Trade in unhealthy foods and obesity: Evidence from Mexico*

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Abstract

This paper investigates the effects of trade in food on obesity in Mexico. We classify Mexican food imports from the U.S. into healthy and unhealthy and match these with anthropometric and food expenditure survey data. We exploit variation across Mexican states in their exposure to food imports from the U.S.. We find that imports of unhealthy foods significantly contribute to the rise of obesity in Mexico. The empirical evidence also suggests that unhealthy food imports may widen health disparities between education groups. By linking imports to food expenditure and obesity, the paper sheds light on an important channel through which globalisation may affect health.

Keywords: Trade, obesity, nutrition transition, Mexico

JEL codes: F60, F16, I10

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1 Introduction

The prevalence of obesity, overweight and other diet-related chronic diseases has increased rapidly in the developing world. Today an estimated 62 percent of obese individuals live in developing countries (Ng and et al., 2014). The number of overweight or obese people living in the developing world has tripled between 1980 and 2008 (Keats and Wiggins, 2014). Over the same period many emerging economies have opened up their food markets to international competition. In response, policy makers have paid more attention to the implications of globalisation and international trade for population health and diets. The World Health Organization (WHO, 2015), for instance, has adopted a clear mandate to help and support member states to better align trade and health policies. Despite the perceived association between trade liberalisation and obesity, the causal effects of trade in foods on obesity and their quantitative importance are not well established.[1]

The rise of obesity in emerging economies has been correlated to a "nutrition transition" whereby diets become richer in animal fats and sugars, and rely more on processed foods as average income increases (Popkin and Gordon-Larsen, 2004). These nutritional changes are intertwined with an epidemiological transition in which populations increasingly suffer from obesity, diabetes and cardiovascular diseases rather than infectious diseases and undernutrition (Omran, 1971).

Greater openness to trade in foods can affect the nutrition transition and hence obesity through changes in income, food prices, tastes and norms. By increasing average income, trade liberalisation can fuel the nutrition transition and contribute to the rise in obesity. Its effects through prices are however ambiguous as they depend on the induced price changes and availability of unhealthy and healthy foods. Furthermore, globalisation and trade openness can affect norms and preferences by, for instance, heightening exposure to food advertising on television and the internet (Oberlander et al., 2017; Dragone and Ziebarth, 2017).

In this paper, we empirically examine the contribution of trade in foods to the obesity epidemic in Mexico. We focus on Mexican imports of U.S. foods. The U.S. ranked first in terms of obesity prevalence among OECD countries in 2017 (OECD, 2017). Our empirical analysis thus aims to assess to what extent Mexico has "imported" obesity from the U.S. over recent decades through trade in foods. After linking food imports from the U.S. to expenditure and health survey data, we estimate the effect of greater exposure to unhealthy

[1] A recent literature in public health has studied the link between trade liberalisation and health outcomes looking at consumption of products containing high-fructose corn syrup (Barlow et al., 2017), such as sugar-sweetened beverages (Lopez et al., 2017; Schram et al., 2015).

food imports on obesity across Mexican states. Mexico is a prime example of a country in the nutrition transition recording spectacular increases in diabetes and obesity rates (Popkin et al., 2012). According to the latest WHO data from 2014, Mexico is among the twenty most obese countries in the world, with an estimated 28 percent of the adult population being obese.[2] At the same time, the economy has increased its exposure to world markets since the 1980s, deepening trade and investment linkages especially with the U.S.. The North America Free Trade Agreement (NAFTA) in 1994 has further reinforced these dynamics (Caliendo and Parro, 2015).

The Mexican case allows us to shed light on the linkages between trade liberalisation, the nutrition transition and diet-related health issues such as obesity. Anecdotal evidence points to a positive correlation between trade liberalisation and the observed rise in obesity in Mexico (e.g., Clark et al. (2012)). As the UN Special Rapporteur on the Right to Food stated in 2012, the widespread belief is that at least part of the obesity emergency could have been avoided if "the health concerns linked to shifting diets had been integrated into the design of the country's trade policies" (Guardian, 2015). This paper tests whether the relationship between the important increase in "unhealthy" food imports and excessive weight gain is indeed causal and quantifies the contribution of food imports from the U.S. to the surge in obesity.

To identify the effect of food imports within Mexico, we allocate trade flows to Mexican states according to their 'exposure' to each type of food as measured by the state's historical expenditure share by food product. The underlying idea is that trade shocks, while being national, affect regions and individuals differentially along many dimensions. Previous work has used, for instance, access to trade routes (Atkin and Donaldson, 2015) and sectors of local employment (Kovak, 2013; Autor et al., 2013) to allocate aggregate trade shocks across regions. In our paper, we exploit each region's weight in the national expenditure basket.[3] The share of total national expenditure of a given food product that goes to each state is the most relevant dimension for our purpose, since it measures exposure to trade shocks as predicted by baseline food consumption (and hence nutrition) patterns. Specifically, our empirical strategy implies that a Mexican state where expenditure in, say, processed foods has been historically higher will receive a larger share of a given increase in imports of processed foods.

Imputed food imports at the state level form the basis of the main explanatory variable in

[2]The obesity epidemic has important implications for health outcomes in Mexico - see e.g. Bargain and Zeidan (2014) for its effects on emotional distress.

[3]Fajgelbaum and Khandelwal (2016) highlight the importance of expenditure shares at the individual level in determining the distribution of the gains from trade

our empirical analysis. To delve into the nutrition channel, we further differentiate between "healthy" and "unhealthy" foods using the USDA Dietary Guidelines for Americans (DGA, 2010). This categorisation allows us to impute the share of unhealthy food imports at the state level. We then estimate the effect of exposure to the share of unhealthy food imports across Mexican states on the obesity status of individuals living in these states.[4]

We document a positive and robust effect of unhealthy food imports on obesity across Mexican states. Our main results are based on a sample of adult women, as male anthropometric data was only collected in later surveys. The estimates imply that a one standard deviation increase in the unhealthy share of imports (equivalent to a 14 percentage point increase) leads to an increase in the risk of being obese by 5 percentage points among adult women. This effect is statistically significant and equivalent to 20 percent of the average obesity prevalence in adult women. The results are robust to the use of food imports statistics for final demand only, and in a sample including also male adults (for which there is data only in the last two waves (2006 and 2012) of the health survey). The findings are also confirmed in empirical specifications where the obesity and import variables are in long differences between their 2012 and 1988 values. Overall, the evidence points to a sizeable contribution of trade in unhealthy foods to the rise of obesity in Mexico, which skyrocketed from 10 to 35 percent of the adult female population between 1988 and 2012.

The estimated effects are driven by the rising importance of unhealthy food imports, rather than by a general increase in imports of food or other products like apparel from the U.S.. While total food imports from the U.S. increased more than sevenfold between 1989 and 2012, we find that only imports of unhealthy food have a detrimental effect on obesity. This evidence accords well with the observed trends in imports of single food categories. Imports of "prepared foods", for instance, are 23 times higher in 2012 than in 1989 - the largest import surge among all food categories, contributing to the rising unhealthy share of U.S. imports. Results from a placebo test using imports of apparel as an alternative measure of states' exposure to trade further suggests that the baseline effect is specific to imports of unhealthy foods rather than overall trends in exposure to U.S. imports.

The strong effect of unhealthy food imports is robust to controlling for other state-level determinants of obesity. The trade effect does not seem to go through changes in the composition of household expenditure aggregated at the state level, or through changes in the relative price of unhealthy foods. We also find little evidence of an income effect.

To dig deeper into the demand mechanism and better assess price and income effects,

[4] Obesity status is derived from the Body-Mass Index (BMI, equal to weight (in kg) over height squared (in meters)), commonly used as a measure of body fat and weight.

we also estimate a household demand equation over healthy and unhealthy foods. Results suggest that unhealthy imports at the state level increase demand for unhealthy foods, contributing to explain the rise in obesity rates, while there is no significant effect for healthy foods. The demand effect of unhealthy food imports does not change when we control for local prices and real household expenditure, supporting a 'taste' channel of influence (see also Atkin (2013)) - in states that are increasingly exposed to unhealthy food imports from the U.S., individuals develop stronger preferences for unhealthy foods and hence face a higher risk of being obese.

We further extend the empirical analysis to investigate how the obesity effect of greater unhealthy food imports varies along important individual characteristics. Our findings point towards an important heterogeneity by levels of education. Results indicate that imports of unhealthy foods increase obesity significantly more among less educated women (i.e. those who have attained at most primary education). Furthermore, our estimates suggest that unhealthy imports magnify existing health disparities: women who have at least completed high school are 5 percentage points less likely to be obese than less educated women if they both live in a state with average exposure to unhealthy food imports. This difference rises to 8 percentage points if the unhealthy share of imports is one standard deviation (14 percentage points) higher.

This paper provides novel empirical evidence on the role of trade in unhealthy foods in driving obesity rates. It expands recent conceptual studies on the implications of trade liberalisation for nutrition and health (WHO, 2015; Thow, 2009). The emerging view is that globalisation in developing countries has contributed to the nutrition transition and to the related rise in obesity, diabetes and other cardiovascular diseases. Existing cross country studies however provide mixed evidence for this view. Miljkovic et al. (2015) and Vogli et al. (2014) report a positive and significant effect of trade openness on obesity and BMI, whereas the evidence from Oberlander et al. (2017) and Costa-Font and Mas (2016) suggests that social (rather than economic) globalisation matters. We use detailed data from a single country, Mexico, and contribute to this nascent line of empirical work by identifying the causal effects of unhealthy food imports (rather than total trade flows), and by assessing the role of interactions between exposure to trade and important socioeconomic drivers of obesity at the micro level.

Our study also complements recent work that has analysed the effect of trade liberalisation on health through supply side mechanisms. Hummels et al. (2016) find that increased participation in world markets by Danish firms increases both effort and injury rates of their workers. Relatedly, McManus and Schaur (2016) demonstrate that heightened exposure to import competition from China leads to higher injury rates, especially in small firms, and Pierce and Schott (2016) show that U.S. counties that were more exposed to unexpected and permanent tariff cuts on Chinese imports experienced higher suicide rates. Similarly, Colantone et al. (2017) find that British workers employed in industries with higher import competition are more likely to suffer from mental distress (see Lang et al., 2016 for similar evidence from the U.S.). These papers analyse supply related mechanisms - increasing trade integration affects workers' physical and mental activities - through which trade affects health outcomes. Our paper applies a comparable empirical methodology to allocate import shocks across regions within a single country, but it is the first one to focus on obesity and on the demand side channel operating through the nutrition transition (Popkin and Gordon-Larsen, 2004; Rivera et al., 2004).

By studying the effects of trade on obesity, the paper adds to a large body of work on the economic determinants of obesity and other diet-related health issues (Cawley, 2015). Courtemanche et al. (2016) find that changing economic conditions explain a significant portion of the observed rise in obesity in the U.S.. Proximity to supercenters (such as Walmart) and restaurants are found to be the most important economic predictors of obesity (see also Currie et al., 2010 on the effects of fast food restaurants on obesity). Handbury et al. (2015), however, find that spatial differences in access to healthy foods explain only a small fraction of the differences in nutritional intake across people from different socioeconomic groups (e.g., across people with different levels of education). Our paper adds to this strand of the literature by highlighting the role of international trade as a novel and quantitatively important economic driver of obesity.

The rest of the paper is organised as follows. Section 2 describes the empirical strategy and the data used in the analysis. Section 3 discusses the results, focusing on a descriptive analysis first (subsection 3.1), and then delving into the econometric results (subsections 3.2 to 3.4). Section 4 concludes.

2 Empirical strategy and data

The empirical analysis aims to identify the effects of Mexican food imports from the U.S. on obesity. It proceeds in three steps. First, we present some descriptive patterns and trends in obesity and food imports from the U.S.. Second, we estimate the effect of greater exposure to unhealthy food imports on the probability of being obese at the individual level, and investigate possible demand-based mechanisms. Finally, we examine the heterogeneity of documented effects as a function of skill (or education) levels and perform a series of robustness checks.

Our baseline specification relates obesity status (i.e., having a BMI of at least 30) for each individual in the sample to exposure to unhealthy food imports allocated to the 32 Mexican states - the lowest level of aggregation where the health and expenditure surveys are both representative. In practice, we estimate the following regression:

$$(1) \quad Obesity_{i,s,t} = \beta_1 UnhealthyImp_{s,t} + \beta_2 C_{i,s,t} + \beta_3 X_{s,t} + \gamma_s + \gamma_s t + \theta_t + \epsilon_{i,s,t}$$

The *Obesity* variable equals one if the individual i living in state s has a BMI greater or equal than 30 in t, the year of the health survey (1988, 1999, 2006, and 2012). The estimation sample is a repeated cross-section of adult women - the same individual is not followed over time. The main covariate of interest is $UnhealthyImp$ and equals the share of total imputed food imports at the state level that is classified as "unhealthy" - i.e., $UnhealthyImp = \frac{M_{s,t}^{unh}}{M_{s,t}}$, where $M_{s,t}^{unh}$ and $M_{s,t}$ represent the imputed imports of unhealthy food products and the total imputed imports of food products of state s at time t from the U.S., respectively.

The coefficient β_1 identifies the effect of unhealthy food imports on obesity in 'reduced-form'. The variable $UnhealthyImp$, measuring states' exposure to unhealthy imports, can be thought of as an instrument for the (unobserved) actual consumption of unhealthy foods from the U.S. by individual i. Individual consumption of unhealthy imports is likely to be endogenous - e.g., if being obese shifts preferences for unhealthy (relative to unhealthy) foods. Our identification strategy relies on variation in local exposure to (rather than actual consumption of) unhealthy food imports to estimate a causal effect on obesity. To identify a plausible source of exogenous variation in unhealthy imports, we use pre-determined (in 1984) state expenditures shares to distribute the national changes in food imports from the US between 1988 and 2012.

Imports from the U.S. for each Mexican state at the product level are imputed from national trade statistics - imports at the state level are not available for the period under study. We use the state's expenditure share for a given product (i.e., the state expenditure for a product relative to total national expenditure for the same product) to allocate imports across states. Specifically, total imputed food imports M of state s at time t are defined as follows:

$$(2) \quad M_{s,t} = \sum_g \frac{E_{g,s,1984}}{E_{g,1984}} M_{g,t}$$

where the subscript g identifies a product within the 'food & beverages' (F&B or 'food' for short) macro-category. The expenditure shares are computed using data from 1984 (the first year where such data are available), and hence before the beginning of our sample in 1988, and held fixed throughout the sample period. Imputed unhealthy food imports, $M_{s,t}^{unh}$ - i.e., the numerator of the unhealthy share of imports, $Unhealthyimp$ -, is computed by restricting the summation in (2) only to food categories g that are classified as unhealthy.

The methodology that we use to impute state food imports is borrowed from the literature on the local labour market impact of import competition (see, e.g., Autor et al., 2013), which has recently been applied also to investigate the effects of imports on workers' health (Colantone et al., 2017). In that line of work, the objective is to investigate trade effects in the labour market and hence imports are allocated within countries according to the employment share of each spatial unit in national employment by sector. In our analysis, we focus on a nutrition channel - expenditure shares are thus the relevant measure of trade exposure at the local level. By differentiating healthy and unhealthy foods on the basis of their nutritional composition, we further attenuate the possible influence of labour market channels (e.g. greater import competition altering the patterns of physical activity) on our estimates of interest.[5]

Our identification strategy combines pre-determined regional expenditures shares and national changes in food imports from the U.S. to identify a plausibly causal impact of unhealthy imports on obesity. Variation in 1984 expenditures shares across states and products and changes in food imports over time are both key to identify our coefficient of interest, β_1, in the regression equation (2). If national expenditure of each food category is equally distributed across states, or if the relative expenditure on unhealthy foods is equally distributed, the $Unhealthyimp$ share does not vary across state and β_1 cannot be identified separately from the times dummies θ_t, which flexibly control for the national unhealthy share of imports as well as for other national, time-varying shocks. If there were no significant changes in relative imports of unhealthy foods over time, the effect of the $Unhealthyimp$ variable would be absorbed by the state fixed effects γ_s. We further add state-specific time trends ($\gamma_s t$) to our specification in order to control for the generalised upward trends in obesity and in trade between Mexico and the U.S.. Deviations from within-state time trends in the share of imputed unhealthy food imports provide thus the source of identifying variation in the linear probability model of equation (1). We further include various socioeconomic determinants of obesity at the individual or household level -

[5]More specifically, the coefficient β_1 in equation (1) could capture the influence of changing physical activity due to import competition if the healthiness categorisation is correlated with the physical effort level required in production and if the pre-determined expenditure shares correlate with initial employment shares.

age, education, employment status, role in the household, and wealth indicators - and collect them in matrix C. The term X denotes a set of other state variables that characterise the economic environment and can channel or confound the effect of unhealthy food imports. Standard errors are clustered at the state level.[6]

A positive and statistically significant coefficient β_1 in equation (1) would back the presumption, so far based largely on anecdotal and descriptive evidence, that unhealthy food imports from the U.S. have contributed to the rise in obesity in Mexico. To corroborate the causal interpretation of our findings and explore the role of possible mechanisms, we include term X in equation (1) collecting a set of state variables that characterise the economic environment and can confound the effect associated with unhealthy food imports.

We focus on the demand channels through which greater availability of unhealthy food imports can influence nutrition and obesity. The influence of changes in the relative exposure to unhealthy imports can thus mask overall changes in states' relative expenditure on unhealthy foods. In regression (1) we control for this confounding factor by including the unhealthy share of total food expenditure. Finding a positive and significant β_1 (and quantitatively more important than the coefficient on the unhealthy share of food expenditure) would thus suggest that for the same unhealthy categorisation, U.S. foods are more obesity-prone (e.g., because of different micro-nutrients used that are not captured by the coarse healthy-unhealthy comparison) than other foods bought by Mexican households.

The demand channel of influence can go through changes in prices and income. Greater imports of unhealthy foods can be associated with a price effect, whereby new and relatively cheaper U.S. varieties of unhealthy foods displace the Mexican varieties in the food consumption basket. This channel can reinforce the nutrition transition by encouraging shifts towards a less healthy diet. Faber (2014) finds strong evidence for an effect of NAFTA liberalisation on relative prices in Mexico, and Cravino and Levchenko (2016) find that the price of tradables rose after the Peso crisis. These recent studies work with a very disaggregated level of food brand or variety and, like the rest of the literature, do not focus on the healthiness of food varieties. In the regression framework of equation (1), we intend to capture this price channel by controlling for the weighted average price of unhealthy foods relative to the weighted average price of healthy foods at the state level, where the weights equal the share of each food product in total spending on healthy or unhealthy foods.

Trade liberalisation can increase average productivity and income, accelerating the nutrition transition and, more generally, the abandoning of traditional life styles and

[6] The average population of each state over time is used as weight in the regressions to correct for sampling error in computing the state-level variables

behaviors. This demand channel is likely to affect the estimates of interest (β_1) if income-enhancing trade integration is biased towards consumption (and imports) of unhealthy foods. In the empirical analysis, we proxy for this mechanism by adding the state GDP per capita (in logs) to our set of covariates.

Being more exposed to trade with the U.S. can be associated with other measures of economic and cultural proximity. To control for these influences, the term X in our baseline regression includes also the state's stock of inward Foreign Direct Investments (FDI) (relative to the state's GDP) and the share of the state's population that lives in the U.S. The confounding role of other time-invariant determinants of trade with the U.S. (e.g., distance to the border) is captured by the state dummies (γ_s) in (1).

To better gauge the possible role of price and income channels in mediating the influence of unhealthy imports, we adapt the approach of Atkin (2013) and estimate the effect of unhealthy state imports within a household demand equation. Using data from expenditure surveys between 1989 and 2012, we regress household expenditure shares on states' import shares controlling for local prices, household real expenditure and other household characteristics. After controlling for these factors, Atkin (2013) attributes any residual variation in household budget shares to differences in tastes across geographical areas. We follow his lead and investigate whether any correlation between import shares and household expenditure shares is absorbed by the effects of prices, real household expenditure, other socioeconomic characteristics, or residual variation interpreted as changes in tastes. The demand specification stems from the linear approximation of the Almost Ideal Demand System (AIDS) of Deaton and Muellbauer (1980) and takes the following form[7]:

$$(3)\quad bshare_{c,h,t} = \beta_{1,c} Impsh_{c,s,t} + \sum_{c'} \beta_{c,c'} \ln p_{c',m,t} + \beta_{2,c} \ln \frac{food_{h,t}}{P^*_{m,t}} + \Pi_c Z_{h,t} + \gamma_{c,s} + \gamma_s t + \theta_t + \epsilon_{c,h,t}$$

The variable $bshare$ equals the share of household h food expenditure on food group c.[8] We identify three groups, healthy (h), unhealthy (unh) and 'other' foods, where the 'other' group serves as the reference category.[9] Unit values from the expenditure surveys are used to

[7] Huffman and Rizov (2010) apply a similar demand specification to assess the relationship between lifestyle, nutrition and obesity in Russia, while Dharmasena and Capps (2012) adopt a quadratic AIDS to study the obesity-reducing effect of a proposed tax on sugar-sweetened beverages in the U.S..

[8] The expenditure data for each survey are available at the individual level and, starting from the 1994 wave, they report the place of purchase (e.g., market, stores). Individual identifiers are however often missing. We thus perform the analysis at the household level and compute prices as weighted averages across individuals and places of purchase. We further aggregate prices across food categories (and within each of the three food groups) using household expenditure shares as weights.

[9] We pool the household budget share data for the healthy and unhealthy groups (the 'other' is the excluded one) and estimate (3) by interacting each explanatory variable with an indicator for unhealthy

compute local prices as median prices at the *municipio* level (subscript m in (3), the smallest geographical unit recorded in the expenditure surveys) in order to attenuate endogeneity concerns (see also Atkin (2013)). Assuming weak separability between food consumption and consumption of other goods, we can use household food expenditure (the $food$ variable) instead of total household expenditure. A Stone price index, $\ln P^*_{m,t} = \sum_c \overline{bshare}_{c,s,t} \ln p_{c,m,t}$, makes the AIDS linear. We also control for the age (and its square term), sex, occupation, education and sector of employment of the household head, as well as for household size (and its square term) and composition, and collect these variables in Z. Their effect is further allowed to vary across food groups h. We follow as close as possible the empirical specification of the obesity regression (1) and include state-food group fixed effects ($\gamma_{c,s}$), year dummies (θ_t) and state-specific linear trends ($\gamma_s t$). We use survey weights and cluster standard errors by state.

The sign and significance of $\beta_{1,c}$ provide an indication of how exposure to imports from the U.S. shifts expenditure patterns between healthy and unhealthy foods. More precisely, a higher correlation between state import shares and household expenditure shares for unhealthy than for healthy foods (i.e., $\beta_{1,unh} > \beta_{1,h}$) would suggest that any pro-obesity effect of unhealthy import share (a positive β_1 in equation (1)) is at least partly channelled through shifts towards less healthy diets. Furthermore, we assess whether the estimates of $\beta_{1,c}$ are robust to the inclusion of local prices, real expenditure and household characteristics, and hence whether the demand effects of exposure to imports from the U.S. can be attributed to changes in tastes.

2.1 Data

To implement our empirical analysis, we use data on health, expenditure and trade. Information on BMI comes from the Encuesta Nacional de Nutricion (ENN, 1988 and 1999) which then became the Encuesta Nacional de Salud y Nutricion (ENSA, 2006 and 2012). The survey changed structure and expanded its content over time. However and importantly for the purposes of our study, all waves are representative at the state-level, which is the level of aggregation that is therefore used to allocate imports. The ENN only surveyed women between 20 and 49 years of age. For this reason, we restrict our main analysis to this sample and present robustness checks using men and other age groups surveyed in the ENSA.

These data contain also information on individual socioeconomic characteristics (education, employment status, household type) that control for individual heterogeneity

foods. The level effect of the food group indicator is absorbed by the state-group dummies $\gamma_{c,s}$.

in the risk of being obese. The individual controls are harmonized across waves and included in the matrix C in equation (1). In absence of data on income, we proxy for the position of each household in the sample wealth distribution. We perform a principal component analysis of different household asset variables for each year (e.g., whether the house has walls made of concrete, a TV, a fridge) and use the first component as an index of household wealth - see Filmer and Pritchett (2001) for details on the methodology and Rutstein and Johnson (2004) for a commonly used application. We then allocate households to quintiles of the index in order to mitigate sampling error and add dummies for each quintile to the term C in equation (1).

Data on expenditure shares and prices (unit values) are drawn from different waves (from 1984 until 2012) of the Encuesta Nacional de Ingresos y Gastos de los Hogares (ENIGH), the Mexican household-level survey on expenditure by detailed product categories. State expenditure shares in 1984 and hence before the beginning of the sample period are used to allocate food imports across states. Expenditures shares in 1984 at the state level are used to impute imports and construct the unhealthy share of imports as shown in equation (2). Thirteen waves of the ENIGH between 1989 and 2012 form the data backbone of the demand equation in (3).

Mexican imports of food from the U.S. starting from 1989 (the values matched with the 1988 anthropometric survey) are obtained from UN COMTRADE. After harmonizing the product classification of the trade (SITC, revision 3) and expenditure data, we obtain a sample of 168 food products with a full time series of expenditures (in values and quantities) and imports.

To identify healthy and unhealthy products, we follow Handbury et al. (2015) and Volpe et al. (2013) and aggregate food products in the 52 groups used by the Quarterly Food-at-Home Price Database (QFAHDP). We classify these 52 products in healthful/unhealthful following USDA Dietary Guidelines for Americans (DGA, 2010; also in Volpe et al., 2013). Healthy foods are those recommended for increased consumption (e.g., "dark green vegetables"), whereas unhealthy foods are those recommended for limited consumption (e.g., "refined flour and mixes"). We assign the food items from the trade and expenditure data to the 52 USDA food categories, allowing us to estimate the share of unhealthy imports (and expenditure) at the state level using the USDA guidelines.

3 Results

Before discussing the results of the econometric analysis, we provide some descriptive evidence on the evolution of obesity and food imports from the U.S. in our sample, which goes from 1988 to 2012, with data on obesity available in four periods. The objective is to better appreciate the key trends and inform the empirical strategy outlined in Section 2.

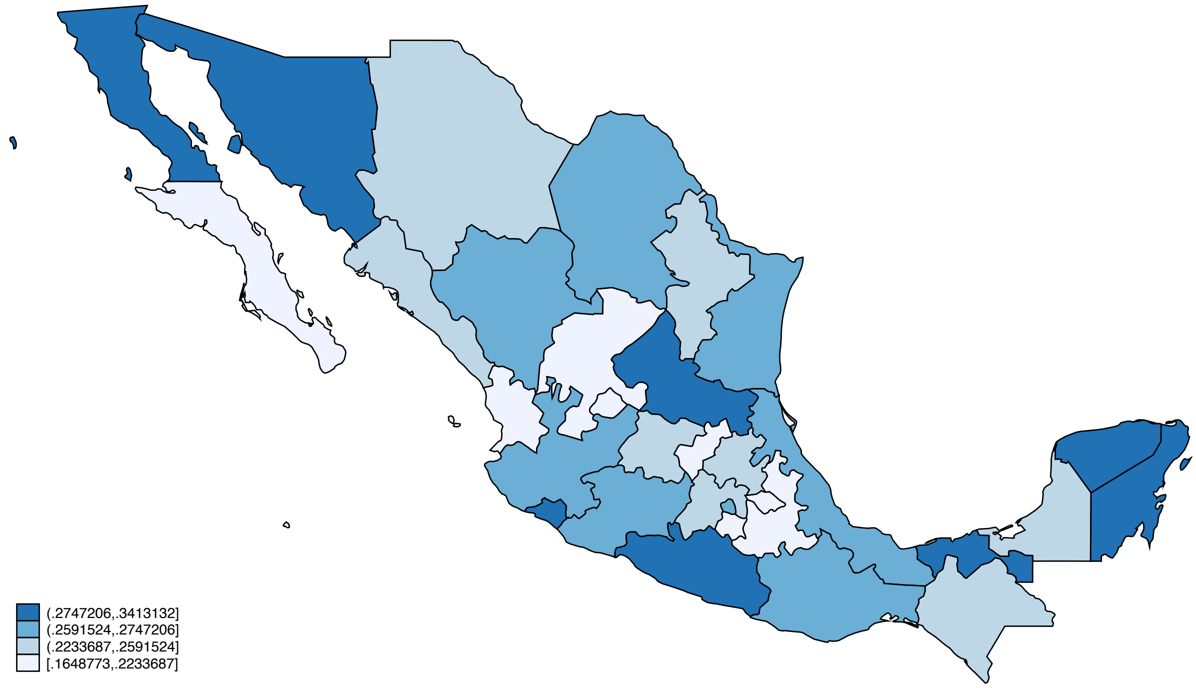
3.1 Descriptive evidence

Descriptive analysis of the anthropometric data strongly confirms the spectacular rise in obesity that has been documented in other work on Mexico (see e.g. Rtveladze et al., 2014). Average BMI in our baseline sample of women aged between 20 and 49 is 18 percent higher in 2012 than in 1988, and the rate of obesity prevalence dramatically increased during the same period, going from 10 to 35 percent.[10] The share of women who are overweight or obese (i.e. with a BMI of at least 25) doubled going from 36 to 73 percent.

Obesity among adult women increased everywhere in Mexico, although the rate of change varies across Mexican states, as shown in Figure 1. The state of Nayarit experienced the smallest increase (16 percentage points), while the biggest increase (34 percentage points) is recorded in Tabasco. The empirical strategy exploits variation in exposure to food imports from the U.S. to explain these observed changes in obesity.

[10] Using an alternative measure of obesity based on the waist-to-height (WTH) ratio (women with a WTH over 0.58 are normally classified as obese), we find that obesity prevalence almost doubles between 1999 and 2012, reaching 60 percent of the sample - we do not have have data on waist in 1988.

Figure 1: Changes in obesity prevalence across Mexican states between 1988 and 2012



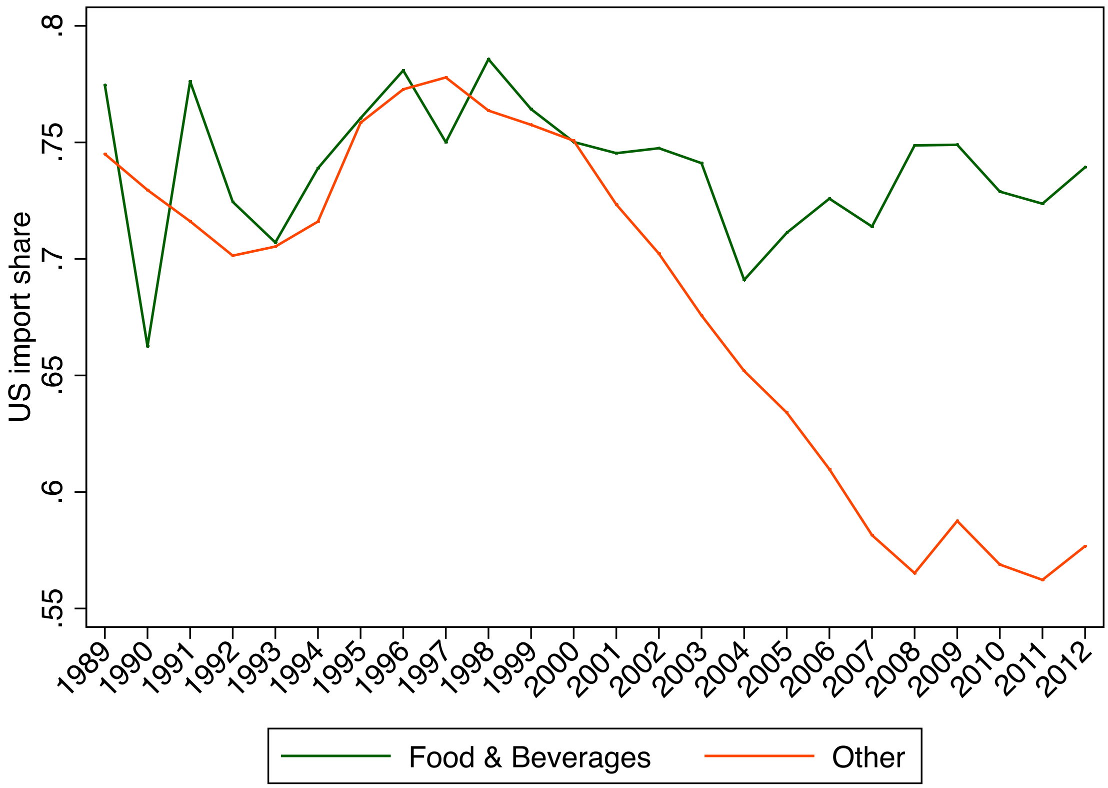
Notes: Differences in obesity rates by state between 2012 and 1988. Individual survey weights are used in calculating obesity rates by state.

Trade flows between Mexico and the U.S. have also been rising steadily since the late 1980's, following economic liberalisation policies adopted by the Mexican government and the formation of the NAFTA between Mexico, Canada and the U.S..[11] The U.S. has been the largest source of Mexican imports during this period across most sectors, maintaining a prominent role in the imports of foods and beverages. As shown in Figure 2, the U.S. share of total Mexican imports has remained stable around 75 percent in the food and beverages sector[12], while the U.S. import share dropped to 55 percent in other sectors in the early 2000's, mainly due to increased competition from China and other emerging economies.

[11] A large literature has examined the implications of Mexican economic liberalisation for economic growth (Hanson, 2010), labour markets and wage inequality (e.g, Hanson, 2007; Verhoogen, 2008), and retail prices and household welfare (Atkin et al., 2015)

[12] "Food and beverages" imports are recoded under chapters 0 ("Food and live animals"), 1 ("Beverages and tobacco"), 22 ("Oil-seeds and oleaginous fruits"), and 4 ("Animal and vegetable oils, fats and waxes") of the Standard International Trade Classification (SITC), Revision 3.

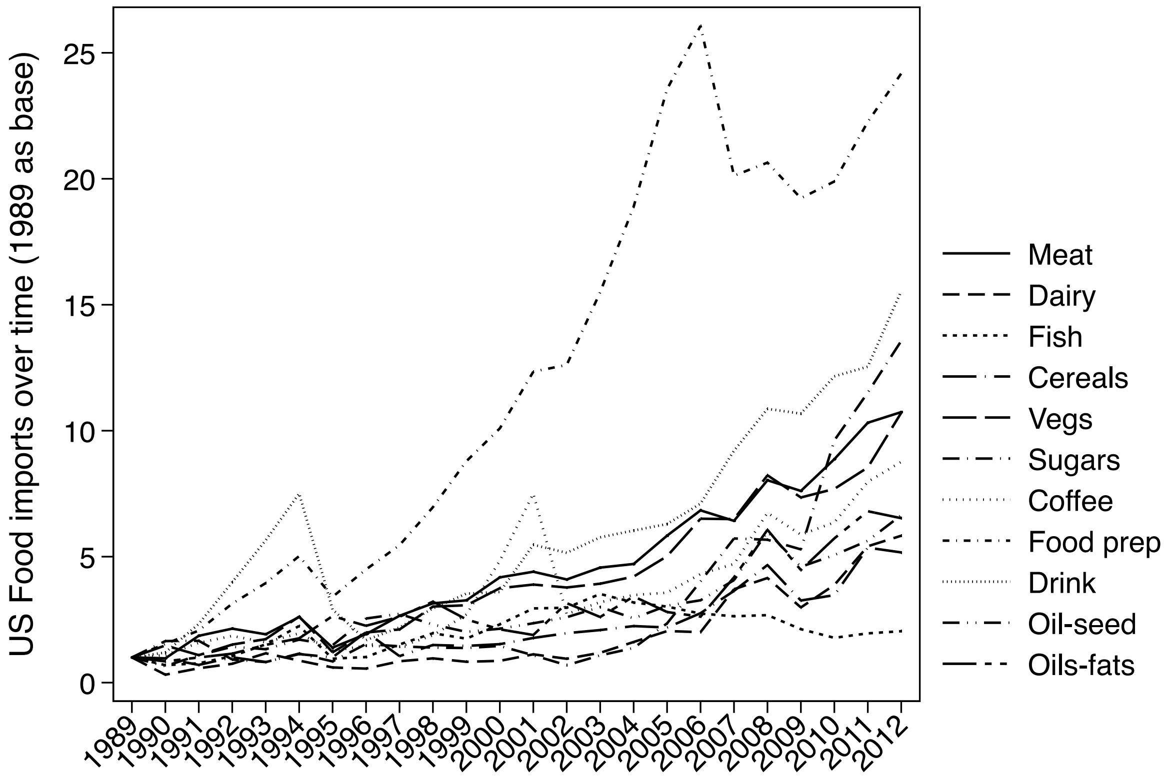
Figure 2: U.S. import share over time in food & beverages and other sectors



To gauge a possible relationship between food imports, nutrition and health, we examine the evolution of different groups of foods and beverages. Figure 3 plots imports from the U.S. of the main food categories over time, relative to their import values in 1989. Products that are generally associated with an unhealthy and obese-prone diet - and also typical in countries undergoing a nutrition transition - have been driving the overall increase of Mexican imports from the U.S.. Imports of "Food preparations" (including preparations of fats, sauces, soups, and homogenised foods) had the highest relative increase among all food categories, going from 35.5 to 859 US$ millions.[13] "Drinks" and "sugars" are the second and third categories when it comes to rate of change in imports from the U.S., recording a fifteen-fold and a fourteen-fold increase, respectively. While purely illustrative, these patterns suggest that the increase of Mexican imports from the U.S., being concentrated in generally 'bad' foods, might have contributed to the obesity epidemic.

[13]Within the chapter "09 - Miscellaneous edible products and preparations", the product category "09893 - Food preparations for infant use" recorded the largest increase in imports relative to the base level in 1989 (a ninety-three-fold increase). "09899 - Miscellaneous food preparations" experienced the second largest relative increase (and the largest absolute one), followed by "09843 -Mustard preparations".

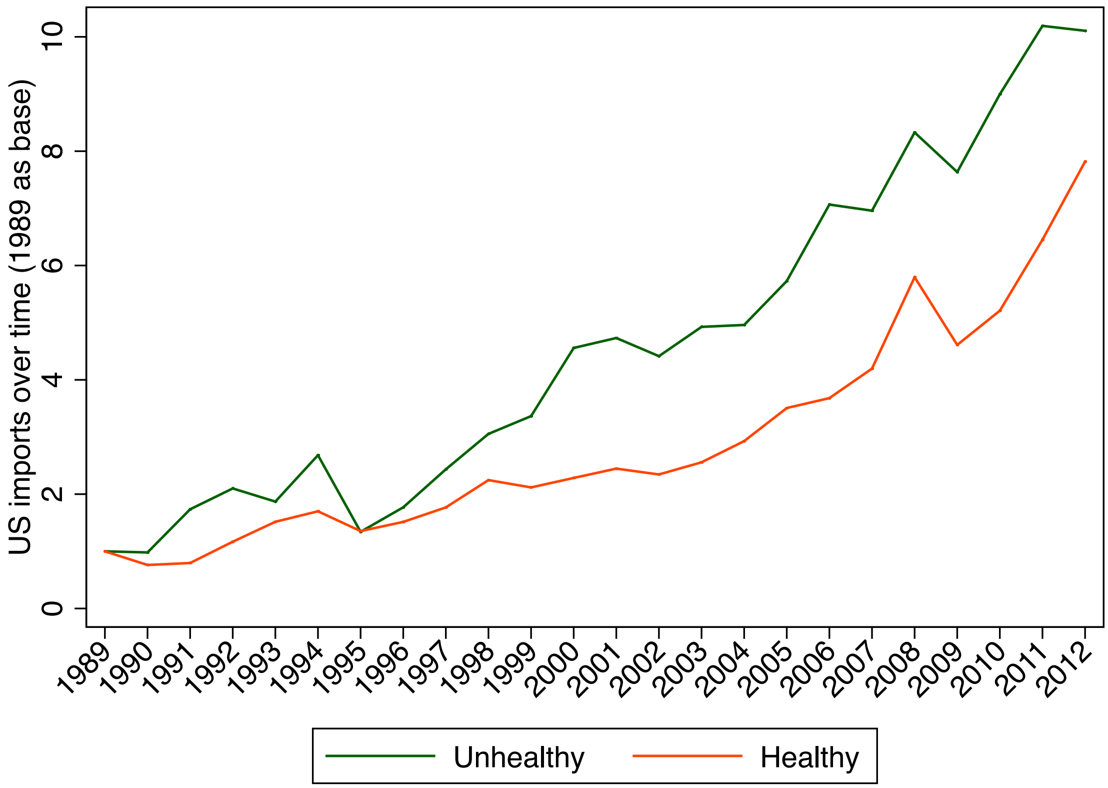
Figure 3: Mexican imports of food & beverages from the U.S. over time



Notes: Food categories are defined following the SITC Rev. 3 product classification: 'Meat' is category "01 - Meat and meat preparations"; 'Dairy' is category "02 -Dairy products and birds' eggs"; 'Fish' is category "03 - Fish (not marine mammals), crustaceans, molluscs and aquatic invertebrates, and preparations thereof"; 'Cereals' is category "04 - Cereals and cereal preparations"; 'Vegs' is category "05 - Vegetables and fruit"; 'Sugars' is category "06 - Sugars, sugar preparations and honey"; 'Coffee' is category "07 - Coffee, tea, cocoa, spices, and manufactures thereof"; 'Food prep.' is category "09 - Miscellaneous edible products and preparations"; 'Drink' is category "11 - Beverages"; 'Oil-seed' is category "22 - Oil-seeds and oleaginous fruits"; and 'Oils-fats' is category "4 - Animal and vegetable oils, fats and waxes".

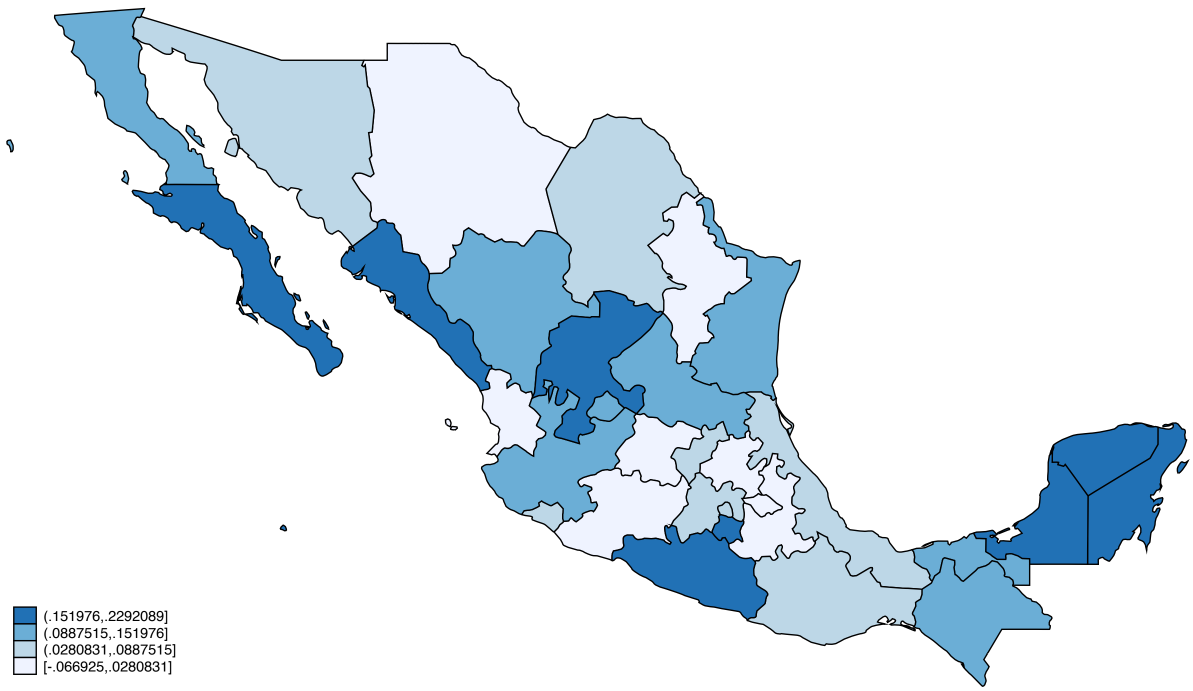
The bias of U.S. exports to Mexico towards unhealthy foods is confirmed after we classify the SITC products according to the 'healthy' and 'unhealthy' categories of the USDA. As shown in Figure 4, imports of unhealthy foods from the U.S. increased much faster than imports of healthy food, especially starting from the mid-1990's.

Figure 4: Unhealthy and healthy Mexican food & beverages imports from the U.S.



To measure the healthfulness of food imports from the U.S., we thus take the unhealthy share of total food imports. In the rest of the analysis, this unhealthy share is estimated at the state level (see equation (2)) and used as the key explanatory variable to assess the impact of food imports on obesity. Consistent with the patterns observed in Figure 4, the average unhealthy share of food imports across Mexican states goes up from 40 to 47 percent between 1989 and 2012. Figure 5 maps the changes in the unhealthy share of imports across Mexican states. While in some states the share even declined slightly, in others it went up by as much as 23 percentage points. Visual inspection of the heat maps in Figures 1 and 5 also suggests a positive association between long-term changes in obesity prevalence and changes in exposure to unhealthy imports. For instance, the state of Nayarit experienced the lowest increase in obesity as well as the lowest change in the unhealthy share of imports (-0.07). On the other hand, two (Quintana Roo and Guerrero) of the five top states when it comes to increase in obesity prevalence are also among the five states that reported the highest increase in exposure to unhealthy imports. The ensuing econometric analysis aims to assess this purely illustrative and descriptive evidence by estimating the causal effects of the unhealthy share of food imports on obesity at the individual level.

Figure 5: Changes in the unhealthy share of total food imports from the U.S. across Mexican states between 1988 and 2012



3.2 Effects of unhealthy food imports on obesity

(a) Baseline results

Our benchmark specification estimates the effect of the unhealthy share of food imports from the U.S. - computed using pre-determined expenditure shares at the product level - on the probability of being obese among a sample of adult women. The regressions span four periods (1988, 1999, 2006, 2012), each corresponding to a wave of the Mexican survey with anthropometric information.

The results reported in Table 1 point to a strong and positive impact of unhealthy imports on obesity. In columns (1) and (2) we include the unhealthy share of food imports as the only state-level determinants of obesity, after controlling for state dummies, year dummies and state-specific linear time trends. The estimates in column (1) with the full sample suggest that a one standard deviation increase in the share of unhealthy food imports (equal to 13 percentage points) is associated with a 3.3 percentage point increase in the likelihood of being obese. Adding the set of individual and household controls from the health surveys makes the sample 40 percent smaller in column (2). The estimated effect of the unhealthy share of imports increases slightly - the same 13 percentage point increase in the unhealthy share of imports (in the smaller sample, the standard deviation of the unhealthy share of imports is 0.14 - see Table A1) would lead to a 4.4 percentage point higher risk of being obese (or one sixth of the average sample probability of being obese; see Table A1 for summary statistics in the estimation sample).[14]

The signs and significance of the other estimated coefficients are in line with the existing evidence on the socioeconomic determinants of obesity (Baum and Ruhm, 2009). Having completed secondary or *a fortiori* college education (only 1.3 percent of the women in the sample) is associated with a significantly lower probability of being obese. Obesity is less prevalent among women who are employed in agriculture than among unemployed women, most likely because of the more intense physical activities involved (see Griffith et al. (2016) for evidence on this mechanism).[15] Students and women employed in other sectors than agriculture tend to be as obese as unemployed ones. Being disabled or retired as well as being affected by chronic diseases (e.g. diabetes, cardiovascular disease) are strong predictors of obesity, while speaking indigenous languages and having a leading role in the household are significantly correlated with lower obesity risk. The estimated coefficients on the four top quintile indicators of the distribution of household wealth suggest that, as expected, obesity increases with income (Dinsa et al., 2012; Prentice, 2006). They also uncover some non-linearity along the wealth distribution, with the obesity risk being highest in the second and third quintiles, and decreasing (but still significantly higher than for women living the poorest households) in the top quintile.

The large obesity effect of being exposed to a high share of unhealthy food imports can be driven by other characteristics of the economic environment, as explained in section 2. In columns (3) to (6), we add to the individual-level regression other state variables that are meant to control for these confounding effects. Results show that the effect of exposure to unhealthy imports remain unchanged. Controlling for the unhealthy share of total food expenditure in column (3) does not affect the coefficient on the import variable, suggesting that trade exposure is not simply capturing the effect of broader shifts in expenditure patterns (correlation between the two unhealthy share variables is 0.43 - see Table A2). Including instead the relative price of unhealthy foods (in logs) also has no effect on the estimated

[14] The difference in the coefficient of $Unhealthyimp$ between columns (1) and the other columns in Table 1 is due to sample selection rather than the addition of control variables at the individual level. In Table A3 in the Appendix, we include observations with missing values and add dummies for missing values of each variable in of the control set C. The coefficient on the unhealthy share of imports is positive and similar in size to the one in the specification without controls (column (1)).

[15] We also estimate a specification controlling for an indicator for weekly moderate physical activity, which is however available only in 2006 and 2012 (we add an indicator for missing values in 1988 and 1999). The coefficient associated with the indicator is negative (suggesting that being physically active lowers the risk of obesity) but insignificant, and the effect of the unhealthy share of imports is unchanged.

impact of unhealthy food imports on the risk of being obese. The relative price variable has an expected negative but insignificant coefficient, suggesting that price effects might well be present at a much finer product level than what is available in the household expenditure surveys. Furthermore, the unit values that are reported in the expenditure surveys can incorporate quality effects (see also Faber, 2014), which have ambiguous implications for nutrition and obesity. In column (4), we include the states' GDP per capita to control for average income effects, and the estimated coefficient on the unhealthy share of imports is again unaltered.[16] Controlling for other state-level and time-varying confounders in column (6) gives the baseline specification of equation (1). The results point again to a positive and sizeable effect of unhealthy food imports on the risk of being obese.

[16]State GDP per capita partly controls for the possibility that our measure of 'estimated' import exposure at the state level correlates with the structure of local food production. By allocating imports of food products across states according to their share in national expenditures in 1984, we might be giving more imports of, say, unhealthy foods to states that both consume and produce locally more of these foods - both in 1984 and in all subsequent years of our sample. If higher concentration of production in unhealthy foods is associated with greater income per capita, the effect of our imputed unhealthy share of imports might be mediated by GDP per capita.

Table 1: Unhealthy share of imports and obesity

	(1)	(2)	(3)	(4)	(5)	(6)
State-level variables						
Unhealthy share of imports	0.259**	0.333**	0.339**	0.337**	0.324**	0.341**
	(0.105)	(0.140)	(0.146)	(0.137)	(0.129)	(0.137)
Unhealthy share of expenditure			0.248			0.268
			(0.362)			(0.410)
Ln(relative price of unhealthy foods)				-0.0114		-0.0220
				(0.0489)		(0.0500)
Ln(GDP per capita)					0.0208	0.0205
					(0.0838)	(0.0843)
Ln(FDI/GDP)						0.00167
						(0.00596)
Migrant share						-0.502
						(1.595)
Individual controls						
Age		0.0132***	0.0132***	0.0132***	0.0132***	0.0131***
		(0.00271)	(0.00271)	(0.00270)	(0.00272)	(0.00271)
Age^2		-6.89e-05*	-6.88e-05*	-6.88e-05*	-6.88e-05*	-6.82e-05*
		(3.58e-05)	(3.58e-05)	(3.57e-05)	(3.59e-05)	(3.57e-05)
Prim. educ.		0.00929	0.00927	0.00926	0.00929	0.00922
		(0.00982)	(0.00981)	(0.00980)	(0.00982)	(0.00980)
Sec. educ.		-0.0406***	-0.0407***	-0.0406***	-0.0406***	-0.0406***
		(0.0119)	(0.0119)	(0.0120)	(0.0119)	(0.0119)
Ter. educ.		-0.171***	-0.171***	-0.171***	-0.171***	-0.171***
		(0.0183)	(0.0183)	(0.0183)	(0.0183)	(0.0181)
Retail		0.00703	0.00699	0.00700	0.00704	0.00696
		(0.00623)	(0.00621)	(0.00621)	(0.00624)	(0.00626)
Agri.		-0.0507***	-0.0512***	-0.0505***	-0.0507***	-0.0507***
		(0.0170)	(0.0172)	(0.0170)	(0.0169)	(0.0172)
Oth. sectors		-0.00573	-0.00593	-0.00572	-0.00567	-0.00580
		(0.0126)	(0.0125)	(0.0126)	(0.0128)	(0.0126)
Student		0.00703	0.00675	0.00704	0.00705	0.00683
		(0.0146)	(0.0147)	(0.0146)	(0.0146)	(0.0147)
Disabled/retired		0.0476**	0.0480**	0.0474**	0.0477**	0.0478**
		(0.0222)	(0.0220)	(0.0219)	(0.0222)	(0.0219)
Speak indigenous		-0.0392***	-0.0392***	-0.0392***	-0.0394***	-0.0392***
		(0.0133)	(0.0134)	(0.0132)	(0.0133)	(0.0133)
Chronic		0.0292***	0.0292***	0.0292***	0.0292***	0.0292***
		(0.00742)	(0.00737)	(0.00742)	(0.00739)	(0.00735)
HH head		-0.0223**	-0.0224**	-0.0223**	-0.0223**	-0.0224**
		(0.00831)	(0.00829)	(0.00825)	(0.00833)	(0.00825)
Household wealth						
2nd quintile		0.0530***	0.0528***	0.0531***	0.0530***	0.0528***
		(0.00708)	(0.00712)	(0.00715)	(0.00708)	(0.00709)
3rd quintile		0.0555***	0.0552***	0.0556***	0.0555***	0.0552***
		(0.0110)	(0.0110)	(0.0110)	(0.0110)	(0.0110)
4th quintile		0.0474***	0.0471***	0.0474***	0.0474***	0.0471***
		(0.00940)	(0.00946)	(0.00947)	(0.00941)	(0.00944)
5th quintile		0.0279**	0.0276**	0.0279**	0.0278**	0.0274**
		(0.0126)	(0.0126)	(0.0126)	(0.0125)	(0.0125)
Obs	56,714	35,971	35,971	35,971	35,971	35,971
R^2	0.069	0.121	0.121	0.121	0.121	0.121

Notes: All regressions include state dummies, state-specific linear trends, and year dummies. The average population of each state during the sample period is used as weight. Standard errors clustered at the state level are in parenthesis. Significant at: *10%, **5%, ***1% level.

(b) Robustness checks and extensions

The baseline results shown in Table 1 suggest a robust and quantitatively important effect of unhealthy food imports on obesity rates in Mexico. In the following, we further investigate the relationship between Mexican food imports and obesity by checking the robustness of our results to alternative definitions of the import variable, to the inclusion of adult men in the sample, to other BMI cutoffs, and to an empirical specification in long differences.

We first test whether the estimated effect is specific to unhealthy foods as classified by USDA (see section 2). Total food imports from the U.S. (i.e., the denominator of the *Unhealthyimp* variable in equation (1), in logs) have no significant impact on obesity, as shown by columns (1) to (3) of Table 2. This is turn suggests that imports classified as healthy would offset the pro-obesity effect of unhealthy imports.

In columns (4) to (6), we investigate whether the documented effect of unhealthy imports is purely capturing the influence of exposure to imports from the U.S.. We thus add (imputed) apparel imports as a tradable product that has no direct influence on diet and nutrition. The positive and significant coefficients in columns (4) and (5) suggest that greater exposure to imports from the U.S. does increase obesity, even if the imported products are not expected to shape directly diets. This effect is however spurious since not robust to the inclusion of other state-level characteristics in column (6). Importantly, the positive coefficient on the *Unhealthyimp* variable remains unchanged when controlling for imports of apparel from the U.S..

In columns (7) and (8), we amend the set of SITC trade food products in order to consider only food imports for final demand - and exclude imports for further industrial use that should not affect directly nutrition and hence obesity. We use the Broad Economic Categories (BEC) classification for trade flows (matched with the more detailed SITC classification) to identify SITC food products that are "mainly for household consumption" (BEC categories 112 and 122) and "other consumer goods" (BEC category 6). The matching between these BEC final demand categories and the SITC products is however not unique - some SITC products have multiple BEC categories -, and we thus take this exercise as a robustness test of the baseline results obtained using all SITC food products that are matched with the Mexican expenditure surveys[17]. The revised unhealthy share of imports correlates strongly with the baseline measure (correlation coefficient being equal to 0.96) and using it in columns (7) and (8) of Table 2 does not alter substantially the empirical findings.

In columns (9) and (10) of Table 2 we run our baseline regression on the full sample of adult men and women (between 20 and 60 years old), which is relevant only to the 2006 and 2012 surveys. The estimated effect of the unhealthy share of food imports is slightly lower and than in Table 1, suggesting that exposure to unhealthy imports in Mexico has had particularly strong effects on obesity for the female population and possibly before 2006.

[17]SITC products are classified for final demand if more than half of the entries fall into the BEC categories for final use.

Table 2: Unhealthy share of imports and obesity - Robustness checks

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Total US food imports			Placebo with apparel imports			Final use imports		Adult men and women	
Ln(US food imports)	0.0550	0.0279	0.0219							
	(0.0450)	(0.0562)	(0.0680)							
Ln(US apparel imports)				0.0735***	0.0510***	0.0251				
				(0.00641)	(0.0128)	(0.102)				
Unhealthy share of imports		0.316**	0.333**		0.333**	0.341**	0.247*	0.249*	0.267**	0.272**
		(0.147)	(0.140)		(0.140)	(0.137)	(0.136)	(0.136)	(0.115)	(0.118)
Unhealthy share of expenditure			0.266			0.268		0.235		0.250
			(0.416)			(0.410)		(0.416)		(0.301)
Ln(relative price of unhealthy foods)			-0.0174			-0.0220		-0.0173		-0.0416
			(0.0505)			(0.0500)		(0.0528)		(0.0413)
Ln(GDP per capita)			0.0118			0.0205		0.0468		-0.00187
			(0.0939)			(0.0843)		(0.0869)		(0.0670)
Ln(FDI/GDP)			0.000214			0.00167		0.00109		0.00366
			(0.00687)			(0.00596)		(0.00605)		(0.00547)
Migrant share			-0.432			-0.502		-0.384		0.185
			(1.450)			(1.595)		(1.704)		(1.195)
Obs	35,971	35,971	35,971	35,971	35,971	35,971	35,971	35,971	41,341	41,341
R^2	0.121	0.121	0.121	0.121	0.121	0.121	0.121	0.121	0.125	0.125

Notes: All regressions include individual and household level controls in columns (2) to (6) of Table 1, state dummies, state-specific linear trends, and year dummies. The average population of each state during the sample period is used as weight. Columns (7) and (8) use trade data only on food products classified for final consumption according to the BEC classification. Columns (1) to (8) are based on the baseline sample including only women. Columns (9) and (10) report results on the full adult sample (men and women between 19 and 60 years old). Standard errors clustered at the state level are in parenthesis. Significant at: *10%, **5%, ***1% level.

Our empirical strategy identifies the effect of exposure to unhealthy imports from variation within the 32 Mexican states over time. In Figure A2, we plot the coefficient on the *Unhealthyimp* variable from our baseline specification (see column (6) of Table 1 and equation (1)) but dropping one state at a time. The estimated coefficient remains stable around the one obtained with the full sample and decreases to 0.2 when excluding the states of Jalisco or Mexico, whereas it increases to 0.45 when dropping the state of Sinaloa. The coefficient remains statistically significant and indistinguishable from the baseline one, indicating that the main findings are not entirely driven by single states.

In the empirical analysis we focus on the effects on obesity, which is conventionally defined as having a BMI of at least 30. To assess whether the BMI threshold for obesity is meaningful in identifying the effect of unhealthy imports, we also estimate the baseline specification (column (6) of Table 1) with BMI as dependent variable and at different quantiles of the BMI distribution. Figure A1 in the Appendix plots the estimated coefficients of these quantile regressions together with the OLS coefficient from the BMI regression. The positive and significant OLS coefficient suggests that higher imports of unhealthy foods from the U.S. increase significantly average BMI. The coefficient rises with BMI and becomes higher than the OLS estimate for BMI levels above the sample median, which is just above the 25 threshold that is used to classify individuals as "overweight", and it is highest for levels that are above the obesity threshold of 30 (corresponding to BMI levels above the third quartile of the sample distribution).[18] This piece of evidence supports the idea that the effect of unhealthy food imports is particularly strong for overweight and obesity levels of BMI, validating the linear probability specification having the obesity dummy as dependent variable.

Our empirical strategy identifies the influence of changes in unhealthy food imports on obesity using data from four periods covering more than twenty years, from 1988 to 2012, before and after Mexico opened up its markets substantially to U.S. products (e.g., through NAFTA in 1994). To further validate the empirical findings, we investigate whether the increase in unhealthy food imports from the U.S. observed during these years contributes to the concomitant rise in obesity. The 32 Mexican states represent the most disaggregated spatial units that are consistently followed throughout the sample period.[19] In Table A5, we thus report the results from cross-state regressions of differences in obesity prevalence between 2012 and 1988 (see the map in Figure 1) on difference in the unhealthy share of food imports (see the map in Figure 5). The reduced sample size makes statistical inference problematic and hence leads us to interpret with caution the evidence from these additional regressions. Yet, this analysis confirms the positive and robust effect of unhealthy imports on obesity. In columns (1) and (2), we regress changes in obesity prevalence on changes in the unhealthy share of imports alone and controlling for initial conditions. The specification is similar to the one adopted by Autor et al. (2013) and in other paper assessing the impact of trade liberalisation on local labour markets. The estimated coefficient does not change and it is more precisely estimated as we add controls - the estimated β_1 in column (1) is significant at the 11% level (p-value=0.105). The results suggest that a 8 percentage point higher change in the unhealthy share of imports (one standard deviation in the sample) would add 1.1 percentage points to the increase in obesity prevalence (25 percentage points on average) recorded between 1988 and 2012. The effect is quantitatively non-negligible and equal to one fourth of the standard deviation in changes in obesity rates across states.

The remaining columns of Table A5 add changes over time in other determinants of obesity that might interact with unhealthy food imports. The results suggest that the net effect of unhealthy imports from the U.S. is not driven by these confounders. Controlling for changes in the unhealthy share of expenditures lowers slightly the coefficient associated with

[18] We also replicate the benchmark empirical analysis using an overweight indicator as outcome variable. Results in Table A4 indicate that exposure to unhealthy imports increase significantly the risk of being overweight, with the effect quantitatively less important than the one on obesity, as Figure A1 already suggests. A one standard deviation increase in the share of unhealthy imports in a state increases the likelihood of self-reported overweight status by 5 percentage points, a 9 percent increase with respect to the average (while the effect on obesity amounts to 17 percent of the average).

[19] Four states are not included in the 1999 wave of the ENN survey.

the unhealthy share of imports, whereas changes in GDP per capita and in the relative price of unhealthy foods do not affect the size and the statistical significance of the coefficient of interest. The coefficients on the changes in these control variables have the expected sign (e.g., changes in obesity rates are negatively associated with changes in the relative price of unhealthy foods) but none of them is significantly different from zero. Including all the control variables at their 1988 values together with the variables in changes in column (6) makes the specification statistically demanding given the high number of parameters to be estimated. The coefficient on the *Unhealthyimp* variable is less precisely estimated but its size does not change considerably.

Finally, we conducted an unconfoundedness test constructing an index of obesity predictors using the data from the first health survey in 1988. In practice, we regressed our obesity indicator on our main set of covariates at the individual and household levels and used the fitted values of this regression as an index of obesity determinants. We then regressed the share of unhealthy imports at the state level on this index of obesity determinants in 1988. We find no evidence of a significant relationship. The point-estimate is negative (coef., -0.0087; std.err., 0.0150), but non-precisely estimated. If anything the share of unhealthy imports is negatively correlated with obesity predictors suggesting that our estimate provides a lower bound of the effect of unhealthy imports on obesity.

Overall, the results of these robustness tests and extensions of the baseline empirical analysis largely confirm the main finding of a strong pro-obesity effect of unhealthy food imports. Greater exposure to imported foods increases obesity only if these foods are classified as unhealthy. The effect appears to be strongest in the female adult population and most important at the BMI obesity threshold of 30. Finally, results from an empirical specification in long differences suggest that rising exposure to unhealthy food imports from the U.S. has contributed to the increase in obesity rates across Mexican states.

3.3 Unhealthy food imports and household demand for unhealthy foods

The evidence presented so far does not support the price and income channels that could explain an effect of greater exposure to unhealthy food imports on nutrition and hence on obesity. Inclusion of controls for relative prices at the state level and GDP per capita does not affect the relationship between the share of unhealthy imports and the risk of being obese. While these aggregate measures might not be ideal in capturing demand adjustments, other mechanisms may explain our main findings. As mentioned above, exposure to trade in foods may significantly alter tastes for products of different healthiness. To further disentangle these demand-based mechanisms, we estimate the household demand equation over healthy and unhealthy foods as specified in equation (3) and based on the empirical strategy of Atkin (2013).

Table 3 reports the estimates of the coefficient on the import share variable. The effect of state exposure to food imports from the U.S. on household food expenditure is allowed to vary between healthy and unhealthy foods. Going from column (1) to column (4) of Table 3, we add local prices, total food expenditure and other household characteristics to the regression equation.

The results are consistent with greater exposure to food imports from the U.S. shifting food consumption towards less healthy foods and hence increasing obesity rates. The positive $\beta_{1,unh}$ coefficient indicates that households spend a higher share of their food expenditure on unhealthy foods as their state's exposure to unhealthy food imports from the U.S. increases. Conversely, we find a negative and insignificant association ($\beta_{1,h}$) between household demand and exposure to imports of healthy foods. The positive and significant difference between $\beta_{1,unh}$ and $\beta_{1,h}$ thus corroborates the idea that greater food imports from the U.S. have contributed to shifting diets towards less healthy foods.

Importantly, price and and real income adjustments do not drive the positive association between demand and exposure to imports of unhealthy foods. Controlling for within-state variation in local prices and real expenditure does not substantially alter the size of the two β_1 coefficients and their difference. When we add real food expenditure in column (3), the $\beta_{1,unh}$ coefficient decreases slightly, but the difference between the $\beta_{1,unh}$ and the $\beta_{1,h}$ coefficients remains unaltered. The correlation between household demand and imports of unhealthy foods more than doubles when we control for the effect of other state-level variables (GDP per capita, FDI to GDP ratio, and the migrant share of the state's population), suggesting that, if anything, omitting other state-level confounders biases downward the effect of exposure to unhealthy imports.

Taken together, these results confirm the evidence from the baseline obesity regressions suggesting that price and income adjustments do not explain the pro-obesity effect of exposure to unhealthy imports. While including state-level imputed imports in a household demand equation weakens the causal interpretation of the estimates, the results clearly indicate that the positive association between demand and imports of unhealthy foods comes from residual variation at the state-level rather than local adjustments in prices or real income. As in Atkin (2013), differences in tastes constitute a plausible source of residual variation in expenditure shares across states (and over time). Our findings thus bolster the idea that households living in states that became more exposed to unhealthy food imports developed also stronger preferences for these unhealthy foods (for given changes in prices and income). This shift in preferences towards unhealthy foods might well be behind the documented pro-obesity effect of unhealthy imports from the U.S..[20]

Table 3: Demand for healthy and unhealthy foods and imports

	(1)	(2)	(3)	(4)	(5)
$\beta_{1,unh}$	0.0794*	0.0956**	0.0706	0.0727*	0.180***
	(0.0447)	(0.0436)	(0.0436)	(0.0440)	(0.0521)
$\beta_{1,h}$	-0.0428	-0.0438	-0.0512	-0.0555	-0.0197
	(0.0343)	(0.0330)	(0.0324)	(0.0330)	(0.0379)
$\beta_{1,unh} - \beta_{1,h}$	0.122***	0.139***	0.122***	0.128***	0.200***
	(0.0434)	(0.0424)	(0.0409)	(0.0394)	(0.0420)
Prices	N	Y	Y	Y	Y
Real expenditure	N	N	Y	Y	Y
Socioeconomic vars.	N	N	N	Y	Y
State-level controls	N	N	N	N	Y
Obs	419,329	419,329	419,329	419,020	413,405
R^2	0.349	0.350	0.356	0.377	0.379

Notes: All regressions include state dummies, state-specific linear trends, and year dummies. Survey weights are used. Standard errors clustered at the state level are in parenthesis. Significant at: *10%, **5%, ***1% level.

3.4 Effects of unhealthy food imports on inequalities in obesity prevalence

The evidence found so far indicates that Mexican women are more likely to be obese if they live in a state with a high exposure to unhealthy food imports from the U.S. This effect seems to go through changes in tastes. Furthermore, this impact of the local food environment can be mediated by individual characteristics that affect diets and can create disparities in the risk of being obese. In this part of our empirical analysis, we thus investigate how the average effect of unhealthy food imports on obesity varies along socioeconomic characteristics such as education and income.

The baseline specification in (1) is augmented by adding interactions of the unhealthy imports variable with the relevant mediating variables. Table 4 reports the results of

[20] Preferences for different types of foods might be correlated with preferences for physical activities - both affect obesity (see Bleich et al. (2008) for evidence on their reltive importance). To explore this additional interpretation of our main findings, we regress an indicator for weekly physical activity, available only in 2006 and 2012 (see footnote n.15), on the unhealthy share of imports, controlling for individual and other state-level characteristics, state and year dummies. We find no significant effect of exposure to unhealthy imports on the likelihood of being physically active, suggesting that the taste channel is acting mainly through the consumption of unhealthy (relative to healthy) foods.

specifications including all state-level variables alone, where the effect of unhealthy food imports is allowed to vary along individual characteristics, and of other specifications with state-year dummies absorbing the 'level' effects of state-level variables.

We first examine the mediating role of education, which is found to have a strong effect on obesity in our sample (Table 1). We interact our unhealthy share variable with an indicator equal to one if the woman has 'high education' - i.e., she has completed secondary or tertiary education, where the two education levels are merged because only 1.3 percent of the women in our sample have obtained a college degree or higher. The estimate on the interaction term in column (1) is negative and significant, suggesting that the pro-obesity effect of unhealthy food imports is concentrated in the less educated segment of the sample.

Replacing the state-level variables with state-year dummies in column (2) permits us to assess the role of unhealthy imports in shaping disparities in obesity prevalence, controlling for the level effect of all aggregate determinants of obesity (e.g., changes in economic conditions, industry structure). The coefficient on the education interaction term is still negative and significant, denoting a strong impact of unhealthy food imports on inequalities in obesity between education groups. More educated women are less likely to be obese than less educated ones, and the difference in probabilities increases with the share of unhealthy foods. To appreciate the importance of this effect, in Figure 6 we use the estimated coefficients from column (2) in order to plot the difference in the probability of being obese between a woman with low or no education (i.e., with at most completed primary education) and a woman with high education, against the unhealthy share of imports. The results imply that a highly educated woman is 5 percentage points less likely to be obese than a low educated one if they both live in a state with average exposure to unhealthy foods from the U.S. (an unhealthy share of imports equal to 0.49). If the unhealthy share of imports becomes one standard deviation higher (i.e., it increases by 14 percentage points), the gap in the risk of obesity between the two education groups would become 3 percentage points larger - or 60 percent higher. In states with exposure to unhealthy imports below the first quintile, the difference in obesity risk between women from different education groups becomes insignificant.

In columns (3) to (6), we explore how the effect of unhealthy imports on obesity varies across household wealth, another important source of health inequalities (Deaton, 2003). The baseline results in Table 1 show that the risk of being obese is significantly lower for women living in households in the poorest quintile of the wealth distribution (the excluded category in the regressions). Furthermore, the differences in obesity risk along the income distribution are smaller between the poorest and the richest quintiles. We thus interact the unhealthy imports variable with an indicator for women in the poorest quintile (columns (3) and (4)) and then with an indicator for women in the richest quintile (columns (5) and (6)). The estimates on the interaction coefficients do not show any strong heterogeneity in the effect of unhealthy imports along the wealth distribution. The coefficient on the interaction with the poor household indicator is not significantly different from zero, and the negative coefficient on the interaction with the rich household indicator is low and loses significance when controlling for the more robust interaction with the education variable (column (7)).

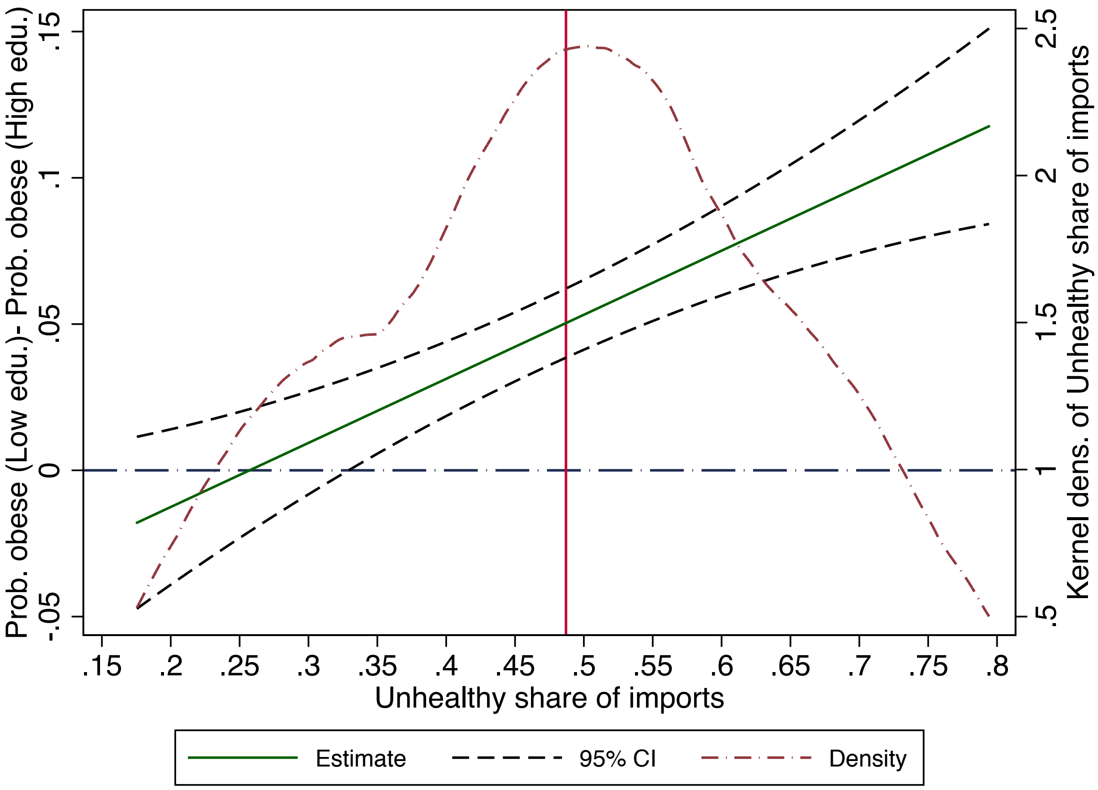
The empirical patterns point to a strong and important interaction between exposure to unhealthy food imports and education in determining the risk of being obese. The results are consistent with the well-known hypothesis that higher educated individuals are more efficient producers of health investment than less educated ones (e.g., because of peer pressure and of better information on the nutritional content of foods). Higher education leads to higher health investment because more educated individuals obtain a higher marginal return from any investment in health capital ("productive efficiency", Grossman, 1972; Michael and Becker, 1973) and because they are more efficient at selecting inputs into health investment ("allocative efficiency", Rosenzweig and Schultz, 1983). This educational gradient may be exacerbated in food environments where individuals are faced with more unhealthy food choices (Mani et al., 2013; Mullainathan, 2011; Dupas, 2011). The findings also suggest that women at different points of the wealth distribution are affected equally by greater availability of unhealthy food imports. Nevertheless, these results should be interpreted with caution because of the various approximations and shortcomings of the procedure used to estimate household wealth in the absence of income data (Vyas and Kumaranayake, 2006).

Table 4: Unhealthy share of imports and health disparities

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Unhealthy share of imports	0.424***		0.339**		0.373**		
	(0.145)		(0.144)		(0.141)		
High educ.	0.0507**	0.0563**	-0.0572***	-0.0562***	-0.0435***	-0.0425***	0.0656***
	(0.0214)	(0.0208)	(0.00768)	(0.00764)	(0.00734)	(0.00732)	(0.0216)
Unhealthy share of imports × High educ.	-0.210***	-0.219***					-0.223***
	(0.0441)	(0.0429)					(0.0471)
Poor HH			-0.0689***	-0.0808***			
			(0.0236)	(0.0234)			
Unhealthy share of imports × Poor HH			0.0400	0.0633			
			(0.0450)	(0.0452)			
Rich HH					0.0325	0.0393	0.000698
					(0.0363)	(0.0375)	(0.0378)
Unhealthy share of imports × Rich HH					-0.112*	-0.125**	-0.0471
					(0.0588)	(0.0610)	(0.0635)
State-level controls	Y	N	Y	N	Y	N	N
State-year FEs	N	Y	N	Y	N	Y	Y
Obs	35,971	35,971	35,971	35,971	35,971	35,971	35,971
R^2	0.121	0.124	0.120	0.122	0.118	0.121	0.122

Notes: All regressions include individual and household level controls in columns (2) to (6) of Table 1, but with *Higheduc.* replacing the education dummies and *RichHH* or *PoorHH* replacing the household wealth dummies. Columns (1), (3), and (5) include state dummies, state-specific linear trends and year dummies. The average population of each state during the sample period is used as weight. Standard errors clustered at the state level are in parenthesis. Significant at: *10%, **5%, ***1% level.

Figure 6: Inequality between education groups in obesity risk and unhealthy food imports



Vertical line indicates the sample average of the unhealthy share of imports. Estimates from column (2) of Table 4 are used to generate the graph.

4 Concluding remarks

In this paper, we provide novel evidence on the effects of trade on nutrition and obesity in Mexico. Combining household survey and trade data, we scrutinise the impact of greater exposure to food imports from the U.S. on the risk of being obese across Mexican states. We find that the risk of being obese among Mexican adult women increases significantly with the unhealthy share of food imports from the U.S. The estimates imply a robust and sizeable effect of unhealthy food imports on obesity. Our findings also suggest that exposure to imports of unhealthy foods affects demand patterns through shifts in preferences, rather than through price and income effects. Furthermore, the empirical evidence points to an important magnification effect of unhealthy food imports on existing inequalities in obesity rates across education groups. Overall these results support the idea that health concerns should matter for the determination of trade policies, especially when it comes to unhealthy food products.

Our findings suggest the existence of possibly important negative health externalities associated with trade integration - especially when trading partners have a comparative advantage in relatively unhealthy foods. It remans unclear however how large these externalities are and their importance relative to the much heralded consumers' welfare gains from trade due to access to new and cheaper varieties. More quantitative work in this area is needed to fully assess the health and welfare implications of trade liberalisation.

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Appendix

Figure A1: Quantile BMI regressions

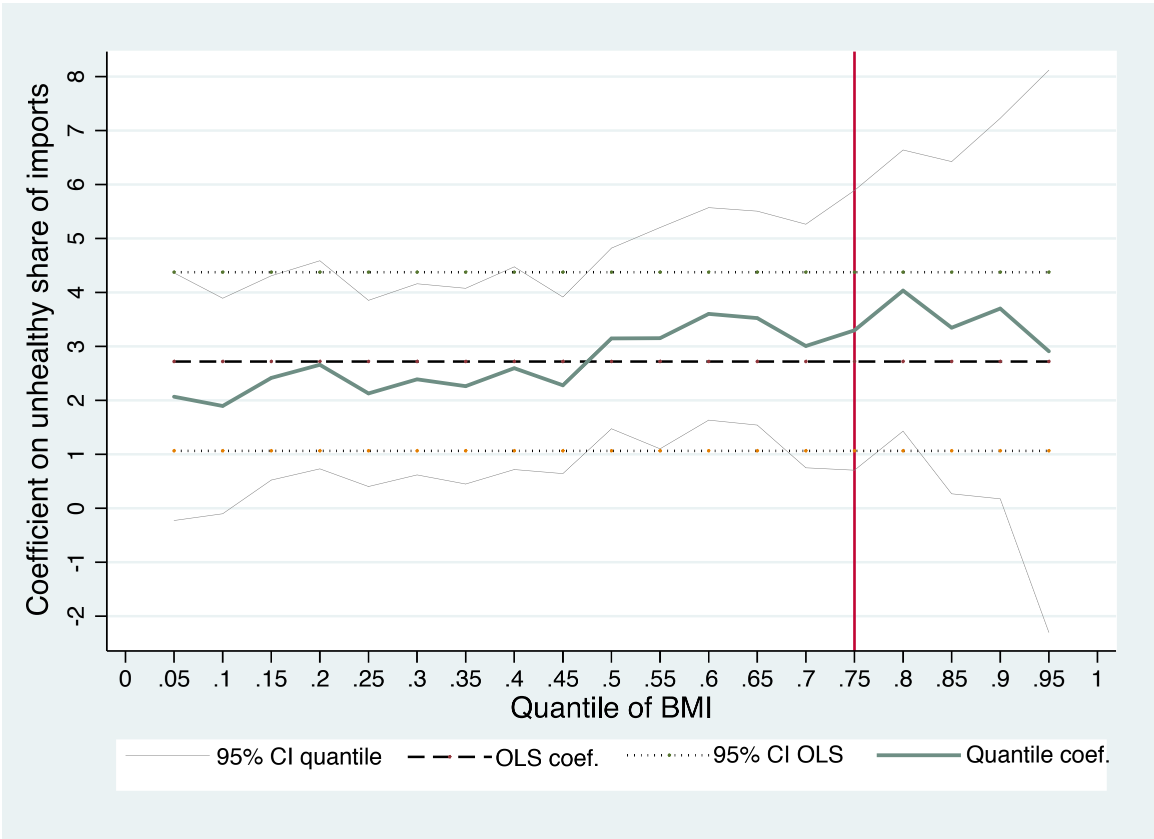

Figure A2: Unhealthy share of imports and obesity - Excluding one state at a time

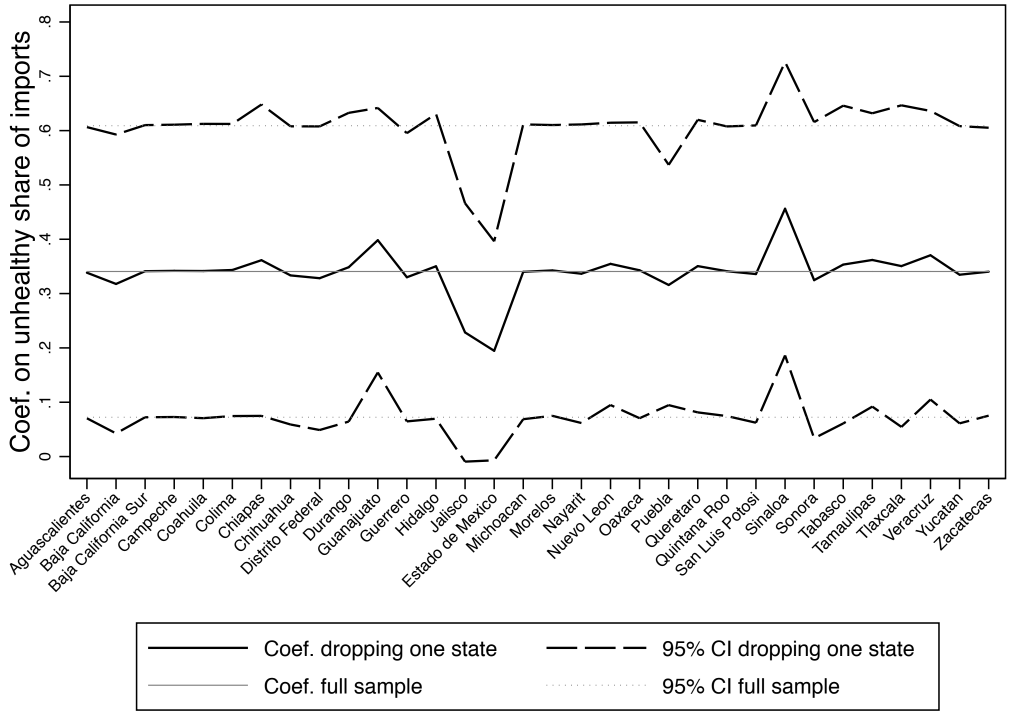

Table A1: Summary statistics for main variables (baseline sample with controls)

	(1)	(2)	(3)	(4)	(5)
	Obs	Mean	Std. Dev.	Min	Max
Obesity	35971	0.25	0.43	0.00	1.00
BMI	35971	26.82	5.59	1.90	59.73
Unhealthy share of imports	35971	0.49	0.14	0.18	0.79
Unhealthy share of expenditure	35971	0.41	0.05	0.28	0.57
Ln(relative price of unhealthy foods)	35971	0.72	0.15	0.31	1.28
Ln(GDP per capita)	35971	10.26	1.36	7.60	13.75
Ln(FDI/GDP)	35971	-4.21	1.23	-8.99	-1.44
Migrant share	35971	0.01	0.01	0.00	0.06
Ln(US food imports)	35971	10.79	1.11	7.08	13.95
Unhealthy share of imports (fin. demand)	35971	0.53	0.16	0.14	0.86
Ln(US apparel imports)	35971	9.92	1.40	6.44	13.21

Table A2: Pairwise correlation table for the main variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10) (11)	
	Obesity	BMI	Unhealthy share of imports	Unhealthy share of expenditure	Ln(rel. price of unhealthy foods)	Ln(GDP per cap.)	Ln(FDI/GDP)	Migrant share	Ln(US food imports)	Unhealthy share of imports (fin. dem.)	Ln(US apparel imports)
Obesity	1										
BMI	0.78	1									
Unhealthy share of imports	0.15	0.2	1								
Unhealthy share of expenditure	0.02	0.01	0.43	1							
Ln(rel. price of unhealthy foods)	-0.06	-0.09	-0.19	0.06	1						
Ln(GDP per cap.)	0.26	0.36	0.46	-0.06	-0.22	1					
Ln(FDI/GDP)	0	0.02	0.2	-0.01	0.01	0.1	1				
Migrant share	0	-0.02	0.15	0.19	0.09	-0.1	-0.1	1			
Ln(US food imports)	0.07	0.11	0.17	-0.11	0.01	0.38	0.33	-0.24	1		
Unhealthy share of imports (fin. dem.)	0.16	0.21	0.96	0.4	-0.19	0.48	0.15	0.14	0.17	1	
Ln(US apparel imports)	-0.04	-0.03	0.08	-0.17	0.06	-0.01	0.35	-0.05	0.69	0.15	1

Table A3: Unhealthy share of imports and obesity - Filling in missing values

	(1)	(2)	(3)	(4)	(5)	(6)
Unhealthy share of imports	0.259**	0.205**	0.198**	0.202**	0.205**	0.202**
	(0.105)	(0.0928)	(0.0926)	(0.0890)	(0.0925)	(0.0877)
Unhealthy share of expenditure			0.163			0.159
			(0.210)			(0.236)
Ln(rel. price of unhealthy foods)				0.0101		0.00454
				(0.0384)		(0.0404)
Ln(GDP per cap.)					0.00133	1.02e-05
					(0.0359)	(0.0373)
Ln(FDI/GDP)						0.00229
						(0.00452)
Migrant share						-0.355
						(0.995)
Obs	56,714	56,714	56,714	56,714	56,714	56,714
R^2	0.069	0.110	0.110	0.110	0.110	0.110

Notes: All regressions include state dummies, state-specific linear trends, and year dummies. The average population of each state during the sample period is used as weight. Column (1) reproduces column (1) of Table 1. Columns (2) to (6) include individual controls (see the list in Table 1) and dummies for missing values of each control variable. Standard errors clustered at the state level are in parenthesis. Significant at: *10%, **5%, ***1% level.

Table A4: Unhealthy share of imports and overweight

	(1)	(2)	(3)	(4)	(5)	(6)
Unhealthy share of imports	0.289**	0.315**	0.310***	0.351***	0.351***	0.381***
	(0.127)	(0.120)	(0.108)	(0.119)	(0.127)	(0.120)
Unhealthy share of expenditure			-0.229			-0.0828
			(0.357)			(0.364)
Ln(rel. price of unhealthy foods)				-0.108		-0.0962
				(0.0691)		(0.0635)
Ln(GDP per cap.)					-0.0813	-0.0776
					(0.104)	(0.0866)
Ln(FDI/GDP)						0.00246
						(0.00761)
Migrant share						-0.507
						(0.914)
Obs	56,714	35,971	35,971	35,971	35,971	35,971
R^2	0.103	0.182	0.182	0.182	0.182	0.183

Notes: All regressions include state dummies, state-specific linear trends, and year dummies. The average population of each state during the sample period is used as weight. Columns (2) to (6) include individual controls (see the list in Table 1). Standard errors clustered at the state level are in parenthesis. Significant at: *10%, **5%, ***1% level.

Table A5: Changes in food imports and the rise of obesity (2012-1988 differences)

	(1)	(2)	(3)	(4)	(5)	(6)
Δ Unhealthy share of imports	0.136	0.144*	0.122	0.143*	0.138*	0.125
	(0.0814)	(0.0778)	(0.0747)	(0.0747)	(0.0745)	(0.0780)
Δ Unhealthy share of expenditure			0.143			0.228
			(0.133)			(0.214)
Δ Ln(relative price of unhealthy foods)				-0.0228		0.0163
				(0.0237)		(0.0409)
Δ Ln(GDP per capita)					0.0424	0.0480
					(0.0322)	(0.0409)
Unhealthy share of imports		0.0425	0.0312	0.0897	0.137**	0.0783
		(0.0880)	(0.0787)	(0.0537)	(0.0593)	(0.101)
Unhealthy share of expenditure		0.266	0.286*			0.361
		(0.161)	(0.167)			(0.257)
Ln(relative price of unhealthy foods)		0.00218		0.00120		0.0190
		(0.0323)		(0.0263)		(0.0499)
Ln(GDP per capita)		-0.0131			0.00184	-0.0303*
		(0.0165)			(0.0111)	(0.0170)
Ln(FDI/GDP)		0.00294				0.00556
		(0.00601)				(0.00488)
Migrant share		-0.187				-0.468
		(0.275)				(0.353)
Ln(dist)		-0.00689				-0.0122*
		(0.00604)				(0.00610)
Obs	32	32	32	32	32	32
R^2	0.089	0.317	0.311	0.236	0.289	0.443

Notes: "Δ" variables are in differences between 2012 and 1988 values, other variables are at their 1988 values. The average population of each state during the sample period is used as weight. Robust standard errors are in parenthesis. Significant at: *10%, **5%, ***1% level.