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Reduction in purchases of energy-dense nutrient-poor foods in Mexico associated with the introduction of a tax in 2014

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ABSTRACT

In 2014, an 8% tax on energy-dense nutrient-poor foods was implemented in Mexico with the aim of reducing its consumption. This paper estimated changes in household purchases of taxed food.

We used the latest five waves of the nationally representative Mexican Income and Expenditure Survey (2008, 2010, 2012, 2014 and 2016). The analytic sample comprises 154,777 households. We estimated changes in purchases based on a before and after comparison.

Results show a reduction in purchases of taxed food of −5.4 g/week per capita, equivalent to a relative reduction of −5.3% in the 2014 and 2016 waves compared to the 2008, 2010 and 2012 rounds. The largest relative reductions were in urban areas (−6.9%), among households with children (−7.0%), households where the head had an intermediate educational level (−9.9%) and the southern region (−14.8%). We did not find a significant reduction in rural areas.

While there is a large heterogeneity, the fiscal instrument has been effective in reducing taxed food purchases and has generated substantial revenue that could be used to finance policies for the prevention and treatment of obesity.

1. Introduction

Obesity is a disease affecting around 641 million people globally in 2014 (NCD Risk Factor Collaboration (NCD-RisC), 2016). In Mexico, the National Health and Nutrition Surveys conducted between 1988 and 2012 showed a rapid and large increase in the prevalence of overweight and obesity in all age groups, particularly in women of childbearing age (Gutiérrez et al., 2012; Barquera et al., 2013).

Obesity is associated with an increased risk of chronic diseases (World Health Organization, 2015). Although obesity is multifactorial in origin, there is evidence of a positive association between the consumption of energy-dense micronutrient-poor foods (normally high in saturated fat, salt and/or sugars) and weight gain (World Health Organization/Food and Agriculture Organization, 2002). The consumption of these foods is also associated with high blood pressure and atherosclerosis (Rauber et al., 2015), conditions that are risk factors for other chronic diseases.

A high proportion of the Mexican population has a low-quality diet, i.e., does not meet international recommendations (Rivera et al., 2016; Batis et al., 2016a). Moreover, a study estimated that in 2012, foods high in saturated fat or added sugars contributed on average 16% to total energy intake (Aburto et al., 2016).

Several food policies have been proposed to reduce the consumption of unhealthy food and beverages, including taxes (World Health Organization, 2013). In addition to a tax on sugar sweetened beverages, since January 2014 in Mexico an ad valorem tax of 8% was applied to energy-dense nutrient-poor foods with an energy density ≥275 kcal/100 g (Congreso de los Estados Unidos Mexicanos, 2014). These food items (denoted as nonessential energy-dense food in the legislative jargon in Mexico and referred from now on as taxed food) include chips and deep-fried salted snacks, sugar confectionery, chocolates, crème caramel and puddings, candied fruits, peanut and hazelnut spreads, caramel sauces, cereal-based sweet foods, ice cream and popsicles. It is estimated that these foods contribute on average 14.4% to the total energy intake of the population (Batis et al., 2017).

A recent study estimated changes in purchases of packaged foods,

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among a panel of representative Mexican households in cities of over 50,000 inhabitants (Batis et al., 2016b). The study found an average 5.1% reduction in the volume of taxed food purchases in the first year after the tax (2014) compared to what would had been expected according to pre-tax trends. The study also found that the reduction was greater in households with a lower socioeconomic status. A more recent study, based on the same panel and using a similar methodology, estimated an overall 6% reduction two years after the tax was implemented (2014–2015) (Taillie et al., 2017). Although this panel of households was longitudinal and had enumerators visiting households every 2-weeks to collect purchases, it only captured packaged foods, and excluded some food items, like candies and chocolates. An additional limitation of the study was that the data did not include households in more rural areas.

The aim of this paper was to estimate changes in household purchases of taxed food in a representative sample of the Mexican population. We used six rounds of the National Income and Expenditure Surveys. The analysis was based on a before and after comparison using a two-part model to account for the large number of non-purchases. We analyzed the heterogeneity of changes in purchases by household income, presence of children at the household, education level for the head of the household, and area of residence (urban/rural).

2. Methods

2.1. Data sources

We analyzed the National Household Income and Expenditure Surveys (ENIGH), in its 2008, 2010, 2012, 2014 and 2016 waves. The ENIGH is a cross-sectional survey carried out every two years between August and November. The survey has a probabilistic, two-stage stratified clustered design, and it is representative both at the national level and of urban and rural strata (Instituto Nacional de Estadística y Geografía, 2013).

The ENIGH collects information on household expenditures in 242 food, beverage, and tobacco categories, which do not include expenditures on food services for consumption away from home. Household expenses on food and beverages are obtained with a daily record instrument which is applied during seven consecutive days (Instituto Nacional de Estadística y Geografía, 2015). Non-monetary expenses related to assets obtained as gifts, at subsidized prices, or produced in a family business are also collected. Quantity purchased corresponding to each expense is recorded. The ENIGH also reports household income and collects sociodemographic information such as household composition, level of education of the head of the household and area of residence (urban/rural).

2.2. Identification of food groups and analytic sample

The categories in the ENIGH are composed by 1) a single food, for foods that are widely consumed (e.g. tomatoes) or by 2) a food group that includes foods in less demand (for example cherries, raspberries, strawberries and blackberries would make up one category of expenditure). When a category was composed by a food group, we considered the category as “taxed” if the tax affected more than half of the foods in the group, and “untaxed” in the opposite case. A thorough classification into taxed/untaxed would had required information at the brand level because energy density varies by brand; however, this information was unavailable therefore our identification was subject to a certain degree of misclassification. Supplemental Table A.1 shows the categories classified as taxed/untaxed. We classified 14 categories of food expenditure in ENIGH as taxed, and we grouped them into four subgroups: sweet bread from large bakeries, chips and salty snacks, candies and chocolates, and cereal-based sweet food.

Sweet bread from bakeries is a particular subgroup because small producers, those with lower annual income, could have benefitted from a fiscal stimulus applied to micro and small enterprises, which was equivalent to a 100% reduction (“Diario Oficial de la Federación,” 2013), thereby undermining the ability of the tax to increase prices. This consideration is important because small bakeries have a 55% market share (Excelsior, 2014). We could not identify purchases from bakeries that took advantage of the fiscal stimulus, but we used information from the survey on the type of establishment in which purchases were made. With this information, we could classify units of sweet bread from a traditional retailer or specialized bakery stores (referred to from now on as “sweet bread from small or specialized bakeries”) separately from sweet bread from large bakeries that were definitely taxed (such as supermarkets, department stores, warehouse clubs, convenience stores and restaurants).

We considered important to estimate changes in the group of untaxed food composed of the remaining 186 food categories, to see if our findings on taxed food could have been the result of a general trend in total food purchases. We divided categories by ultra-processed untaxed (26 categories), and non-ultra-processed (160 categories) foods, following the NOVA classification criteria. The NOVA classification categorizes foods according to the extent and purpose of food processing rather than in terms of nutrients (Monteiro et al., 2016), to identify possible substitutions.

We excluded households without purchases in any food category and those who reported a zero income, which represented $< 0.9\%$ of households with completed interviews for each wave of ENIGH. The analytic sample comprised of 154,777 households (29,222 households in 2008, 27,414 in 2010, 8926 in 2012, 19,360 in 2014 and 69,855 in 2016).

We excluded quantities associated with non-monetary expenses. We considered that these purchases could not be affected by the tax in the same way as monetary expenses because they did not imply a food choice under market prices. Non-monetary expenses made up approximately one-fifth of the monetary expenses on food in each wave, so we included them in the sensitivity analysis. We also conducted a sensitivity analysis that excluded households with taxed food purchases above the 99th percentile in the set of households with non-zero purchases, because the corresponding per capita quantities could be considered implausible for individual consumption.

2.3. Statistical analyses

The tax was applied nationally, so there was not a straightforward comparison group. We estimated changes in household purchases associated with the tax through a before and after approach, comparing purchases in a period prior to the application of the tax (2008–2012) with purchases in a period where the tax was in force (2014–2016), adjusting for variables that change over time and could potentially influence food purchases.

For each household in the analytical sample, we calculated the per capita quantity in grams of weekly purchases by dividing total household quantities by household size, both for taxed food, untaxed food, and for each subgroup. We estimated the average quantities of groups and subgroups as the weighted average of per capita quantities, taking into consideration the complex sample design of the ENIGH.

The percentage of households that did not report purchases of taxed food in each ENIGH wave was very high (~60%), so we followed a two-part estimation strategy (Belotti et al., 2015). We first modeled the probability of purchasing as a function of a binary variable indicating the taxed or pre-taxed period (0 = 2008, 2010, 2012; 1 = 2014, 2016), adjusting for demographic, socioeconomic, and contextual covariates. In the second part, we estimated a generalized linear model with log-link and gamma distribution on households with positive taxed food purchases, adjusting for the same variables as the first part. Changes in purchases were calculated as the average marginal effect of the variable indicating taxed or pre-taxed period, considering both parts of the model (i.e. multiplying the predicted probabilities and quantities).

We adjusted the models for variables at the household and environmental levels that are potentially associated to food purchases: level of education of the head of the household (elementary or lower, junior high school, high school or higher), household composition (number of members in five categories of age, by sex: less than 2 y, 2–5 y, 6–12 y, 13–18 y, > 18 y), type of household according to presence/absence of children (a binary variable indicating households with individuals up to 18 years old), per capita household income (in tertiles calculated for each wave), the log of per capita household income at 2008 prices, month of data collection to adjust for seasonality (binary variables), area of residence (two categories: urban = 2500 inhabitants or more, rural = 2499 inhabitants or less), and region (Northern, Central and Southern). In addition, we included a contextual state-level variable created from official sources other than ENIGH ("Banco de Información Económica (BIE)," 2017; "Consejo Nacional de Población," 2016), namely the log of gross domestic product (GDP) per capita at 2013 prices, which was potentially associated with the outcome variable and some of the previously mentioned independent variables. In addition, we adjusted the models by a binary variable indicating the 2010 survey, to avoid possible biases due to the negative impact that the global financial crisis had on food access in 2010 compared to 2008 (Programa Universitario de Estudios del Desarrollo, 2015).

Also, we carried out two additional analysis to test for robustness of our results. The first one was a falsification test that excluded the 2014–2016 information, treating 2012 as the post-tax period and comparing against the 2008–2010 rounds. In this specification, given the absence of a tax policy in 2012 we would not expect to see any reductions in purchases. Findings of a reduction would mean a previous trend that could not have been due to the tax implementation. The second approach excluded rounds 2008 and 2010, keeping only 2012 as the pre-tax period. Since descriptive analysis showed an increase in purchases in 2012, we expected that using only 2012 as the pre-tax period would lead to an over-estimation of the effect of the tax; therefore, we conducted this test to verify how conservative our primary approach was. In addition, it was useful to have an appropriate comparison with other studies that do not use information prior to 2012 (Batis et al., 2016b; Taillie et al., 2017).

All estimates were made considering the complex sample design of ENIGH. Robust estimation of standard errors was performed and significance at conventional levels was determined. The relevance of the models was evaluated with F-tests for the joint significance of the variables and Hosmer-Lemeshow test for goodness-of-fit where they applied. All analyses were performed in STATA 13 (STATA Corp., 2013).

3. Results

The unadjusted average quantity of taxed food purchases increased between 2008 and 2012, decreased in 2014 and increased slightly in 2016 (Table 1). Across all ENIGH waves, proportions/means for household composition variables, area of residence and region were similar. In contrast, we see positive changes in indicators of education of the head of the household and GDP per capita over time, and small reductions in the proportion of households with children.

Table 2 shows the unadjusted purchases and percent of households with non-zero purchases for each subgroup of taxed food. There were reductions in unadjusted purchases between 2012 and 2014 for 3 of the 4 subgroups. Supplemental Table A.2 exhibit unadjusted purchases by strata showing, for example, households in the highest income tertile purchased on average more than twice as much taxed food as households in the lower income tertile.

Estimated changes in food purchases are shown in Table 3. There was a significant relative reduction of −5.3% on taxed food purchased in 2014–2016 compared to 2008–2012, equivalent to −5.4 g/week per capita. By subgroups, the largest significant reduction at the 5% significance level was observed for cereal-based sweet foods.

By strata, the largest significant relative reductions were in urban areas (−6.9%), in households where the head completed junior high school schooling (−9.9%), in households with children (−7.0%), and in the southern region (−14.8%). In urban areas, we found that the lower the income, the highest the relative reduction, although the estimated change did not reach statistical significance. There was not statistically significant change in rural areas.

For untaxed food, results showed a statistically significant relative increase of 2.8%. By subgroups of untaxed food, we found a statistically significant increase in purchases of non-ultra-processed foods (2.8%). Meanwhile, sweet bread from small or specialized bakeries had a relative increase of 8.6%.

In our sensitivity analyses, excluding households with purchases of taxed food above the 99th percentile among those with non-zero purchases, we saw that changes in purchases were similar and, in some cases, reached or even strengthened statistical significance (Supplemental Table A.3). On the other hand, when considering purchases related to non-monetary expenditures, the estimated changes were higher (Supplemental Table A.4).

4. Discussion

We estimated changes in purchases of taxed food before and after the tax was implemented, using a representative sample of the Mexican population. Our results showed a 5.3% reduction in purchases, lower than the 8% tax. Our hypothesis was that the reduction was due to the tax. This hypothesis is supported by an increase in purchases of untaxed food, suggesting potential substitutions from taxed to untaxed food. We also found a remarkable heterogeneity of changes in purchases, highlighting the statistically significant changes in urban areas (−6.9%), among households with children (−7.0%), households where the educational level of the head of household was junior high school (−9.9%) and those in the southern region (−14.8%). We did not find a statistically significant change in rural areas.

Our estimations were similar to findings in two previous studies, which saw a reduction of 5.1% the first year of the tax compared to what would have been expected based on pre-tax trends (Batis et al., 2016b), and a reduction of −6.0% from two post-tax years (Taillie et al., 2017). These two studies were similar in terms of methodology and sample but with some differences to our study worth noting. First, the prior two studies had different samples from ours and did not provide estimates for communities with < 50,000 inhabitants, which represent 37% of the Mexican population. For urban areas, we estimated a reduction closer to the size of the tax (−6.9%). Secondly, purchase data in the other studies did not include sweet bread from bakeries, candies and chocolates, which represents approximately 20% of the weekly amount (g/week) of taxed food purchases estimated in our study. Thirdly, the other studies used longitudinal household data while ours was based on analyses of cross-sectional surveys. Finally, we used three rounds of pre-taxed data (2008, 2010 and 2012) whereas the other studies had monthly data from January 2012 to December 2013.

Our results were consistent with a study in Mexico that reported own-price elasticities of −1.13 for candies and −0.97 for snacks, respectively, between 2006 and 2010 (Colchero et al., 2015a).

To discard the possibility that findings were due to pre-tax trends, we performed two tests. We first conducted a falsification test as if 2012 was the year in which the tax was implemented, excluding 2014 and 2016. In this specification, we found a statistically significant increase of 14.3%, suggesting that our main results are not biased by a pre-downward trend. Given that in descriptive analysis we saw an increase in purchases in 2012, we then performed an estimation excluding the 2008 and 2010 rounds keeping only 2012 as the pre-taxed period. The estimated change was a statistically significant reduction of −10.9%, suggesting a potential overestimation when including a shorter pre-tax period.

We found heterogeneity by area of residence. Also, there was

Table 1
Characteristics of households in the analytic sample[a].

Variable	2008	2010	2012	2014	2016
	Proportion (SE)	Proportion (SE)	Proportion (SE)	Proportion (SE)	Proportion (SE)
Households with purchases of taxed food	0.43 (0.0)	0.41 (0.0)	0.45 (0.0)	0.43 (0.0)	0.42 (0.0)
Taxed food purchases (g/week per capita)[b]	90 (2.3)	97 (2.4)	110 (4)	97 (2.3)	101 (1.8)
Household characteristics					
Education of the head of the household					
Elementary or lower	0.54 (0.0)	0.51 (0.0)	0.49 (0.0)	0.46 (0.0)	0.43 (0.0)
Middle school	0.24 (0.0)	0.25 (0.0)	0.27 (0.0)	0.28 (0.0)	0.29 (0.0)
High school or higher	0.22 (0.0)	0.23 (0.0)	0.25 (0.0)	0.27 (0.0)	0.28 (0.0)
Household composition[b]					
Male					
Less than 2 y	0.07 (0.0)	0.07 (0.0)	0.06 (0.0)	0.06 (0.0)	0.06 (0.0)
2–5 y	0.15 (0.0)	0.14 (0.0)	0.14 (0.0)	0.14 (0.0)	0.13 (0.0)
6–12 y	0.3 (0.0)	0.29 (0.0)	0.25 (0.0)	0.27 (0.0)	0.25 (0.0)
13–18 y	0.27 (0.0)	0.25 (0.0)	0.23 (0.0)	0.23 (0.0)	0.21 (0.0)
More than 18y	1.16 (0.0)	1.15 (0.0)	1.14 (0.0)	1.15 (0.0)	1.13 (0.0)
Female					
Less than 2 y	0.07 (0.0)	0.06 (0.0)	0.06 (0.0)	0.06 (0.0)	0.05 (0.0)
2–5 y	0.15 (0.0)	0.15 (0.0)	0.14 (0.0)	0.14 (0.0)	0.13 (0.0)
6–12 y	0.29 (0.0)	0.26 (0.0)	0.25 (0.0)	0.25 (0.0)	0.24 (0.0)
13–18 y	0.26 (0.0)	0.23 (0.0)	0.22 (0.0)	0.22 (0.0)	0.21 (0.0)
More than 18 y	1.31 (0.0)	1.29 (0.0)	1.25 (0.0)	1.29 (0.0)	1.27 (0.0)
Per capita income[c]					
Low	0.34 (0.0)	0.31 (0.0)	0.28 (0.0)	0.32 (0.0)	0.31 (0.0)
Medium	0.33 (0.0)	0.34 (0.0)	0.34 (0.0)	0.33 (0.0)	0.32 (0.0)
High	0.33 (0.0)	0.35 (0.0)	0.38 (0.0)	0.35 (0.0)	0.36 (0.0)
Log of per capita income at 2008 prices[b]	8.83 (0.0)	8.78 (0.0)	8.82 (0.0)	8.77 (0.0)	8.90 (0.0)
Type of household					
Without children (individuals up to 18 y old)	0.32 (0.0)	0.34 (0.0)	0.37 (0.0)	0.36 (0.0)	0.38 (0.0)
With children (individuals up to 18 y old)	0.68 (0.0)	0.66 (0.0)	0.63 (0.0)	0.64 (0.0)	0.62 (0.0)
Environmental characteristics					
Area of residence					
Urban	0.79 (0.0)	0.79 (0.0)	0.78 (0.0)	0.78 (0.0)	0.78 (0.0)
Rural	0.21 (0.0)	0.21 (0.0)	0.22 (0.0)	0.22 (0.0)	0.22 (0.0)
Region					
Northern	0.27 (0.0)	0.27 (0.0)	0.27 (0.0)	0.27 (0.0)	0.27 (0.0)
Central	0.50 (0.0)	0.50 (0.0)	0.50 (0.0)	0.50 (0.0)	0.50 (0.0)
Southern	0.23 (0.0)	0.23 (0.0)	0.22 (0.0)	0.22 (0.0)	0.23 (0.0)
Contextual conditions[d]					
Log of GDP per capita (Mexican pesos)[b]	11.61 (0.0)	11.59 (0.0)	11.64 (0.0)	11.66 (0.0)	11.70 (0.0)

[a] The analytic sample comprises 154,777 households, 29,222 households in 2008, 27,414 in 2010, 8,926 in 2012, 19,360 in 2014 and 69,855 in 2016. The complex sample design was considered to calculate proportions/means. SE = Standard error. Data source: The Mexican National Household Income and Expenditure Surveys 2008–2016.
[b] Mean instead of proportion.
[c] Categories were defined by tertiles of the distribution in each wave.
[d] Variable at the state level. Logarithm of GDP per capita at 2013 prices, without oil production.

heterogeneity by education of the level of education for the head of the household, type of household (presence/absence of children at home) and between subgroups. This could be partly explained by the reported heterogeneity of the effect of the tax on prices. For rural and semi-urban areas (communities with up to 20,000 inhabitants) prices increased less than the amount of the tax (Colchero et al., 2017), which could explain in part why there was no change in taxed food purchases in rural areas. In contrast, in urban areas with > 20,000 inhabitants, prices increased close to the amount of the tax (Colchero et al., 2015b). Moreover, several of the major food and beverage companies supply their products with their own distribution network in rural areas, so they may have had some control over the supply chain in order to reduce the impact of the tax on their sales. Finally, the market of several ultra-processed products in Mexico is oligopolistic (Pan American Health Organization, 2015), such that the biggest companies could influence prices, availability, and other factors affecting food choices (Institute of Medicine and National Research Council, 2015).

Our study shows that, while greater consumption of taxed food was

Table 2
Weekly purchases of taxed food, by subgroup[a].

Subgroup	g/week per capita, mean (SE)					Households with non-zero purchases, % (SE)				
	2008	2010	2012	2014	2016	2008	2010	2012	2014	2016
Cereal-based sweet food	63 (1.7)	66 (1.8)	76 (3.2)	65 (1.7)	70 (1.5)	31 (0.5)	31 (0.5)	34 (0.8)	32 (0.5)	32 (0.3)
Chips and salty snacks	9 (0.8)	11 (0.8)	15 (0.9)	12 (0.7)	13 (0.4)	12 (0.3)	11 (0.3)	14 (0.5)	12 (0.3)	12 (0.2)
Sweet bread from large bakeries	9 (0.8)	8 (0.5)	6 (0.8)	9 (1.0)	7 (0.4)	4 (0.2)	4 (0.2)	3 (0.3)	4 (0.2)	3 (0.1)
Candies and chocolates	9 (0.7)	13 (1)	13 (1.2)	11 (0.6)	11 (0.5)	12 (0.3)	11 (0.3)	13 (0.5)	11 (0.3)	10 (0.2)

[a] Unadjusted purchases. The complex sample design was considered to calculate means and proportions. SE = standard error. Data source: The Mexican National Household Income and Expenditure Surveys 2008–2016.

Table 3
Changes in food purchases before and after the tax (2014–2016 compared to 2008–2012).

Group/subgroup/stratum	n	Change g/week (SE)[a]	Change %[b]
Taxed food	154,777	−5.4 (2.5)*	−5.3
Candies and chocolates	154,777	−1 (0.7)	−8.8
Chips and salty snacks	154,777	0.4 (0.7)	3.7
Cereal-based sweet foods	154,777	−4.7 (1.9)*	−6.8
Sweet bread from large bakeries	154,777	0.1 (0.7)	0.8
Untaxed food	154,777	143.1 (41)**	2.8
Ultra-processed untaxed[c]	154,777	4.8 (4.5)	1.9
Non-ultra-processed[d]	154,777	137.1 (39.7)**	2.8
Sweet bread from small or specialized bakeries	154,777	9 (4)*	8.6
Taxed food by strata			
Per capita household income			
Low	51,594	−1.8 (2.6)	−3.1
Medium	51,592	−5.5 (3.6)	−6.5
High	51,591	−7.6 (5.3)	−4.9
Area of residence			
Urban	108,252	−7.6 (3)*	−6.9
Rural	46,525	1.3 (3.8)	1.8
Urban areas, by per capita income			
Low	36,085	−4.5 (3.2)	−7.1
Medium	36,085	−7.1 (4.6)	−7.4
High	36,082	−9 (6.7)	−5.4
Rural areas, by per capita income			
Low	15,510	−1.5 (4.6)	−2.7
Medium	15,508	0.4 (5.4)	0.6
High	15,507	10.7 (6.8)	11.7
Education of the head of the household			
Elementary or lower	76,307	−1.8 (2.7)	−2.5
Junior high school	42,298	−10.6 (4.3)*	−9.9
High school or higher	36,172	−7.2 (6.4)	−4.7
Type of household			
Without children (individuals up to 18 y old)	54,855	−0.4 (4.9)	−0.3
With children (individuals up to 18 y old)	99,922	−6.3 (2.6)*	−7.0
Region			
Northern	49,255	−3.5 (5)	−2.6
Central	66,227	−1.5 (3.5)	−1.7
Southern	39,295	−13.5 (4.2)**	−14.8

[a] Changes in g/week per capita, estimated following a two-part estimation strategy, adjusting models by education of the head of the household, type of household, per capita income, month of data collection, area of residence, region and GDP per capita. The complex sample design was considered to calculate the estimates. SE = standard error. ** = significant at 1%; * = significant at 5%; + = significant at 10%. Data source: The Mexican National Household Income and Expenditure Surveys 2008–2016.

[b] Estimated change in g/week per capita, relative to purchases in pre-tax period.

[c] Examples of ultra-processed untaxed food are industrialized bread for sandwiches, hamburgers or hot dogs, processed meats of pork and chicken, flour tortillas, ice cream, sorbets, ice lollipops, salty cookies, crème caramel, jelly, pudding, etc.

[d] Examples of non-ultra-processed food are fruits, vegetables, beans, corn and rice in bulk, corn tortilla, eggs, sugar, unprocessed chicken, pork or beef, food prepared for consumption at home, dairy, white bread, baguette, oils and fats, wheat pasta, etc.

observed in households with higher per capita income, which is usual for an upper-middle income country like Mexico, changes in purchases were larger in the lowest income tertile in urban areas. This was expected from an economic point of view, because households under these conditions generally devote a larger proportion of their income to purchasing food.

Although studies on the medium or long term impact of the tax on diet quality and health outcomes would be relevant, our study provides essential evidence on the reduction of purchases of taxed food and potential substitutions. Our results suggest that there were substitutions from taxed to untaxed food. While there was a large increase in more nutritious foods such as non-ultra-processed foods, there was also a large increase in sweet bread from small or specialized bakeries. The fiscal stimulus for small bakeries may be a good policy for economic development but could overshadow the potential health benefits of the tax. Hence, the effect of the taxes on total energy and dietary quality intake requires further investigation.

From 2014 to 2016, revenues from the tax to energy-dense nutrient-poor foods exceeded USD 2600 million. Even if changes in calories were small due to potential substitutions, the positive health effects of the tax could be extended if the revenue was used for obesity prevention.

4.1. Study limitations and strengths

We could not use a control group for the analysis since the tax was implemented nationally. We therefore acknowledge that in the absence of an experimental design, the estimated changes should not be interpreted as causal effects of the tax. Although we adjusted for several variables at the household and macroeconomic level, we cannot determine the extent to which unobserved factors explain our results (Lance et al., 2014). For example: industry strategies aimed at reducing the impact of the tax on sales (marketing campaigns, sales promotions, differential pricing) may have increased the probability of purchasing taxed food. Also, interventions implemented by the government virtually at the same time as the food tax to subvert the epidemic of overweight and obesity, such as the tax on sugar-sweetened beverages (Congreso de los Estados Unidos Mexicanos, 2014), and some regulations included in the national strategy for the prevention and control of obesity and diabetes (Secretaría de Salud, 2013), could have had direct effects on purchases. Economic growth and household income may also have affected purchases. We attempted to improve the reliability of our estimations by adjusting the models for a contextual variable associated with these factors, namely, GDP per capita, which was statistically

significant in most models. However, despite the possible biases mentioned, in high-income countries like the United States there is some evidence, based on experimental designs, that additional interventions other than those acting through prices involve, at best, limited independent effects or interactions with price interventions on purchasing (Epstein et al., 2012). Therefore, the bias due to other interventions implemented to prevent obesity may be modest.

The study is based on existing data, with a specific structure and categorization of foods and beverages, so the identification of taxed/untaxed food in our study is prone to a certain degree of misclassification, which could impact our findings. However, 97% of food purchases in the ENIGH are classified in single food categories, which reduces potential misclassifications.

We did not have anthropometry, limiting our ability to test for differential effects among households with individuals who are currently more affected by obesity.

The information on expenditures of food services for consumption away from home was excluded because it did not include the description of the food consumed in ENIGH. However, food services specialized in offering complete meals rarely offer in their menus taxed foods or meals that use them as an ingredient, so we believe that there were few of these in the excluded expenditures. If any bias was a result of this, we would expect it to be low.

A barrier to effectively evaluating policies related to food systems is the lack of information on the actions taken by producers and retailers (Institute of Medicine and National Research Council, 2015). In middle-income countries, studies to characterize changes on the supply side are needed. For example, modern retail stores have expanded above the general economic growth in Mexico (PwC Mexico, 2015), increasing availability of taxed food, which could have led to changes in food expenditures (Popkin et al., 2012) and therefore potentially attenuate the effect of the tax. We could not control for these trends with the available data.

One strength of the study is that it was based on a nationally representative sample, which allowed estimating changes in purchases of taxed food in rural areas, which had not been studied. In addition, we used a long pre-tax period preventing us from making estimates based on temporary changes.

5. Conclusion

The tax appears to be effective in reducing purchases of taxed food even when the rate seems small; however, there was great heterogeneity between strata. For instance, no changes in taxed food purchases were found in rural areas, where other strategies should be implemented to improve diet quality. However, the reductions in purchases of taxed food shown in our study support the continuation of the tax.

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Conflict of interest

The authors have no conflict of interest to declare.

Abbreviations used

ENIGH for the National Household Income and Expenditure Survey (Spanish acronym).

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ypmed.2018.09.019.

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