The Impact of Sugar Sweetened Beverages (SSBs) Taxes on Consumption and Health Outcomes in Latinx Youth Residing in Los Angeles County

Jacquelyn Campos-Araujo
The Impact of Sugar Sweetened Beverages (SSBs) Taxes on Consumption and Health
Outcomes in Latinx Youth Residing in Los Angeles County

A Thesis Presented

by

Jacquelyn Campos-Araujo

To the Keck Science Department
of
Claremont McKenna, Scripps, and Pitzer Colleges
In Partial Fulfillment of
The Degree of Bachelor of Arts

Senior Thesis in Human Biology

May 1, 2023
# TABLE OF CONTENTS

Abstract............................................................................................................................................2
Introduction......................................................................................................................................3
  Sugar Sweetened Beverages (SSBs)..............................................................................................3
  Added Sugar..................................................................................................................................4
  Health Impacts of SSBs................................................................................................................5
    Poor Diet.....................................................................................................................................6
    Weight Gain..............................................................................................................................7
    Obesity.....................................................................................................................................7
    Diabetes....................................................................................................................................8
    Dental Caries...........................................................................................................................9
  Reduction of Consumption of SSBs for Better Health...............................................................10
  Taxes on SSBs............................................................................................................................11
    Efficacy....................................................................................................................................11
    Limitations..............................................................................................................................12
  Population of Interest....................................................................................................................13
    Latinx Youth............................................................................................................................14
    Los Angeles County...................................................................................................................15
  Present Study.................................................................................................................................16
Methods..........................................................................................................................................18
  Participants and Recruitment........................................................................................................18
  Study Design................................................................................................................................19
    Phase 1......................................................................................................................................19
    Phase 2......................................................................................................................................21
    Phase 3......................................................................................................................................21
    Timeline...................................................................................................................................22
  Data Collection............................................................................................................................23
    SSB Survey Questions..............................................................................................................23
    Health Examination................................................................................................................23
  Data Analysis...............................................................................................................................24
Expected Results and Discussion....................................................................................................26
  Significance.................................................................................................................................28
  Future Direction..........................................................................................................................28
Acknowledgements........................................................................................................................30
References.........................................................................................................................................31
Abstract

This proposed research study aims to investigate whether the implementation of sugar-sweetened beverage (SSB) taxes will lead to reduced consumption and improved health outcomes in the Latinx youth population residing in Los Angeles County. The study will utilize a mixed-methods design, including a baseline survey and health examination, the implementation of SSB taxes, and a follow-up survey and health examination. The expected results suggest a statistically significant reduction in SSB consumption and improved glycemic control following the implementation of the SSB taxation intervention. However, I predict a slight decrease in the number of participants with dental caries, indicating that further research is needed to fully understand the intervention's impact on oral health outcomes. The insights provided by this study can guide future policy decisions aimed at promoting healthier dietary habits and reducing the incidence of diet-related diseases in vulnerable populations.
**Introduction**

**Sugar Sweetened Beverages (SSBs)**

Sugar-sweetened beverages (SSBs) or sugary drinks have been identified as one of the primary sources of added sugars in the American diet, according to the Centers for Disease Control and Prevention (CDC) in 2022. These drinks include soda, fruit drinks, sports drinks, energy drinks, and sweetened tea or coffee. Added sugars are those that are not naturally occurring in foods but are added during processing or preparation. The World Health Organization (WHO) reported in 2015 that sugary drinks were a notable source of added sugars in the diets of children and adolescents, and their consumption was escalating in most countries. In some countries, the intake of sugary drinks among children and adolescents has reached alarming levels. For instance, a report from the CDC revealed that half of American children under 5 years old do not eat a single vegetable daily, and one-third do not eat a single daily fruit. However, an alarming 60% consume sugary drinks (Hamner et al. 2023).

There exists a range of motives behind the consumption of SSBs. One such reason pertains to the convenience factor, whereby some individuals opt for SSBs due to the convenience of availability and ease of accessibility (Falbe et al. 2016). Some experience strong cravings (DiNicolantonio et al. 2018) or use SSBs as a means of coping with stress (Gibson 2012). Finally, it is worth noting that SSBs are designed to be hyperpalatable, thereby rendering them highly enjoyable and pleasurable to consume (Moss 2014). The highly palatable nature of SSBs, combined with the aforementioned drivers, may contribute to their widespread consumption, particularly among children and adolescents who may be more vulnerable to the effects of sugar on health outcomes.
The consumption of SSBs has been linked to various health problems. As a public health concern, one potential solution that has garnered attention and demonstrated success in reducing SSBs consumption is the implementation of taxes. The aim of this proposed research study is to investigate whether the implementation of SSBs taxes will result in reduced consumption and improved health outcomes in the Latinx youth residing in Los Angeles County. In order to comprehend the importance of this proposed study, it is essential to consider the adverse health impacts associated with SSBs, as well as the efficacy and limitations of implementing taxes, and the reasoning for concentrating on Latinx youth. Through this study, we aim to generate evidence that could inform policies to improve the health of Latinx youth in Los Angeles County and other similar communities.

**Added Sugars**

According to the Dietary Guidelines for Americans 2020-2025, added sugars contribute to more than 13% of total calorie intake in the US population, which is equivalent to approximately 270 calories or 67.5 grams of added sugars per day on average. The guidelines recommend that individuals with a daily intake of 2,000 calories limit their added sugar intake to less than 7% of their total calories, which is about 35 grams of added sugar per day (Dietary guidelines for Americans, 2020-2025). For those requiring 3,000 calories per day, their added sugar intake should be limited to 75 grams per day. It is estimated that SSBs contribute to 24% of an individual's total consumption of added sugars (Dietary guidelines for Americans, 2020-2025). SSBs include various forms of added sugars, such as brown sugar, corn sweetener, corn syrup, dextrose, fructose, glucose, high-fructose corn syrup, honey, lactose, malt syrup, maltose, molasses, raw sugar, and sucrose (sugar) (2015-2020 Dietary Guidelines). Many SSBs
contain enough added sugar to reach the maximum recommended daily value with just one serving (Table 1).

Table 1. Shown are the grams of added sugar, the percentage of the maximum daily value, and types of sugars in one serving (12 oz) of different sugar-sweetened beverages.

<table>
<thead>
<tr>
<th>Brand</th>
<th>Added Sugar (grams)</th>
<th>% Daily Value (DV)</th>
<th>Types of Sugars</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coca Cola Original</td>
<td>39</td>
<td>78</td>
<td>high-fructose corn syrup</td>
</tr>
<tr>
<td>Red Bull Energy Drink</td>
<td>37</td>
<td>74</td>
<td>sucrose, glucose</td>
</tr>
<tr>
<td>Monster Original Energy Drink</td>
<td>41</td>
<td>81</td>
<td>sucrose, glucose</td>
</tr>
<tr>
<td>Gatorade Lemon-Lime Thirst Quencher</td>
<td>21</td>
<td>41</td>
<td>sucrose</td>
</tr>
<tr>
<td>Arizona Green Tea With Ginseng and Honey</td>
<td>24</td>
<td>48</td>
<td>high-fructose corn syrup, honey</td>
</tr>
<tr>
<td>Sunny D Berry Juice</td>
<td>41</td>
<td>82</td>
<td>high-fructose corn syrup</td>
</tr>
</tbody>
</table>

*The % Daily Value (DV) tells you how much nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice (Using the nutrition facts label in the CACFP).

*Information retrieved from (Coca-cola® original), (Foodsco.net), (Kroger.com), (Pepsicoproductfacts.com), (Sunny D berry juice - 12 oz, nutrition information).

**Health Impacts of SSBs**

The high consumption of sugary drinks among children and adolescents is a major public health concern, as it has been associated with a myriad of detrimental health outcomes. The WHO has emphasized the alarming consequences of excessive sugary drinks intake on overall health (Fiscal policies for diet and the prevention of noncommunicable diseases 2016 Sep 21). Research has linked the consumption of SSBs to nutritionally inadequate diets, weight gain,
obesity, type 2 diabetes, and dental caries (CDC 2022 Apr 11). Although the exact behavioral and biological processes that link SSB consumption to negative health effects are still under investigation, some mechanisms have been firmly established by research (Malik and Hu 2022). For instance, there is strong evidence supporting the association between consuming sugary beverages and weight gain (Malik et al. 2006). While further research seeks to uncover the underlying mechanisms, current studies offer valuable perspectives on these connections. We will delve into potential pathways through which SSBs can contribute to adverse health outcomes in more detail.

Poor Diets

Regular consumption of sugary drinks can lead to excessive intake of added sugars, empty calories, and nutrient deficiencies, ultimately resulting in a poor diet. A single can of sugar-sweetened soda provides about 150 calories, almost all of which come from added sugar (Sugary drinks 2013 Sep 4). Consuming even one sugary drink per day can add hundreds of extra calories to one's diet. Furthermore, SSBs offer little to no essential nutrients, making them a source of empty calories that do not provide significant nutritional value (Todd and Ver Ploeg 2015). A study conducted on children and adolescents in the United States found that soda and fruit drinks, both sugar-sweetened beverages, were the primary sources of added sugars in the diet of almost all age and demographic groups (Reedy and Krebs-Smith 2010). Additionally, the consumption of added sugars from these beverages increased with age, ranging from 60 kcal/day for 2- to 3-year-olds to 260 kcal/day for 14- to 18-year-olds. The results of this study emphasize the significance of promoting healthy dietary habits, especially among children and adolescents. The consumption of added sugars, especially through sugar-sweetened beverages, significantly contributes to unhealthy dietary habits. Therefore, promoting a balanced diet that provides
sufficient energy and essential nutrients while limiting the intake of added sugars is crucial to prevent potential health consequences.

Weight Gain

In addition to the negative impact on overall diet, the consumption of SSBs has also been linked to weight gain, which can have significant health consequences. Several studies have explored the potential relationship between sugary drink consumption and weight gain, and they consistently reveal that an increased intake of these beverages leads to a rise in caloric intake, leading to weight gain over time (The Nutrition Source, 2023). One explanation is the poor satiating properties of sugar in liquid form (Brownell et al. 2009). SSBs do not provide the same level of satiety as solid foods, causing individuals to consume more calories than they need. This can lead to overconsumption of calories and, consequently, weight gain. Numerous studies have shown a significant association between sugary drink consumption and weight gain. In adults, a 20-year study on 120,000 individuals revealed that those who increased their daily intake of sugary drinks by one 12-ounce serving gained more weight over time, averaging an extra pound every 4 years, compared to those who did not change their intake (Mozaffarian et al. 2011).

Overconsumption of sugary drinks can lead to weight gain, which increases the risk of obesity (Obesity causes 2012 Oct 21).

Obesity

Frequent intake of sugary drinks is strongly linked to one of the most significant health issues - obesity, which can arise from various factors, including lifestyle choices and food environment (CDC 2022 Apr 11). However, SSBs pose a significant risk factor as they contribute to excessive calorie consumption, which ultimately leads to weight gain and obesity.
Of particular concern is the impact on children (age 11.7 years, SD 0.8), where research indicates that their likelihood of developing obesity within 18 months increases by 60% with each additional 12-ounce soda consumed daily (Ludwig et al. 2001). Consuming high-sugar or high-carbohydrate foods and drinks can promote hyperinsulinemia, which is a mechanism that contributes to weight gain and obesity (Malik and Hu 2019). This process involves the breakdown of glucose molecules, causing a surge in insulin production, which signals the body to store excess glucose as fat.

In addition, the consumption of SSBs can activate the dopaminergic reward system in the brain, which further contributes to weight gain and obesity (Malik and Hu 2019). When individuals consume sugary foods, the dopaminergic reward system is activated, leading to the release of dopamine and feelings of pleasure and reward. Over time, this can cause changes in the brain that increase the likelihood of seeking out and consuming these foods, leading to overeating and weight gain. Obesity is a significant health concern due to its association with an increased risk of various health problems such as cardiovascular diseases, some cancers, and type 2 diabetes mellitus (Malik and Hu 2022). Therefore, it is crucial to consider the role of SSBs in reducing the consumption of such drinks.

Diabetes

Consumption of sugary beverages, particularly SSBs, has been associated with an elevated risk of type 2 diabetes, a chronic condition that affects the body's ability to process sugar (Imamura et al. 2015). Type 2 diabetes is characterized by the body's inability to produce enough insulin or to use insulin effectively, leading to elevated levels of sugar in the blood (CDC 2023 Apr 25). The high sugar content and glycemic load of SSBs have been identified as
potential factors in the development of insulin resistance, which is a hallmark of type 2 diabetes, according to Ludwig (2002). When an individual drinks a sugary beverage, their blood sugar levels rise rapidly, prompting the body to release insulin to help move the sugar into cells for energy. However, chronic exposure to high levels of sugar and insulin can lead to insulin resistance over time, causing the body to become less responsive to the insulin it produces and resulting in a buildup of sugar in the bloodstream. Additionally, sugary beverages have a direct impact on pancreatic islet cells, which are responsible for producing insulin in the body.

Research suggests that the high glycemic load of SSBs can harm these cells, resulting in impaired insulin production and secretion (Ludwig 2002). An expanding body of evidence has established a link between the intake of sugary drinks and an elevated risk of type 2 diabetes, a condition that impacts millions of individuals globally. It is imperative to take this into account, as type 2 diabetes can result in a variety of severe health complications, such as heart disease, stroke, kidney disease, and nerve damage.

Dental Caries

In addition to their negative impact on overall health, SSBs can also have adverse effects on oral health. A primary concern is their large quantities of sugar and are highly acidic, which can contribute to the development of dental caries, also known as tooth decay and cavities (Tahmassebi et al. 2006). This common oral health issue occurs when bacteria in the mouth metabolize sugars from food and drinks to produce acid (Oral health 2022 Aug 19). As a result, this acid then attacks the hard tissues of the teeth, causing demineralization and ultimately resulting in cavities. SSBs are a leading source of free sugars, which are a crucial dietary factor in dental caries development (Touger-Decker and van Loveren 2003). Additionally, dental caries risks accumulate over time from childhood to adulthood due to lifelong exposure to free sugars.
(Broadbent et al. 2008). Thus, even reducing the risk of dental caries in childhood can significantly minimize the lifelong risk of this issue (Touger-Decker and van Loveren 2003). Thus, it is essential to reduce free sugar intake starting at a young age, which includes minimizing SSBs consumption, to maintain good oral health.

Reducing the Consumption of SSBs for Better Health

Reducing SSBs consumption is crucial to prevent the negative health impacts discussed above, which can have long-term consequences, including an increased risk of chronic diseases. Reducing the consumption of SSBs can have a notable impact on public health. The scientific, medical, and public health communities are in firm agreement regarding the harmful impact of SSBs on weight gain, heart disease, type 2 diabetes mellitus, and other host of health conditions (Johnson 2016). The urgency for nations to take action to reduce consumption, as emphasized by the World Health Organization, highlights the need for immediate action. (WHO urges global action to curtail consumption and health impacts of sugary drinks). Thus, the reduction of SSB consumption on a larger scale is crucial, emphasizing the need for effective interventions to accomplish this objective. While individual efforts are important, larger-scale interventions are necessary to address the high consumption rates of SSBs, particularly among vulnerable populations. These interventions may include policy changes such as implementing taxes on sugary drinks to discourage their consumption. Taxation can also reduce the availability of SSBs in certain environments, such as schools and public places. Overall, reducing SSBs consumption is a critical step towards promoting healthier dietary habits and preventing negative health outcomes associated with high sugar intake.
Taxes on SSBs

To address the issue of excessive consumption of SSBs and their negative impact on health, one approach is to use taxes on these beverages. This strategy involves increasing the price of SSBs to make them less affordable and ultimately decrease their consumption. This strategy is based on the premise that when prices are raised, individuals may be more inclined to seek out healthier alternatives or reduce their consumption altogether. By discouraging people from consuming SSBs, which are known to contain high amounts of added sugars and empty calories, this strategy aims to improve overall diet quality. The Institute of Medicine recommended tax measures for "energy-dense, nutrient-poor foods," with an emphasis on SSBs, as early as 2009 (Committee on Childhood Obesity Prevention Actions for Local Governments et al. 2009). Nevertheless, it was only in 2014 that Berkeley, California, became the first city to introduce a $0.01/ounce SSB excise tax (Falbe et al., 2020). Although large SSB taxes have not been widely adopted in the United States, many countries and cities across the globe have imposed SSB taxes. In 2022, the World Health Organization (WHO) published its first comprehensive global tax manual for SSBs, highlighting the need for such guidelines as over 85 countries have already implemented some form of SSB taxation. As an increasing number of countries act, studies are underway to evaluate the effectiveness of SSB taxes in reducing consumption and improving public health.

Efficacy

High-quality studies from Mexico, UK, and South Africa demonstrate the effectiveness of taxes in reducing the consumption of sugar-sweetened beverages (SSBs) and encouraging the reformulation of products to reduce sugar levels (Countries that have implemented taxes on
sugar-sweetened beverages (SSBs)). For example, Mexico implemented a volumetric tax of 1 peso per liter on SSBs in 2014, leading to a 37% reduction in the total volume of SSBs purchased by 2016 compared to the year before the tax (Pedraza et al. 2019). Likewise, the UK's Soft Drinks Industry Levy (SDIL), which was introduced in April 2018, resulted in a 43.7% decrease in sugar content for drinks subject to the tax by the fourth year of implementation (Sugar reduction: progress report, 2015 to 2019, 2020 Oct 7). Studies evaluating the impact of SSB taxes indicate that they have a substantial effect on reducing consumption, particularly among price-sensitive groups such as young people and low-income individuals (Colchero et al. 2017). For instance, in Berkeley, California, SSB purchases in supermarkets decreased by 10% within one year of implementing the tax (Silver et al. 2017). The reduction in SSB consumption was particularly pronounced in lower-income neighborhoods (Falbe et al. 2016), indicating that SSB taxes can effectively reduce consumption among vulnerable populations at a higher risk of overconsumption and associated health consequences. Overall, implementing taxes has been shown to be an effective strategy for addressing excessive consumption of SSBs.

Limitations

While SSB taxes have shown promising results in reducing consumption and improving public health, their implementation is not without challenges. The most significant obstacle is the opposition from the beverage industry, which can hinder the implementation and enforcement of effective SSB tax policies (Fooks et al. 2019). Policymakers also face the challenge of navigating the complex process of transposing SSB taxes into administrative regulations, implementing them, monitoring their effects, and enforcing compliance. This process can be time-consuming and resource-intensive, leading to potential bureaucratic coordination challenges. Moreover, the political and public acceptability of SSB taxes is influenced by various factors, such as beliefs
about their effectiveness and cost-effectiveness, the appropriateness of such taxes, the economic and socioeconomic benefits of tax revenue, and public mistrust of the beverage industry, government, and public health experts (Eykelenboom et al. 2019). Effective communication and engagement with stakeholders are essential to ensure the successful implementation of SSB taxes. Despite these challenges, SSB taxes have led to substantial reductions in consumption and reformulation of products in some countries, indicating potential positive health outcomes. Ongoing evaluation and exploration of their effectiveness on reduction and health impacts are crucial, particularly among vulnerable populations who are at higher risk of health problems (CDC 2023 Jan 10).

**Population of Interest**

Certain demographics are more prone to consuming unhealthy foods and beverages, including children and adolescents who are still developing their eating habits and are easily influenced by advertising and peer pressure (Naderer 2021). Additionally, low-income individuals may face greater vulnerability due to limited access to nutritious food options and reliance on cost-effective, calorie-dense foods (Rose 2010). Regarding SSBs, high levels of consumption persist among low-income individuals and racial and ethnic minorities (Bleich and Vercammen 2018). Therefore, interventions targeting these populations should be a priority. The WHO reports that those with low incomes, young people, and frequent consumers of unhealthy foods and beverages are most receptive to changes aimed at reducing SSB consumption (Fiscal policies for diet and the prevention of noncommunicable diseases 2016 Sep 21). Implementing policies such as SSB taxes can greatly reduce consumption of unhealthy beverages and improve overall health outcomes for these groups. Despite numerous studies examining the effectiveness of SSB taxes across different countries and regions, there remains a lack of research that
examines the specific health outcomes associated with these taxes before and after their implementation. Furthermore, additional research is needed to better understand how SSB taxes impact different population subgroups, such as those defined by socioeconomic status and race/ethnicity, and the implications for potential disproportionate effects on these populations. This is especially important when it comes to Latinx youth, who are at higher risk of consuming SSBs and experiencing related negative health outcomes.

Latinx Youth

Latinx youth, referring to young people who identify as Latinx or have Latin American ancestry, are at a higher risk of consuming sugary drinks and experiencing negative health outcomes due to excess sugar intake. Studies have found that Latinx children and adolescents consume more daily calories from SSBs than their non-Hispanic white counterparts (Bleich and Vercammen 2018). This trend is influenced by a complex mix of individual, family, community, and cultural factors that have been established since childhood (Cuy Castellanos and Miller 2020). Moreover, about half of Latinx parents set no rules about SSB consumption at home, and among those with rules, most parent-child pairs differ on their beliefs about the content of the rules, and youth report few consequences for breaking them (Bogart et al., 2013). These factors contribute to the higher prevalence of obesity, type 2 diabetes, and related health conditions among Latinx youth compared to their non-Latinx peers (Cuy Castellanos et al. 2022). Given the high rates of SSB consumption and related negative health outcomes among Latinx youth, it is important to develop targeted public health interventions, such as SSB taxes, to reduce SSB consumption in this vulnerable population. However, there is a lack of research on the effectiveness of SSB taxes on Latinx youth specifically, making it crucial to further investigate the impact of these policies on this group. By investigating the impact of SSB taxes on Latinx
youth, this study can shed light on the effectiveness of such policies for this population and contribute to the development of targeted public health interventions. Of specific interest are the Latinx youth residing in Los Angeles County.

Los Angeles County

In 2022, the Los Angeles County Department of Public Health published a report on the consumption of SSBs among children and adolescents in the area. The report used data spanning from 2007 to 2018 and revealed the ongoing health disparities among children and adolescents in Los Angeles County. The report indicated that in 2018, roughly one in three children aged 17 years and younger consumed at least one SSB on an average day. In particular, Black and Latino children have continued to consume SSBs at roughly twice the rate of White and Asian children over the past decade (SUGAR-SWEETENED BEVERAGE CONSUMPTION among children and adolescents in Los Angeles County 2022). The findings also revealed significant regional disparities in child SSB consumption across Los Angeles County. The West Service Planning Area (SPA), which includes communities such as Santa Monica, Beverly Hills, and Malibu, had the lowest SSB consumption rates in 2018 (16.7%), while the South SPA, which encompasses neighborhoods such as Crenshaw, Lynwood, and Compton, had the highest (51.6%) (SUGAR-SWEETENED BEVERAGE CONSUMPTION among children and adolescents in Los Angeles County 2022). Finally, the report showed that among households living below 100% of the federal poverty level (FPL), 47% of children consumed one or more SSB per day, compared to 22% of children living in households at or above 300% FPL. These findings highlight the critical need to address health inequities and the impact of SSB consumption on vulnerable populations in Los Angeles County.
Present Study

Based on existing literature, it is widely recognized that the consumption of SSBs can have detrimental effects on an individual's health. In particular, the regular consumption of SSBs can lead to nutritionally inadequate diets, weight gain, obesity, type 2 diabetes, and dental caries. One effective solution for addressing these health issues is to implement SSB taxes, which aim to increase the price of SSBs and decrease their affordability and attractiveness to consumers. Despite the effectiveness of SSB taxes in reducing consumption, the long-term health effects of such taxes remain uncertain. There is limited research on the effects of SSB taxes on health outcomes before and after their implementation, and the existing studies do not specifically focus on a particular group of individuals, particularly those who are most affected. Therefore, this proposed research study aims to investigate whether the implementation of SSBs taxes will lead to reduced consumption and improved health outcomes in the Latinx youth population residing in Los Angeles County. The Latinx youth population is a crucial group to examine since they are disproportionately impacted by the adverse health outcomes associated with consuming SSBs. Los Angeles County is an ideal location to conduct this study, as it has a large Latinx population and has not yet implemented SSBs taxes. This community is known to have a higher prevalence of SSBs consumption and related health problems, making it an optimal population to investigate the impact of SSBs taxes on health outcomes.

To obtain a comprehensive understanding of the impact of SSBs taxes on the Latinx community in Los Angeles County, this study will utilize a mixed-methods design that incorporates both quantitative and qualitative data collection methods. The study will be conducted in three phases: a baseline survey and health examination, the implementation of SSBs taxes, and a follow-up survey and health examination. The study will use dental caries and
A1c levels as health measures to evaluate the impact of SSB taxes on health outcomes. As previously mentioned, the high sugar content of sugary beverages has been shown to have a negative impact on oral health, which is significant and at risk, but has not been sufficiently studied in the context of SSB taxes. A1c is a simple blood test that measures an individual's average blood sugar levels over the past three months and can be easily administered. Higher A1c levels indicate poorer blood sugar control and an increased risk of diabetes complications. Statistical techniques will be utilized to analyze the data and evaluate the impact of SSBs taxes on these outcomes.

Specifically, this study aims to answer the following research questions: How effective are SSB taxes in reducing SSB consumption among the targeted population? What is the effect of introducing a SSB tax on health outcomes? I predict that the implementation of a SSB tax will lead to a decrease in both the incidence of dental caries, as well as sustained normalization of A1c levels in the targeted population. By addressing these research questions and predictions, this study aims to provide valuable insights into the effectiveness of SSBs taxes in reducing consumption and improving health outcomes for Latinx youth in Los Angeles County. This information can be used to guide future policy decisions aimed at promoting healthier dietary habits and reducing the incidence of diet-related diseases in vulnerable populations.
Methods

Participants and Recruitment

Eligibility criteria for the study will be limited to individuals between the ages of 11 and 18 who self-identify as Latinx. Given that the target population for this study is young adolescents, it is crucial to obtain consent from their legal guardians before recruiting them. To effectively recruit participants, the research team plans to reach out to potential candidates in various settings, including schools, homes, parks, and community centers, where young adolescents frequently gather. When potential participants express interest in joining the study, the research team will provide a detailed explanation of the study's purpose and procedures. This will help ensure that the participant understands the goals, potential risks and benefits, and the extent of their involvement in the study. The research team will also emphasize the voluntary nature of participation, and the participant's right to withdraw from the study at any time. Since the target population primarily consists of English and Spanish speakers, information will be available in both languages, with a specific focus on ensuring parents comprehend the details.

To ensure long-term commitment from participants, the research team will set up data collection days in various locations across Los Angeles County. These locations will be chosen based on their familiarity and accessibility to the targeted population and may include community centers, health clinics, or educational facilities. Participants who can participate will have the opportunity to complete both the survey and health screening in one convenient location and in a reasonable amount of time. Additionally, participants will receive compensation for their time and effort. To encourage participants to return for the second portion of the study, after the implementation of the tax policy, the research team will emphasize the importance of their
contribution to the study. Participants will be informed that they will be compensated for their time, and their contribution will be crucial in advancing the understanding of the effects of the tax policy on young adolescents' health behaviors.

Overall, the recruitment process will prioritize obtaining informed consent from legal guardians, ensuring that participants fully understand the study's purpose and procedures, and providing a convenient and incentivized environment for data collection.

**Study Design**

**Phase 1**

The first step of this study will involve conducting a baseline survey and health examination to collect data on the current patterns of SSB consumption and health status of participants prior to the implementation of an SSB tax. The survey will be designed to gather information on various aspects related to SSB consumption, such as the frequency, amount, and type of SSBs consumed, as well as the sources of SSBs and the factors that influence SSB consumption. The survey will also collect demographic data on the participants, including age, gender, income, and education level. This survey will serve as a situational analysis in line with the WHO manual on sugar-sweetened beverage taxation policies (2022), which involves collecting and analyzing information on health, social, demographic, economic, and political factors to gain a better understanding of the context for implementing an SSB tax. Conducting a comprehensive analysis can help to justify the need for the tax and identify potential opportunities and challenges in its development and implementation (WHO manual on sugar-sweetened beverage taxation policies to promote healthy diets 2022 Dec 13).
The 2018 Los Angeles County Health Survey, a population-based telephone survey, is an established tool used to gather valuable information on the health of county residents, including the Latinx community (Department of public health - health assessment unit - Los Angeles County health survey). Therefore, it will serve as a template for conducting the surveys in this study. While the surveys for this study will not be conducted via telephone, some questions will be adapted from the 2018 survey. Table 2 provides a detailed outline of the components of the baseline survey.

Table 2. Components of baseline survey. Modified from (Sorlie et al. 2010).

<table>
<thead>
<tr>
<th>Details of study and process</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Informed consent</td>
<td>Obtain signed informed consent that complies with all required standards.</td>
</tr>
<tr>
<td>Personal Information</td>
<td>Name of participant and guardian(s).</td>
</tr>
<tr>
<td>Contact Information</td>
<td>Collect names, addresses, and telephone numbers of two other persons who would know the participant.</td>
</tr>
<tr>
<td>Demographics</td>
<td>Age, gender, marital status, ethnicity, education, household composition, employment status, income, location, public assistance, food insecurity etc.</td>
</tr>
<tr>
<td>Healthcare</td>
<td>Health insurance, use of health care facilities, barriers to health care and utilization access.</td>
</tr>
<tr>
<td>Health and medical history</td>
<td>General health status, height and weight, chronic diseases.</td>
</tr>
<tr>
<td>Family history</td>
<td>All conditions under the study such as cardiovascular disease, diabetes, hearing loss, kidney disease, and cancer.</td>
</tr>
<tr>
<td>Physical activity</td>
<td>Current physical activity including work, household, leisure, and sport-related activity.</td>
</tr>
<tr>
<td>Oral/dental health</td>
<td>Access and barriers to care, oral cancer, oral health-related quality of life.</td>
</tr>
<tr>
<td>SSB consumption</td>
<td>Frequency, amount, and type of SSBs consumed, sources of SSBs, and factors that influence consumption.</td>
</tr>
</tbody>
</table>
In addition, the study will measure A1c levels and dental caries during the health examination along with the baseline survey. The analysis will examine whether the implementation of a sugar-sweetened beverage tax is associated with a decrease in both the incidence and severity of dental caries and whether it leads to sustained normalization of A1c levels in the targeted population. Trained healthcare professionals will carry out the health examination using standard procedures and equipment.

Phase 2

The implementation of the SSB tax will follow established tax policies and regulations, including those outlined in the World Health Organization (WHO) manual on implementing taxes on sugar-sweetened beverages. The appropriate tax rate and duration of implementation will be determined based on the examples and suggestions outlined in the WHO manual on sugar-sweetened beverage taxation policies (2022). The manual recommends a 10% tax on SSBs, but it will also serve as a practical guide for problem identification and policy design (WHO manual on sugar-sweetened beverage taxation policies to promote healthy diets 2022 Dec 13).

Phase 3

A follow-up survey and health examination will be conducted to evaluate changes in SSB consumption patterns and associated health outcomes resulting from the implementation of the tax. The survey will be structured similarly to the baseline survey (Table 2) but particularly designed to collect data on participants' SSB consumption, as well as their awareness of, attitudes towards, and compliance with the tax. Similar to the baseline phase, a health examination will be conducted to measure A1c levels and assess dental caries. The follow-up
survey and examination will also serve as a monitoring and evaluation tool to assess the overall impact of the tax and its effect on key indicators, helping to identify issues that need to be addressed and creating a strong evidence base for future reform efforts (WHO manual on sugar-sweetened beverage taxation policies to promote healthy diets 2022 Dec 13).

Timeline

As previously noted, Berkeley, located in California, provides a useful model for implementing taxes on SSBs in Los Angeles County. This is due to the fact that Berkeley was the first city in the United States to pass a significant tax on SSBs (one cent per ounce) in November 2014 (Falbe et al. 2020). The study by Silver et al. (2017) offers valuable insights into the tax implementation process and the timeline for collecting study data, which can be used as a reference for this study. Berkeley followed a specific timeline for data collection, which included baseline collection data at the beginning of 2013, prior to the approval of the tax by voters at the end of 2014. Following the tax approval, a baseline survey was conducted to assess dietary and shopping behaviors at the end of 2014. Tax collection began at the beginning of 2015, and follow-up surveys were conducted at the end of 2015 to assess changes in these behaviors. Finally, another point of scale data was collected in 2016. This timeline provides a useful framework for this study to follow. Below is a proposed timeline based on the Berkeley study:

January 2024: Recruit participants

February 2024: Start baseline survey and health examination

March - December 2024: Tax Implementation

December 2025: Follow up survey and health examination
Data Collection

SSB Survey Questions

To measure SSB intake, the survey will be using questions from the Behavioral Risk Factor Surveillance System sugary beverage module (Park and Pan). Respondents will be asked: During the past 30 days, how often did you drink regular soda or pop that contains sugar (do not include diet soda or diet pop)? Respondents will be then asked: During the past 30 days, how often did you drink sugar-sweetened fruit drinks, sweet tea, sports drinks, or energy drinks? Respondents were asked to NOT include 100% fruit juice, diet drinks, or artificially sweetened drinks. For both questions, respondents answer in times per day, week. Responses will be then converted to daily intake.

Health Examination

At both baseline and follow-up, the blood examinations will be identical and conducted by professionals. A1c is a blood test that provides an average blood sugar level over the past three months, which is useful for diagnosing and monitoring diabetes (CDC 2022 Sep 23). A normal A1C level is below 5.7%, and a level between 5.7% to 6.4% indicates prediabetes, while a level of 6.5% or higher indicates diabetes (CDC 2022 Sep 23). The test is convenient because it can be performed using a blood sample from a finger stick or arm, and no special preparation is required.

At both baseline and follow-up, the oral examinations will be identical and conducted by licensed professionals. To assess dental caries, the study will use two methods. The first method, which has been used in other studies (Valenzuela et al. 2021), involves assessing the presence or absence of dental caries. The second method is the DMFT/dmft index, which tracks the number
of decayed (D), missing (M), and filled (F) teeth to assess the severity of dental caries (Touger-Decker and van Loveren 2003). The DMFT index is a widely used measure in epidemiological surveys of dental caries that quantifies dental health status (Anaise 1984). Participants with a DMFT/dmft score of zero will be classified as caries-free, while those with a score greater than or equal to one will be considered to have caries, consistent with previous studies (Valenzuela et al. 2021).

Data Analysis

A paired t-test will be conducted to compare consumption of SSBs before and after taxation. The consumption of SSBs will be measured in drinks per week. The mean consumption of SSBs before and after the policy will be calculated, and the paired t-test will be used to determine whether there is a statistically significant difference between the two means. The data on A1c levels will be analyzed using a paired t-test to compare the differences in A1c levels before and after the implementation of the taxation intervention. This analysis will provide insights into the effectiveness of the SSB taxation intervention in influencing A1c levels, with a focus on sustaining a normalization of A1c levels in the targeted population and potentially improving health outcomes. The DMFT/dmft scores data will be divided into two categories: scores of zero and scores greater than or equal to one. This categorization allows us to analyze the impact of the pre- and post-taxation intervention on two groups: those who are caries-free (scores of zero) and those who are considered to have caries (scores greater than or equal to one). To determine if there is a significant difference between the pre- and post-taxation intervention on these scores, a contingency chi-square test (2x2 table) will be conducted. The two categorical variables are the pre- and post-taxation intervention and the DMFT/dmft scores. By conducting a chi-square test, it will determine if the pre- and post-taxation intervention had a significant
impact on the oral health status of the population. If there is a significant difference between the pre- and post-taxation intervention on the DMFT/dmft scores, it suggests that the taxation intervention was effective in improving oral health status.
**Expected Results and Discussion**

The expected results of the impact of SSB taxes on consumption suggest a statistically significant reduction in consumption following the implementation of the taxation (Figure 1). This could indicate that the SSB taxation intervention has been effective in influencing behavior change and reducing consumption of sugar-sweetened beverages. Figure 2 illustrates the reduction of A1c levels as they approach the optimal percentage of 5.7 or less following the implementation of taxation. Finally, there was a small decrease in the percentage of people with dental caries (Figure 3) but not significant to indicate that the tax policy may not have had a significant impact on oral health outcomes. Further health assessments in the years following the implementation of the tax may be essential to gather additional data.

![Figure 1. The mean difference (and 95%CI) of weekly consumption of SSBs after-before implementation of SSB tax (n=100).](image)
Figure 2. The mean difference (and 95% CI) of A1c blood levels after-before implementation of SSB tax (n=100).

Figure 3. The number of patients who were considered to have no caries or caries before and after implementation of SSB tax (n=100).
Significance

Through a comprehensive examination of the effectiveness of SSB taxes as a public health intervention, this study aims to shed light on their potential benefits in reducing SSB consumption and improving health outcomes. The insights gained from this study can provide valuable information to policymakers and health officials on how to reduce SSB consumption and address health disparities within the Latinx community and other vulnerable populations. Moreover, this study can guide researchers to explore the potential revenue benefits of SSB taxes, which can be utilized to improve the health of the community. The generated revenue can be invested in community programs and organizations that promote physical activity, prevent obesity and diabetes, and encourage healthier diets (World Health Organization 2017). For instance, investing in initiatives that create green spaces, reduce food deserts, and improve access to whole foods can significantly improve health outcomes. The generated revenue can also be utilized to improve healthcare systems and build capacity for effective tax administration, further enhancing the value of this intervention (World Health Organization 2017). By exploring the potential revenue benefits of SSB taxes, this study can provide a pathway for investing in initiatives that promote better health outcomes, highlighting the importance of preventative measures in the fight against chronic diseases. Ultimately, this study emphasizes the need for a comprehensive approach that considers social determinants of health in designing and executing dietary policies to address health disparities and inequities.

Future Direction

A potential future direction for this study could involve conducting a longitudinal follow-up to evaluate the long-term effects of SSB taxes on SSB consumption and health
outcomes. To gather in-depth insights into the perceptions, attitudes, and behaviors of Latinx youth towards SSBs and the SSB tax, qualitative research methods such as interviews or focus groups could be used. Additionally, exploring contextual factors that may affect consumption patterns and health outcomes could also be beneficial. Another potential avenue for future research could be to investigate whether the increase in price of SSBs due to the tax leads individuals to switch to sugar-free and low-calorie soft drinks that contain artificial sweeteners, and the potential health impacts of this shift in consumption behavior. Artificial sweeteners are low-calorie or calorie-free sugar substitutes. They are commonly used in diet products, but studies have linked their consumption to negative health outcomes (Low-calorie sweeteners 2013 Sep 4). Lastly, it would be important to consider examining the amount of water consumption and any changes following the implementation of the tax, as these beverages can make it challenging to drink enough water (Low-calorie sweeteners 2013 Sep 4). These directions can further inform future policy decisions and interventions aimed at promoting healthier dietary habits and reducing diet-related diseases in vulnerable populations.
Acknowledgements

I am incredibly grateful to Professor Ferree and Finseth for their support and guidance every step of the way. Throughout my time as a student, they have played a pivotal role in shaping my academic trajectory and helping me achieve my goals. I would like to express my deep appreciation to my thesis peer group for their invaluable feedback and constructive critiques. Their insights and perspectives have challenged me to think more critically. Finally, I must acknowledge the support of my family and close friends. Their encouragement and motivation have been a source of inspiration throughout my academic journey at Pitzer College and Keck Science Department. From celebrating my successes to helping me navigate challenges, they have been there for me. I am grateful for their love and support, which have made all the difference in my academic success.


Department of public health - health assessment unit - Los Angeles county health survey.
Lacounty.gov. [accessed 2023 Apr 6].


http://dx.doi.org/10.1136/bjsports-2017-097971.


http://dx.doi.org/10.2105/AJPH.2020.305795.


Foodsco.net. [accessed 2023a Apr 6].

Foodsco.net. [accessed 2023b Apr 36].
https://www.foodsco.net/p/red-bull-energy-drink/0061126981899.


Imamura F, O’Connor L, Ye Z, Mursu J, Hayashino Y, Bhupathiraju SN, Forouhi NG. 2015. Consumption of sugar sweetened beverages, artificially sweetened beverages, and fruit
juice and incidence of type 2 diabetes: systematic review, meta-analysis, and estimation of population attributable fraction. BMJ. 351:h3576. doi:10.1136/bmj.h3576.
http://dx.doi.org/10.1136/bmj.h3576.

doi:10.1161/CIRCULATIONAHA.115.020453.
http://dx.doi.org/10.1161/CIRCULATIONAHA.115.020453.

Kroger.com. [accessed 2023 Apr 36].


https://www.hsph.harvard.edu/nutritionsource/healthy-drinks/artificial-sweeteners/.

http://dx.doi.org/10.1001/jama.287.18.2414.


35
http://dx.doi.org/10.3390/nu11081840.


https://www.hsph.harvard.edu/nutritionsource/oral-health/.

Park S, Pan L. A data user’s guide to the BRFSS sugar-sweetened beverage questions: How to analyze consumption of sugar-sweetened beverages. Cdc.gov. [accessed 2023 Apr 6].


Pepsicoproductfacts.com. [accessed 2023 Apr 6].


http://dx.doi.org/10.3945/jn.109.113183.

http://dx.doi.org/10.1016/j.annepidem.2010.03.015.

https://www.hsph.harvard.edu/nutritionsource/healthy-drinks/sugary-drinks/.


Sunny D berry juice - 12 oz, nutrition information. innit.com. [accessed 2023 Apr 6].
https://www.innit.com/nutrition/sunny-d-berry-juice/p/00050200957024.


Using the nutrition facts label in the CACFP. Usda.gov. [accessed 2023 Apr 6].

http://dx.doi.org/10.1093/eurpub/ckaa147.


https://www.who.int/publications/i/item/9789240056299.

WHO urges global action to curtail consumption and health impacts of sugary drinks. Who.int. [accessed 2023 Apr 6].