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**Adolescents' Soda Consumption in Mexico Before and After the
Sugar-Sweetened Beverages Tax:
Results from National Health and Nutrition Surveys**

Capstone Project

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Executive summary

In 2014 Mexico implemented a national tax on sugar-sweetened beverages (SSBs) as a public health strategy. Over the last decades, obesity has significantly increased among adolescents (12-19 years). In addition, the consumption of high-energy beverages among adolescents more than doubled from 1999 to 2006. The current study investigates the relationship between the SSBs tax and the caloric soda consumption in the Mexican adolescent population utilizing cross-sectional data from two nationally representative nutrition surveys. One from 2012 which took place before the tax was implemented and one conducted in 2016, two years after tax implementation.

Results show a positive association between the SSBs tax and the caloric intake among Mexican adolescents. Descriptive statistics show that within the physical state categories, only normal weight adolescents cut their soda intake by an average of 29.3 mL or 11.3 percent per day relative to the 2012 survey. When analyzed by gender, only normal weight female adolescents show a statistically significant drop in soda consumption of 17.2 percent relative to 2012. Although male adolescents consume larger volumes of soda per day, a soda consumption plunge was only significant for the overall female population. The average female soda consumption was found to be 189.4 mL per day after tax implementation, a decline of 33.3 mL or 15 percent relative to the 2012 survey. The only geographical region that showed a statistically significant decrease in soda consumption was the south, suggesting that geographical location has an impact on the tax effectiveness. In addition, a statistically significant decrease in soda consumption was observed in the urban areas but not in the rural areas.

Importantly, the biggest drop in daily soda intake was observed among the adolescents in the lowest socioeconomic status group by quintiles. Adolescents in this group cut their soda consumption by an average of 67.7 mL per day or by 30 percent relative to the 2012 survey (99% CI; 33.1-102.3, $p < 0.0001$). A differences-in-differences (DD) estimator utilizing milk (untaxed product) as a control finds a drop in caloric soda intake among the very low socioeconomic quintile group of 49 mL or 22 percent relative to the 2012 survey.

Key policy recommendations include increasing the transparency and accountability of the tax revenue in order to focus more resources on the treatment and prevention of overweight, obesity and diabetes, particularly among male adolescents who appear to be less responsive to the tax. Additionally, healthy foods subsidies and rebates should be evaluated as a companion to the SSBs policy, considering that study results show that the lower income groups are most impacted by the tax.

Further dietary evaluations among different age groups and demographics are necessary to observe the casual relationship between the SSBs Tax, the Mexican dietary patterns and long-term population health outcomes.

Introduction

Mexico is in the midst of an obesity epidemic. In 2016 the Secretary of Health declared an epidemiological emergency given the high rates of obesity and diabetes in the country (Secretaria de la Salud 2016). Mexico occupies the 5th place in number of people with diabetes in the world with over 12 million people, By 2045 Mexico is expected to rank 4th with over 21 million people (International Diabetes Federation 2017).

In 2014 Mexico became the first country in the world to introduce a national tax on sugar-sweetened beverages (SSBs) and a tax on nonessential high energy foods as strategies to tackle overweight, obesity and health related conditions (Backholer, Blake, and Vandevijvere 2017). Four years after policy implementation, the health and economic impacts of the tax remain subject of debate. Despite various research papers supporting the positive impacts of the tax, few published studies evaluate the health and biological impacts. No study focuses on the adolescents' dietary response.

In this paper, I investigate the relationship between the SSBs tax and the caloric soda consumption in the Mexican adolescent population utilizing cross-sectional data from two Mexican National Health and Nutrition Surveys, ENSANUT 2012 and ENSANUT 2016. Results from the ENSANUT 2016 survey show an increase in the overweight and obesity prevalence in all age groups, with the highest rate of increase among female adolescents (Hernández-Cordero et al. 2017). The ENSANUT 2016 is the first survey of its kind conducted after SSBs tax policy implementation. For that reason, it represents an important opportunity to evaluate the direct dietary responses of the Mexican population to the SSBs tax. Furthermore, authors have called

for further research that looks the consumption, dietary patterns and health outcomes impacts of the tax (Colchero et al. 2017).

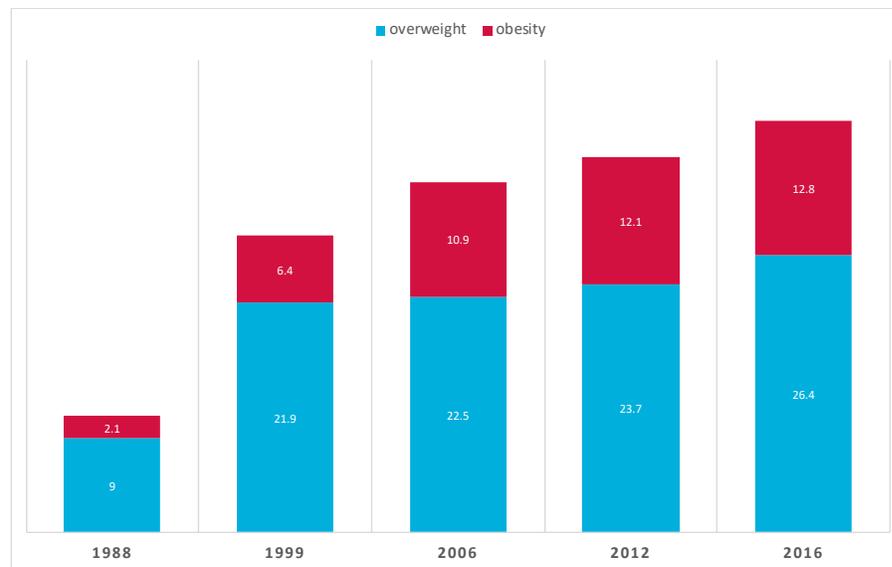


Figure 1: Prevalence of overweight and obesity in female adolescents and ENSANUT surveys: 1988-2012. Adapted from (Hernández-Cordero et al. 2017) and with data from ENSANUT MC 2016. As a percent of the total group population.

Although the rate of increase in overweight and obesity among Mexican adolescents appears to be slowing down over the last decades, graph 1 demonstrates that the combined prevalence is still increasing. By 2016, as figure 1 shows, the prevalence of combined overweight and obesity among Mexican female adolescent reached 39.2 percent (Hernández-Ávila M et al. 2016).

Understanding the trends and characteristics of the Mexican adolescent group are essential components to evaluate the impacts of the SSBs tax policy in order to further develop public policies that adapt to the unique adolescent characteristics as they persist the complexity of overweight, obesity and health related diseases. Adolescence is one of the most rapid phases of human development and given the changes in physiological and biological maturity during this period, the World Health Organization (WHO) has recognized different implications for

policy and program responses during adolescence (WHO 2017). In addition, worldwide, the rate of increase in childhood and adolescent obesity has been greater than the rate of increase in adult obesity (GBD 2015 2017). Therefore, future policies and evaluation efforts will require more focus in the population group.

The Mexican adolescents directly represent the future social and economic conditions in the country. Evidence suggest that overweight and obesity among Mexican adults is associated with a decrease in work productivity (Dibonaventura et al. 2018), and as more adolescents become overweight or obese, the country will experience more work absenteeism and higher public costs. Research and media attention has focused on the health and nutritional changes and challenges for the adolescent population. The trimestral Mexican National Bioethics Commission magazine dedicated an edition to the overweight, obesity and diabetes crisis particularly in Mexican adolescents (CONBIOÉTICA 2017). Consequently, this paper hopes to contribute in the areas regarding the Mexican adolescent population health and nutrition policy.

Sugar-Sweetened Beverages (SSBs) Taxation in Mexico

In 2013 the Mexican government launched a National Strategy for the Prevention and Control of Overweight, Obesity, and Diabetes. This strategy included the use of fiscal policies to discourage sugar-sweetened beverage consumption. Caloric sugary beverages have been found to be the top sources of calories from beverages in the Mexican population (Stern et al. 2014). A study published in 2014, showed that caloric sugary beverages are currently one of the top sources of calories from beverages in the Mexican population. By 2012, beverages represented 17.5 percent of the total daily energy intake per capita in children aged 1-19 years (Stern et al. 2014). The study showed an important increasing trend in consumption of caloric beverages, and

in 2012 caloric soda represented one of the top 3 most important contributors to total daily energy intake per capita in children and adolescents. High-sugar energy beverages were consumed by 97 percent of the adolescents and 80 percent reported soda consumption (S. Barquera et al. 2008). Barquera et al. found that from 1999 to 2006 energy intake from beverages doubled across all Mexican age groups. Furthermore, a study utilizing data from the 2006 National Health and Nutrition survey shows a positive relationship between the consumption of soft drinks and Body Mass Index (BMI) in the Mexican male adolescents (Jimenez-Aguilar et al. 2009).

By December 2013, the Mexican Congress passed the SSBs national tax as a Special Tax on Production and Services to be implemented in 2014. Mexico's tax reform includes an excise sales tax of 1 peso per liter of SSB (close to 10 percent of the price) to those taxpayers that manufacture or import these products. Taxed SSBs include: caloric sodas, energy drinks, bottled teas and coffees, and fruit drinks. Milk, mineral and bottled waters, diet sodas and beverages registered as medicines are exempt from taxation. This tax reform was accompanied by an 8 percent tax on non-essential food products with high caloric content.

Various aspects are identified as contributing factors to the tax approval. Several studies called for an SSBs tax, providing different modelling studies, rationale from previous research papers and international organization's recommendations. One key published article was particularly essential for the support of the tax. Colchero et al. found that the implementation of a tax on soft drinks or to SSB could decrease consumption particularly among the poor according to their price elasticity of demand estimates (Colchero et al. 2015). Authors found the price elasticity of for SSBs of 1.16, and therefore, elastic. It was estimated that a 10 percent increase in soft drinks decreased in quantity consumed 10.6 percent a year after the tax was implemented.

The paper calculated more elastic demand among lower-income households and more marginalized areas, therefore stating that the financial burden of the tax would be higher among the higher socio-economic status population.

Several studies exist regarding the Mexican SSBs policy impact. Aguilar et al. 2016, find more than tax price pass-through rate to consumers of sugary drinks (Aguilar, Gutierrez, and Seira 2016). When analyzing the change in price of sodas alone, prices of regular sodas increased more than the amount of the tax right after the tax took effect (Jeffrey 2016), suggesting the potential of the tax to discourage consumption. Two modeling studies so far have been published that evaluate the impact of the SSBs and non-essential energy dense foods tax on health. Sánchez-Romero et al., projected that a 10 percent reduction in SSBs consumption would result in fewer incidents of type 2 diabetes and fewer incidents of strokes and heart attacks, saving Mexico 983 million international dollars (Sánchez-Romero et al. 2016). Barrientos-Gutierrez T et al., calculate that after 10 years of an average tax impact, the prevalence of obesity can decrease up to 2.54 percent (Barrientos-Gutierrez et al. 2017). According to this results, it is expected to see a relationship in the consumption of soft drinks in the nutrition surveys and the implementation of the SSBs tax in Mexico.

As evidence of the sustained response to the tax, a longitudinal analysis of panel data of Mexican urban households shows that purchases of taxed beverages decreased 5.5 percent in 2014 and 9.7 percent in 2015 (Colchero et al. 2017). Furthermore, this analysis shows that households in the lowest socioeconomic level had the largest decrease in taxed beverages purchases. The study also found that purchases of untaxed beverages increased by over 2 percent. These authors explicitly call for an analysis of the ENSANUT 2016 in order to further

examine the impact of the tax on dietary patterns and the long-term implications. Importantly, this paper hopes to contribute to the future and already existent policy evaluation efforts.

Additionally, the effectiveness of this tax as a policy tool to reduce obesity has been a major source of debate. Mexican Association of Sodas and carbonated drinks (ANPRAC) launched a website with information and studies in order to argue against the effectiveness of tax on SSB (Economista 2016). According to a 2017 study, there were no significant changes in employment associated with the SBBs and nonessential energy foods taxes (Guerrero-López, Molina, and Colchero 2017).

Finally, the Mexican SSBs tax has been extensively covered by the international media (Malkin 2015, Rosenberg 2017). A *Reuters* article, interviewed Dr. Kirsten Bibbins-Domingo who described Mexican tax policy case as “encouraging for many cities and countries around the world” (Cohen 2017). The American Heart Association has supported the implementation of such taxes citing the evaluation experiences from Mexico (Nancy Brow 2016). The Johns Hopkins University Bloomberg School of Public Health published the report “Advocating for a Sugar-Sweetened Beverage Taxation: A Case Study in Mexico,” as a case study to the efforts involved in passing the SSBs tax in Mexico (Donaldson 2015). This report was discussed by key decision makers from Latin America during the recent “Regional Workshop on Non-Communicable Diseases” held in Panama City, Panama, and hosted by the Pan-American Health Organization, Panama Ministry of Health and the Healthy Latin America Coalition (Bloomberg Shool of Public Health 2015). Given the popularity of the Mexican SSBs tax, this research hopes to contribute to the past, current and future evaluation efforts of the tax policy. In addition, this research hopes to provide a better understanding on the potential dietary outcomes the SSBs tax policy can have.

Data collection

This research utilizes cross-sectional nutrition survey data from before and after the SSBs tax was implemented in Mexico. The surveys are named the National Health and Nutrition Survey [Encuesta Nacional de Salud y Nutrición, ENSANUT]. The ENSANUT is a probabilistic and cross-sectional survey that is representative of the national, state, and rural and urban levels. ENSANUT 2012 data is publicly available and access was obtained online upon request. Preliminary results from the 2016 survey have been published (ENSANUT 2016), however, original data sets are not publically available yet.¹

The Mexican Government mandates the Institute of Public Health (INSP) to carry out health and nutrition surveys every 6 years. In Mexico, the first National Nutrition Surveys took place in 1988 and 1999. By 2006 a health component was incorporated in the survey. With the new Secretary of Health, Dr. José Narro Robles, taking office in February 2016 (Secretariat of the Interior 2016), the INSP would realize a smaller version of the Mexican Health and Nutrition Survey in 2016. 2018 will mark 6 years after the mandated last Health and Nutrition Survey, however it is uncertain whether this survey will take place, particularly coinciding with the 2018 presidential elections. Therefore, the ENSANUT 2016 presents an important and unique opportunity to evaluate the dietary responses to the SSBs tax.

The 2012 survey was conducted between October 2011 and May 2012. Observations with missing calculated soda intakes (n=100) were excluded from the analysis. To obtain information about the consumption pattern of adolescents two main data sets were merged, one

¹ I was granted access to the ENSANUT 2016 rough data for adolescents upon request to the Mexican Institute of Public Health (INSP). Special thanks to Dr. Sonia Rodríguez Ramírez and Dra. Teresa Shamah Levy.

with the frequency of consumption questionnaires and one with the total overall dietary information. 10 observations from the frequency questionnaire were eliminated given the lack of information in the other data set with information on the overall diet. 2,201 observations from adolescents (12-19 years) were selected for further analysis.

The 2016 survey was conducted between May and October 2016. The overall sample in this survey was significantly smaller from the ENSANUT 2016, however, the same institutions participated in the development and implementation of the survey, carrying the same national, cross-sectional, multi-stage, stratified methods, representative of the Mexican population. Design methodology and validity of the ENSANUT 2016 has been published elsewhere (Romero-Martínez et al. 2017). Therefore, it is assumed that both surveys are comparable and adolescent samples are representative of the Mexican adolescent population.

To estimate the dietary intake of individual foods, the ENSANUT surveys utilizes a Semi- quantitative food frequency questionnaire (FFQs) methodology. FFQs have been used as practical and efficient methods to comply population data. The methodology to calculate the dietary intake from the FFQs has been published before (Ramírez-Silva et al. 2016). Since FFQs were utilized in both the before that tax and after the tax nutrition survey, this method allows the identification of changes in food intake over time. The FFQs was administered by trained health personnel using laptop computers. Adolescents were asked directly to recall all foods and portions consumed in the last seven days prior to the interview, then asked to specify the number of days and the number of times per day they consumed the food, as well as the number of portions each time (Ramírez-Silva et al. 2016).

The surveys classify households by socioeconomic status (SES). Quintiles were utilized for this analysis. Age and gender was obtained for adolescents. Area was classified as either rural

and urban. Urban areas were defined as those with ≥ 2500 inhabitants (Aburto, 2016). Regions were classified as north, center, Mexico City area, and south. In addition, adolescent's health condition was categorized as normal, overweight, and obesity. The health condition variable was available for 94 percent of the sample. That is for a total of 4,563 adolescents (with 260 missing observations). The outcome variable for this study was the adolescents' caloric soda consumption. Soda consumption is reported in mL per day.

Sample Demographics

The final cross-sectional data consisted of 4,830 adolescents (12-19 years). 2,111 adolescents from the 2012 survey and 2,719 from the 2016 survey. Sample demographics are summarized in table 1. Sample demographics from the surveys representative of before and after SSBs tax implementation are very similar. Demonstrating the equivalent characteristics of the groups. An important difference was observed in the Area variable, where in the 2012 survey, 38 percent of adolescents were found in the rural region, compared to 52 percent in the 2016 survey.

Table 1. Sample Demographics: Mexican Adolescents from the National Health and Nutrition Surveys

Variable	Demographic Characteristics	Before the Tax	After the Tax
		(2012 survey) percentage of population	(2016 survey) percentage of population
Gender	Male	48.8	46.5
	Female	51.2	53.5
Age	Mean Age (years)	15.26	15.25
Region	North	23.8	21.7
	Center	37.7	33.9
	Mexico City Metropolitan Area	4.7	10.1
	South	33.8	34.3
Area	Urban	61.8	48.22
	Rural	38.2	51.78
Socio-economic status (tertiles)	Low	34.2	33.3
	Medium	33.3	35.3
	High	32.5	31.4
Socio-economic status (quintiles)	Very low	21.2	19
	Low	19	21.5
	Medium	21	21.7

	High	20.9	19.5
	Very High	17.9	18.3
Physical state	Normal	63.8	62.7
	Overweight	22.3	23
	Obese	13.9	14.3

The following figure shows the distribution of the adolescent population in both nutrition surveys by age group. The figure show that the distribution is consistent between the two surveys, thus not expecting a response in the change in the soda consumption by particular age group.

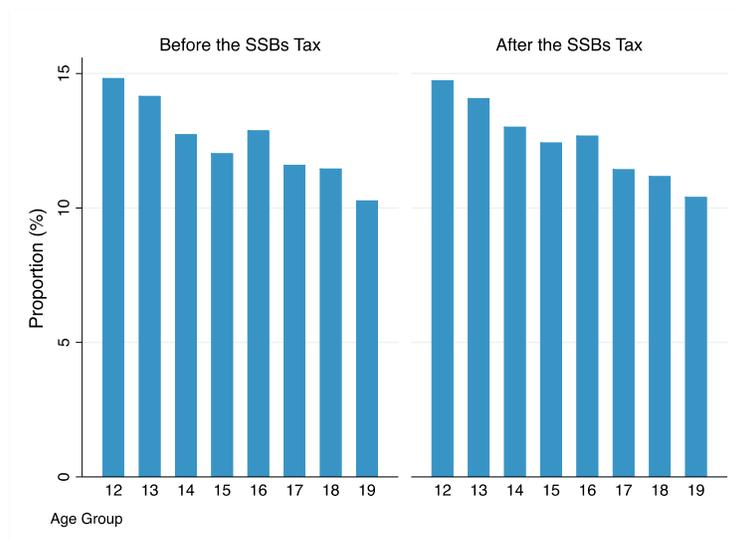


Figure 2: Proportion of Mexican Adolescents by age group in the 2012 and 2016 National Health and Nutrition Surveys representative of the samples before and after SSBs Tax implementation.

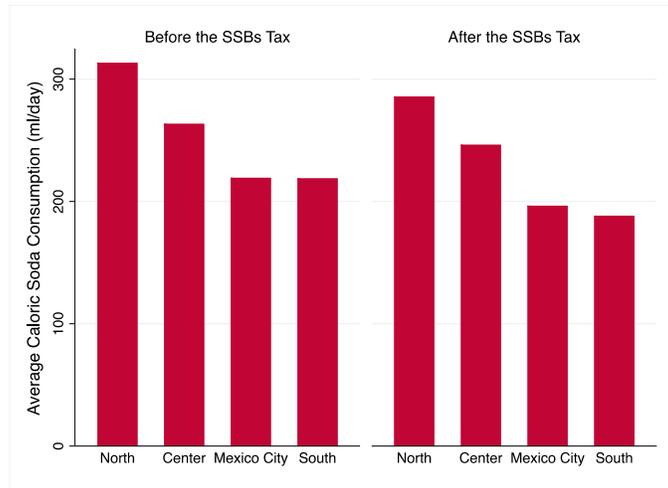


Figure 3: Average Soda Consumption among Mexican Adolescents by region in the 2012 and 2016 National Health and Nutrition Surveys representative of the samples before and after SSBs Tax implementation.

Figure 3 shows that the distribution of soda consumption among regions remained relatively consistent between surveys, where adolescents in the north region consume the highest amount of soda per day and adolescents in the south region consume the least.

Descriptive Statistics

All analyses were conducted using the means and 95% CIs for volume consumption. Student’s two sample t-test were used to test for differences between samples. A p-value of < 0.05 was considered significant.

The first part of the research involved analysis of the proportion of adolescents who were categorized as regular soda consumers before and after the SSBs tax implementations, as represented by the before and after surveys. A Dummy variable was created to categorize regular adolescent caloric soda consumers. Those respondents that answer to the first FFQs question negatively, that is, have not consumed soda over the last week, were categorized as non-

consumers. Respondents who had consumed soda at least one time during the last 7 days at time of interview were categorized as regular soda consumers. Two-sample t-tests were conducted to test whether the proportion of adolescents categorized as regular soda consumers decreased after the SSBs tax. Results are shown in table 2.

Before tax implementation, in the 2012 survey sample, 83 percent of the adolescents consumed soda at least once over the last week at the time of the interview. This finding is consistent with previous research, Barquera et al., found that 80 percent of adolescents reported soda consumption utilizing data from the Mexican Health and Nutrition Survey of 2006. (S. Barquera et al. 2008). After SSBs tax implementation, 78 percent of the adolescents in the sample consumed soda at least once over the last week at the time of the interview according to data from the ESANUT 2016. This result is summarized in table 2. Data from the 2012 and 2016 survey suggests that a 5 percent drop in the proportion of adolescents who are regular soda consumers occurred after the SSBs tax was implemented (99% CI; 0.03-0.07, p 0.000). Although this analysis cannot prove a causal relationship between the SSBs tax and the decline in regular soda consumers, this result is consistent with previous research papers and might indicate an important advancement in the impact of the SSBs tax among this group. Colchero et al. 2016 find that the volume of taxed beverages purchased monthly was 6 percent lower in 2014 than would have been expected without the tax (M. Arantxa Colchero et al. 2016). In the current analysis, we are only looking at caloric soda, therefore we can expect this fall consumption to be lower than for the overall SSBs group. It should be noted that the largest drop was observed in the very low socioeconomic group with an average of 11 percent drop in the proportion of adolescents considered regular soda consumers relative to the 2012 survey. Interesting, the only apparent change in proportion of soda consumption by region was observed in the north.

Table 2. Mexican adolescents (12-19 yrs.) proportion of regular soda consumers before and after the SSBs Tax

Proportion of regular soda consumers by demographic characteristics	Before the Tax (2012 survey)	After the Tax (2016 survey)	Mean Difference	Standard error	Confidence intervals
Total Adolescents	0.83 (n=2,111)	0.78 (n=2,719)	0.05***	0.01	0.03-0.08
Males	0.86 (n=1,031)	0.81 (n=1,263)	0.054***	0.02	0.02-0.08
Females	0.81 (n=1,080)	0.78 (n=1,456)	0.051**	0.02	0.02-0.08
Urban	0.85 (n=1,305)	0.79 (n=1,311)	0.063***	0.02	0.03-0.09
Rural	0.81 (n=806)	0.78 (n=1,408)	0.035**	0.02	-0.07
North	0.89 (n=503)	0.70 (n=589)	0.091**	0.02	0.05-0.13
Center	0.84 (n=795)	0.82 (n=922)	0.017	0.02	0.02-0.05
Mexico City Metropolitan Area	0.78 (n=99)	0.74 (n=274)	0.027	0.05	0.07-0.13
South	0.80 (n=713)	0.74 (n=934)	0.06	0.02	0.02-0.10
Very Low SES (quintile)	0.81 (n=448)	0.69 (n=517)	0.11***	0.03	0.05-0.17
Low SES (quintile)	0.84 (n=400)	0.83 (n=585)	0.01	0.02	-0.035-0.059
Medium SES (quintile)	0.85 (n=444)	0.81 (n=590)	0.04	0.02	-0.01-0.08
High SES (quintile)	0.83 (n=442)	0.80 (n=531)	0.03	0.02	-0.02-0.07
Very High SES (quintile)	0.85 (n=377)	0.76 (n=496)	0.09***	0.03	0.04-0.14
Physical Condition Normal	0.83 (n=1,271)	0.79 (n=1,611)	0.04**	0.01	0.01-0.07
Physical Condition Overweight	0.84 (n=445)	0.85 (n=592)	-0.00	0.02	-0.05-0.04
Physical Condition Obese	0.86 (n=276)	0.80 (n=368)	0.05*	0.03	-0.00-0.11

*significant at the p-value < .05. ** p-value < .01. *** < 0.001.

Importantly, the largest drop in the proportion of regular soda consumers was observed among the very low socioeconomic status group (quintiles), where there was an average drop of 11 percent in the proportion of adolescents considered regular soda consumers in 2016 relative to the 2012 survey.

Analyzing the proportion of soda consumers in relationship to the tax is important in order to observe any differences across demographics and to inform whether tax policy is discouraging consumption overall, or only lowering the rate of intake. The following section will

focus the adolescents' response to the tax as observed by the volume of soda consumed in the 2012 and 2016 surveys.

Two-sample t-tests were conducted to test whether the mean soda consumption per day was different after the SSBs tax policy was implemented as reported by the 2016 survey. The significance test results are displayed in table 3. (Where the null hypothesis $H_0: 2012_{consumption} = 2016_{consumption}$, and $H_a: 2012_{consumption} > 2016_{consumption}$).

Table 3. Mexican adolescents (12-19 yrs.) soda consumption before and after the SSBs Tax

Adolescents Characteristics	Before the Tax (2012 survey) soda consumption (ml/day)	After the Tax (2016 survey) soda consumption (ml/day)	Mean Difference (ml/day)	Standard error	Confidence intervals for difference
Total Adolescents (n= 4,830)	258 (n=2,111)	229.9 (n=2,719)	28**	9.1	10.2-46
Female adolescents (n=2,536)	222.7 (n=1,080)	189.4 (n=1,456)	33.3**	11.1	11-5-55.1
South Region (n=1,647)	218.8 (n=713)	188.4 (n=934)	13.8*	13.8	3.4-57.4
Urban areas (n=2,616)	288.1 (n=1,305)	249.7 (n=1,311)	38.4**	13	12.9-63.9
Low Socio-economic status by tertiles (n=1,627)	232.5 (n=722)	187.5(n=905)	45 ***	14.3	16.9-73
Medium Socio-economic status by tertiles (n=1,665)	272.7 (n=704)	245.7 (n=961)	27*	15.9	-4.1-58.2
Very low Socio-economic status by quintiles (n=965)	222.9 (n=448)	155.2 (n=517)	67.7***	17.6	33.1-102.3
Normal physical status (n=2,882)	256.4 (n=1,271)	227.2 (n=1,611)	29.3**	11.8	6.1-52.5

*significant at the p-value < .05. ** significant at the p-value < .01. *** significant at the p-value < .001

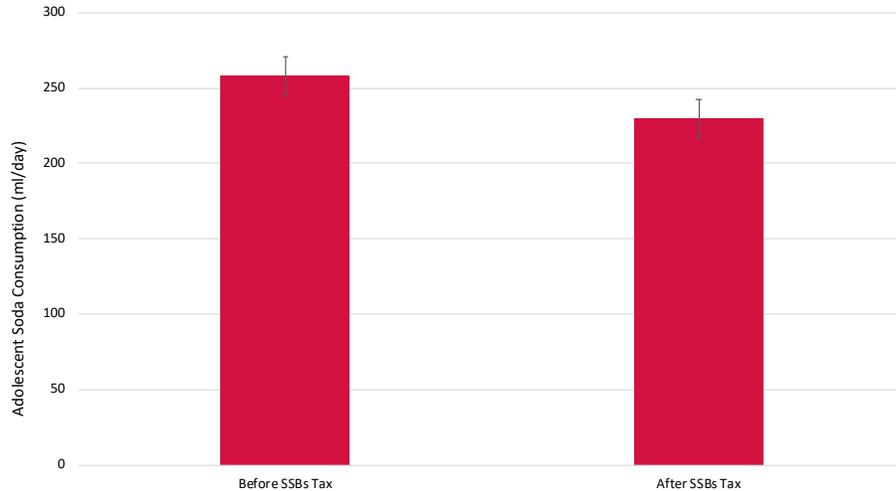


Figure 4: Average Soda Consumption among Mexican Adolescents according to the National Health and Nutrition Surveys representative of the samples before and after SSBs Tax implementation

Figure 4 shows a drop in the adolescent soda consumption between the surveys. In the 2016, after tax implementation, the average soda consumption in the adolescent population was 229.9 ml per day, a 10.89 percent drop in consumption relative to the 2012 survey. A higher proportion of males were regular soda consumers in both surveys.

When analyzed by consumption by mL per day, male adolescents also consume larger quantities of soda per day. Nevertheless, a soda consumption decline after the tax was only significant for the female population (99% CI; 11.5-55.11, p 0.0014). The average female soda consumption was 189.4 mL per day after that tax was implemented, a decline of 33.3 mL per day or 14.9 percent relative to the 2012 survey. Figure 5 displays the average change in soda consumption between the two surveys by gender.

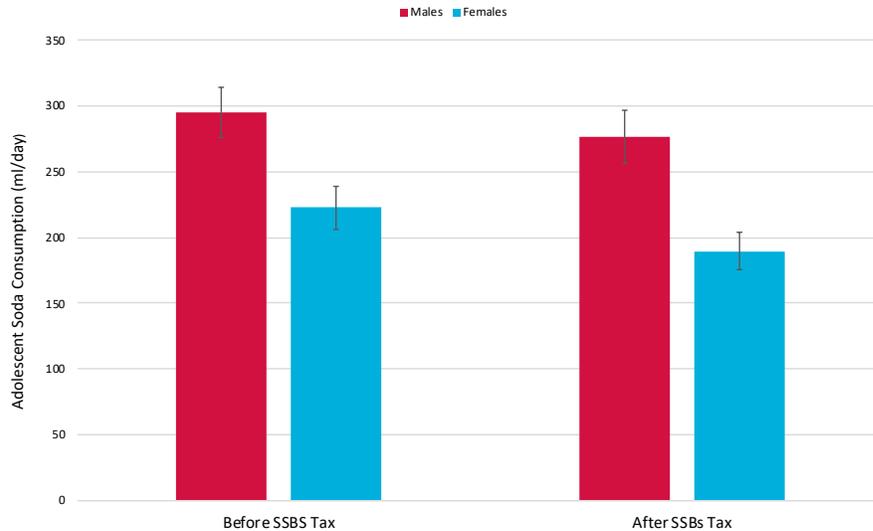


Figure 5: Average Soda Consumption among Mexican Male and Female Adolescents according to the National Health and Nutrition Surveys representative of the samples before and after SSBs Tax implementation.

The only statistically significant region where females reduced soda consumption was in the south of the country (99% CI; 9.0-76.52, p 0.0066). Overall, the only geographical region that showed a statistically significant decline in consumption was the south (95% CI; 3.4-57.4, p 0.0014), suggesting that geographical location has an impact on the effectiveness of the tax. In an effort to review the evidence of the extent to which Mexican health economy is affected by diabetes, authors found compared the unbalanced nutrition/epidemiological transitions in Mexico, where the southern region has showed an increase of diabetes from 1980-200 of 128 percent compared to 32.5 percent in the northern region (Simon Barquera et al. 2013). Therefore, these results are significant for the prevention and risk management of obesity and diabetes yet also produce equity concerns.

A decline in soda consumption was significant in the urban areas but not in rural areas (99% CI; 12.9-63.9, p 0.0016). On average, adolescents that live in urban areas consumed 38 mL less of soda relative to the 2012 survey. These results are important for policy implications given

that the tax has been successful in the areas of high food availability and higher soda consumption patterns. In addition, this finding is similar to previous research that observed a lower reduction in the purchase of SSBs in rural areas (M Arantxa Colchero, Molina, and Guerrero-López 2017).

In the social-economic status groups by quintiles, the only statistically significant decline was observed in the very low socio-economic category. After the SSBs tax, adolescents in this group decreased their soda consumption by an average of 67.7 mL or 30.37 percent relative to the 2012 survey (99% CI; 33.1-102.3, p 0.0001). This finding is of particular interest given that the purpose of the tax was to “reduce consumption of soft drinks even further in the poorest quintile of the population” (PAHO 2015). Research utilizing cross-sectional data from four nationally representative National Income and Expenditure Surveys shows the greatest drop of SSBs purchases (10.3 percent) in the low-income households associated to the tax policy (M Arantxa Colchero, Molina, and Guerrero-López 2017).

The consumption of milk among adolescents in the very low socioeconomic category was also analyzed. Two sample t-test show an average drop in milk consumption of 18.6 mL per day or 16.98 percent in 2016 relative to the 2012 survey. Compared to milk consumption, soda consumption fell dramatically in this group. However, a drop in the milk consumption also suggest the potential economic burden of the tax in the very low socio-economic population and a potential economic recession in this group. Previous studies have estimated that sale of untaxed beverages increased after that tax. Therefore, these findings are interesting and require further examination. In addition, milk was an untaxed product and substitution patterns could be expected.

However, previous research has found that that the increases in the purchases of untaxed beverages were mainly attributed to plain bottled water. In addition, authors conclude that the change in purchasing was no longer statistically significant by November of 2014 (Colchero et al. 2016). Therefore, a differences-in-differences (DD) model with milk as a control group is considered to be a good strategy to strategy measures the change in soda consumption against untreated product, milk. A DD approach captures the broader macroeconomic trends in beverage consumption. Descriptive statistics results showed that a drop in soda consumption was statistically significant among the very low socioeconomic status group, but not significant with milk consumption, and although the study utilizes cross-sectional data, both surveys are equivalent and representative of the national adolescent population. The DD model specification is presented in equation2, where Q_{volume} is the quantity of drink consumed in mL per day of product i . $Year_i$ is an indicator for the SSBs tax treatment, where 0 was the 2012 before implementation, and 1 was the 2016 survey, after tax implementation. The coefficient of interest is B_3 , the interaction of soda, taxed product, and year, where SSBs tax was implemented.

$$\begin{aligned}\beta_{1diffs-in-diffs} &= (\bar{Y}_{soda,after} - \bar{Y}_{soda,before}) - (\bar{Y}_{milk,after} - \bar{Y}_{milk,before}) \\ &= \Delta\bar{Y}_{soda} - \Delta\bar{Y}_{milk}\end{aligned}$$

Equation 1. Differences-in-differences Estimation Model

$$\begin{aligned}Q_{volume} &= B_1Year_i + B_2Soda_i + B_3(Soda * Year)_i + B_4Area_i \\ &+ B_5Gender_i + B_6Age_i + B_7Center_i + B_8City_i + B_9South_i + B_{10}Normal_i + B_{11}Overweight_i \\ &+ \varepsilon_1\end{aligned}$$

Equation 2. Differences-in-differences Regression Model Specification

A regression (equation 2) was conducted to obtain the differences-in-differences estimator.

Results are summarized in table 4.

Table 4. Differences-in-differences estimator for Mexican adolescents (12-19 yrs.) soda consumption before and after the SSBs Tax utilizing milk as a control

Consumption (mL/day)	Before the Tax (2012 survey)	After the Tax (2016 survey)	Mean Difference (95% CI)
	mean consumption	mean consumption	
Caloric Soda	222.9	155.2	-67.7***
Milk	109.9	91.1	-18.62**
DD Estimator			-49.1** (-89.4, -8.7)
R-squared			0.07

*significant at the p-value < .05. ** significant at the p-value < .01. *** significant at the p-value < .001

The differences-in-differences estimator using milk as a control finds a drop in caloric soda intake of 49 mL or 22 percent relative to the 2012 survey among the very low socio-economic quintile group. Therefore, we can conclude that despite an observed decreased in the consumption of both milk and soda among the very low socioeconomic status group, there is a statistically significant drop in the soda consumption after tax implementation in 2016 relative to the 2012 survey.

Previous research has shown that the burden of obesity and overweight is shifting towards the lower socioeconomic status populations. This finding is also consistent with other literature that suggests the SSBs tax has a higher impacts in the lower socioeconomic households (M. Arantxa Colchero et al. 2016; Arantxa Cochero et al. 2017). Given that the burden of obesity is shifting towards the group in the lower socioeconomic level (Hernández-Cordero et al. 2017).

These findings show the potential positive impact of the SSBs among the lower income adolescent population.

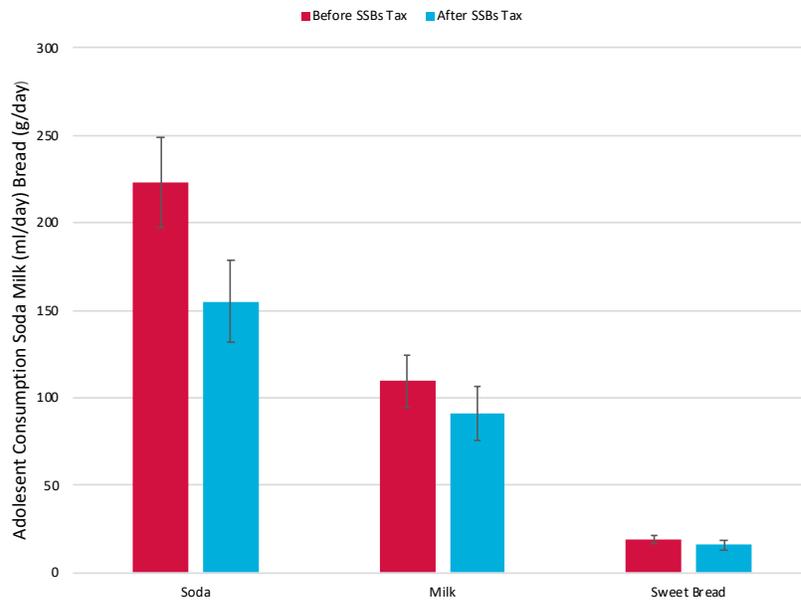


Figure 6: Average Soda, Milk and Sweet Bread Consumption among Mexican Adolescents in the very low socioeconomic group according to the National Health and Nutrition Surveys representative of the samples before and after SSBs Tax implementation

Figure 6 shows displays the drop in the soda consumption among the very low socioeconomic status adolescents in 2016 relative to 2012 survey. The bar charts display the intake of milk and sweet bread, which are untaxed products, in order to demonstrate the potential impact of the tax among this adolescent group. As DD results suggest, the drop in soda consumption in relationship to the SSBs tax was statistically significant, controlling for milk consumption patterns.

Finally, the impact of the tax seems to be most effective in the adolescents with a normal physical state compared to the overweight and obese categories. This result is consistent with economic theory, given that we can expect regular soda consumers to be more likely to have overweight or obesity, and consequently a more inelastic demand for soda. Normal weight

adolescents reduced their soda intake by an average of 29.3 ml per day relative to the 2012 survey (99% CI; 6.1-52.5, p 0.0068). For the female sample, the only statistically significant drop in soda consumption was observed in the normal weight adolescents (99% CI; 9.50-65.2, p 0.0014). Importantly, the drop in normal weight male adolescent's soda consumption was not statistically significant.

Previous analysis show that from 1988-2012 the prevalence of overweight and obesity increased in all age groups, with the highest rate of increase in female adolescents (Hernández-Cordero et al. 2017). Authors note that the rate of increase began to slow down in 1999, the increase has been steady. Consequently, the findings of the significant tests shown in table 3 are meaningful for the overall tax evaluation efforts. It is important that the SSBs impacts the female group, however, there needs to be further research on the reasons of this occurrence. No previous studies highlight any important gender differences as a response of the tax. Although the observed decline in consumption by the female group, it is central to target the male adolescent population given that this group consume more quantities of soda per day. Furthermore, a study which utilized cross-sectional data for the Mexican Health and Nutrition Survey of 2006 found a positive association between consumption of sodas and adolescents BMI only among the male group (Jimenez-Aguilar et al. 2009). Therefore, further tax policy evaluations should focus on gender differences and the long-term health impacts.

Importantly, the normal weight adolescents seem to be more responsive to the tax. A modelling study found that a population-wide 10 percent reduction in SSB intake can reduce new cases of diabetes by 189,300 (95% UI 155,400–218,100) for the time period 2013 to 2022, and almost a 5 percent lower incidence than what is projected when assuming no change in SSBs consumption (Sánchez-Romero et al. 2016). This study, however, depends on the extent to which

calories reduced through SSBs lower consumption translate to weight changes. These descriptive statistics findings, suggest that the normal weight population is the only adolescent group being statistically significant impacted by the tax. Therefore, further policy and public health strategies need to ensure that the SSBs tax is also targeting the already overweight and obese populations particularly in the young population.

Discussion

The full extent of substitutions made by Mexican consumers is not known. The findings from this analysis are consistent with previous literature and suggest a positive impact of the tax in the female adolescents. The WHO and Pan-American World Health Organization (PAHO) recommend SSBs taxes of at least 20 percent in order to have an impact in obesity and non-communicable disease (PAHO 2015). Therefore, the Mexican SSBs tax might discourage consumption but not sufficiently to have a health impact. These findings show that if tax was to be incremented, it might be impacting normal weight adolescents and the very low socioeconomic status groups disproportionately. Powell et al., 2009 found that in the U.S, the current state-level tax rates are not found to be significantly associated with adolescent weight outcomes. It is likely that taxes would need to be raised substantially to detect significant associations between taxes and adolescent weight (Powell, Chriqui, and Chaloupka 2009), or overweight and obese adolescents are less responsive to the price change.

Furthermore, the PAHO recommends that SSBs tax revenues are combined with subsidies focused on the lower-socioeconomic status families. Given the analysis that the soda consumption was only reduced among the very low socio-economic quintiles, there is no evidence on the tax revenue utilization goes directly to benefit this group. WHO

recommendations include utilization of the tax revenue to increase access to drinking water. Professor Pacheco-Vega has investigated the bottle water market evolution in Mexico. He finds that public perception of Mexicans on the capacity of municipalities to provide drinking water is very weak. In addition, the municipalities water installations and services are highly heterogeneous (Pacheco-Vega 2015). Therefore, tax revenues utilized to increase access to drinking water should be accompanied by education and communication campaigns, particularly among the male youth. In addition, further research is necessary to evaluate the consumption patterns of adolescents in school and outside of school. In 2010, the Government of Mexico published an agreement in the Official Journal of the Federation to ban unhealthy foods to be sold at schools. The impact of this policy on the adolescent population, and particularly on the very low-socioeconomic group is uncertain. According to data from the OECD, in 2014 the proportion of Mexicans 15-19 years old enrolled in education was 53 percent (OECD 2014). Furthermore, unemployment rates for this group are high, with more than 20 percent of 15 to 29 year-old Mexicans neither employed nor in education or training.

Another restriction particular to the Mexican SSBs tax case is the evaluation of the competitive markets in the policy context. Coca-Cola could have some monopolistic behavior and thus affect elasticity of demand (Jeffrey 2016). A successful monopoly would have a relatively inelastic demand curve. Those could explain additional Aguilar et al, 2016 findings that consumer often substituted sugary beverages for the same products but in different containers. Another consideration is that if the definition of the good is broad, elasticity will be lower. For example, food in general has a low elasticity, whereas a specific product has higher elasticity. It is possible that in this analysis the decline in soda consumption results from a more elastic aggregation of all soda brands. It could be interesting from a policy perspective to

compare particular products and brands of sugary beverages. In addition, soda prices vary significantly across brands. Industry efforts to reformulate might also play an important role. Reformulation targets might have an impact in total energy and sugar intake of adolescents. It is possible that differences in consumption occur across brands and are not reflected in these study results.

It is possible that by the time of the 2016 survey, communication efforts and campaigns might have had some effect in the dietary patterns of Mexicans, particularly of sodas given the SSB tax. It is also possible that campaign effort to pass the policy affected perception on soda intake and SSBs consumption. However, these campaign efforts would have been dominant in the capital, Mexico City, and also less observed by the very low socio-economic group. Secretary of Health, Dr. José Narro Robles took office in February 2016 and stated the fundamental role media can play in order to help spread health communication as well as the participation and further responsibility for the civil society (“Mensaje Del Secretario de Salud, José Narro Robles” 2016).

Research Limitations

Given that the tax was implemented nationally, there is difficulty in conducting an experimental study because there is no true control group. Other scholars have recognized the limitation to construct a true experimental design to analyze the association between the SSBs tax and SSBs purchases (M. Arantxa Colchero et al. 2016). Furthermore, confounding is a key difficulty in observational studies (Freedman 2006). In this study, there are important limitations from the descriptive statistics results and the differences-in-differences estimation. It should be stressed that the two-sample tests are limited and do not account for any other variables known to

influence consumption, e.g. income, price, season, etc. In addition, both surveys were conducted in different time periods and months of the year, thus not accounting for any seasonality trends in soda consumption. The differences-in-differences estimator is relatively weak given the lack of panel data and additional control variables e.g. education level.

One of the most important features of different research methods is being able to estimate consumer heterogeneity, as these descriptive results show that different demographic characteristics might influence the adolescent response to the tax. A paper by Wang, shows results that suggest that populations characterized by higher rates of obesity are more sale sensitive and more likely to stockpile soda (Wang 2015). Therefore, SSBs taxes can have important consumer welfare implications and in the Mexico case, it is possible that the overweight and obese adolescents even from the lower socioeconomic status where adjusting their consumption bundles to sustain soda intake.

It is important to consider that the tax does not cover all SSBs that Mexicans consume. A previous analysis of ENSANUT 2012 found that energy contribution of all SSBs, including homemade coffee or tea with sugar and agues frescos (sweetened and blended multi-ingredient beverages), was 9.8 percent kcal (Aburto et al. 2016). This analysis is also limiting because it only covers the caloric soft drink consumption patterns.

Finally, the Food Frequency Questionnaire methodology (FFQ) can both over and underestimate food and dietary intake. This occurs principally due to desirability response bias. One of the advantages of this study is that both surveys from before and after the tax analyze the consumption patterns using the same FFQ methodology. The limitations of this study include those related to self-response biases and measurement errors. In addition, this research utilized food consumption as opposed to dietary intakes. Although the FFQ method controls for portion

sizes, different types of soda might have different sugar content and caloric content. These differences could be further analyzed by replicating this study and utilizing soft drink calories (or total sugar content) as opposed to average total consumption per day in mL per day.

Nevertheless, there are important methodological advantages by the use of secondary data. In addition, descriptive statistics results show that both samples, before and after the tax, are relatively similar. Given that both surveys utilize the same sampling method, this research has a broader external validity.

Further analysis can focus on utilizing the nutrition surveys to evaluate the total caloric intake relationships to the tax and potential substitutions. A preliminary paper by Aguilar et al., (2015) conclude that the consumption of total calories do not change significantly as a result of the tax policy. An important research area is whether consumer “seem to have changed their consumption bundle in such ways that their total calorie intake was not reduced” (Aguilar, Gutierrez, and Seira 2016).

Policy Recommendations

This research provides an overall picture of the impact SSBs taxes can have on dietary patterns. Given that overweight and obese adolescents seem to be less responsive to the tax, these group of adolescents would benefit from an increase in public health expenditure, particular investments in programs that treat and prevent obesity and diabetes. The federal nature of the tax policy directs all revenues directly to the general budget. Therefore, tax revenue requires a stronger and more accountable utilization.

Furthermore, additional incentives should be analyzed in order counteract the impact of the tax on the normal weight and female adolescent population and shift the burden to the overweight and obese populations. One strategy that other researchers have analyzed is to provide cash incentives to buy healthy foods. For example, results from South Africa show that rebates of 10 percent for healthy foods are associated with an increase in the ratio of healthy food expenditures (Sturm et al. 2013).

The Mexican government has not announced any specific plan to cover the low-income population in relation to the potential impact of the SSBs tax. It has been estimated that collection of the SSBs taxes and high energy food taxes in 2014 account for MXN 124,016,000 million (PAHO 2015). According to the differences-in-differences finding, further research should focus on the impact of the SSBs among lower income populations, particularly in the south of the country.

Further studies can catalyze the dietary patterns in other age groups before and after the SSBs tax. In Mexico, Pre-school and school children seem to obtain less of their total energy intake from whole milk, and increasing intake of sugar-sweetened beverages (Simon Barquera et al. 2010). Therefore, an analysis of the impact of the tax among children is also necessary. In a 2017 report the National Academy of Medicines supported and encouraged governments and policymakers to adapt sugary drink taxes to prevent childhood obesity. Researchers and policymakers have recognized the complexity of the childhood obesity problem in Latin America and conclude that to tackle this issue will require “a set of multisector, multilevel policies based on the best available evidence.” (Pérez-Escamilla et al. 2017). In relation, authors in a commentary call for a need to better understand the *policy process* underlying the development and implementation of SSBs. A multidimensional and evidence-based approach is necessary to

solve the rising overweight, obesity and related health disease crisis in the Mexican adolescents and the wider population.

Conclusions

This paper has demonstrated the potential to evaluate the Mexican SSBs tax utilizing data from the health and nutrition surveys. Employing original data bases and exploring a variety of methods is important in order to monitor, evaluate and implement better policies that yield significant health outcomes. Different methods allow results to be compared and contrasted with existing studies.

Results indicate that there is a significant relationship in the female consumption of caloric soda and the SSBs tax. Given, the higher rates of obesity and overweight among adolescent females this result is of major importance for policymakers and public health institutions in Mexico. Additionally, further research would be necessary to observe an expected decrease in the prevalence of overweight and obesity among females given this fall in soda consumption, and assuming no significant caloric substitution. In addition, the drop in soft drink consumption seems to be only present among the very low socioeconomic status urban residents, that are normal weight. The relationship between the SSBs tax and the lower income population can result in slowing down the incidence of overweight and obesity among this group of adolescents.' Given that previous research has shown a shifting trend in the prevalence of overweight and obesity towards the lower socioeconomic population group, these results require further equity analysis on the overall dietary caloric intake in relationship to the SSBs tax.

Lastly, this research suggests there is a lack of significant impact of the SSBs among the overweight and obese adolescents. Thus, the potential of the tax seems promising among the

normal weight population and as a preventative measure of obesity and overweight. However, other policy tools are recommended to combated overweight and obesity rates among adolescents, and particularly among the males who appear to be less responsive to the SSBs tax. Other policies including healthy foods rebates and subsidies should also be evaluated as an effort to compensate the impact of the tax among lower income populations.

Evidence and learnings from the Mexican tax policy will continue to gain global attention. Further research on the relationship between SSBs taxes, dietary patterns and health outcomes among adolescents should remain studied.

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