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After Mexico Implemented a Tax, Purchases of Sugar-Sweetened Beverages Decreased and Water Increased: Difference by Place of Residence, Household Composition, and Income Level

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Abstract

Background: In January 2014, Mexico implemented a tax on sugar-sweetened beverage (SSB) purchases of 1 peso/L.
Objective: We examined the heterogeneity of changes in nonalcoholic beverage (SSB and bottled water) purchases after the tax was implemented by household income, urban and rural strata, and household composition.
Methods: We used 4 rounds of the National Income and Expenditure Surveys: 2008, 2010, 2012, and 2014. Changes in purchases in per capita liters per week were estimated with the use of 2-part models to adjust for nonpurchases. We compared absolute and relative differences between adjusted changes in observed purchases in 2014 with expected purchases in 2014 based on prior trends (2008–2012). The models were adjusted for sociodemographic characteristics of the households, place of residence, and lagged gross domestic product per capita.
Results: We found a 6.3% reduction in the observed purchases of SSBs in 2014 compared with the expected purchases in that same year based on trends from 2008 to 2012. These reductions were higher among lower-income households, residents living in urban areas, and households with children. We also found a 16.2% increase in water purchases that was higher in low- and middle-income households, in urban areas, and among households with adults only.
Conclusions: SSB purchases decreased and water purchases increased after an SSB tax was imposed in Mexico. The magnitude of these changes was greater in lower-income and urban households. *J Nutr* 2017;147:1552–7.

Keywords: sugar-sweetened beverages, bottled water, taxes, Mexico, household purchases

Introduction

Several systematic reviews and meta-analyses have shown positive associations between the consumption of sugar-sweetened beverages (SSBs) and weight gain, diabetes, and other chronic diseases (1–4). As a consequence, the WHO recommended limiting the amount of added sugars to ≤10% of total energy intake (5). In Mexico, added sugars represent 12.5% of total energy intake, which is above the recommendation. SSBs represent 70% of total added sugars in the diet (6, 7). Taxes have been proposed as a policy to discourage SSB consumption through increases in prices (8).

In the context of high SSB consumption, an excessive burden of overweight and obesity (which reached 70% of adults and 30% of children in 2012) and a high prevalence of diabetes (9–11), Mexico implemented a 1-peso/L excise tax to all SSBs with added sugars in 2014 (12). The tax excludes 100% fruit juices and all beverages with added artificial sweeteners.

Other countries have implemented taxes on SSBs, such as Denmark, Hungary, France, Chile, and the United States. However, few evaluations have been conducted to assess changes in consumption or purchases or sales. Two evaluations from Berkeley, California, have shown reductions in the frequency of consumption in low-income households and reductions in sales as well as increases in untaxed beverage sales (13, 14). A recent report from France showed a 6.7% reduction in the demand for regular sodas and 6.1% for low-calorie beverages 2 y after an excise tax on SSBs and non-SSBs was implemented (15).

In Mexico, several evaluations have shown reductions in the purchases or sales of SSBs after the tax was implemented as well

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as increases in untaxed beverages or bottled water (16–18). Two studies (16, 18) revealed that reductions in the purchases of SSBs were larger among the lowest socioeconomic groups.

To our knowledge, no other studies have been published that have assessed other differential effects of the tax, such as place of residence and household composition. In particular, 2 of the studies previously mentioned (16, 18) relied on data from a panel of households in areas with ≥50,000 inhabitants. To our knowledge, this is the first study that uses nationally representative surveys to evaluate changes in beverage purchases in urban and rural areas. The usage of these surveys is highly relevant because potential changes in beverage purchases associated with the tax may be different in rural areas than in urban settings, and evidence suggests that in less-populated areas the tax passed through prices incompletely (prices increased less than the amount of the tax), so the effect on consumption may have been lower (19). Analyzing how beverage purchases changed over time in households with children and adolescents is also highly important because the consumption of added sugars and caloric beverages in these age groups is high and has been increasing (20). Moreover, the analysis relies on publicly available data collected by the National Institute of Geography and Statistics that has consistently assessed, with a comparable methodology, household income and expenditure data for the country since 1992.

We sought to estimate how purchases of nonalcoholic beverages (SSBs and bottled water) changed after the SSB tax was implemented and to explore the heterogeneity of these changes by household income, urban and rural strata, and household composition with the use of 4 rounds of cross-sectional nationally representative surveys. We compared absolute and relative differences between adjusted changes in observed purchases in 2014 with expected purchases in 2014 based on prior trends (2008–2012).

Methods

Data sources. We used 4 rounds of ENIGH (National Income and Expenditure Survey): 2008, 2010, 2012, and 2014 (21). ENIGH has a 2-stage stratified probabilistic design. The survey is representative at the national level and urban and rural strata. The surveys are collected every 2 y between August and November. Several questionnaires are applied during 7 d in each household. On the first day, enumerators train the household member responsible for purchasing food and beverages to complete the daily expenditures section. Enumerators also interview other members of the household (except children aged <12 y) to obtain information on individual purchases and other information. Daily food and beverage expenditures are collected for 1 wk, including the monetary value of gifts, transfers, and consumption of household-produced foods. The sample number of dwellings varies by year: 35,146 in 2008; 30,169 in 2010; 10,062 in 2012; and 21,427 in 2014.

Empirical estimation and variables. We estimated changes in beverages purchased in a 2-part model to account for potential biases if households with 0 purchases were not considered (22). We used a 2-part model to estimate changes in beverage purchases. We chose the 2-part model instead of Heckman or Tobit models for 3 reasons. First, 2-part models provide an appropriate method for estimating data with a considerable number of zeros (23). Second, our data were not censored because zeros in ENIGH truly represent no purchases in a specific food or beverage item at the time of the survey (22). Third, evidence suggests that the 2-part model produces better estimates than the Tobit model (22).

In the first part of the 2-part model, a probit regression was estimated with the complete sample in which the dependent variable was 1 if beverage purchases were >0. The independent variable was a dummy variable that equaled 1 if the survey round was 2014 and 0 for rounds 2008, 2010, and 2012, adjusting for other covariates. In the second part, the model estimated beverage purchases only for households with purchases greater than zero with the use of a generalized linear model in which the dependent variable was the logarithm of beverage purchases in per capita liters per week as a function of the same dummy-round variable as in the first part to indicate the year the SSB tax was implemented, adjusting for other covariates. For both parts of the model, we obtained the predicted values (predicted probabilities of purchasing and predicted purchases before and after the tax was implemented). We then multiplied the predicted probabilities and predicted purchases (back-transformed from logarithm to level) to account for zero beverage purchases. To estimate changes in purchases observed in 2014 compared with expected purchases (based on the predicted values for 2008–2012 in 2014), we computed the absolute and relative differences between the adjusted predicted values for 2014 and the predicted values for the 3 previous rounds in 2014. We tested whether the absolute and relative differences were statistically significant ($\alpha < 0.05$) with the use of a t test for equality of means. These estimations provided a comparison of observed and expected changes in beverage purchases in which the expected changes reflected what would have happened if the tax was not implemented based on purchased trends between 2008 and 2012. We stratified the models by household income, urban and rural strata, and household composition to test for heterogeneity in changes in beverages among different groups. For descriptive analysis and models, we used the survey design as weights to obtain data representative at the national level and to correct SEs for complex survey designs.

The dependent variable was weekly purchases of beverages (SSBs or water) in per capita liters per week, which was estimated by dividing for each beverage the total liters purchased by the household by the number of members of the household. SSBs included diet or low-calorie sodas, fruit juices with added sugar, flavored water, and energy drinks. We were able to exclude untaxed 100% fruit juices from the SSB category because these beverages were reported in a different category in the survey. Water included plain and sparkling bottled water.

We adjusted the models for household income, place of residence, household composition, education of the head of the household, household size, and month of the interview to adjust for seasonality. We also included a per capita lag of the gross domestic product as a macroeconomic variable to capture structural changes in the economy as well as the availability of resources, goods, and services that could have modified consumption decisions. Household income was estimated as the sum of all sources of income reported by the members of the household. We then created tertiles of income and grouped them as low, medium, and high. Place of residence equaled 1 if the household was located in an urban area and 0 if rural (<2500 inhabitants). For household composition, we distinguished 4 types of households: those with adults only, those with all age ranges, those with adults and children only, and those with adults and adolescents only. We included education of the head of the household. The models were also adjusted for per capita quarterly gross domestic product to account for macroeconomic changes associated with the demand for beverages. We lagged the per capita gross domestic product (previous year, same quarter) because the effect of economic growth on the demand for beverages is not simultaneous.

The analytical sample for the analysis included 85,118 households with complete information on all variables. Households that did not report on any beverage or food expenditures were excluded from the analysis (486 of 85,604). We tested whether there were differences between the analytical sample and households that were excluded from the analysis. Excluded households had a lower income, lower education of the head of the household, and lower household size and were more likely to be in rural areas than those in the analytical sample. Although the potential biases associated with these exclusions for the overall results are unknown, because we ignored the reasons for the nonresponse on expenditures, the proportion of households excluded and sociodemographic characteristics in each round was similar, so the samples across rounds were comparable.

Results

Table 1 presents the descriptive statistics (unadjusted) for all variables included in the analysis. For SSBs, we observed lower mean quantities purchased in 2014 than previous rounds, and the proportion that reported positive purchases was lower in 2014. Purchases of bottled water and the proportion of purchasers were higher in 2014. Across all survey rounds, we observed that ~78% of the households in the sample were located in urban areas. Most of the households were headed by persons with a primary or middle-school education. The proportion of household heads with a university or higher level of education increased over time, and the proportion of household heads with only a primary education decreased.

Supplemental Tables 1 and **2** compare the mean purchases and proportion of purchasers in rounds 2008, 2010, and 2012 with 2014 for the complete sample and by income, place, or residence and type of household.

The first part of the 2-part model shows that the probability of purchasing SSBs decreased by 2.3% in 2014 compared with the previous rounds (2008–2012). In contrast, the probability of purchasing bottled water increased 3.1% in 2014 (**Supplemental Table 3**). For SSBs and water, the probability of purchasing was higher for middle- and high-income groups and for those living in urban areas; it also increased with the education of the head of the household and gross domestic product per capita.

Table 2 shows the predicted values from the second part of the 2-part model weighted by the probability of purchasing from the first-part model to estimate changes in beverages. Results show a reduction of 6.3% in observed SSB purchases compared with expected purchases in 2014 (based on the 2008–2012 trend). We also found a 16.2% increase in bottled water purchases. Supplemental Table 3 presents the coefficients from the first- and 2-part model.

Table 3 displays the results stratified by household income, place of residence, and household composition. Low-income households had the greatest reductions in SSB purchases (−10.3%) as well as increases in purchases of bottled water. Reductions in SSB purchases were higher in urban areas (−6.9%) than in rural areas (−3.9%); bottled water purchases were higher in urban areas. In households with children, the reduction in SSB purchases was higher than households with adults only. Purchases of bottled water were higher among households with adults only.

Discussion

We estimated changes in household purchases of SSBs and bottled water with the use of 4 rounds of a nationally representative survey in Mexico. In both descriptive and regression-adjusted estimates, we found that SSB purchases decreased and bottled water purchases increased in 2014. Results show a 6.3% reduction in observed purchases of SSBs in 2014 compared with expected purchases based on trends from 2008 to 2012. We also found a 2% reduction in the probability of purchasing SSBs during the posttax period. These reductions were higher among lower-income households, residents living in urban areas, and households with children. For bottled water, we found a 16.2% increase in purchases in 2014 that was higher in low- and middle-income households and urban areas and among households with adults only. In addition to an increase in the amount

TABLE 1 Descriptive statistics of 75,954 households by round[1]

Variable	2008	2010	2012	2014
SSB purchases				
All, per capita L/wk	1.12 ± 0.014	1.11 ± 0.016	1.14 ± 0.023	1.06 ± 0.015
Purchasers only, per capita L/wk	1.6 ± 0.016	1.63 ± 0.020	1.66 ± 0.026	1.59 ± 0.019
Proportion of purchasers	70.00 ± 0.005	67.90 ± 0.005	68.30 ± 0.009	66.50 ± 0.005
Bottled water purchases				
All, per capita L/wk	2.94 ± 0.068	2.81 ± 0.072	2.99 ± 0.112	3.43 ± 0.082
Purchasers only, per capita L/wk	8.87 ± 0.131	8.94 ± 0.144	9.04 ± 0.218	9.5 ± 0.142
Proportion of purchasers	33.20 ± 0.006	31.40 ± 0.005	33.10 ± 0.009	36.20 ± 0.006
Quarterly household income in 2010 Mexican pesos	42,029 ± 584.08	37,159 ± 412.31	37,618 ± 918.14	36,177 ± 864.32
Place of residence, % urban	78.60 ± 0.006	78.60 ± 0.006	78.10 ± 0.005	78.00 ± 0.002
Household composition				
Adults only	32.30 ± 0.004	34.40 ± 0.004	36.80 ± 0.008	35.90 ± 0.005
Adults and children only	28.40 ± 0.004	27.80 ± 0.004	27.70 ± 0.007	28.30 ± 0.004
Adults and adolescents only	15.90 ± 0.003	15.40 ± 0.003	15.60 ± 0.005	15.10 ± 0.003
All age ranges	23.30 ± 0.004	22.40 ± 0.004	19.80 ± 0.006	20.70 ± 0.004
Household size, *n*	4.0 ± 0.019	3.8 ± 0.020	3.7 ± 0.031	3.8 ± 0.019
Education of head of household				
No education	9.60 ± 0.003	9.20 ± 0.003	8.90 ± 0.004	7.90 ± 0.003
Primary	40.40 ± 0.006	38.30 ± 0.005	36.20 ± 0.008	34.20 ± 0.006
Middle school	25.10 ± 0.004	26.10 ± 0.004	27.20 ± 0.007	27.50 ± 0.005
High school	11.30 ± 0.003	11.20 ± 0.003	12.80 ± 0.005	14.70 ± 0.004
≥University	13.50 ± 0.003	14.50 ± 0.003	14.80 ± 0.007	15.60 ± 0.004
Per capita gross domestic products[2]	126,381	118,960	128,368	125,850
Observations	27,770,738	29,446,924	31,396,337	31,552,971

[1] Values are percentages ± SEs, unless otherwise indicated. Values were estimated with the use of ENIGH 2008–2014. All estimations were weighted with the use of the survey design. ENIGH, National Income and Expenditure Survey; SSB, sugar-sweetened beverage.
[2] The variable is aggregated at the national and year level therefore it does not vary by round and SEs are not provided.

TABLE 2 Expected and observed purchases of SSBs and bottled water in 2014[1]

Variable	SSBs	Bottled water
Expected purchases, per capita L/wk	1.12 ± 0.003	2.92 ± 0.010
Observed purchases, per capita L/wk	1.05 ± 0.003	3.39 ± 0.012
Absolute change, per capita L/wk	−0.07** ± 0.000	+0.50** ± 0.003[2]
Relative change, %	−6.3** ± 0.006	+16.2** ± 0.036[2]

[1] Values are means or percentages ± SEs. Values were estimated with the use of ENIGH 2008–2014 and adjusted for household income, place of residence, household composition, household size, month of the interview, education of the head of the household, and per capita lagged gross domestic product. The second-stage estimation from a 2-part model used generalized linear models. All estimations were weighted with the use of the survey design. **$P < 0.001$. ENIGH, National Income and Expenditure Survey; SSB, sugar-sweetened beverage.
[2] Expected purchases (predicted values) were based on prior trends (2008–2012).

purchased, the probability of purchasing bottled water increased by 3%.

For SSBs, the 6.3% reduction in 2014 is similar to other studies that used different models and data sets as well as to those that have shown that the greatest reduction was among the lowest-income households (16, 17).

The lower reduction in SSB purchases in rural compared with urban areas could be associated with the incomplete pass-through prices in rural settings (prices in 2014 increased less than the amount of the tax of 1 peso/L) (19). In contrast, evidence has shown that the SSB tax passed completely through prices in urban areas in which there was a larger reduction in SSB purchases (24).

Although the data set lacked information on individual consumption, our findings of larger reductions among households with children may suggest that their consumption decreased, which is relevant given the high and increasing levels of consumptions in these age groups (7, 20). Other surveys with information on individual consumption will be needed to confirm these results.

We acknowledge that the adjusted 16.2% increase in purchases of water found in this study is larger than other studies that have documented smaller but substantial increases in untaxed beverages (16, 18) and water (17), suggesting a potential substitution from SSBs to water after the tax was implemented. A potential explanation is that unadjusted purchases of bottled water in ENIGH were larger than the other data sets used in the cited studies. For 2012, per capita purchases of water were ~3 L/wk, which gives 144 L/y. National sales of water reported in one of the studies (17) were lower (57 L per capita in 2012) because it only included water produced by the industry that produces SSBs. Our figures are closer to Euromonitor on-and-off trade volumes of bottled water in 2012 estimated at 182 L per capita (25). In addition, data from the Monthly Surveys of the Manufacturing Industry showed that the proportion of sales of bottled water among all beverages increased during the posttax period, whereas the proportion of SSBs decreased (data not shown), supporting the hypothesis of substitution from SSBs to water (26). Although switching from SSBs to bottled water represents a healthier option for the population, the production and waste of plastic bottles for water represent an environmental threat similar to SSBs.

Smaller increases in water purchases in rural areas than in urban settings may be related to the lower availability of bottled water; however, to our knowledge, there is no evidence to support this hypothesis. Another potential factor is differences in consumer preferences because a qualitative study (27) found that bottled water is seen as a good that is not worthy enough to be purchased compared with sodas or other beverages. Despite a larger reduction in SSB purchases in households with children, we found a smaller increase in water among them. These households may have substituted for beverages not reported in the data set such as potable water or other homemade beverages. More information on individual consumption from other surveys will be needed to study more in depth potential substitutions among children.

This study has some limitations. We recognize that ENIGH did not allow us to differentiate between taxed and untaxed beverages. The SSB category includes untaxed beverages such as sodas or flavored waters with artificial sweeteners. However, untaxed beverages in the SSB category represented only 6% of total beverages sales, and there were no substantial increases after 2014 (17).

TABLE 3 Absolute and relative changes in observed and expected purchases of SSBs and bottled water in 2014[1]

	SSBs		Bottled water	
Stratification	Absolute, per capita L/wk	%	Absolute, per capita L/wk	%
Household income				
Low	−0.09** ± 0.001	−10.3** ± 0.011	+0.52** ± 0.004	+21.7** ± 0.049
Medium	−0.04** ± 0.000	−3.7** ± 0.005	+0.59** ± 0.004	+20.3** ± 0.017
High	−0.07** ± 0.000	−5.8** ± 0.001	+0.35** ± 0.002	+9.6** ± 0.008
Place of residence				
Urban	−0.08** ± 0.000	−6.9** ± 0.006	+0.58** ± 0.002	+18.2** ± 0.015
Rural	−0.03** ± 0.000	−3.9** ± 0.007	+0.48** ± 0.000	+2.4** ± 0.022
Household composition				
Adults only	−0.03** ± 0.000	−2.4** ± 0.003	+0.91** ± 0.002	+22.2** ± 0.041
Adults and children only	−0.10** ± 0.000	−11.0** ± 0.009	+0.25** ± 0.000	+10.5** ± 0.024
Adults and adolescents only	−0.11** ± 0.000	−10.4** ± 0.010	+0.33** ± 0.000	+11.5** ± 0.037
All age ranges	−0.10** ± 0.000	−11.6** ± 0.020	−0.01** ± 0.000	−0.1** ± 0.014

[1] Values are means or percentages ± SEs. Values were estimated with the use of ENIGH 2008–2014 and adjusted for household income, place of residence, household composition, household size, month of the interview, education of the head of the household, and per capita lagged gross domestic product. The second-stage estimation from a 2-part model used generalized linear models All estimations were weighted with the use of the survey design. **$P < 0.001$. ENIGH, National Income and Expenditure Survey; SSB, sugar-sweetened beverage.

As discussed elsewhere (28), beverage purchases may have been underestimated in ENIGH, but there is no reason to believe that underreporting changed across rounds. In addition, like any income and expenditure survey, the consumption of potable water or any homemade beverage was not reported.

Finally, we acknowledge that in the absence of an experimental design and given that we used cross-sectional surveys, our results should be interpreted as associations rather than causal effects.

The observed reductions in SSB purchases and the increases in purchases of bottled water may have an effect on nutrition and health. Although calories could be linked to the ENIGH data, the information would lack precision because beverages were aggregated in broad categories and untaxed beverages were included. In addition, the effects of the tax on nutrition should be evaluated, taking into consideration both the effect on total energy intake and on the quality of the diet. A recently published simulation model showed potential cases of averted diabetes and other chronic diseases and economic savings (29).

Our article provides novel estimations on the heterogeneity of changes in household purchases of SSBs and water in 2014 when the SSB tax was implemented in Mexico. Our results provide relevant information for public policies aimed at reducing the consumption of caloric beverages. For instance, other interventions should be implemented in rural areas in which reductions in SSB purchases and increases in water were lower than in urban areas, such as the provision of potable water, front-of-pack labeling, or any other educational program. Similarly, strategies targeted toward children and adolescents to increase the consumption of water should be developed. Finally, despite the potential health benefits of switching from SSBs to healthier beverages such as bottled water as found in this and other studies, Mexico is one of the largest consumers of bottled water in the world (30), despite the relatively high availability of drinking water (31). Potable water should be available as an affordable healthier beverage option, particularly for low-income households.

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