of-noncommunicable-diseases-0.pdf?sfvrsn=84ee20c_2
10. Cawley J, Thow AM, Wen K, Frisvold D. The Economics of Taxes on Sugar-Sweetened Beverages: A Review of the Effects on Prices, Sales, Cross-Border Shopping, and Consumption. *Annu Rev Nutr.* 2019;39:317-338. doi:10.1146/annurev-nutr-082018-124603
11. Jones-Smith JC, Knox MA, Coe NB, et al. Sweetened beverage taxes: Economic benefits and costs according to household income. *Food Policy.* 2022;110:102277. doi:10.1016/J.FOODPOL.2022.102277

12. Popkin BM, Ng SW. Sugar-sweetened beverage taxes: Lessons to date and the future of taxation. *PLoS Med.* 2021;18(1):e1003412. doi:10.1371/journal.pmed.1003412
13. Silver LD, Ng SW, Ryan-Ibarra S, et al. 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 Med.* 2017;14(4):e1002283. doi:10.1371/journal.pmed.1002283
14. Bollinger B, Sexton SE. *Local Excise Taxes, Sticky Prices, and Spillovers: Evidence from Berkeley's Soda Tax.*; 2018. Accessed June 23, 2021. <https://ssrn.com/abstract=3087966>
15. Roberto CA, Lawman HG, LeVasseur MT, et al. 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.* 2019;321(18):1799-1810. doi:10.1001/jama.2019.4249
16. Bleich SN, Dunn CG, Soto MJ, et al. Association of a Sweetened Beverage Tax With Purchases of Beverages and High-Sugar Foods at Independent Stores in Philadelphia. *JAMA Netw Open.* 2021;4(6):e2113527. doi:10.1001/jamanetworkopen.2021.13527
17. Cawley J, Frisvold D, Hill A, Jones D. The impact of the Philadelphia beverage tax on purchases and consumption by adults and children. *J Health Econ.* 2019;67:102225. doi:10.1016/j.jhealeco.2019.102225
18. Lawman HG, Bleich SN, Yan J, et al. One-year changes in sugar-sweetened beverage consumers' purchases following implementation of a beverage tax: A longitudinal quasi-experiment. *American Journal of Clinical Nutrition.* 2020;112(3):644-651. doi:10.1093/ajcn/nqaa158
19. Cawley J, Frisvold D, Hill A, Jones D. Oakland's sugar-sweetened beverage tax: Impacts on prices, purchases and consumption by adults and children. *Econ Hum Biol.* 2020;37:100865. doi:10.1016/j.ehb.2020.100865
20. Saelens B, Rowland M, Qu P, et al. *Twelve Month Report: Store Audits and Child Cohort - The Evaluation of Seattle's Sweetened Beverage Tax.*; 2020. Accessed March 22, 2022. https://www.seattle.gov/Documents/Departments/CityAuditor/auditreports/SBT_12MonthReport.pdf
21. Powell LM, Leider J. The impact of Seattle's Sweetened Beverage Tax on beverage prices and volume sold. *Econ Hum Biol.* 2020;37:100856. doi:10.1016/j.ehb.2020.100856
22. Jones-Smith JC, Pinero Walkinshaw L, Oddo VM, et al. Impact of a sweetened beverage tax on beverage prices in Seattle, WA. *Econ Hum Biol.* 2020;39:100917. doi:10.1016/j.ehb.2020.100917
23. Powell LM, Leider J. Impact of a sugar-sweetened beverage tax two-year post-tax implementation in Seattle, Washington, United States. *J Public Health Policy.* 2021;42(4):574-588. doi:10.1057/s41271-021-00308-8
24. Powell LM, Leider J. Evaluation of Changes in Beverage Prices and Volume Sold following the Implementation and Repeal of a Sweetened Beverage Tax in Cook County, Illinois. *JAMA Netw Open.* 2020;3(12). doi:10.1001/jamanetworkopen.2020.31083

25. Cawley J, Frisvold D. Review: Taxes on sugar-sweetened beverages: Political economy, and effects on prices, purchases, and consumption. *Food Policy*. 2023;117:102441. doi:10.1016/J.FOODPOL.2023.102441
26. Falbe J, Thompson HR, Becker CM, Rojas N, McCulloch CE, Madsen KA. Impact of the Berkeley Excise Tax on Sugar-Sweetened Beverage Consumption. *Am J Public Health*. 2016;106(10):1865-1871. doi:10.2105/AJPH.2016.303362
27. Edmondson EK, Roberto CA, Gregory EF, Mitra N, Virudachalam S. Association of a Sweetened Beverage Tax With Soda Consumption in High School Students. *JAMA Pediatr*. 2021;175(12):1261-1268. doi:10.1001/jamapediatrics.2021.3991
28. Zhong Y, Auchincloss AH, Lee BK, McKenna RM, Langellier BA. Sugar-Sweetened and Diet Beverage Consumption in Philadelphia One Year after the Beverage Tax. *Int J Environ Res Public Health*. 2020;17(4):1336. doi:10.3390/ijerph17041336
29. Lee MM, Falbe J, Schillinger D, Basu S, McCulloch CE, Madsen KA. Sugar-Sweetened Beverage Consumption 3 Years After the Berkeley, California, Sugar-Sweetened Beverage Tax. *Am J Public Health*. 2019;109(4):637-639. doi:10.2105/AJPH.2019.304971
30. Silver LD, Padon AA, Li L, Simard BJ, Greenfield TK. Changes in sugar-sweetened beverage consumption in the first two years (2018 - 2020) of San Francisco's tax: A prospective longitudinal study. *PLOS global public health*. 2023;3(1):e0001219. doi:10.1371/JOURNAL.PGPH.0001219
31. Saelens BE, Rowland MG, Kidane S, Qu S, Jones-Smith JC, Chan NL. 24 Month Report: Child Cohort Examining Beverage Consumption - The Evaluation of Seattle's Sweetened Beverage Tax. Report for City of Seattle and Seattle City Council. Published online 2023. Accessed June 19, 2023. https://www.seattle.gov/documents/Departments/CityAuditor/auditreports/SBT_ChildCohort_24MonthReport.pdf
32. Gračner T, Marquez-Padilla F, Hernandez-Cortes D. Changes in Weight-Related Outcomes Among Adolescents Following Consumer Price Increases of Taxed Sugar-Sweetened Beverages. *JAMA Pediatr*. Published online December 13, 2021. doi:10.1001/JAMAPEDIATRICS.2021.5044
33. Jones-Smith J, Godwin J, Knox M, et al. *Association Between Seattle's Sweetened Beverage Tax and Change in BMI Among a Patient Population of Adults - The Evaluation of Seattle's Sweetened Beverage Tax. Report to the City of Seattle and Seattle City Council.*; 2023. Accessed September 17, 2023. https://www.seattle.gov/documents/Departments/CityAuditor/auditreports/SBT_BMIAdultPt.pdf
34. Jones-Smith JC, Chakrabarti S, Knox M, et al. Association Between Seattle's Sweetened Beverage Tax and Change in BMI Among a Patient Population of Youth - The Evaluation of Seattle's Sweetened Beverage Tax. Report to the City of Seattle and Seattle City Council. Published online September 2023. Accessed September 17, 2023. https://www.seattle.gov/documents/Departments/CityAuditor/auditreports/SBT_BMIYouthPt.pdf

35. Petimar J, Gibson LA, Wolff MS, et al. Changes in Dental Outcomes After Implementation of the Philadelphia Beverage Tax. *Am J Prev Med*. Published online February 28, 2023. doi:10.1016/J.AMEPRE.2023.02.009
36. Mazarello Paes V, Hesketh K, O'Malley C, et al. Determinants of sugar-sweetened beverage consumption in young children: A systematic review. *Obesity Reviews*. 2015;16(11):903-913. doi:10.1111/obr.12310
37. Tasevska N, DeLia D, Lorts C, Yedidia M, Ohri-Vachaspati P. Determinants of Sugar-Sweetened Beverage Consumption among Low-Income Children: Are There Differences by Race/Ethnicity, Age, and Sex? *J Acad Nutr Diet*. 2017;117(12):1900-1920. doi:10.1016/j.jand.2017.03.013
38. Sharma A, Hauck K, Hollingsworth B, Siciliani L. The effects of taxing sugar-sweetened beverages across different income groups. *Health Econ*. 2014;23(9):1159-1184. doi:10.1002/hec
39. Finkelstein EA, Zhen C, Nonnemaker J, Todd JE. Impact of Targeted Beverage Taxes on Higher- and Lower-Income Households. *Arch Intern Med*. 2010;170(22):2028-2034. doi:10.1001/archinternmed.2010.449
40. McAdams RH. *The Expressive Powers of Law: Theories and Limits*. Harvard University Press; 2015. <http://www.jstor.org/stable/j.ctt21pxk8q>
41. Alvarado M, Penney TL, Unwin N, Murphy MM, Adams J. Evidence of a health risk 'signalling effect' following the introduction of a sugar-sweetened beverage tax. *Food Policy*. 2021;102. doi:10.1016/J.FOODPOL.2021.102104
42. Barigozzi F, Villeneuve B. The Signaling Effect of Tax Policy. *J Public Econ Theory*. 2006;8(4):611-630. doi:10.1111/j.1467-9779.2006.00281.x
43. Álvarez-Sánchez C, Contento I, Jiménez-Aguilar A, et al. Does the Mexican sugar-sweetened beverage tax have a signaling effect? ENSANUT 2016. *PLoS One*. 2018;13(8). doi:10.1371/journal.pone.0199337
44. Donnelly GE, Guge PM, Howell RT, John LK. A Salient Sugar Tax Decreases Sugary-Drink Buying. *Psychol Sci*. 2021;32(11):1830-1841. doi:10.1177/09567976211017022
45. Cornelsen L, Quaife M, Lagarde M, Smith RD. Framing and signalling effects of taxes on sugary drinks: A discrete choice experiment among households in Great Britain. *Health Econ*. 2020;29(10):1132-1147. doi:10.1002/hec.4123
46. Cornelsen L, Quaife M, Lagarde M, Smith RD. Framing and signalling effects of taxes on sugary drinks: A discrete choice experiment among households in Great Britain. *Health Economics (United Kingdom)*. 2020;29(10):1132-1147. doi:10.1002/hec.4123
47. Munsell CR, Harris JL, Sarda V, Schwartz MB. Parents' beliefs about the healthfulness of sugary drink options: opportunities to address misperceptions. *Public Health Nutr*. 2016;19(1):46-54. doi:10.1017/S1368980015000397

48. Musicus AA, Hua S v., Moran AJ, et al. Front-of-package claims & imagery on fruit-flavored drinks and exposure by household demographics. *Appetite*. 2022;171. doi:10.1016/j.appet.2021.105902
49. Hall MG, Lazard AJ, Higgins ICA, et al. Nutrition-related claims lead parents to choose less healthy drinks for young children: a randomized trial in a virtual convenience store. *Am J Clin Nutr*. Published online January 18, 2022. doi:10.1093/ajcn/nqac008
50. O’leary C, Cummins S, Smith RD, Cornelsen L. Like parent, like child: a cross-sectional study of intra-household consumption patterns of non-alcoholic beverages among British households with children. *Public Health Nutr*. Published online 2022. doi:10.1017/S1368980021005061
51. Haughton CF, Waring ME, Wang ML, Rosal MC, Pbert L, Lemon SC. Home Matters: Adolescents Drink More Sugar-Sweetened Beverages When Available at Home. Published online 2018. doi:10.1016/j.jpeds.2018.06.046
52. Jensen ML, Choi YY, Fleming-Milici F, Harris JL. Caregivers’ Understanding of Ingredients in Drinks Served to Young Children: Opportunities for Nutrition Education and Improved Labeling. *Curr Dev Nutr*. 2022;6(1):nzab151. doi:10.1093/cdn/nzab151
53. Cruz-Casarrubias C, Tolentino-Mayo L, Nieto C, Théodore FL, Monterrubio-Flores E. Use of advertising strategies to target children in sugar-sweetened beverages packaging in Mexico and the nutritional quality of those beverages. Published online 2020. doi:10.1111/ijpo.12710
54. Kumar G, Onufrak S, Zytnick D, Kingsley B, Park S. Self-reported advertising exposure to sugar-sweetened beverages among US youth. *Public Health Nutr*. 2015;18(7):1173-1179. doi:10.1017/S1368980014001785
55. Andreyeva T, Marple K, Marinello S, Moore TE, Powell LM. Outcomes Following Taxation of Sugar-Sweetened Beverages: A Systematic Review and Meta-analysis. *JAMA Netw Open*. 2022;5(6):e2215276-e2215276. doi:10.1001/JAMANETWORKOPEN.2022.15276
56. Seattle City Council. Sweetened Beverage Tax Ordinance 125324. Published online 2017. <https://www-seattle-gov.offcampus.lib.washington.edu/license-and-tax-administration/business-license-tax/other-seattle-taxes/sweetened-beverage-tax>
57. Grummon AH, Roberto CA, Krieger JW. Is the Association Between Beverage Taxes and Reductions in Sales Driven by Communication of Health Consequences in Addition to Price Increases? *JAMA Netw Open*. 2020;3(12). doi:10.1001/jamanetworkopen.2020.32537
58. Cawley J, Frisvold D, Jones D. The impact of sugar-sweetened beverage taxes on purchases: Evidence from four city-level taxes in the United States. *Health Econ*. 2020;29(10):1289-1306. doi:10.1002/hec.4141
59. US TVDB. Seattle-Tacoma, WA Media Market. Published 2023. Accessed April 9, 2023. <https://ustvdb.com/markets/seattle-tacoma/>

60. Hedrick VE, Savla J, Comber DL, et al. Development of a Brief Questionnaire to Assess Habitual Beverage Intake (BEVQ-15): Sugar-Sweetened Beverages and Total Beverage Energy Intake. *J Acad Nutr Diet.* 2012;112(6):840-849. doi:10.1016/J.JAND.2012.01.023
61. Glanz K, Sallis JF, Saelens BE, Frank LD. Healthy nutrition environments: Concepts and measures. *American Journal of Health Promotion.* 2005;19(5):330-333. doi:10.4278/0890-1171-19.5.330/ASSET/0890-1171-19.5.330.FP.PNG_V03
62. Glass TA, McAtee MJ. Behavioral science at the crossroads in public health: Extending horizons, envisioning the future. *Soc Sci Med.* 2006;62(7):1650-1671. doi:10.1016/J.SOCSCIMED.2005.08.044
63. Harris PA, Taylor R, Minor BL, et al. The REDCap consortium: Building an international community of software platform partners. *J Biomed Inform.* 2019;95:103208. doi:10.1016/J.JBI.2019.103208
64. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap)—A metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inform.* 2009;42(2):377-381. doi:10.1016/J.JBI.2008.08.010
65. Braun V, Clarke V. Using thematic analysis in psychology. *Qual Res Psychol.* 2006;3(2):77-101. doi:10.1191/1478088706qp063oa
66. SocioCultural Research Consultants LLC. Dedoose Version 9.0.86, cloud application for managing, analyzing, and presenting qualitative and mixed method research data. Published online 2023.
67. Jones-Smith JC, Knox M, Walkinshaw LP, et al. *Impact of the Tax on Norms and Attitudes. Report for City of Seattle and Seattle City Council.* .; 2021. Accessed January 28, 2022. <https://www.seattle.gov/Documents/Departments/CityAuditor/auditreports/NormsReport.pdf>
68. Edmondson EK, Shea JA, Gregory EF, et al. Low-income parents' perceptions of a sweetened beverage tax in Philadelphia. *J Nutr Sci.* 2022;11:1-9. doi:10.1017/JNS.2022.64
69. Benesch TD, Sokal-Gutierrez K, Madsen K, Freedman L. Parents' knowledge, attitudes and behaviors regarding sugar-sweetened beverages in light of the Berkeley Soda Tax (Measure D) [Thesis]. Published online 2017. Accessed October 21, 2023. https://escholarship.org/content/qt2cz1x4t2/qt2cz1x4t2_noSplash_64624d2344333131567f18c0ab78f635.pdf?t=pjdyh0
70. Sawyer L, Oddo VM, Fretts A, et al. Impacts of the Seattle Sweetened Beverage Tax on the Perceived Healthfulness of Sweetened Beverages. *Nutrients* 2022, Vol 14, Page 993. 2022;14(5):993. doi:10.3390/NU14050993
71. Daly K, Fort M, Falbe J. Framing and Themes of the City of Boulder's Sugar-Sweetened Beverage Tax Coverage in the Local News from 2016-2018. *AJPM Focus.* Published online January 20, 2023:100068. doi:10.1016/J.FOCUS.2023.100068

72. Asada Y, Taher S, Pipito A, Chriqui JF. Media Coverage and Framing of Oakland's Sugar-Sweetened Beverage Tax, 2016-2019. *Am J Health Promot.* 2021;35(5):698-702. doi:10.1177/0890117120986104
73. Essman M, Stoltze FM, Carpentier FD, Swart EC, Taillie LS. Examining the news media reaction to a national sugary beverage tax in South Africa: a quantitative content analysis. *BMC Public Health.* 2021;21(1):454. doi:10.1186/s12889-021-10460-1
74. Nixon L, Mejia P, Cheyne A, Dorfman L. Big Soda's long shadow: news coverage of local proposals to tax sugar-sweetened beverages in Richmond, El Monte and Telluride. <https://doi.org/10.1080/095815962014987729>. 2014;25(3):333-347. doi:10.1080/09581596.2014.987729
75. The Seattle Times. Initiative to ban local soda and grocery taxes leading in Washington. Published 2018. Accessed April 9, 2023. <https://www.seattletimes.com/seattle-news/politics/initiative-to-ban-local-soda-and-grocery-taxes-leading-in-washington/>
76. Saelens BE, Rowland M, Chan N, Jones-Smith J. *The 24-Month Child Cohort Report [Placeholder until Posted Online].*; 2023.
77. Altman EA, Madsen KA, Schmidt LA. Missed Opportunities: The Need to Promote Public Knowledge and Awareness of Sugar-Sweetened Beverage Taxes. *Int J Environ Res Public Health.* 2021;18(9). doi:10.3390/ijerph18094607
78. Taylor RLC, Kaplan S, Villas-Boas SB, Jung K. Soda wars: the effect of a soda tax election on university beverage sales. *Econ Inq.* 2019;57(3):1480-1496. doi:10.1111/ECIN.12776
79. Powell LM, Leider J. Evaluation of Changes in Beverage Prices and Volume Sold Following the Implementation and Repeal of a Sweetened Beverage Tax in Cook County, Illinois. *JAMA Netw Open.* 2020;3(12):e2031083. doi:10.1001/jamanetworkopen.2020.31083
80. Madsen KA, Falbe J, Olgin G, Ibarra-Castro A, Rojas N. Purchasing patterns in low-income neighbourhoods: implications for studying sugar-sweetened beverage taxes. *Public Health Nutr.* 2019;22(10):1807-1814. doi:10.1017/S1368980019000375
81. MacNeill V, Foley M, Quirk A, McCambridge J. Shedding light on research participation effects in behaviour change trials: a qualitative study examining research participant experiences. *BMC Public Health.* 2016;16(1). doi:10.1186/S12889-016-2741-6
82. McCambridge J, Kypri K. Can Simply Answering Research Questions Change Behaviour? Systematic Review and Meta Analyses of Brief Alcohol Intervention Trials. *PLoS One.* 2011;6(10). doi:10.1371/JOURNAL.PONE.0023748
83. McCambridge J, Kypri K, Elbourne D. Research participation effects: a skeleton in the methodological cupboard. *J Clin Epidemiol.* 2014;67(8):845. doi:10.1016/J.JCLINEPI.2014.03.002
84. Friedenreich CM. Improving Long-Term Recall in Epidemiologic Studies. *Epidemiology.* 1994;5(1):1-4. <http://www.jstor.org/stable/3702995>

85. Teng AM, Jones AC, Mizdrak A, Signal L, Genç M, Wilson N. Impact of sugar-sweetened beverage taxes on purchases and dietary intake: Systematic review and meta-analysis. *Obesity Reviews*. 2019;20(9):1187-1204. doi:10.1111/obr.12868
86. McAdams RH. *The Expressive Powers of Law: Theories and Limits*. Harvard University Press; 2015. <http://www.jstor.org/stable/j.ctt21pxk8q>
87. Licari MJ, Meier KJ. Regulation and Signaling: When a Tax is not Just a Tax. *J Polit*. 2000;62(3):875-885. <http://www.jstor.org/stable/2647964>
88. Taylor RLC, Kaplan S, Villas-Boas SB, Jung K. Soda wars: The effect of a soda tax election on university beverage sales. *Econ Inq*. 2019;57(3):1480-1496. doi:10.1111/ECIN.12776
89. Paarlberg R, Mozaffarian D, Micha R. Viewpoint: Can U.S. local soda taxes continue to spread? *Food Policy*. 2017;71:1-7. doi:10.1016/J.FOODPOL.2017.05.007
90. Kantor D. MAHAPICK: Stata module to select matching observations based on a Mahalanobis distance measure. Published online February 2006. Accessed June 27, 2023. <https://ideas.repec.org/c/boc/bocode/s456703.html>
91. U.S. Census Bureau. 2012-2016 American Community Survey 5-Year Estimates. Accessed April 18, 2022. <https://www.census.gov/programs-surveys/acs>
92. Sisti JS, Tamar ·, Mezzacca A, Anekwe A, Farley SM. Examining Trends in Beverage Sales in New York City During Comprehensive Efforts to Reduce Sugary Drink Consumption, 2010-2015. *J Community Health*. 2021;46:609-617. doi:10.1007/s10900-020-00911-y
93. Kathya DC, Schythe T. Implementing the Panel Event Study. Published online 2020. Accessed August 25, 2023. www.iza.org
94. Olden A, Møen J. The triple difference estimator. *Econom J*. 2022;25(3):531-553. doi:10.1093/ectj/utac010
95. Wasserstein RL, Schirm AL, Lazar NA. Moving to a World Beyond “ $p < 0.05$.” *Am Stat*. 2019;73(sup1):1-19. doi:<https://doi.org/10.1080/00031305.2019.1583913>
96. Asa N, Jones-Smith J, Knox M, Pinero-Walkinshaw L. Associations between the Sweetened Beverage Tax Implementation in Seattle, WA and Changes in Supermarket Interior Marketing Displays [Thesis]. *University of Washington*. Published online 2022. Accessed September 13, 2023. <https://digital.lib.washington.edu:443/researchworks/handle/1773/48987>
97. Neff Warner LR, Kidane S, Rowland M, et al. *Understanding Behavior Changes in the Seattle Shopping and Wellness (SeaSAW) Cohort Study: Qualitative Follow-Up Interviews - The Evaluation of Seattle's Sweetened Beverage Tax. Report for the City of Seattle*. .; 2023. Accessed September 14, 2023. https://www.seattle.gov/documents/Departments/CityAuditor/auditreports/SBT_QualCohortReport.pdf
98. Bleich SN, Lawman HG, LeVasseur MT, et al. The Association Of A Sweetened Beverage Tax With Changes In Beverage Prices And Purchases At Independent Stores. *Health Aff (Millwood)*. 2020;39(7):1130-1139. doi:10.1377/hlthaff.2019.01058

99. Bleich SN, Dunn CG, Soto MJ, et al. Association of a Sweetened Beverage Tax With Purchases of Beverages and High-Sugar Foods at Independent Stores in Philadelphia. *JAMA Netw Open*. 2021;4(6):e2113527. doi:10.1001/jamanetworkopen.2021.13527
100. Leider J, Powell LM. Longer-term impacts of the Oakland, California, sugar-sweetened beverage tax on prices and volume sold at two-years post-tax. *Soc Sci Med*. 2022;292. doi:10.1016/j.socscimed.2021.114537
101. He X, Balagtas J V. Spatial retail competition reduces the effects of soda taxes on price and quantity: Evidence from the Philadelphia Beverage Tax. *Food Policy*. 2022;112:102334. doi:10.1016/J.FOODPOL.2022.102334
102. Hangoma P, Chewe M. Should We Worry About Spillover Effects of Sugar Sweetened Beverage Taxation Policies? Comment on “Understanding Marketing Responses to a Tax on Sugary Drinks: A Qualitative Interview Study in the United Kingdom, 2019” Commentary. *Kerman University of Medical Sciences*. 2023;12:7793. doi:10.34172/ijhpm.2023.7793
103. Houghtaling B, Holston D, Szocs C, Penn J, Qi D, Hedrick V. A rapid review of stocking and marketing practices used to sell sugar-sweetened beverages in U.S. food stores. *Obes Rev*. 2021;22(4):e13179. doi:10.1111/obr.13179
104. Zenk SN, Leider J, Pugach O, Pipito AA, Powell LM. Changes in Beverage Marketing at Stores Following the Oakland Sugar-Sweetened Beverage Tax. *Am J Prev Med*. 2020;58(5):648-656. doi:10.1016/j.amepre.2019.12.014
105. Roth J, Sant’anna PHC, Bilinski A, Poe J. What’s Trending in Difference-in-Differences? A Synthesis of the Recent Econometrics Literature *. Published online 2022.
106. U.S. Census Bureau. 2015-2019 American Community Survey 5-Year Estimates. Accessed March 29, 2022. <https://www.census.gov/acs/www/data/data-tables-and-tools/narrative-profiles/2019/report.php?geotype=place&state=53&place=63000>
107. Álvarez-Sánchez C, Contento I, Jiménez-Aguilar A, et al. Does the Mexican sugar-sweetened beverage tax have a signaling effect? ENSANUT 2016. *PLoS One*. 2018;13(8). doi:10.1371/JOURNAL.PONE.0199337
108. Acton RB, Vanderlee L, Adams J, et al. Tax awareness and perceived cost of sugar-sweetened beverages in four countries between 2017 and 2019: findings from the international food policy study. *Int J Behav Nutr Phys Act*. 2022;19(1):38. doi:10.1186/S12966-022-01277-1
109. Fleming-Milici F, Phaneuf L, Harris JL. Marketing of sugar-sweetened children’s drinks and parents’ misperceptions about benefits for young children. *Matern Child Nutr*. 2022;18(3):e13338. doi:10.1111/MCN.13338
110. Kasman M, Hammond RA, Reader L, et al. Childhood Sugar-Sweetened Beverage Consumption: an Agent-Based Model of Context-Specific Reduction Efforts. *Am J Prev Med*. Published online July 13, 2023. doi:10.1016/J.AMEPRE.2023.07.004

111. Oddo VM, Krieger J, Knox M, et al. Perceptions of the possible health and economic impacts of Seattle's sugary beverage tax. *BMC Public Health*. 2019;19(1):910. doi:10.1186/s12889-019-7133-2
112. US Department of Health and Human Services. 2017 Poverty Guidelines. Federal Register. Published 2017. Accessed November 3, 2023. <https://aspe.hhs.gov/topics/poverty-economic-mobility/poverty-guidelines/prior-hhs-poverty-guidelines-federal-register-references/2017-poverty-guidelines>
113. Martin C, Clemens J, Moshfegh A. *Beverage Choices among Children: What We Eat in America, NHANES 2017-2018*.; 2020. Accessed June 11, 2021. https://www.ars.usda.gov/ARSUserFiles/80400530/pdf/DBrief/32_Beverage_children_1718.pdf
114. Russo RG, Northridge ME, Wu B, Yi SS. Characterizing Sugar-Sweetened Beverage Consumption for US Children and Adolescents by Race/Ethnicity. *J Racial Ethn Health Disparities*. 2020;7(6):1100-1116. doi:10.1007/s40615-020-00733-7
115. Knox MA, Oddo VM, Walkinshaw LP, Jones-Smith J. Is the public sweet on sugary beverages? Social desirability bias and sweetened beverage taxes. *Econ Hum Biol*. 2020;38:100886. doi:10.1016/j.ehb.2020.100886
116. Azur MJ, Stuart EA, Frangakis C, Leaf PJ. Multiple imputation by chained equations: what is it and how does it work? *Int J Methods Psychiatr Res*. 2011;20(1):40. doi:10.1002/MPR.329
117. Stuart EA, Huskamp HA, Duckworth K, et al. Using propensity scores in difference-in-differences models to estimate the effects of a policy change. *Health Serv Outcomes Res Methodol*. 2014;14(4):166-182. doi:10.1007/S10742-014-0123-Z
118. Linden A. Improving causal inference with a doubly robust estimator that combines propensity score stratification and weighting. *J Eval Clin Pract*. 2017;23(4):697-702. doi:10.1111/jep.12714
119. Lowery CM, Wen S, Lindsey N, et al. Sugar, substitution, and perceived beverage healthfulness: Insights from the Philadelphia and San Francisco beverage taxes. Published online 2023.
120. Falbe J, Adler SS, Roberto CA. Sugar-Sweetened Beverage Tax Preemption and the Urgency of Unified Mobilization. *Am J Public Health*. 2021;111(4):546-548. doi:10.2105/AJPH.2021.306163
121. Powell LM, Chiqui JF, Khan T, Wada R, Chaloupka FJ. Assessing the potential effectiveness of food and beverage taxes and subsidies for improving public health: a systematic review of prices, demand and body weight outcomes. *Obes Rev*. 2013;14(2):110-128. doi:10.1111/OBR.12002

Appendix 1.1 Qualitative Interview Guide for Cohort Participants

Thank you for talking with me today. I'm going to take us through several questions about sweetened drinks that you, your family, and your friends may typically drink.

Since you previously participated in the SeaSAW study that asked about sweetened drinks over time, we are also interested in understanding more about the survey responses that we received during the study between the years 2017 and 2019.

The questions I will ask you are open-ended, and I invite you to share as many details as you would like throughout our conversation. My goal is to understand your experiences, perspectives, and day-to-day decisions about buying and drinking sweetened drinks.

Building rapport

1. To start off, just to get us thinking about different types of drinks and those that you drink, can you describe for me your most favorite drink? It does not have to be sweetened or something that you typically drink.
 - What makes this drink your favorite?
 - How and when do you typically drink this drink?

Current sweetened drink intake

2. Now I am going to ask about sweetened drinks, in particular. I want to take a moment to explain what I mean by “sweetened drinks.” These include regular soft drinks, soda or pop (such as [pick one] Coke, Pepsi, Orange Soda, and Jarritos), fruit-flavored drinks (such as [pick one] lemonade, Sunny Delight, and Hawaiian Punch), sports drinks (such as [pick one] Gatorade and Powerade), sweetened teas or coffees (such as [pick one] Arizona Iced Tea, Snapple, Starbucks Frappuccino, mochas, or bubble teas), and energy drinks (such as [pick one] Red Bull and Rockstar). Sweetened drinks do NOT include milk, 100% fruit juice, diet drinks, or artificially sweetened drinks.

Do you have any questions about what I mean by sweetened drinks?

Can you describe for me all of the kinds of sweetened drinks you typically drink?

- *In a typical day, or a typical week?*

[If necessary, paraphrase, reflect back. E.g., “Okay, so it sounds like you typically have X once a day in the morning and sometimes you drink Y a couple times a week...”]

[For each drink type mentioned, cover the following details as applicable. Repeat with each drink type]

For [X drink]...

- How often would you say you drink this drink?
- How much do you usually drink?
- Why do you choose to drink this drink? *What are your top reasons you choose this drink?*
- Where do you typically buy this drink?
 - *Can you describe the store(s)? E.g., store type, in your neighborhood, close to your neighborhood?*
 - *What makes you decide to get the drink from this place instead of others?*

3. [If not previously mentioned in above responses] Some people add their own sweeteners to drinks, like adding sugar to coffee or tea [or making horchata at home]. Do you typically add sweeteners to any of your drinks?

YES → Can you tell me more about what you drink and what you add to sweeten it?

[For each drink mentioned, cover the following details as applicable]

- How often would you say you drink this drink?
- How much do you usually drink?
- Why do you choose to drink this drink?
- Where do you typically prepare and drink this drink? (Could also ask where you buy, if applicable)

NO → [proceed]

Contextual factors: home/work location, peer and child intake, media messaging

4. Next, I'd like to get a better understanding of where you live and work, since this can sometimes influence where someone grocery shops and buys sweetened drinks.

What is the name of the neighborhood where you currently live? How long have you lived in this neighborhood?

[If less than 4 years] In what neighborhood did you live previously? *What neighborhood were you living in when you participated in the SeaSAW study?*

Do you work outside your home?

YES → In which neighborhood or city do you work?

- Do you typically buy or drink sweetened drinks as part of your workday or commute? *What does that look like for you? Can you tell me more about that?*
- How long have you worked in that area?

[If less than 4 years] In what neighborhood or city did you work before the place where you work now? *What neighborhood or city were you working in when you participated in the SeaSAW study?*

- Did you typically buy or drink sweetened drinks as part of your work day or commute? *Can you tell me more about that?*

NO → [proceed]

5. Thinking about your current sweetened drink habits you shared earlier, in general, how do you think your intake of sweetened drinks compares to other people in your city? *More than, less than, about the same?*

How do you think it compares to your friends and family? *More than, less than, about the same?*

6. Now I am interested specifically in the drinks that your child or your children drink. You were eligible for this interview because you have at least one child. Can you please tell me how many children you have at home and how old they are?
7. What kinds of sweetened drinks does your child/do you children typically drink? *It can be hard to know exactly what they drink, especially if they are older and in school. Please give me your best guess!*

[For each drink mentioned, cover the following details as applicable]

- In a typical day, in a typical week?
- How often would you say they drink these drinks?
- How much or what size drink do they usually drink?
- What do you think are the top reasons they drink these drinks?
- Where do you think they usually get or buy these drinks?

8. Next, I am interested in what information you notice and hear about sweetened drinks.

What sorts of things have you heard, seen, or read in the news or on social media about sweetened drinks?

- *What radio stations, TV channels, or news stations do you remember sharing this information? Were these national or local?*
- *On what social media sites?*
- *Do you remember around what year or time period you noticed this information?*
- *Is there anywhere else that you've heard or seen information about sweetened drinks?*

How has this information affected your decision making around drinking sweetened drinks?

How has it affected your decision making around serving sweetened drinks to your child/children?

Past sweetened drink intake and serving to children

9. Now, I'm going to ask about what you liked to drink several years ago. Think back over the last five years, going back to the year 2017. I realize that's a long time!

So, this would be around the time you signed up for the SeaSAW cohort and completed the first survey. You may remember meeting us at a community event or health clinic, or you may have completed the survey online after getting a text message, letter, or online ad from us about the study.

- To help you think back to this time period, it can also be useful to try to imagine what your day-to-day life was like. For example, how old [was your child/were your children] in 2017 and what activities were they were doing? Remembering family events, like weddings, could also be helpful.
- *It may also help to think about national events that happened then. For example, 2017 was the first year of Donald Trump's presidency. In the 2017 Super Bowl, the New England Patriots beat the Atlanta Falcons.*

So, thinking of life five years ago, what sweetened drinks would you say you chose to typically drink then?

[If necessary, paraphrase, reflect back]

[For each drink type mentioned, cover the following details as applicable]

For [X drink]...

- How often would you say you drank this? *Per day, per week?*
- How much did you usually drink?
- Why did you choose to drink this drink? *What are your top reasons you choose this drink?*
- Where did you typically buy this drink?
 - *Can you describe the store(s)? Type of store, in your neighborhood or close to your neighborhood?*
 - *What made you decide to get the drink from this place instead of others?*

10. Now, I have a few questions about a specific time frame during the SeaSAW study that you participated in. We asked you about what sweetened drinks you typically drink at each survey in 2017, 2018, and 2019. From the beginning of the study to 1 year later, so from 2017 to 2018, your survey responses indicated that you [**decreased** / **increased** / **did not change**] the amount of sweetened drinks that you drink.

[If increased or decreased] What do you think are the top reasons you changed what you drink during this time frame?

[If about the same] Can you think of times when you wanted to change what you typically drink but did not during this time frame?

- *What were your reasons for wanting to change?*
- *What were the reasons why you did not change?*

Now I have similar questions about your survey responses at the 2-year survey. From the beginning of the study to 2 years later, so from 2017 to 2019, your survey responses indicated that you [**decreased** / **increased** / **did not change**] the amount of sweetened drinks that you drink.

[If increased or decreased] What do you think are the top reasons you changed what you drink during this time frame?

[If about the same] Can you think of times when you wanted to change what you typically drink but did not during this time frame?

- *What were your reasons for wanting to change?*
- *What were the reasons why you did not change?*

11. Thinking back, again, over the last five years from 2017 until now, can you describe any change you have made to the drinks you buy or serve to your [child/children]?

[If changes]

- *What drinks did you used to serve?*
- What were the top reasons for this change?

[If no changes]

- Can you think of times when you wanted to change what you typically serve them but did not? *What were your reasons for wanting to change? What were the reasons why you did not change?*

Tax awareness and impacts

12. In the year 2018, about four and a half years ago, a tax was added to sweetened drinks in Seattle. Do you know about this tax?

YES → What sorts of things have you heard about it?

- Do you remember when you first heard about the tax? Around what time frame was this?
- What do you remember hearing about it at that time?
- Can you describe where you heard this information? For example, the local newspaper, social media, or community organizations.

NO → May I tell you a bit about it?

YES → In January 2018, the City of Seattle added a tax of 1.75 cents per ounce on sweetened drinks – so, for example, an extra 35 cents on a 20oz bottle of soda. Since the tax, most businesses have raised prices for sweetened drinks in Seattle. The purpose of the tax is to raise money to help give more people access to healthy food, expand childhood education, and help high school graduates enter college.

NO → Okay, I'll move on to the next question.

13. Do you think the tax has affected your decisions to buy or drink sweetened drinks?
Why/why not?

Do you think the tax has affected your decisions to serve sweetened drinks to your child/children? *Why/why not?*

14. Thinking about other people you know in your community or city, do you think the tax has affected what they drink? *Why/why not?*

Cohort study experience

15. Finally, I am wondering about your experience with the SeaSAW cohort study. Do you recall participating in this cohort study?
- If you could think back to the cohort survey visits, after completing the surveys, did you think anything differently about the sweetened drinks you typically drink?
 - Did this have any impact on what you drink?
 - Did this have an impact on what your child drinks/children drink?

Wrap up and close out

16. To wrap up, are there other things you think about when deciding to buy or drink sweetened drinks that we have not covered today?

Great, those are all the questions I have. Thank you for taking the time to share your perspectives and experiences with me. Do you have any additional comments or questions for me before we end our interview?

Appendix 1.2 Qualitative Coding Framework and Protocol

Coding framework and protocol for thematic analysis of interview transcripts with parents living in Seattle and South King County, Washington, who participated in the Seattle Shopping and Wellness cohort study.

SEM Level	Code	Definition	Examples / Characteristics	Rules/Reminders
Determinants of and reasons for sweetened beverage consumption (SSB)				
Micro-level: Intrapersonal and Family	1. Bev-preferences	Taste or preferences for SSBs that the participant articulates as a reason for their SSB consumption. Include aspects of habit, tradition, culture, and special occasions here.	Include if it is a reason why someone chooses to drink SSBs or the reasons why they made changes or did not make changes to their SSBs intake.	Does not include basic mentioning of the types of beverages. Does not include non-SSBs that are mentioned as a favorite drink, except for those mentioned as a replacement for SSBs or if they are frequently consumed.
	2. Bev-perceived-healthfulness	Statements about perceived healthfulness of SSBs and perceived appropriate levels of consumption as it relates to their behavior. Focus on concepts involving learning about health harms of SSBs, becoming more aware.	Aiming to capture evidence of signaling effects of the tax such as increased awareness of health harms of SSBs.	Include attitudes about health risks of SSBs and one's awareness of their current or past intake.
	3. Health-status/goals	Mentions of a health condition or health-related goals as drivers of their SSB consumption. Include statements about one's motivation and/or ability to make intended changes to SSB intake.	Examples: learning of a diagnosed health condition, mentioning the health status of their children as a motivator.	

		<p>Purpose: to understand how health-related reasons for SSB intake differed between study groups and may serve as a moderator to tax effects.</p>		
Interpersonal	4. Social-norms-acceptability	<p>Perceived family-, peer- or community-level norms around SSB consumption, including values and attitudes about consuming SSBs and acceptable amounts. May or may not have an influence on one's SSB consumption and one's purchasing decisions for their child.</p> <p>Purpose: Understand potential pathways from exposure to the tax or media/information and changes to SSB intake; social norms may moderate this pathway; may indicate signaling effects of the tax.</p>	When the participant is talking about what and how much other people drink and why. E.g., responses to the questions about how their consumption compares to others in their city and family/friends.	Do not code the tax influence responses as social norms.
Settings and food environment	5. Bev-sourcing/access	Places where the participant purchases or accesses SSBs and the reasons for accessing SSBs at these places. Include child's SSB access. Include preparing SSBs at home.	Places such as grocery stores, restaurants, school. Reasons such as convenience (same location where all groceries are purchased), having a preferred beverage in stock, and close to one's home.	<p>If specifically related to work or commuting), overlap with Work/commute.</p> <p>Overlap with Bev-affordability if beverage costs are a determinant of their SSB purchasing at these sources.</p>

	a. Cross-border-shopping	A subcode of Bev-sourcing/access. This code captures shopping decisions to avoid the tax by shopping outside of Seattle for SSB. Also captures the reverse, where a non-Seattle resident is unable to avoid the tax by working, shopping in Seattle and says they reduce purchasing because of it.		Only code if the action of tax avoidance (or reduced purchasing as result of non-avoidance) is mentioned directly. Overlap with Bev-sourcing/access when applicable.
Settings and food environment	b. Work/commute	A subcode of Bev-sourcing/access. Whether the participant works outside the home and shops for SSBs in this context, including the commute. Purpose: The place of work may alter one's SSB tax exposure and response to it.	Code responses to the specific questions about purchasing beverages in the context of their work and/or other routine commutes.	Always overlap with bev-sourcing/access. Code here even if they do not work or they work at home.
	6. Bev-affordability	Mentions of absolute and relative costs of SSBs as a determinant of the participant's SSB purchasing and consumption.	Making shopping decisions to find cheaper items, SSB cost changes over time, increased personal resources that make food/beverages more affordable	Overlap with Bev-sourcing/access if beverage costs are a determinant of their SSB purchasing.
	7. Cohort-effects	Whether the participant believes their cohort participation made them think differently about what they drink/buy and whether it ultimately influenced what they drink/buy	Code responses to the specific questions about the cohort and elsewhere if the participant raises the topic	Code the response to all cohort effect questions as one excerpt. Do not overlap this excerpt with Cohort-period or Child codes. Avoid overlapping with other determinant codes.

				Peer participants: Code responses to questions about the cohort participant who referred them.
Macrolevel (city- and county-level policies, media)	8. Bev-information	The information seen, heard, read about SSBs and how that information did or did not influence their SSB decisions. Include sources of the information, including from their community.	News media, online, community/friends, doctor, etc. Include when the participant remembers hearing it and how the info has changed over time. Include nutrition information such as nutrition labels.	Code the whole response to the information questions as one excerpt. Do not overlap with Child code. Limit overlapping with other determinant codes in most cases. Can overlap if there is a separate thought describing a different influence on one's SSB intake and it is not appropriate to create separate excerpts. Overlap with Tax-awareness/information only if the participant spontaneously brings up the tax (verbatim) in response to the question about hearing beverage information. Overlap with Pre-cohort or Cohort-period codes if the participant describes the timing in which they received the information.
	9. Tax-awareness/information	Whether the participant is aware of the SSB tax. When they became aware; What they have seen, heard, read about the SSB tax.	Include responses to the questions that specifically ask about the information they have received about the tax.	May overlap with codes above, but if the response reflects the content of the information the participant received, rather than their own experiences with the tax, then no need to overlap.

	10. Tax-influence	Whether the participant perceives the tax to have influenced their own SSB habits and/or others' SSB habits.	Code responses to the questions that ask specifically about this. Do not overlap with social-norms code for the responses to the tax influence question.	May overlap with other codes above to describe the way that the participant believes the tax has influenced them—e.g., higher prices, signaling a health risk.
Indicator codes (can be used on the same text coded with the above determinants of beverage consumption)				
	11. Intake	Use to capture responses about the participant's SSB intake or their children's SSB intake. Focus on quantifiable responses that often detail the beverage type, amount, frequency. If reporting none, code that response and the info about non-SSBs. Include responses about adding sweeteners at home.	Often accompanying the amount that they drink and types of beverages they drink. Include responses to what parents recall serving to their children in the pre-tax/beginning of the cohort period.	Can overlap with Child, Pre-cohort. Do not use when coding the determinants of the intake and/or change. Describe the determinants using the codes above instead. Do not include sources of the SSBs; code with Bev-sourcing/access instead
	12. Child	To indicate the excerpt relates to the determinants of or reasons for their child/children's SSB intake. Also use when capturing descriptions of the child's intake and what the participant serves to their child, overlapping with the Intake code.	Include responses to the questions that specifically what the parent serves or buys for their children and the influences of those decisions, including information received, taxes.	
	13. Cohort-period	Indicates that a determinant of SSB intake or a change in SSB intake occurred (or did not occur) during the cohort study period, 2017-2019. Overlap with determinant codes and other	Combine with Child to code answers to the question about changes to what parents served their children from 2017 to now, and the	Do not use with the Change 12mo and Change 24mo codes. Exclude determinants that clearly occurred after the study: 2020-2022

		indicator codes as needed. E.g., Child and Cohort study period would describe a factor of the child's SSB intake during the study period.	top reasons for these changes or no changes.	
	14. Pre-cohort	To indicate that the excerpt relates to determinants of SSB intake or a change to SSB intake or reasons for the participant's SSB intake, or the SSB intake itself, prior to the SeaSAW study and tax (prior to 2017). Can overlap with determinant codes and indicator codes as needed.	Combine with Child to code answers to the question about what parents served their children around 2017 or earlier.	
	15. Quote	Capture quotes that reflect larger themes and main ideas in the data		Not counted in the interrater agreement calculations
	16. Children-age	Code responses to the question about number of children and their ages		Not counted in the interrater agreement calculations
	17. Change-12mo	Code responses to the question about the top reasons for change or no change in the cohort study from baseline to 12 months		Do not overlap with Intake or Cohort-period. Code the response to the specific question. Overlap with determinant codes above as needed.
	18. Change-24mo	Code responses to the question about the top reasons for change or no change in the cohort study from baseline to 24 months		Do not overlap with Intake or Cohort-period. Code the response to the specific question. Overlap with determinant codes above as needed.

	19. Unclear: E	(English speakers) Request for clarification on what was said or meant.	Flag the excerpt to potentially bring back to interviewer or listen to audio.	Not counted in the interrater agreement calculations
	20. Unclear: Sp	(Spanish speakers) Request for clarification on what was said or meant.	Flag the excerpt to potentially bring back to interviewer or listen to audio.	Not counted in the interrater agreement calculations
	21. Unclear: So	(Somali speakers) Request for clarification on what was said or meant.	Flag the excerpt to potentially bring back to interviewer or listen to audio.	Not counted in the interrater agreement calculations