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Beverage purchases from stores in Mexico under the excise tax on sugar sweetened beverages: observational study

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ABSTRACT

STUDY QUESTION

What has been the effect on purchases of beverages from stores in Mexico one year after implementation of the excise tax on sugar sweetened beverages?

METHODS

In this observational study the authors used data on the purchase of beverages in Mexico from January 2012 to December 2014 from an unbalanced panel of 6253 households providing 205 112 observations in 53 cities with more than 50 000 inhabitants. To test whether the post-tax trend in purchases was significantly different from the pretax trend, the authors used a difference in difference fixed effects model, which adjusts for both macroeconomic variables that can affect the purchase of beverages over time, and pre-existing trends. The variables used in the analysis included demographic information on household composition (age and sex of household members) and socioeconomic status (low, middle, and high). The authors compared the predicted volumes (mL/capita/day) of taxed and untaxed beverages purchased in 2014—the observed post-tax period—with the estimated volumes that would have been purchased if the tax had not been implemented (counterfactual) based on pretax trends.

STUDY ANSWER AND LIMITATIONS

Relative to the counterfactual in 2014, purchases of taxed beverages decreased by an average of 6% (–12 mL/capita/day), and decreased at an increasing rate up to a 12% decline by December 2014. All three socioeconomic groups reduced purchases of taxed beverages, but reductions were higher among the households of low socioeconomic status, averaging a 9% decline during 2014, and up to a 17% decrease by December 2014 compared with pretax trends. Purchases of untaxed beverages were 4% (36 mL/capita/day) higher than the counterfactual, mainly driven by an increase in purchases of bottled plain water.

WHAT THIS STUDY ADDS

The tax on sugar sweetened beverages was associated with reductions in purchases of taxed beverages and increases in purchases of untaxed beverages. Continued monitoring is needed to understand purchases longer term, potential substitutions, and health implications.

FUNDING, COMPETING INTERESTS, DATA SHARING

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Introduction

Myriad studies suggest that added sugar in beverages is linked with obesity and many cardiometabolic problems and have recommended that efforts to reduce consumption of sugar sweetened beverages to obtain meaningful improvement to health would require a tax that leads to price increases.^{1–7} Aside from industry funded studies, the consensus from a large literature of randomized controlled trials,⁸ longitudinal cohort studies, and smaller clinical studies is that humans do not reduce food intake when consuming caloric beverages. The lack of dietary compensation is hypothesized to be due to form (liquid versus solid), beverage type (for example, carbohydrate content, fat content), and resultant release of hormones such as ghrelin and insulin.⁹ Therefore, reducing the intake of sugar sweetened beverages could reduce body weight and many cardiometabolic problems.^{5 10–12}

The likelihood of obesity among Mexicans of all ages is high.^{13 14} The prevalence of overweight and obesity is more than 33% for young people aged 2–18 years (about the same across all age groups) and around 70% for adults (half of whom are obese).^{15–17} The prevalence of diabetes in Mexico (based on hospital admissions) is the highest among the Organization for Economic Cooperation and Development countries,¹⁸ and ischemic heart disease and diabetes are the two leading causes of mortality in Mexico.¹⁹ Additionally, the prevalence of overweight and obesity increased by 12% between 2000 and 2006 and reached 72% among adults in 2012.¹⁴ Concomitant with the rise in obesity and diabetes in Mexico are large increases in the consumption of sugar sweetened beverages^{20 21}—Mexico had the largest per capita (163 liters) intake of soft drinks in 2011. Several studies showed that before the debate over this tax the intake of sugar sweetened beverages was rapidly increasing in Mexico.^{20–22} Reducing such consumption has been an important target for obesity and diabetes prevention.^{23 24} A Ministry of

WHAT IS ALREADY KNOWN ON THIS TOPIC

Mexico has one of the highest prevalence rates for diabetes, overweight, and obesity in the world

Reducing the consumption of sugar sweetened beverages has been an important target for obesity and diabetes prevention efforts

Mexico implemented an excise tax of 1 peso/L on sugar sweetened beverages from 1 January 2014

WHAT THIS STUDY ADDS

During the first year of the tax, the average volume of taxed beverages purchased monthly was 6% lower in 2014 than would have been expected without the tax

The reduction was greatest among the households of the lowest socioeconomic status

Health beverage guidance panel had proposed a tax years earlier and it was endorsed, among others, by many medical societies.²⁴

In September 2013, as part of the federal budget, the Mexican congress passed an excise tax on sugar sweetened beverages and a sales tax on several highly energy dense foods.²⁵ A specific excise tax of 1 peso/L (approximately a 10% price increase based on 2013 prices) on non-dairy and non-alcoholic beverages with added sugar and an ad valorem tax of 8% on a defined list of non-essential highly energy dense foods (containing ≥ 275 calories (1151 kJ) per 100 g) came into effect on 1 January 2014. Agencies collect the excise tax on sugar sweetened beverages from the manufacturers, and other research indicates that this tax is entirely passed on to consumers at the point of sale. Prices of sugar sweetened beverages increased on average by 1 peso/L in 2014 (exactly the amount of the tax), and these changes in prices, which began in the tax's first month, were observed throughout the year.^{26,27} Using scanned and recorded food purchase data from a representative group of Mexican households in cities with more than 50 000 residents from January 2012 through December 2014, we evaluated changes in the purchases of consumer beverages after the implementation of the excise tax.

Methods

We obtained data on purchases from January 2012 through December 2014 from Nielsen Mexico's Consumer Panel Services, which is equivalent to the data from the US Nielsen Homescan panel.²⁸ In the US, Nielsen Homescan data have been used in several studies, including some that have linked purchases to data on nutrition labels to determine the caloric content of purchases and to evaluate industry efforts.^{29,30} However, linking purchases to nutrition data is currently not possible in Mexico owing to the lack of comprehensive data sources related to labeling. Therefore we focused on changes in the volumes of beverages purchased.

Each year the Nielsen Mexico Consumer Panel Services samples Mexican households in 53 cities (in 28 states plus Mexico City) with more than 50 000 inhabitants. Based on government statistics, this sample represents 63% of the Mexican population and 75% of food and beverage expenditures in 2014.³¹ The original dataset contained 205 827 household-month observations from 6286 households. We used complete case analysis; 715 observations (0.3%) were dropped because of missing information on the highest educational attainment of the heads of the households. Consequently, our analytic sample included 205 112 household months across 6253 households, of which 86% participated in all rounds. Each household is weighted based on household composition, locality, and socioeconomic measures through iterative proportional fitting to match demographic estimates from the National Institute of Statistics and Geography (Instituto Nacional de Estadística Geografía e Informática, INEGI). Enumerators visited the households every two weeks to collect diaries, product packaging from special bins provided

for this study (scanned by the enumerators), and receipts, and to carry out pantry surveys. Bar code information provided all other data.

For descriptive purposes, we categorized the sample into the six regions used by INEGI: central north, central south, Mexico City, north east, north west, and south. The variables we used in the analysis included demographic information on household composition (age and sex of each household member) and socioeconomic status; information that is updated annually. Socioeconomic status groups (low, middle, and high) were based on a six category measure derived from annually updated questions on household ownership of assets (for example, number of bathrooms, number of bedrooms, number of vehicles owned) and education attainment of the head of the household. Onto the Nielsen Mexico Consumer Panel Services data we overlaid two contextual measures: the state's quarterly unemployment rate from INEGI,³² and the two economic minimum daily salary for each year from Mexico's National Commission of Minimum Salaries³³ (after adjusting for state and quarter specific inflation from INEGI's consumer price indices, www.inegi.org.mx/est/contenidos/proyectos/inp/inpc.aspx).

In this analysis we used the purchase of beverages by each household between 1 January 2012 and 31 December 2014. Data from the Nielsen Mexico Consumer Panel Services include the number of units purchased and the volume and price of each unit. From these we totalled the monthly volume and beverage categories each household purchased across each of the 36 months. Then we calculated the volume per capita per day for interpretability. Our beverage categories followed the 2012 National Health and Nutrition Survey (Encuesta Nacional de Salud y Nutrición) groupings for beverage intake as much as possible;^{22,34} these were further grouped into larger categories or subgrouped as described in supplemental table 1. We classified products into beverage categories in 2014 based on product descriptions and sources available on the internet and in stores. In this study we focus on the top level taxed and untaxed beverages. Our two categories for taxed beverages were carbonated sodas and non-carbonated sugar sweetened beverages, and our three categories for untaxed beverages were carbonated drinks such as diet sodas; sparkling, still, or plain water; and other drinks, including unsweetened dairy beverages and fruit juices. The Consumer Panel Services did not collect information on purchases of dairy products from all of the sampled households until October 2012 (personal communication). Therefore we limited our analyses of the categories "other untaxed drinks" and "overall untaxed beverages" to October 2012 through December 2014.

Patient involvement

No patients were involved in setting the research question or outcome measures, nor were they involved in the design and implementation of the study. There are no plans to involve patients in the dissemination of results.

Table 1 | Weighted descriptive statistics of analytic sample from Nielsen Mexico Consumer Panel Services. Values are weighted means* (standard errors) unless stated otherwise

Characteristics	2012	2013	2014
No of sample households	5813	5775	5657
No of projected households*	16 215 694	16 419 030	16 618 996
Household socioeconomic status (%):			
Low	20.2	23.4	25.2
Middle	58.0	52.7	51.5
High	21.8	23.9	23.3
Household composition, by sex and age:			
Boys (0-1 year)	0.20 (0.01)	0.14 (0.01)	0.05 (0.01)
Girls (0-1 year)	0.18 (0.01)	0.11 (0.01)	0.05 (0.01)
Boys (2-5 years)	0.21 (0.01)	0.22 (0.01)	0.27 (0.01)
Girls (2-5 years)	0.21 (0.01)	0.19 (0.01)	0.22 (0.01)
Boys (6-12 years)	0.35 (0.01)	0.35 (0.01)	0.36 (0.01)
Girls (6-12 years)	0.34 (0.01)	0.33 (0.01)	0.34 (0.01)
Male adolescents (13-18 years)	0.32 (0.01)	0.33 (0.01)	0.34 (0.01)
Female adolescents (13-18 years)	0.36 (0.01)	0.36 (0.01)	0.37 (0.01)
Men	1.70 (0.02)	1.83 (0.02)	1.93 (0.03)
Women	1.87 (0.02)	2.01 (0.03)	2.12 (0.03)
INEGI regions (%):			
Central north	14.5	14.6	14.6
Central south	14.2	14.1	14.1
Mexico City	27.1	26.8	26.8
North east	19.3	19.4	19.4
North west	15.6	15.7	15.7
South	9.3	9.4	9.4
Unemployment rate (monthly)	5.20 (0.02)	4.70 (0.02)	4.70 (0.02)
Minimum salary (Mexican pesos/day)†	58.90 (0.03)	59.50 (0.03)	59.30 (0.04)

INEGI=Instituto Nacional de Estadística Geografía e Informática.

Sources: INEGI and authors' own analyses and calculations based on data from Nielsen through its Mexico Consumer Panel Service for food and beverages, January 2012 to December 2014.

*Weights or "projection factors" provided by Nielsen to represent populations in areas with more than 50 000 inhabitants.

†Adjusted using state quarter specific Consumer Price Index (CPI) from INEGI, with Mexico City in first quarter of 2012 as base (CPI=100).

Descriptive statistics

We present descriptive statistics of the households in the analytic data. Then we present the unadjusted trends in household purchases as reported during the period January 2012 through December 2014, which includes the first year of the post-tax period (beginning 1 January 2014). We conducted simple *t* tests to determine whether the volume of beverages purchased in each post-tax month was statistically different from that of the same month in 2012 and 2013. Stata 13 was used for all analyses.³⁵

Difference in difference fixed effects analyses

As the tax was implemented nationally, it was not possible to construct a true experimental design to study the association between the tax on sugar sweetened beverages and purchases. Therefore we applied a pre-post quasiexperimental approach using difference in difference analyses along with fixed effects models,^{36 37} with fixed effects at the household level. Fixed effect models have several advantages, mainly that they account for non-time varying unobserved characteristics of households (for example, preference for certain types of beverages). As such, non-time varying measures (for example, region of household's residence) are omitted in the model.

As the distribution of beverage purchases per capita were skewed and not normally distributed, we used the

logarithm of beverage purchases as outcomes in the models. The model adjusts for the seasonality of beverage purchases using a variable for each quarter of the year and demographic information on household composition, socioeconomic status, and contextual factors (unemployment rate and minimum salary).

To allow for interpretability, we back transformed the logged outcomes into milliliters per capita by calculating and applying Duan smearing factors.³⁸ Specifically, Duan smearing ensures that in the presence of non-zero variances in the volume purchased, the back transformed predicted outcome is not downward biased.³⁸ This also allowed us to compare in absolute and relative terms the estimated post-tax volume of beverages purchased in January through December 2014 to the estimated counterfactual post-tax volume assuming a pretax trend. We did consider presenting predicted values that also detrended seasonality, by setting all quarters to the same quarter, but these seasonal trends are interesting and more accurately reflect the changing demand for beverages over the course of the year. We also corrected the standard errors by clustering the analyses at household level.

The model also takes into consideration periods of non-purchases of beverage categories, when more than 10% of the observations using inverse probability weights were non-purchases. We calculated inverse probability weights by modeling the probability of

purchasing, adjusted for the same covariates as the main regression for the log of purchases (the inverse of the predicted values obtained from this model being used in the main regression as a weighting factor).^{39,40} We conducted analyses for the full sample and stratified the analyses by socioeconomic status (low, middle, high), using separate models to determine if there were differences for these subsamples. The supplemental materials provide additional details on the analytic approach. We used Stata 13 for all analyses.³⁵

Sensitivity analysis among untaxed beverages

We conducted sensitivity analysis for the untaxed beverages modeled from October 2012 to December 2014. Given the large number of missing values for dairy beverages from January to September 2012, imputation was not an adequate option. Instead, we repeated the models excluding dairy beverages and compared the results from January 2012 to December 2014 with those from October 2012 to December 2014.

Results

Descriptive trends in household purchases

Table 1 presents the unadjusted characteristics of the households for each year. This analytic sample of reported purchases represents more than 16 million households (approximately 90-100 million residents) in Mexico in each of these years.

Before controlling for any potential factors, strong seasonal effects on beverage purchases need to be considered. In Mexico, seasonality can be due to changes in temperature (though these temperature changes are not extreme in Mexico), holidays and festivities, and fewer purchases at the beginning of the year after the festivities in December (see supplemental fig 1). There is also a decrease in overall purchases of taxed beverages (see supplemental fig 1a), particularly in 2014. We are only able to present unadjusted purchases since October 2012 for untaxed beverages (see supplemental fig 1b), and there is an absolute increase in the volume purchased over time.

Model predicted differences in beverage purchases in stores: overall findings

Supplemental table 2 presents the coefficient estimates for each of the beverage categories from the difference in difference fixed effects models at the household level controlling for socioeconomic status, age, and sex, and for contextual measures of households. Based on these estimates, we back transformed the predicted log volumes for each of the 12 post-tax months using Duan smearing.³⁸ We compared estimated counterfactual volumes purchased in the post-tax period based on pretax trends (expected volumes if the tax had not been implemented) to adjusted volumes purchased in the post-tax period (based on predicted values from the model) and derived the absolute and relative differences from January to December 2014.

Table 2 and figure 1 show that for taxed beverages the absolute and relative differences between the post-tax volume and its counterfactual widened over the 12 post-

tax months from -11 mL/capita/day (-5.6% relative to the counterfactual) in June to -22 mL/capita/day (-12% relative to the counterfactual) by December 2014, giving an average change of -6.1% over 2014. In total, during 2014 the average urban Mexican purchased 4241 mL (seven 600 mL or 20 oz bottles) fewer taxed beverages than expected (based on pretax trends). This was related to a decrease in purchases of non-carbonated sugar sweetened beverages (-17% relative to the counterfactual) and taxed sodas (-1.2% relative to the counterfactual). See supplemental Figure 2.

For untaxed beverages the absolute (and relative) differences were initially higher, at 63 mL/capita/day (7.5% relative to the counterfactual) in January 2014, and though the difference remained positive, it decreased over the 12 month post-tax period and was no longer statistically different from the counterfactual by November 2014. None the less, this represents an average increase in the purchase of untaxed beverages, of 36 mL/capita/day (4% relative to the counterfactual), which translates to the purchase of 12827 mL (21 600 mL or 20 oz bottles) more untaxed beverages by the average urban Mexican over 2014 than expected.

Sensitivity analyses among the untaxed beverages showed that the model appears sensitive to the pretax period used. Limiting the analyses to untaxed beverages excluding dairy beverages, we found a relative increase in purchases by 2% when using January 2012 to December 2013 as the pretax period. This was 5% when using October 2012 to December 2013 as the pretax period. These results suggest that the estimated 4% for all untaxed beverages may be an overestimate, but positive (relative increase) none the less. Given the nature of incomplete data on beverages from the diaries, we are unable to provide an estimate on the magnitude of the overestimation without making major assumptions, but to provide context, dairy beverages represent 17% of the untaxed beverages since October 2012.

Difference in store purchases after the tax by household socioeconomic status

Supplemental table 3 provides the coefficient estimates for each of the beverage categories from the difference in difference fixed effects models stratified by socioeconomic status. Based on these estimates, we back transformed the predicted log volumes for each of the 12 post-tax months using Duan smearing. Supplemental table 4 presents the absolute and relative differences in the estimated counterfactual volumes that would have been purchased in the post-tax period based on pretax trends (expected volumes if the tax had not been implemented) and the predicted volumes purchased in the post-tax period by the three socioeconomic status levels. Figures 2 and 3 present the results for taxed and untaxed beverages, respectively. Both figures show clear seasonal trends in the purchases of taxed and untaxed beverages, with higher purchases in April to September of each year.

Purchases of taxed beverages were already declining during the pretax period across all three socioeconomic

Table 2 | Overall absolute and relative differences in estimated adjusted counterfactuals and post-tax volume purchased (mL/capita/day)

Post-tax months (2014)	Mean (SE)		Difference			
	Estimated adjusted counterfactual (expected volume purchased based on pretax trends)	Estimated adjusted post-tax volume purchased	Absolute difference (post-tax volume purchased minus counterfactual volume)	Relative difference (absolute difference as % of counterfactual, 100%×absolute difference/adjusted counterfactual volume)		
Taxed beverages						
Jan	182	0.37	182	0.37	0	0.0
Feb	181	0.36	179	0.36	-2	-1.2
Mar	180	0.36	176	0.35	-4**	-2.3
Apr	202	0.41	195	0.40	-7**	-3.4
May	201	0.41	192	0.39	-9**	-4.5
Jun	199	0.41	188	0.38	-11**	-5.6
Jul	200	0.41	187	0.38	-13**	-6.7
Aug	199	0.40	183	0.37	-15**	-7.8
Sep	197	0.40	180	0.37	-17**	-8.8
Oct	188	0.38	170	0.34	-19**	-9.9
Nov	187	0.38	166	0.34	-20**	-10.9
Dec	185	0.38	163	0.33	-22**	-11.9
Average over 2014	192	—	180	—	-12**	-6.1
Untaxed beverages						
Jan	845	1.88	908	2.02	63**	7.5
Feb	842	1.87	899	2.00	58**	6.8
Mar	838	1.86	890	1.98	52**	6.2
Apr	1005	2.28	1060	2.40	56**	5.5
May	1001	2.27	1050	2.38	49**	4.9
Jun	998	2.26	1040	2.36	42**	4.2
Jul	991	2.28	1027	2.36	36**	3.6
Aug	987	2.27	1017	2.34	29**	3.0
Sep	984	2.27	1007	2.32	23**	2.3
Oct	909	2.03	925	2.07	16**	1.7
Nov	906	2.03	916	2.05	10	1.1
Dec	903	2.03	907	2.04	4	0.5
Average over 2014	934	—	971	—	36**	3.9

Source: authors' own analyses and calculations based on data from Nielsen through its Mexico Consumer Panel Service for food and beverage categories, January 2012 to December 2014.

**P<0.001; in order to show seasonal trends in beverage purchases, predictions do not adjust for quarter.

†Models use October 2012 to December 2014 data only.

status groups, and the households in the highest category had the steepest rates of decline during the pretax period (fig 2). In the post-tax period both the absolute and the relative differences in predicted post-tax purchases compared with the counterfactual were largest for households of low socioeconomic status, reaching -35 mL/capita/day (-17.4%) by December 2014 and averaging -19 mL/capita/day (-9.1%). Households of middle and high socioeconomic status both reduced purchases of taxed beverages by about 5.5% to 5.6% compared with their counterfactuals.

The purchase levels of untaxed beverages before the tax were stable across all socioeconomic status households (fig 3). In the post-tax period, households of middle socioeconomic status showed the greatest increase in purchase of untaxed beverages compared with their counterfactuals, averaging 53 mL/capita/day (5.9%), followed by households of low socioeconomic status (19 mL/capita/day; 2.4%). Households of high socioeconomic status had the smallest increase (15 mL/capita/day; 1.5%). However, households of middle and low socioeconomic status both showed larger differences in the earlier months that became smaller over the year, whereas changes among households of high socioeconomic status were less steep over the 12 months,

maintaining a difference of 13 to 17 mL/capita/day (1.4% to 1.8%) throughout.

Discussion

This study examines the short term change in purchases of sugar sweetened beverages in stores one year after Mexico implemented a 1 peso per liter excise tax on them. The average volume of taxed beverages purchased monthly was 6% lower in 2014 compared with expected purchases with the tax absent. Moreover, the reductions accelerated, reaching a 12% decline by December 2014. The reduction was greatest among households of low socioeconomic status, averaging -9.1%, and reaching -17.4% by December 2014. Purchases of untaxed beverages were 4% higher than the counterfactual, mainly related to bottled water. Households of middle socioeconomic status increased their purchases the most.

Comparison with other studies

This study shows the initial changes during the first year of the tax. Economic models of addiction and related behavioral models imply that the long term impact of a price change will be much larger than the short term effect,⁴¹ but this has been shown only for

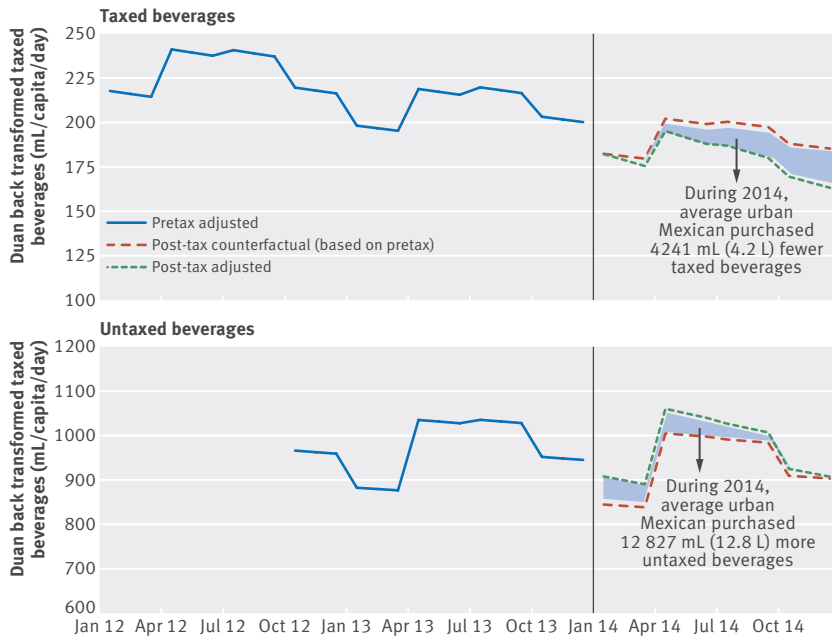


Fig 1 | Monthly predicted purchases of beverages comparing counterfactual with post-tax from full sample models (to show seasonal trends in beverage purchases, predictions do not adjust for quarter). Total 2014 changes calculated using only months with significant differences ($P < 0.001$) by taking summation of product of difference for month and number of days in month. Source: authors' own analyses and calculations based on data from Nielsen through its Mexico Consumer Panel Service for food and beverage categories, January 2012 to December 2014

tobacco, alcohol, and illicit drugs.⁴²⁻⁴⁴ The acceleration of the reduction over time in the purchases of taxed sugar sweetened beverages suggests that this is true for these beverages, so in the future we might expect slightly greater decreases in purchases of sugar sweetened beverages and increases in purchases of untaxed beverages. Additionally, given that the tax on sugar sweetened beverages is approximately 10% of 2013 prices, the reduction of more than 10% in the last quarter of 2014 shows that the demand was price elastic (at least in that quarter), and that even a relatively small tax can make some difference in the demand for beverages (with potential substitution to plain bottled waters). The tax is to be adjusted for inflation every two years, so only a real growth in income might be expected to reduce the decline in purchases of taxed beverages. Moreover, Mexican scholars and most researchers who have focused on taxes for sugar sweetened beverages using model based approaches (owing to the lack of empirical data on actual taxations) recommend that taxes need to be set at a minimum of 20% to observe the higher reductions in purchases and consumption that may have an effect on health outcomes.⁴⁵ The current Mexican tax is half that level.

However, unpublished monitoring in-store and by the media has revealed aggressive in-store promotions and marketing to try to retain market shares for sugar sweetened beverages, which may limit both short term and long term effects. The impacts of these in-store and out of store marketing efforts are unclear. For example, industries may use a cost shifting strategy of passing more of the tax to the smaller beverage package sizes

than to the larger packages.²⁶ Consequently, consumers may choose to purchase the larger versions, which are cheaper per liter. Future work that incorporates additional data and qualitative monitoring of industry marketing and promotions will allow the study of the longer term effects of the tax on sugar sweetened beverages and the response by industry.

We also found larger reductions in purchases of non-carbonated taxed beverages compared with carbonated taxed beverages. We hypothesize that this could be due to higher prices and high price elasticities of non-carbonated beverages, as shown in earlier work⁴⁶; and consumers shifting to lower priced versions of taxed carbonated beverages given the large variation in prices.²⁶ Moreover, the reduction in purchases of taxed sodas and carbonated beverages may be underestimated if purchases of smaller package sizes (which showed a larger increase in price than larger packages after the tax) are not well reported in the data, as these are individual purchases that may be consumed on the go and may be underreported by the key household informant.

Our findings on differential changes by socioeconomic status also shed light on the potential health implications of the tax in Mexico. Over the 12 month taxation period, households of low socioeconomic status reduced their intake of taxed beverages by more than 9%, but, more importantly, by December the decline was 17.1% more than the counterfactual, with a mean of almost 35 mL. Though prevalence rates for overweight and obesity in the low socioeconomic status group are not significantly higher than those in the higher socioeconomic status groups for all ages, trends in overweight and obesity are increasing faster in children and adolescents in low socioeconomic status groups than in the middle and high socioeconomic status groups.¹⁷ Taxes on food and beverages have been argued to be regressive as the poor pay a higher proportion of their income. However, results from this study showing a larger reduction in purchases among households of low socioeconomic status suggest that the burden of the tax was lower than it would have been if there was no differential impact by socioeconomic status. Additionally, if the tax revenue is appropriated toward decreasing disparities in health or socioeconomic status, the broader fiscal effects of the tax could arguably be progressive. Although the tax revenue has not been specifically earmarked, the senate made a resolution to use part of the taxes for providing potable water to public schools, particularly in low income areas.

Strengths and limitations of this study

A major limitation of this work is that causality cannot be established, as other changes are occurring concurrent with the tax, including economic changes, health campaigns about sugar sweetened beverages, and anti-obesity programs. We attempted to deal with potential contextual economic factors by controlling for state quarterly unemployment rates and state yearly minimum salaries, but this may have been insufficient.

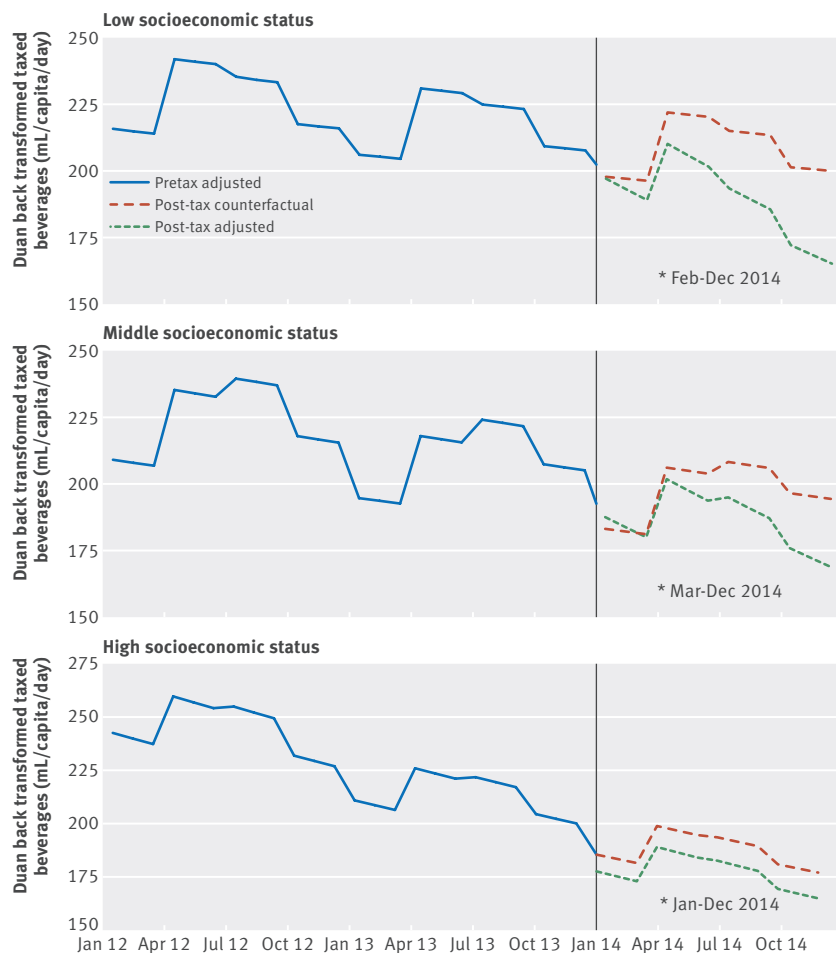


Fig 2 | Monthly predicted purchases of taxed beverages comparing counterfactual with post-tax from socioeconomic status stratified models (to show seasonal trends in beverage purchases, predictions do not adjust for quarter). Source: authors' own analyses and calculations based on data from Nielsen through its Mexico Consumer Panel Service for food and beverage categories, January 2012 to December 2014. *P<0.001

The difference in difference approach attempts to take into account any pre-existing (pretax) trends in purchases, but it assumes that these trends would have continued if the tax had not been instituted.

Weaknesses include the incomplete data on dairy beverages before October 2012, which limited the overall analysis for untaxed beverages to a shorter period and likely overestimated the relative increase in purchases of untaxed beverages during the post-tax period. This is not ideal, as a longer pretax period may have allowed findings to be more robust. This is true in general (for all beverages), but we were limited by how far back we were able to obtain the data from Nielsen Consumer Panel Survey, and, regardless, the incomplete data on use of dairy beverages would have persisted.

Also, the data only represent consumers in Mexican cities with more than 50 000 residents. Consequently, the sample does not represent a small but important subpopulation living in towns and rural localities with fewer than 50 000 people that comprise about 25% of food and beverage expenditures and around 37% of the population.³¹ Given that we found a larger reduction in purchases of taxed beverages among households of low

socioeconomic status, we hypothesize that reductions among rural households would be greater than those among urban households. However, without actual data, this assumption is purely speculative.

Additionally, we currently do not have data on nutrients for packaged beverages and foods in Mexico, so we cannot quantify any potential changes in calories and other nutrients purchased, and their potential health implications. We also do not have actual data on dietary intake and comparable data on purchases of taxed beverages out of stores. The average increase in purchases of untaxed beverages of 4% may be underestimated if households shifted to beverages not sold in stores and therefore not reported in the dataset, such as tap water or beverages prepared at home with or without sugar, including aguas frescas (drinks comprising fruits, flowers, cereals, or seeds blended with sugar and water). However, because the beverage tax was structured as an excise tax, these price changes should affect all venues, including fast food outlets using concentrates and syrups and street stalls. Thus our results probably underestimate the total impact, as we did not cover beverages consumed away from home, such as those purchased from street vendors or in restaurants. We are also currently unable to quantify the use of revenues from the tax on sugar sweetened beverages to supply potable water in schools, which could influence the demand for both taxed and untaxed beverages in the longer term.

Furthermore, not only must the effects of the tax be understood but also the effects of the tax on non-essential energy dense foods. On the basis of ENSANUT 2012 data, the two taxes covered approximately 19% of the daily caloric intake of Mexicans, with 7.5% coming from taxed beverages.⁴⁷ Since these taxes were implemented concurrently, we cannot determine the independent role of each until changes are made to one of them.

Conclusions and policy implications

This study documented the change in purchases of beverages after the implementation of a national excise tax on sugar sweetened beverages, and the findings are relevant for policy discussions and decisions. Other than a few business reports on beverage sales for specific companies in Mexico that seem to be in line with what we found,^{48,49,50} no comparable studies have been done to date, as most research on the effects of price changes or taxes on sugar sweetened beverages is derived from model simulations.¹ France is the only other country to implement a tax on sugar sweetened beverages similar to that of Mexico.⁵¹ However, France does not have comparable scanned data on household food purchases in relation to its tax, and analyses are limited to sales data (V Requillart, Toulouse School of Economics, personal communication, 2014). In the United States, Berkeley in California instituted a tax on sugar sweetened beverages in March 2015, and initial studies indicate that there is some price pass through,⁵² though it is too early to determine how purchases or consumption would be affected and how generalizable these results would be given the limited geographic coverage of the Berkeley tax. The results for Mexico

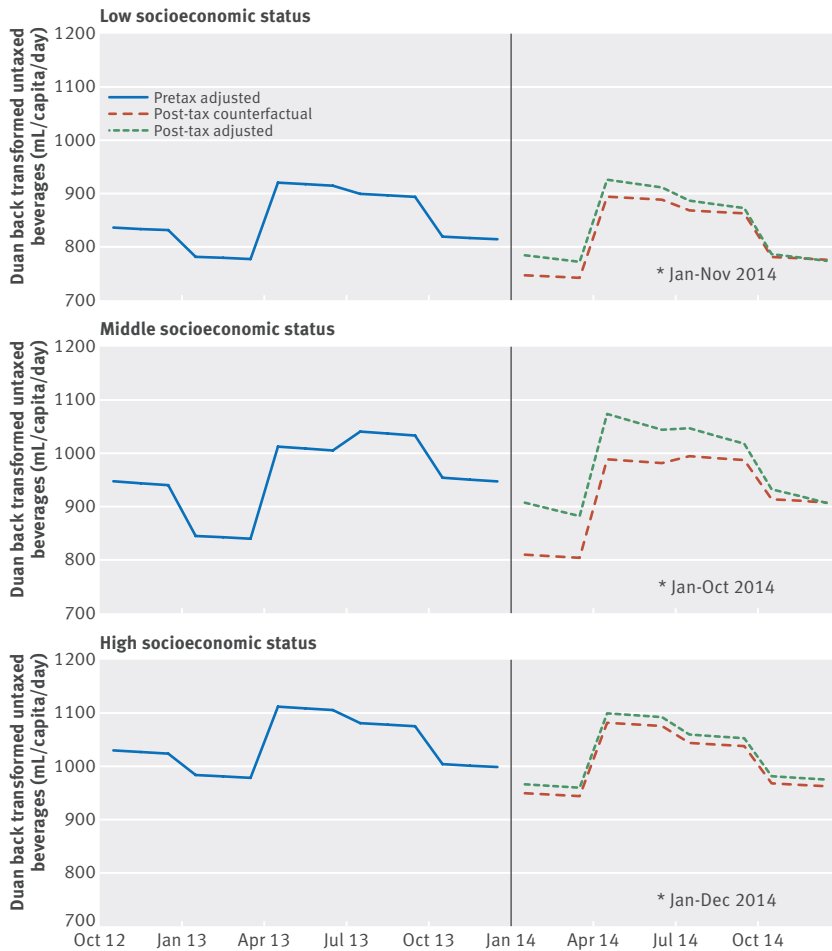


Fig 3 | Monthly predicted purchases of untaxed beverages comparing counterfactual with post-tax from socioeconomic status models (to show seasonal trends in beverage purchases, predictions do not adjust for quarter). Based on models using October 2012 to December 2014 data only. Source: authors' own analyses and calculations based on data from Nielsen through its Mexico Consumer Panel Service for food and beverage categories, January 2012 to December 2014. *P<0.001

show that in the short term the tax on sugar sweetened beverages is generally passed on through prices (the tax passed close to 1 peso/L for carbonated beverages and <1 peso/L for non-carbonated beverages in urban areas)^{26,27} to consumers, who reduced their purchases of taxed beverages.

These reductions became larger over time, while the purchases of untaxed beverages increased. This short term change is moderate but important, and it will be critical to continue monitoring purchases to note whether the trend continues or stabilizes; consumers substitute cheaper brands or untaxed foods and beverages for the taxed ones, or adjustments occur in the longer term. This will allow for an understanding of the long term effects of taxes on both sugar sweetened beverages and non-essential energy-dense food on purchases, diets, and ultimately health outcomes. In addition, future analysis will look at the distribution of changes in food purchases to determine if the tax on sugar sweetened beverages is more strongly associated with changes among consumers who purchase and consume larger quantities of sugar sweetened beverages.

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Data sharing: Owing to the proprietary nature of the main data source used for this analysis, the authors are contractually bound and unable to share the data.

Transparency: The lead authors (BMP and SWN) affirm that the manuscript is an honest, accurate, and transparent account of the study reported; that no important aspects of the study have been selectively omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

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Beverage purchases from stores in Mexico under the excise tax on sugar sweetened beverages: observational study

**Beverage purchases from stores in Mexico under the excise tax on sugar-sweetened
beverages: observational study**

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SUPPLEMENTAL MATERIALS

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**Supplemental Table 1. Beverage categories and levels for Consumer Packaged Goods
beverage products purchased by Mexican households**

Level 1*	Level 2	Level 3**
Taxed beverages	Sodas taxed	Sodas taxed
	Other taxed beverages (e.g., flavored water or sweetened juice)	Flavored water taxed
		Sweetened juices taxed
Untaxed beverages	Carbonated drinks untaxed (e.g., diet sodas and sparkling water)	Carbonated drinks untaxed
	Still plain water untaxed	Still plain water untaxed
	Other untaxed beverages (e.g., unsweetened dairy beverages, 100% fruit juices, flavored water without caloric sugars, beer)	Dairy without added sugar untaxed
		Flavored water untaxed
		Juices untaxed
		Beer untaxed
		Other untaxed

*In this study we only present purchases and prices for levels 1 and 2.

**Level 3 beverage categories are most similar to the 2012 Encuesta Nacional de Salud y Nutrición (ENSANUT) categories.

Technical Appendix. Difference-in-Difference (DinD) Fixed Effects Models and Predicted Outcomes

Since the Mexican SSB tax was implemented nationally, it is not possible to construct a true experimental design to study the association between the tax and purchases. Therefore we applied a pre-post quasi-experimental approach using difference-in-difference (DinD) analyses along with fixed effects models (1, 2). Fixed effects models have a number of advantages, the key being that they account for the non-time-varying unobserved characteristics of households (e.g., preference for certain types of beverages). The model adjusts for the preexisting downward trend of purchases of taxed beverages observed since 2012 and for macroeconomic variables that can affect household purchases. We wanted to determine whether there were significant changes in the trends in beverage purchases during the posttax period compared to the pretax period after controlling for household composition and contextual factors. We constructed a counterfactual for what the purchases in the posttax period would have looked like in the absence of the tax and compared the observed posttax purchases to this counterfactual, holding all other factors constant.

The distribution of beverage purchases per capita were skewed and not normally distributed, so we used the logarithm (log) of beverage purchases as outcomes. The continuous explanatory variables were more normally distributed and did not require any transformations. The model specification is:

$$\log(BEV_{hsm_y}) = \beta_T T_{hmy} + \beta_M M_{my} + \beta_{TM}(T_{hmy} * M_{my}) + \delta Q_{qy} + \vartheta SES_{hsy} + \gamma H_{hsy} + \varphi C_{sy} + \alpha_{hs} + \mu_{hsm_y}$$

The outcome is the log of the average volume of beverage BEV purchased per capita per day by household h living in state s during month-year my . T denotes the posttax period, M denotes the month-year linear time trend (a continuous measure from 1 to 36), Q denotes quarters to account for seasonality in purchases, SES denotes socio-economic status, H denotes the vector of year-specific household characteristics, C denotes contextual measures (state-month level unemployment rate and state-quarter level consumer price index adjusted minimum salary), α denotes the unobserved time-invariant characteristics of each household, and μ denotes the time-

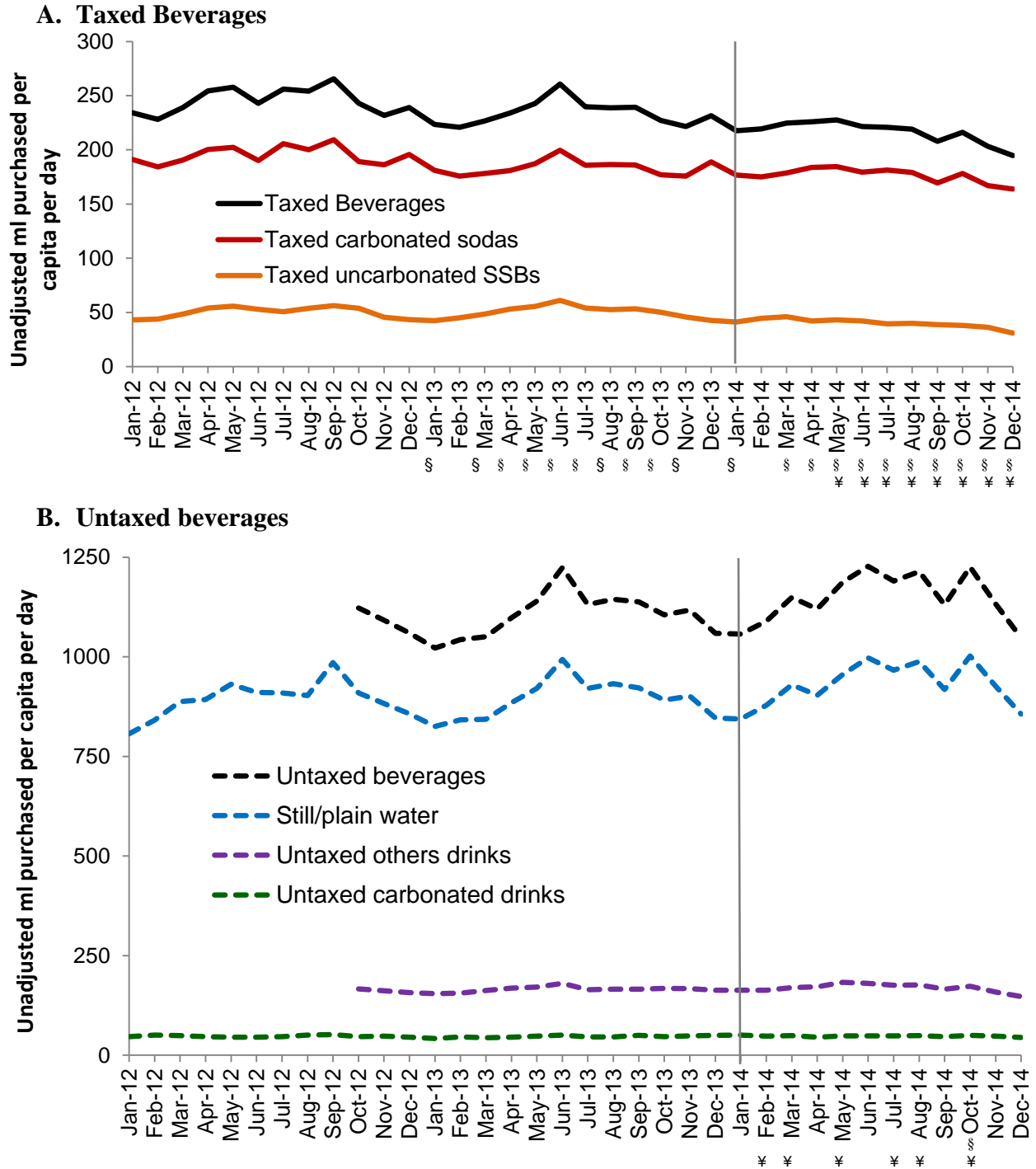
varying error. β_{TM} denotes the difference between the change in the log average per capita per day volume of *BEV* purchased during the posttax period compared to the pretax period. β_M denotes the pretax trend in the purchase of *BEV*, and the posttax trend in the purchase of *BEV* will be $(\beta_M + \beta_{TM})$.

To allow for interpretability in these coefficients, we back-transformed the logged outcomes by calculating and applying Duan smearing factors (3). Specifically, Duan smearing ensures that in the presence of nonzero variances in the volume purchased, the back-transformed predicted outcome is not downward biased (3). This also allowed us to compare in absolute and relative terms the estimated posttax volume purchased in January through December 2014 to the estimated counterfactual posttax volume assuming a pretax trend. We considered presenting predicted values that also detrended seasonality by setting all quarters to the same quarter, but these seasonal trends are interesting and more accurately reflect the changing demand for beverages over the course of the year. We also corrected the standard errors by clustering the analyses at the household level. We conducted all analyses with Stata 13 (4).

For beverage categories where $\geq 10\%$ of the household quarter observations did not report purchases (taxed sodas and carbonated drinks, other taxed SSBs, and untaxed still plain water), we applied time-varying inverse probability weights to the fixed effects model using `-areg, absorb-` in Stata (4). We estimated the inverse probability weights from longitudinal (random effects) probit models to address the potential selection bias associated with the probability of purchasing (5). In the case of untaxed carbonated drinks (e.g., diet sodas and sparkling water), because only 27% of the household month observations reported purchases, we used a longitudinal probit model to estimate the probability of purchasing any untaxed carbonated drinks, adjusting for demographic and household composition measures, contextual factors, and region.

For the models stratified by SES, we used the same modeling approach with the exception of removing household SES from the models and ran three separate models for each outcome for each for the SES subsamples. We based the three SES categories (low, middle, and high) on a six-category measure that the Nielsen Company derived from annually updated questions on household asset ownership (e.g., number of half and full bathrooms in the home, number of bedrooms in the home, number of vehicles owned) and the education of the head of the household.

Supplemental Figure 1. Monthly unadjusted purchases (ml/capita/day) of taxed and untaxed beverages



§ Statistically significant difference from the same month in 2012 at $p < 0.01$; ¥ statistically significant difference from the same month in 2013 at $p < 0.01$. Incomplete data for dairy beverages in Jan-Sept 2012.

Source: Authors' own analyses and calculations based on data from Nielsen through its Mexico Consumer Panel Service (CPS) for the food and beverage categories for January 2012 – December 2014. Copyright © 2015, The Nielsen Company. Nielsen is not responsible for and had no role in preparing the results reported herein.

Supplemental Table 2. Coefficient estimates from DinD model results, β (P value)

Beverage outcome	Pretax trend			DinD in trends			Posttax dummy	
	β_M	P		β_{TM}	P		β_T	P
log(volume purchased taxed beverages) ^a	-0.007	(0.000)	**	-0.015	(0.000)	**	0.254	(0.000)
log(volume purchased taxed carbonated drinks) ^{a, b}	-0.009	(0.000)	**	-0.005	(0.001)	**	0.131	(0.005) *
log(volume purchased taxed noncarbonated drinks) ^{a, b}	-0.003	(0.000)	**	-0.028	(0.000)	**	0.583	(0.000) **
log(volume purchased untaxed beverages) ^{a, d}	-0.004	(0.001)	**	-0.006	(0.000)	**	0.258	(0.000) **
log(volume purchased untaxed water) ^{a, b}	0.003	(0.000)	**	-0.011	(0.000)	**	0.383	(0.000) **
log(volume purchased untaxed other) ^{a, d}	-0.004	(0.000)	**	-0.011	(0.000)	**	0.327	(0.000) **
Pr(any untaxed carbonated drinks) ^c	-0.003	(0.002)	*	-0.004	(0.116)		0.115	(0.143)

^a Fixed effects model that uses the $\log(BEV \text{ volume}) = f(\text{mthyr}, \text{posttax}, \text{posttax} * \text{mthyr}, \text{quarter}, \text{contextual measures}, \text{household composition}, \text{household SES})$ clustered by household. Unless otherwise noted, 36 months of data, $n = 205,112$ observations from 6,253 households.

^b Due to >10% nonpurchasing household month observations, the model also accounts for time-varying inverse probability weight for probability of purchasing said beverage in given month with fixed effects in Stata using -areg, absorb-.

^c Random effects model of the probability of purchasing untaxed carbonated drinks.

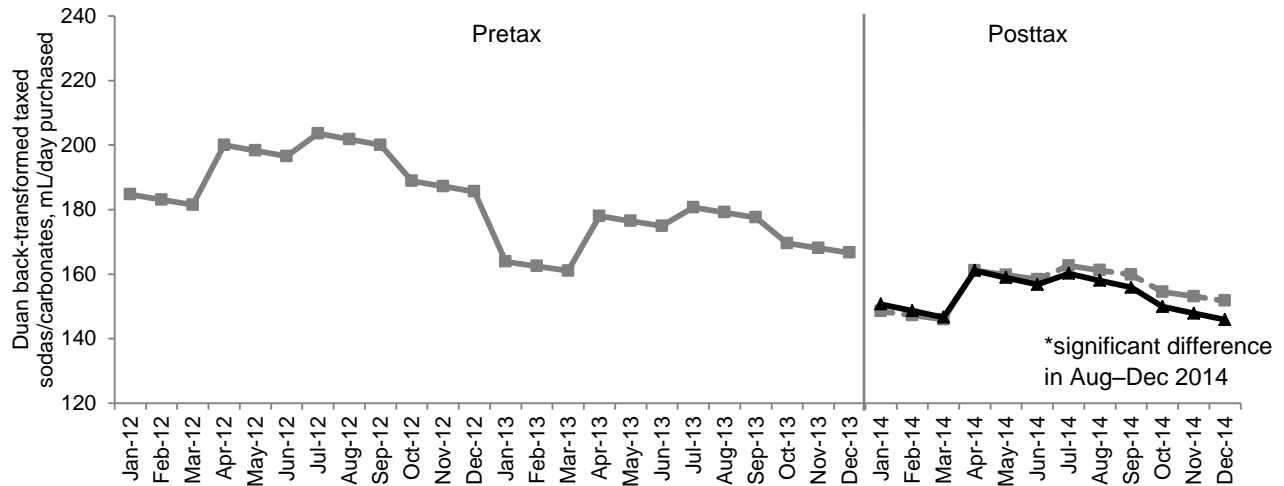
^d Limited to October 2012–December 2014 (27 months of data only); $n = 153,387$ observations from 6,239 households.

* Statistically significant at $p < 0.01$; ** statistically significant at $p < 0.001$.

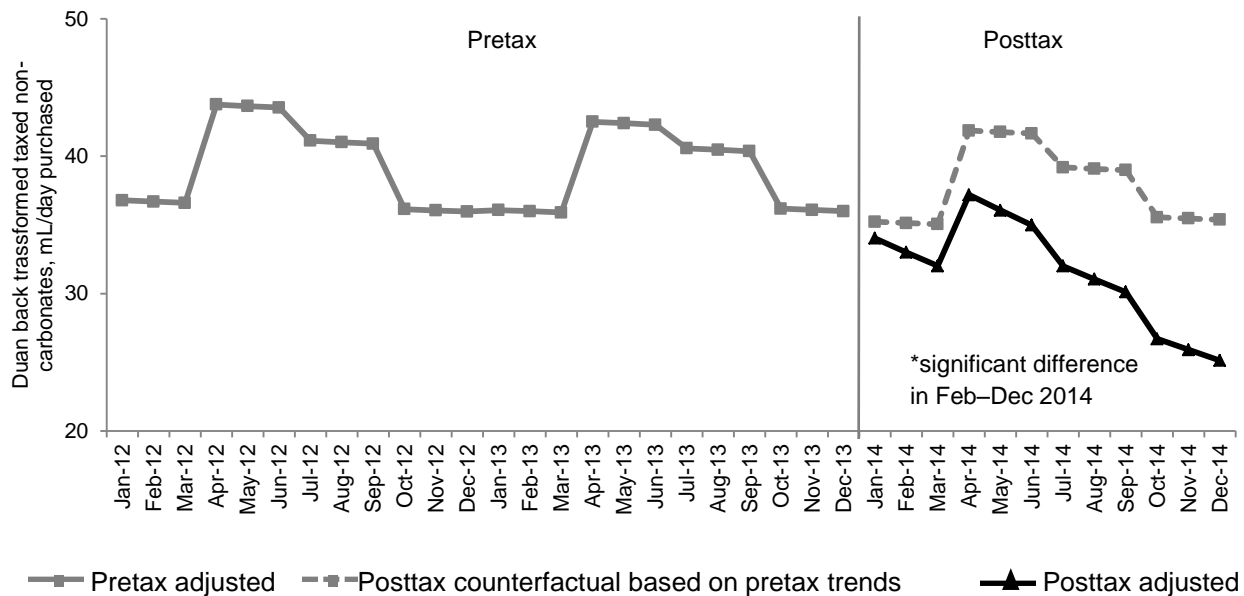
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Supplemental Figure 2. Monthly predicted purchases of taxed sodas and carbonated drinks and taxed noncarbonated SSBs comparing the counterfactual to posttax

A. Taxed sodas/carbonated drinks



B. Taxed noncarbonated SSBs



* Statistically significant at $p < 0.01$. Predictions do not adjust for quarter in order to show seasonal trends in beverage purchases. Back-transformation of predicted $\log(BEV \text{ volume})$ from DiD fixed effects models used Duan smearing factors to handle potential heteroskedasticity.

Source: Authors' own analyses and calculations based on data from Nielsen through its Mexico Consumer Panel Service (CPS) for the food and beverage categories for January 2012 – December 2014. Copyright © 2015, The Nielsen Company. Nielsen is not responsible for and had no role in preparing the results reported herein.

Supplemental Table 3. Coefficient estimates from SES stratified DinD models

Lowest SES ¹	Pretax trend		DinD in trends		Posttax dummy	
	β_M	P	β_{TM}	P	β_T	P
log(volume purchased taxed beverages) ^a	-0.004	0.075	-0.017	0.000**	0.374	0.000**
log(volume purchased taxed carbonated drinks) ^{a, b}	-0.005	0.001**	-0.009	0.006**	0.183	0.061
log(volume purchased taxed noncarbonated drinks) ^{a, b}	0.001	0.788	-0.035	0.000**	0.784	0.000**
log(volume purchased untaxed beverages) ^{a, d}	-0.003	0.203	-0.005	0.193	0.186	0.064
log(volume purchased untaxed water) ^{a, b}	0.010	0.000**	-0.012	0.004**	0.310	0.018*
log(volume purchased untaxed other) ^{a, d}	-0.012	0.000**	-0.008	0.080	0.277	0.020*
Pr (any untaxed carbonated drinks) ^c	-0.002	0.490	-0.008	0.214	0.177	0.375
Middle SES ²	Pretax trend		DinD in trends		Posttax dummy	
	β_M	P	β_{TM}	P	β_T	P
log(volume purchased taxed beverages) ^a	-0.005	0.000**	-0.015	0.000**	0.369	0.000**
log(volume purchased taxed carbonated drinks) ^{a, b}	-0.008	0.000**	-0.010	0.000**	0.303	0.000**
log(volume purchased taxed noncarbonated drinks) ^{a, b}	0.002	0.088	-0.032	0.000**	0.670	0.000**
log(volume purchased untaxed beverages) ^{a, d}	-0.004	0.011*	-0.010	0.000**	0.420	0.000**
log(volume purchased untaxed water) ^{a, b}	0.003	0.005*	-0.017	0.000**	0.577	0.000**
log(volume purchased untaxed other) ^{a, d}	-0.002	0.209	-0.016	0.000**	0.481	0.000**
Pr (any untaxed carbonated drinks) ^c	-0.002	0.322	-0.003	0.455	0.096	0.402
Highest SES ³	Pretax trend		DinD in trends		Posttax dummy	
	β_M	P	β_{TM}	P	β_T	P
log(volume purchased taxed beverages) ^a	-0.011	0.000**	-0.003	0.415	-0.012	0.892
log(volume purchased taxed carbonated drinks) ^{a, b}	-0.011	0.000**	0.005	0.080	-0.168	0.067
log(volume purchased taxed noncarbonated drinks) ^{a, b}	-0.008	0.000**	-0.017	0.000**	0.301	0.003**
log(volume purchased untaxed beverages) ^{a, d}	-0.003	0.048	0.000	0.852	0.040	0.517
log(volume purchased untaxed water) ^{a, b}	-0.001	0.535	-0.003	0.468	0.120	0.265
log(volume purchased untaxed other) ^{a, c}	-0.004	0.026	-0.005	0.109	0.130	0.121
Pr (any untaxed carbonated drinks) ^c	-0.005	0.015	-0.004	0.358	0.099	0.448

¹ 36 months: 37,123 observations from 1,421 households; 27 months: 28,661 observations from 1,416 households.

² 36 months: 104,905 observations from 3,794 households; 27 months: 76,989 observations from 3,790 households.

³ 36 months: 63,084 observations from 2,126 households; 27 months: 47,737 observations from 2,121 households.

^a Fixed effects model that uses the log(BEV volume)= f(mthyr, posttax, posttax*mthyr, quarter, contextual measures, household composition) clustered by household.

^b Due to >10% nonpurchasing household month observations, the model also accounts for time-varying inverse probability weight for probability of purchasing said beverage in given month with fixed effects in Stata using -areg, absorb-.

^c Random effects model of the probability of purchasing untaxed carbonated drinks.

^d Limited to October 2012–December 2014 (27 months of data only), n = 153,387 observations from 6,239 households.

* Statistically significant at p <0.01; ** significant at p <0.001.

Source: Authors' own analyses and calculations based on data from Nielsen through its Mexico Consumer Panel Service (CPS) for the food and beverage categories for January 2012 – December 2014. Copyright © 2015, The Nielsen Company. Nielsen is not responsible for and had no role in preparing the results reported herein.

Supplemental Table 4. Differences between the counterfactual and posttax predictions in monthly purchases of beverages in 2014 from SES stratified DinD models

Taxed beverages	Low SES		Middle SES		High SES	
	Absolute difference (ml/day)	% of counterfactual	Absolute difference (ml/day)	% of counterfactual	Absolute difference (ml/day)	% of counterfactual
Jan. 2014	-0.69	-0.4%	4.41	2.4%	-8.40**	-4.2%
Feb. 2014	-3.99*	-2.0%	1.61	0.9%	-8.78**	-4.5%
Mar. 2014	-7.20**	-3.7%	-1.11**	-0.6%	-9.15**	-4.7%
Apr. 2014	-11.72**	-5.3%	-4.31**	-2.1%	-10.54**	-5.0%
May 2014	-15.19**	-6.9%	-7.27**	-3.5%	-10.92**	-5.2%
June 2014	-18.57**	-8.5%	-10.15**	-5.0%	-11.30**	-5.4%
July 2014	-21.43**	-10.0%	-13.31**	-6.4%	-11.73**	-5.7%
Aug. 2014	-24.59**	-11.6%	-16.12**	-7.8%	-12.09**	-5.9%
Sept. 2014	-27.66**	-13.1%	-18.86**	-9.1%	-12.44**	-6.1%
Oct. 2014	-29.03**	-14.5%	-20.66**	-10.5%	-12.32**	-6.4%
Nov. 2014	-31.83**	-16.0%	-23.13**	-11.8%	-12.63**	-6.6%
Dec. 2014	-34.54**	-17.4%	-25.55**	-13.1%	-12.94**	-6.8%
Average over 2014	-18.87**	-9.1%	-11.20**	-5.6%	-11.10**	-5.5%

Untaxed beverages [‡]	Low SES		Middle SES		High SES	
	Absolute difference (ml/day)	% of counterfactual	Absolute difference (ml/day)	% of counterfactual	Absolute difference (ml/day)	% of counterfactual
Jan. 2014	37.59**	5.0%	97.58**	12.1%	16.73**	1.8%
Feb. 2014	33.80**	4.5%	87.87**	10.9%	16.29**	1.7%
Mar. 2014	30.04**	4.0%	78.33**	9.7%	15.84**	1.7%
Apr. 2014	31.84**	3.6%	85.13**	8.6%	17.70**	1.6%
May 2014	27.39**	3.1%	73.76**	7.5%	17.20**	1.6%
June 2014	23.00**	2.6%	62.58**	6.4%	16.70**	1.6%
July 2014	18.29**	2.1%	52.46**	5.3%	15.77**	1.5%
Aug. 2014	14.08**	1.6%	41.48**	4.2%	15.28**	1.5%
Sept. 2014	9.91**	1.1%	30.69**	3.1%	14.81**	1.4%
Oct. 2014	5.26**	0.7%	18.66**	2.0%	13.40**	1.4%
Nov. 2014	1.56	0.2%	8.99**	1.0%	12.96**	1.3%
Dec. 2014	-2.10	-0.3%	-0.52	-0.1%	12.52**	1.3%
Average over 2014	19.22**	2.4%	53.08**	5.9%	15.43**	1.5%

[‡] Analysis only uses data from October 2012 onward due to incomplete dairy data from January 2012 to September 2012.

* Statistically significant at $p < 0.01$; ** statistically significant at $p < 0.001$. Predictions do not adjust for quarter in order to show seasonal trends in beverage purchases. Back-transformation of predicted $\log(\text{BEV volume})$ from DinD fixed effects models used Duan smearing factors to handle potential heteroskedasticity.

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