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Childhood obesity in Mexico: the effect of international migration

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Abstract

This article estimates the effect of international migration from Mexico to the United States on the obesity status of children who remain in Mexico. Theory suggests that increased liquidity as well as changing time allocations resulting from migration may influence obesity outcomes. Natural disasters are used as an identification strategy. Results suggest that older boys in urban areas are more likely to become obese when either a male or female migrates from the household, while girls in urban areas are less likely to become obese. Both changes in food expenditure patterns and time use changes after migration are likely pathways that affect childhood obesity. While there are some changes in food expenditures, we find more importantly that urban girls engage in more housework and screen time after migration, whereas urban teen boys do not substitute for adult work as much as girls. These changes in strenuous activities, particularly for girls, likely explain the differential effect that migration has on boys' and girls' obesity outcomes in Mexico.

JEL classifications: F22, I15, J13

Keywords: Obesity; Mexico; International migration; Household economics

1. Introduction

Obesity rates in many developing countries are alarming and continue to rise. Mexico's obesity prevalence has risen to epidemic levels in the recent past. The OECD reports that in 2009, 30% of Mexican adults were obese (34.5% of women and 24.2% of men) and about 29% of children, ages 5–17, were overweight or obese (OECD, 2011).[1] These rates are only slightly lower than those in the United States where 36% of adults and 17% of kids (ages 2–19) were obese in 2009–2010 (Ogden et al., 2012). In addition to undernutrition, rising rates of obesity are likely to be an important development concern in many middle-income countries in the coming years.

Obesity results from a caloric imbalance. However, the social and economic factors driving this caloric imbalance are complex. Research on the causes of obesity in the United States offers some insight, but relatively little is known about contributing factors in developing countries. Lakdawalla et al. (2005) argue that rising obesity rates can be explained surprisingly well using standard neoclassical economic explanations. They argue that welfare-improving technology that facilitates economic growth has caused a drop in relative food prices, increasing caloric consumption, while at the same time has also led to a reduction in caloric expenditure from work activities.

Changing economic conditions in many developing countries have led to other structural shifts as well. Internal and international migration, and the financial flows between migrants and those that stay behind, characterize an important livelihood strategy in many communities and households in developing counties. In the case of Mexico, international migration to the United States has a long history and remains a common livelihood strategy for many families. Between 2000 and 2005, the Mexican-born population in the United States increased by 23%, reaching approximately 12 million in 2005 (Passel et al., 2012).[2]

In this article, we examine the relationship between international migration and the rising obesity rates for children in Mexico using the 2002 and 2005 Mexican Family Life Surveys. There are several pathways by which international migration

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Data Appendix Available Online
A data appendix to replicate main results is available in the online version of this article.

[1] Recent aggregate statistics on obesity alone (rather than combined with overweight) in children is not readily available. A 2006 estimate states that about 10% of all 15 year olds in Mexico were obese (OECD, 2010).

[2] http://www.pewhispanic.org/files/2012/04/Mexican-migrants-report_final.pdf

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may change the obesity status of Mexicans left behind. International migration may increase unearned income, change time allocations of remaining family members, or change food consumption patterns. We estimate the effect of a family member's international migration from Mexico on the overweight and obesity status of children who remain in Mexico. We further test two pathways by which migration can affect obesity status. Specifically we examine the effect of migration on: (1) food expenditure patterns; and (2) changes in daily caloric expenditure resulting from changing time allocations of family members.

Given the potentially long-term negative effects that persistent obesity has on health status, it is important to understand the causal mechanisms contributing to this epidemic in Mexican households. If migration contributes to obesity and results in negative health outcomes for those who remain in Mexico, this could potentially eliminate or reduce the positive effect of remittances on household welfare. Policymakers interested in health and poverty outcomes need more information about factors affecting obesity outcomes to develop appropriate government programs, public health initiatives, and health care infrastructure to deal with this rising problem in Mexico.

Identifying the effect of international migration on weight outcomes is complicated by the fact that migrants self-select into migration and may differ in both observable and unobservable ways from individuals who do not migrate. Since randomized control trials are not easily implemented in the case of international migration, instrumental variable (IV) techniques that exploit exogenous events affecting migration, but not the outcome variable, are employed as an identification strategy. This article uses measures of historic natural disasters at the community level to identify the first-stage migration equation. Natural disasters have been effectively employed to explain migration in previous migration studies (Halliday, 2006; Yang, 2008).

Researchers have been paying closer attention to the economic causes and outcomes of obesity in less-developed countries. Popkin (1999) and Asfaw (2011) suggest that the so-called nutrition transition, where diets shift away from cereals and fiber toward higher proportions of fat, animal protein, and added sugars, is a major contributing factor to increases in obesity rates in the developing world. Further, maternal education, employment status, and ethnicity all have been found to influence a child's weight status in developing countries (Abdulai, 2010; Martorell et al., 2000). Huffman and Rizov (2010) find that height, age, and gender, as well as changes in diet and opportunity costs of time all affect obesity outcomes in Russia.

While a broader understanding of the economics of obesity in developing countries is still emerging, there is some evidence that migration affects other health outcomes in developing countries. Evidence suggests that long-term migration reduces infant mortality rates and increases birth weights (Frank and Hummer, 2002; Hildebrandt and McKenzie, 2005; Kanaiaupuni and Donato, 1999). Conversely, children in migrant households are less likely to visit a medical professional during their first year, less likely to be fully vaccinated, and less likely to be breastfed (Hildebrandt and McKenzie, 2005).

Several studies document the effect of international migration on nutrition outcomes of remaining family members, and the findings are mixed. If a parent migrates, children are more likely to be underweight (Cameron and Lin, 2007; de Brauw and Mu, 2011). Without differentiating between parental migrants and others, Azzarri and Zezza (2011) find that migration increases height-for-age z-scores in Tajikistan, and Anton (2010) finds that remittances have a positive short-term effect on height-for-weight z-scores but no positive long-term nutritional effects in Ecuador. Gibson et al. (2011) find that children who stay behind experience deterioration in diet quality and decreases in weight-for-age and height-for-age in Tonga. Karamba et al. (2011) explicitly examine the relationship between food consumption choices (rather than nutrition outcomes) and migration in Ghana, and find that migration leads to increased consumption of sugar, beverages, and food away from home.

Stillman et al. (2012) use evidence from a migration lottery program for Tongans to enter New Zealand and examine the effect of migration on multiple child health outcomes for migrants themselves, including obesity. They find that for children, migration increases body mass index (BMI) and obesity in three to five year olds and that this effect is largely a result of dietary changes. Other studies (Kaushal, 2009; Popkin and Udry, 1998) have corroborated the finding that immigrants often experience increased risk of obesity. Creighton et al. (2011) suggest a correlation between international migration and an increased risk of becoming obese for those who remain behind in Mexico. They find that a child in a household exposed to a migrant network has a predicted probability of becoming overweight of 0.24 compared to 0.17 for children with no migrant network. However, Creighton et al. do not address the inherent selection problem in the migration decision and do not establish causality. This article makes a contribution to the literature by estimating the effect of international migration on obesity outcomes for children who remain in Mexico using natural disasters as an identification strategy for migration. Further, two pathways to childhood obesity that are affected by migration are investigated, namely, household food expenditure patterns and time use for household members.

2. Theory

Lakdawalla et al. (2005) and Philipson and Posner (1999) provide helpful theory to frame the potential effect of migration on weight status. In both models, weight is an outcome resulting from personal choices made by individuals who seek to maximize their utility within a set of constraints. Both models suggest that obesity is a by-product of technology gains that have otherwise increased welfare and economic growth. Technological change has lowered the cost of calories through agricultural innovation in production and processing while at the same time, increased the cost of using calories by decreasing the physical demand of work both at home and in the workplace (Philipson and Posner, 1999). In pre-industrial economies, people were paid to expend energy through manual labor. With technological change, work activities became, and are becoming, less strenuous causing people to pay to expend energy in the form of forgone leisure (ibid).

Lakdawalla and Philipson (2002) and Lakdawalla et al. (2005) provide a model of weight gain that is briefly summarized here. The dynamic problem characterizes an individual that chooses his weight, *W*, which can increase by consuming more food, *F*, or decreased through strenuous activity, *S*. The model characterizes the steady state of food consumption, *F*(S,p,Y)*, as a function of activity, food prices (*p*), and income (*Y*). The steady state of weight is *W*(S,p,Y)*. Migration can affect weight gain through two pathways in this framework. First migration causes an increase in unearned income from migrant remittances. Lakdawalla et al. (2005) show that increased unearned income has differential effects on weight gain depending on the initial level of income. For low-income individuals, income increases food consumption, $F_Y^* > 0$, and increases weight, $W_Y^* > 0$, but for relatively high-income households, this relationship will be reversed. This outcome is predicated on the assumption that all individuals have an ideal weight, and that low-income people are more likely to be underweight and high-income people are more likely to be overweight. Therefore, as unearned income increases, low-income people will increase their food intake and increase their weight. If high-income people are overweight, they will desire to decrease their weight and unearned income will help buy more leisure to exercise. For a more comprehensive discussion of this theoretical model, see Lakdawalla and Philipson (2002).

The second pathway by which migration can affect weight status is through changes in household time allocation and work after a household member migrates. If the migrant is contributing to household work, such as food preparation, child care, or agricultural production, and labor markets are imperfect, the loss of this family member causes substitution of duties within the household. In Nicaragua (Funkhouser, 1992), El Salvador (Acosta, 2011), the Philippines (Rodriguez and Tiongson, 2001), and Mexico (Amuedo-Dorantes and Pozo, 2006; Hanson, 2007), studies have found that migration and remittances can change labor allocations and participation. If remaining household members change their work/leisure balance, changes in physical activity levels are an important component in the relationship between migration and weight status. The effect of earned income in the Lakdawalla et al. (2005) model depends on the nature of the work and activity level, *S*. The intuitive result is that when work is sedentary, increased labor market activities increase weight gain, whereas if work is physically strenuous, increased labor market activities will decrease weight gain. Lastly, it is possible that migration may lead to investment in labor saving technologies in both home and agricultural production thus decreasing the caloric expenditure in these activities for remaining family members.

The results from the Lakdawalla et al. (2005) and Lakdawalla and Philipson (2002) models, in the context of migration, are helpful in that they provide several hypotheses to explore and suggest important control variables in the empirical analysis, namely, a measure of income and food prices. The model outlined above suggests that by itself, unearned income will increase weight gain. However, if activities change after migration, this effect could be mitigated by increased strenuous activity through work. It is also possible that increased unearned income can buy leisure time, thereby increasing weight directly if leisure is sedentary. The magnitude of these two effects is ambiguous and unknown; therefore, empirical analysis can help determine the direction of the relationship between migration and weight gain.

Lastly, some have hypothesized that migration is a conduit that alters preferences of family members who remain in Mexico toward those seen in the United States. If food habits and preferences of the migrant are communicated back to family members in Mexico, changes in food consumption patterns could affect the weight status of remaining family members.

3. Data

This article examines the effect of international migration on the obesity status of Mexican children using rounds 1 and 2 of the Mexican Family Life Survey (MXFLS). The MXFLS is a high-quality, nationally representative longitudinal survey. The first round (MXFLS-1), which was collected in 2002, recorded detailed data at the individual, household, and community level for 150 communities, 8,440 households, and 35,701 individuals (Rubalcava and Teruel, 2006). A follow-up survey in 2005/2006 (MXFLS-2) had a recontact rate of 90% at the household level. Further, 91% those individuals who migrated to the United States between 2002 and 2006 were contacted. The MXFLS-2 interviewed 8,435 households,[3] representing 40,206 individuals. For a more comprehensive overview and discussion of the Mexican Family Life Survey, see Rubalcava and Teruel (2006).

3.1. Anthropometric measures

Anthropometric measurements were recorded including height, weight, head circumference, and others.[4] The primary outcome of interest in this study is the obesity status of children in Mexico. Using BMI for children is problematic given the rapid pace of growth that children experience and the bias that BMI creates in measuring their growth status. It is important therefore to use an age-adjusted weight measure. Each child was categorized based on their weight, height, and age into percentiles according to international standardized growth charts provided by the World Health Organization (WHO). WHO growth charts are age-adjusted and are a more appropriate measure of a child's nutritional and anthropometric status than

[3] The number of households in MXFLS-2 includes new households formed by individuals previously in original households in the MXFLS-2. The 90% recontact rate is based on original households who were revisited.

[4] Respondents were first asked if he/she knew his/her own height and weight. The individual reported their estimate, otherwise they are coded as DK (Don't know). Unless the respondent refused (the reason for refusal is also recorded), the interviewer measured both height and weight of the person.

Table 1
Mean and standard deviations for outcome variables

Variable	N	2002		2005		Change (2005–2002)	
		Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
Obese boys	3,110	0.172	0.377	0.214	0.411	0.042	0.437
Obese girls	3,204	0.151	0.358	0.178	0.382	0.027	0.382
Hours of leisure—boys (12–18)	814	16.388	12.353	7.792	13.866	−8.596	17.978
Hours of leisure—girls (12–18)	833	13.303	12.283	5.543	10.014	−7.760	13.970
Hours of work—boys (12–18)	814	4.668	7.722	2.136	5.591	−2.532	9.662
Hours of work—girls (12–18)	833	7.905	9.771	4.403	9.147	−3.502	13.638
Hours of screen time—boys (12–18)	814	13.931	11.169	7.753	11.851	−6.178	15.860
Hours of screen time—girls (12–18)	833	14.412	11.477	7.586	11.130	−6.826	15.015
Change in household expenditure		Urban		Rural			
Processed foods		2.747	26.059	0.765	13.066		
Food away from home		1.826	37.797	−0.125	19.309		
Soda		−0.267	99.200	2.917	77.866		
Fruits and vegetables		5.344	36.125	4.182	25.198		
Meat		14.541	71.486	10.523	48.417		
Dairy and eggs		3.352	124.532	19.152	97.713		
Cereal, grains, and beans		−1.375	18.689	−0.881	27.195		

Note: $N = 1{,}717$ for urban households and $N = 1{,}560$ for rural households in the household expenditure results. The 2002 and 2005 expenditures across different food categories are presented in changes for parsimony and adjusted using OECD equivalence scales. Screen time includes both computer and television time. Sample sizes for hours of activities are limited to only children 12–18 years old to explore changes in activities where significant changes in obesity statuses are observed.

BMI alone. If a child fell between the 95th and 100th age-adjusted BMI percentile, they were categorized as obese. They were assigned a 1 if they fell within this interval and 0 otherwise. The weight status of each child was calculated for both 2002 and 2005. The analysis below relies on changes in a child's obesity status. There are 6,314 children included in the sample, 3,110 boys and 3,204 girls, ages 4–18 years, for which anthropometric information is recorded in both 2002 and 2005. These 6,314 children and their households are used for the analysis.

Table 1 demonstrates obesity prevalence by gender and age. Obesity prevalence in boys (ages 4–18)[5] increased from 17% in 2002 to 21% in 2005. In the case of girls, the increase was more modest, from 15% to 18%. Table 1 suggests an overall increase in obesity prevalence, but it is yet to be determined whether these figures vary systematically with migration decisions.

3.2. Food expenditure and time allocation measures

Also included in Table 1 are descriptive statistics for the outcome variables that we use to investigate the potential causal pathways to obesity. First, weekly time allocation variables including leisure, work, and screen time for both boys and girls are presented in levels for 2002 and 2005 and also in differences. The child time use data was collected from an adult household member, typically the mother, who could accurately report the child's activities in the past Monday through Sunday period. In general, we observe that both boys and girls spend a majority of their time on leisure activities, which include cultural activities, lessons out of school, reading, and playing. Screen time includes both television and Internet consumption and is close in magnitude to all other leisure activities combined. Work hours for children are also reported. Children engaged in a number of different work activities including elderly care, housework, agricultural work, and firewood and water collection. Descriptive statistics indicate that there is a decrease in leisure, work, and screen time overall between 2002 and 2005.

Table 1 also reports the change in weekly expenditures for seven different food categories between 2002 and 2005 at the household level. Food expenditure levels are reported using equivalence measures.[6] The food expenditures were collected by asking individuals to recall how much the household had spent on highly specific food items in the last seven days. The sample of households is restricted to only those with observations on weight status for boys or girls, ages 4–18, for 2002 and 2005. In other words, only households whose children are represented in the individual level regressions are included in the sample. In urban households, we see an increase in weekly expenditures across all categories except soda and basic grains/beans. In rural households, we observe a similar pattern, but the magnitudes of the increases are remarkably smaller, especially in the cases of processed foods and food-away-from-home; however, dairy and eggs experience a large increase in expenditure in rural households compared to urban

[5] This age range represents children who were at least four years old in 2002 and 18 years old and younger in 2005.

[6] Given that food is a private and rival good and there are unlikely to be significant economies of scale we opted to use the OECD scale, defined as

$$FoodExp_{\text{eq}} = \frac{Food\ Exp}{(1 + \delta(a-1) + \theta c)},$$

where a is the number of adults and c is the number of children, $\delta = 0.7$, and $\theta = 0.5$. This measure has the desirable property in the case of food expenditure, of weighting the relative food needs of different family members according to the first adult (Bellu and Liberati, 2005).

Table 2
Descriptive statistics of independent variables

Variable	Mean	Std. dev.	Minimum	Maximum
Household demographic controls				
Female headed	0.16	0.36	0	1
Family size	5.79	2.04	2	15
Number of senior citizens	0.16	0.49	0	6
Number of children	3.26	1.59	0	10
Indigenous household (1 = indigenous)	0.22	0.41	0	1
Other controls				
Change in total monthly expenditure	1,114.79	14,875.52	−146,491.30	154,429.30
Laspeyres price index	100.29	7.37	85.58	117.23
Number of disasters between 2002 and 2005	2.84	2.42	0	12
Age in 2005	11.70	3.80	4	18
Family member migrated (2002–2006)	0.08	0.27	0	1
Female member migrated (2002–2006), $N = 313$	0.03	0.16	0	1
Male member migrated (2002–2006), $N = 472$	0.06	0.24	0	1
Excluded instruments				
Number of disasters at the community level, 1997–2002	1.95	1.60	0	7
Time since disaster (months) × number of disasters, 1997–2002	24.49	21.76	0	96
Number of fatalities from disasters	5.34	5.70	0	27

Note: Households characteristics and demographic controls are in levels from the 2002 survey.

Table 3
Obesity rates of boys and girls by community disaster status, 2002

	No disaster		Disaster	
	N	Mean	*N*	Mean
Obese boy, 2002	685	0.19 (0.39)	2,120	0.17 (0.37)
Obese girl, 2002	698	0.17 (0.37)	2,519	0.15 (0.35)

Note: Using a simple *t*-test, the difference in the means between disaster and nondisaster communities is not different from zero. Standard deviations are in parentheses.

households. These changes, of course, do not control for relative price changes, changes in migration status, or other factors that might change consumption decisions.

3.3. Migration status

The MXFLS-2 tracked individuals who were interviewed in 2002 but migrated to the United States between 2002 and 2006. There were 854 people, out of 35,701, who moved to the United States and were identified between the two survey periods. Of these migrants, 785 have complete records including the sex of the migrant. We measure 313 female migrants and 472 male migrants. Two migration dummy variables are created for each household called migrant female and migrant male.[7] Migrant female, for example, equals 1 if at least one female migrated from the household between 2002 and 2006 and 0 if no female from the household migrated. The same method is used for identifying migrant males. Using this approach, 1,071 adults and children who remain in Mexico had at least one female migrate from their household and 1,959 had at least one male migrate. These people represent 462 (171 for female migrants and 314 for male migrants)[8] households that acquired a new international migrant between the two survey periods. In total, there are 519 children (253 boys and 266 girls) ages 4–18 years in households who acquired a migrant and who also have observed anthropometric data for both 2002 and 2005. The total sample of children used in the regression analysis is much larger because it includes both children in migrant households and children in nonmigrant households. This specification of migration allows us to examine the characteristics of households before and after a migration event, taking into account the gender of the migrant. Further, the household analysis for food expenditure includes 1,717 urban households who have at least one child with anthropometric information for both years. This analysis was restricted to urban households because we observed the most change in obesity status in urban households after a migration event.

3.4. Control variables

In addition to BMI and migration status, household and individual level control variables were calculated using the 2002 and 2005 data. Table 2 presents mean, standard deviation, minimums, and maximums for the control variables included in the analysis. Control variables can be categorized in three primary

[7] A majority of these migrants are sons or daughters of the household head. A complete table of migrant relationship is available upon request for all migrants where the household relationship is available. Note that some records are incomplete and therefore the number of migrants in this table does not equal the number of migrants mentioned in the text.

[8] It is possible for a household to have both a female and male migrant; hence, the number of households does not add up to 462, but this happened relatively rarely.

groups. First, a set of demographic control variables includes household size, number of senior citizens, number of children, if the household is female headed, if the household is categorized as indigenous and, in the case of regressions at the child level, the age of the child. These variables are called "demographic controls" in Tables 6–16. Second, total household expenditures for both 2002 and 2005 are included as a proxy for income. The number of disasters between 2002 and 2005 and the Laspeyres price index are also included. The Laspeyres food price index measures the difference in relative food prices across communities.[9] Three prices for each of the 39 food items in the basket were recorded from three different sources, typically the supermarket, the open air market, and another small store in each community and used to calculate the food price index. Since prices were not available in the 2002 survey, the base for the index is a random village. The price index therefore captures regional differences, rather than time trends, in food prices that may affect children's obesity outcomes. Dummy variables for each federal state represented are also included. Lastly, Table 2 reports the mean and standard deviation for the percentage of the sample that had a family member migrate and the description of the three excluded instruments included in the analysis.

3.5. Attrition

When using longitudinal data, systematic attrition is a concern. In the case of the MXFLS, heroic efforts were made to mitigate attrition, including identifying and interviewing migrants who left Mexico for the United States between MXFLS-1 and MXFLS-2. Velasquez et al. (2010) provide a comprehensive discussion of the characteristics of attrition in the panel. In the second round of the survey, 89% of the original respondents were found and reinterviewed, leading to an 11% attrition rate. Of this 11%, 8.8% represented the loss of an entire household. This attrition rate is not driven by migration to the United States since approximately 2.4% of the original sample moved to the United States and a vast majority of these migrants (91%) were identified and interviewed in the United States (ibid). A majority of the attrition were people who migrated from states included in the MXFLS to states within Mexico that were not covered by the MXFLS. Velasquez et al.'s (2010) comprehensive attrition analysis suggests that attrition is small but should be considered particularly in the case of analysis of earnings. Concerns about attrition bias are mitigated to some extent in this article since it appears that international migration is not an important reason for attrition and obesity outcomes for children in 2002 are not significantly different[10] between children that remain in the survey and those that are lost in round 2.

[9] The Laspeyres price index is calculated using the following formula: $\frac{\sum_f^{3Q} Pfk\, Qfk}{\sum_f^{3Q} Pf_1\, Qf_1}$ for 39 food types, *f*, in each community, *k*, using a random community as a base.

[10] The *P*-value is 0.88 for boys and *P*-value is 0.93 for girls for a *t*-test of a difference in means of obesity rates in 2002.

4. Empirical approach

To estimate the effect of international migration on the change in overweight and obesity status of household members remaining in Mexico, the outcome variable is specified as a first difference between the weight status of a child in 2002 and 2005. To address the potential endogeneity between changes in migration and changes in body weight, a two-stage IV approach is employed.

People who migrate from Mexico to the United States are not randomly selected, and differ in both observable and unobservable ways from people who do not migrate to the United States. It is likely that the households where migrants originate are different from nonmigrant households. Suppose, for example, migrant households have deeper unobserved social networks than nonmigrant households. If these networks serve to both increase the probability of migration and lead to a stronger adherence to a traditional diet reducing the probability of obesity, the estimated coefficient on migration using a standard Ordinary least Squares (OLS) would be biased downward. Or, an alternative possibility is that migrant families are more open to external cultural influences and embrace U.S. norms about food. In this case, these households would be both more likely to migrate and more likely to be overweight leading to an upward bias on the parameter estimate for migration on obesity outcomes using simple OLS estimates. This presents a challenge for this analysis if, as we suspect, the unobservable characteristics that affect the probability of migration also potentially affect weight status within the household. This leads to a direct violation of the assumption, $E(u_i X_i) = 0$, or that the mean value of the error term conditional on X_i is equal to zero. To address this concern, in the absence of a randomized experiment where exogeneity is constructed, an IV approach is used. For an IV model to be valid, one must identify an IV that is strongly correlated with the endogenous variable of interest, in this case migration, but has no explanatory power on the outcome variable of interest, except through its effect on the endogenous regressor.

In this article, we employ a set of three instruments measuring the severity and frequency of historic natural disasters and time elapsed since the first disaster. Natural events are attractive IVs since their occurrence is unanticipated and randomly distributed. It is true that the severity of a hurricane, for example, will be more intense in coastal communities, but the approach here uses different types of natural disasters and the effect of this geographic placement is mitigated. The instance of natural disasters was collected at the community (town) level by interviewing community key informants, generally a community official who has good information on the recent history of natural disasters in the town. The natural disasters included are: flood, earthquake, landslide, fire, hurricane, droughts, plagues, frost, and hail.

The primary concern in using these instruments is that natural disasters could change the food environment in a community and that this may cause a change in obesity status leading to a violation of the exclusion restriction. The direction of this bias is unclear. Typically, we think of disasters as decreasing food security in households and leading to malnutrition in children. However, a natural disaster may change the food environment by destroying crops or interrupting livelihoods and may lead to more consumption of store bought goods and possibly increase weight gain. The first strategy we employ to reduce the contemporaneous correlation between nutrition outcomes and natural disasters is to use only reported natural disasters that happened from 0 to 5 years previous to the 2002 survey. This means that the natural disasters used to identify migration occurred between three and eight years prior to the second round of the survey. The number of disasters times the number of months since the first disaster in that community is also used as an instrument. This interaction allows us to account for the time elapsed between the last natural disaster and the survey and also include communities where there were no natural disasters (where the time since the natural disaster would be missing). In this case, the interaction term is zero. Lastly, the total number of people who died in natural disasters between 1997 and 2002 is used to measure the severity of the disaster. To mitigate concerns that contemporaneous natural disasters still affect obesity changes, a variable is included in the primary regression that measures if the community experienced natural disasters between 2002 and 2005, or during the same period migration is measured. On average, communities experienced 1.95 different natural disasters between 1997 and 2002 and just over five fatalities from these disasters. The number of months multiplied by the number of disasters is, on average, 24.49, see Table 2. In sum, there are two "natural disaster" sets of variables included in the analysis. The historic natural disasters (and the other related intensity and time measures) that occurred before 2002 are used as instruments. The second disaster variable measures the number of contemporaneous natural disasters that occurred between 2002 and 2006 and is included in the second stage as a control variable.

The first regression specification, explaining the change in obesity status for individual *i,* in household *h*, in community *k,* in state *j* is

$$\Delta y_{inkj} = \alpha + \beta_1 \Delta Mig_{sh} + \beta_2 LPI_{k,2005} + \beta_3 \Delta HHExp_n + \beta_4 age_{i,2002} + \beta_5 D_{k,2005} + y_j + \varphi' X_{n,2002} + \in_{inkj} . \quad (1)$$

The dependent variable is the change in weight status of child *i* between 2002 and 2005, and equals 1 if the individual was not obese in 2002 but was in 2005, 0 if there was no change and -1 if they were obese in 2002 but not in 2005. The constant term, α, is the average change in weight status across all individuals included in the regression. The variable of interest, the migration variable (Mig_{sh}), is also in first differences since it measures if the household had a male or female (*s*) member migrate to the United States between the 2002 and 2005 survey.[11] Further, we calculate a Laspeyres price index (*LPI*) based on community reported prices in 2005 for 29 popular food items. Total household expenditures ($HHExp_h$) are included in first differences and measure the change in expenditure between 2002 and 2005 survey rounds.

A dummy variable, $D_{k,2005,}$ indicating if the community experienced natural disasters, between 2002 and 2005, is included as mentioned above. Including this variable helps address the concern that natural disasters alter the food environment and may change weight outcomes either through changes in the food prices or the labor market. In addition, a fixed effect for the individual's federal state, $y_{j,}$ is included. This state-level fixed effect accounts for state-level time trends. Including a state fixed effect implies that the interpretation of the migration change variable should be the impact of migration on an individual's difference from the mean change within a state.

The age of the individual is included as well as a set of household level measures of demographics. Control variables, $X_h,_{2002}$, from the 2002 survey control for demographic characteristics, and are described in Section 3. The error term, $\in_{ihkj}$, is normally distributed with a mean of zero. Errors are clustered at the village level to account for correlation within the village.

Equation (1) is estimated using a two-staged least-squares IV approach. The first stage explains the change in migration status by gender of the migrant for a household in the form

$$\Delta Mig_{sh} = \rho + \theta_2 Z_{hkj} + \theta_3 \sum_{t=1997}^{t=2002} D_t + \theta_4 T_k * D_t + \theta_5 F_k + Yj + \mu_{ihkj}. \quad (2)$$

Three excluded instruments are included in the first stage (Eq. (2)) to identify the change in migration. In addition to the explanatory variables in Eq. (1), Z_{hkj}, the regression in (2) includes the sum of the number of natural disasters experienced by a community between 1997 and 2002, D_t, the time elapsed (in months) from the first natural disaster in that period, T_k, interacted with the number of natural disasters between 1997 and 2002, the number of human deaths from natural disasters between 1997 and 2002, $F_{k,}$, and a set of state level dummy variables.

While the measurement for migration change in Eq. (2) takes a value of 0/1 and the change in obesity status of children takes a value of -1, 0, and 1, we opted to use a standard two-staged least-squares approach rather than a dichotomous or ordered variable approach in either stage, such as a probit or multinomial logit. This decision was made based on comparing the predictive performance of these kinds of models with OLS and finding that the OLS performed comparably to the probit and multinomial logit models in predicting the outcomes of interest. In order to adhere to the standard approach in the literature and implement

[11] An alternative specification attempted to examine the differential effect on weight if a mother, father, or sibling left the household. However, the sample of migrants is not sufficient to parse out migrant relations in this way. Also, we investigated if the change in the number of migrants affected obesity status of children and we found that these results were very consistent with the ones presented here.

Table 4
Regressions explaining food prices, wages, and 2002 obesity status using historic disaster variables

Variables	(1) Food price index	(2) Monthly wage, 2002	(3) Boys obesity, 2002	(4) Girls obesity, 2002
Number of disasters, 1997–2002	0.183	−97.273	−0.068	0.063
	(0.120)	(149.345)	(0.091)	(0.090)
Time since first disaster × number of disasters, 1997–2002	−0.014*	9.743	−0.004	0.001
	(0.008)	(10.084)	(0.006)	(0.005)
Number of fatalities from disasters, 1997–2002	−0.003	25.463	0.008	−0.016
	(0.034)	(29.847)	(0.015)	(0.017)
Number of disasters, 2002–2005	−0.142**	138.082*	0.042	−0.003
	(0.066)	(79.870)	(0.036)	(0.037)
Constant	101.852***	1,100.031	−0.042	−0.161
	(0.978)	(934.939)	(0.489)	(0.493)
State dummy variables	YES	YES	YES	YES
Observations	202	1,103	420	443
R^2	0.906	0.019		
F-test: excluded IVs = 0	0.280	0.636	0.561	0.730

Note: Dependent variable in column (1) is the Laspeyres price index for food items in 2005 measured at the community level. The dependent variable in column (2) is the reported monthly wages in 2005 at the individual level, and dependent variables in columns 3 and 4 are boys and girls obesity status in 2002, respectively. Results are from an OLS regression in columns 1 and 2 and from a probit regression in columns 3 and 4.

the IV approach and required diagnostics, we opted for the two-staged least-squares approach.

Lastly, to explore some of the possible causal pathways between migration and obesity, three additional outcomes are estimated using the same strategy. The first explains changes in types of weekly household food expenditure, the second examines the changes in weekly time allocation for children, and the third estimates changes in adult time allocation after migration. The adult time regressions explore the hypothesis that some changes in children's time allocations are due to changes in adult time allocation decisions. Similar to the above specification, changes in household migration status are instrumented with historic natural disasters. Food expenditure was broken into seven different categories and estimated at the household level. While it is common to use a seemingly unrelated regression approach to estimate this kind of system, Green (2003) points out that when the right-hand side variables are the same across all equations, there is nothing gained from estimating the equations jointly.

4.1. Validity of instrumental variables

Here, we investigate the possibility that historic natural disasters would change the food, health, or activity environment of the community in the future and threaten the validity of the instruments. It should be noted that this violation is only likely to take place if the effects of a disaster persist into the future (up to eight years) to change the local food or activity environment. To test this possibility, two tests are conducted. Even though this analysis examines the changes in obesity status between 2002 and 2005, a violation of the exclusion restriction would emerge if natural disasters before 2002 differentially affected obesity outcomes in the 2002 data. As a first step, a Spearman rank correlation coefficient between child obesity measures in 2002 and measurements of natural disasters between 1997 and 2002 is examined. For both boys and girls, the correlation coefficients between the outcome variables and the natural disaster variables are not statistically significant and the magnitude of the correlation coefficient is small and negative.[12]

To examine the validity of the instruments, we test the difference between obesity outcomes in 2002 in communities with and without natural disasters with a simple t-test (see Table 3). We fail to reject the null hypothesis that the obesity prevalence in disaster affected communities and nonaffected communities is the same at the 5% level. In other words, we see that at the 5% level, the obesity prevalence rates are equal across these communities. While the correlation coefficients and t-tests provide some preliminary evidence that historic natural disasters are unrelated to changes in obesity status between 2002 and 2005, regressions in Table 4 help substantiate this evidence.

The first column in Table 4 is a regression that examines if historic natural disasters affected food prices in the area. This test assumes that prices are at least partially transmitting information about food availability or the food environment in the area. Our findings suggest that historic natural disasters do not affect food prices in 2005, meaning that the effects of these historic natural disasters do not persist over years in the case of the food environment. Only one of these IVs weakly explains food prices, but they are jointly insignificant. It is reasonable to be concerned that current or recent natural disasters do affect the current food environment. Indeed, we see evidence of this when we include natural disasters between 2002 and 2005 as an explanatory variable in the food price index regression (column 1, Table 4). As such, we control for 2002–2005 natural disasters in all of our regressions.

The second specification to examine the validity of the instrument regresses historic natural disaster variables (the excluded IVs) on monthly wages in 2002. This regression is presented

[12] Results available upon request.

Table 5
First-stage regression for boys and girls

Variables	Boys (1) Family migrates	(2) Male migrates	(3) Female migrates	Girls (4) Family migrates	(5) Male migrates	(6) Female migrates
Number of disasters between 1997 and 2002	0.011**	0.012***	0.003	0.007	0.008**	0.004
	(0.005)	(0.004)	(0.003)	(0.005)	(0.004)	(0.003)
Time since first disaster × number of disasters 1997–2002	−0.000	−0.000	−0.000	−0.001***	−0.001***	−0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Number of fatalities from disasters, 1997–2002	−0.007***	−0.006***	−0.001**	−0.005***	−0.002*	−0.001*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Female headed, 2002	0.055***	0.025**	0.040***	0.044***	0.035***	0.026***
	(0.013)	(0.012)	(0.008)	(0.013)	(0.012)	(0.008)
Family size, 2002	0.029***	0.019***	0.016***	0.027***	0.021***	0.014***
	(0.005)	(0.004)	(0.003)	(0.004)	(0.004)	(0.003)
Number of senior citizens, 2002	−0.027**	−0.022**	−0.004	−0.036***	−0.018	−0.008
	(0.011)	(0.010)	(0.007)	(0.012)	(0.012)	(0.008)
Number of children, 2002	−0.003	0.004	−0.006*	−0.001	0.007	−0.002
	(0.006)	(0.005)	(0.004)	(0.005)	(0.005)	(0.003)
Member of indigenous group, 2002	−0.029**	−0.029**	−0.012	0.013	0.025**	−0.016**
	(0.013)	(0.012)	(0.008)	(0.013)	(0.011)	(0.008)
Change in total monthly expenditure	−0.000***	−0.000***	−0.000	−0.000***	−0.000***	−0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Laspeyres food price index	−0.005	−0.005	−0.001	−0.004	−0.001	−0.002
	(0.004)	(0.003)	(0.002)	(0.003)	(0.001)	(0.002)
Number of disasters between 2002 and 2005	−0.003	−0.004**	−0.001	−0.005**	−0.003	−0.002*
	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.001)
Age in 2005	−0.000	0.000	−0.001	0.001	−0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Constant	0.375	0.391	0.076	0.286	0.028	0.126
	(0.363)	(0.328)	(0.226)	(0.325)	(0.067)	(0.198)
State dummies	YES	YES	YES	YES	YES	YES
Observations	3,110	3,110	3,110	3,204	3,204	3,204
R^2	0.106	0.091	0.056	0.109	0.053	0.059
F-test	12.54	13.64	1.486	12.93	4.244	2.310
Prob > F	3.80e-08	7.71e-09	0.216	2.14e-08	0.00531	0.0744

Note: Robust standard errors in parentheses.
***$P < 0.01$, **$P < 0.05$, *$P < 0.1$. Dependent variable is the change in migration status of the individual's household, and equals 1 if the household engaged in migration between MXFLS-1 and MXFLS-2. Results are from OLS regressions based on the samples used in Tables 6–9. F-test results are from the Cragg-Donald Wald F-statistic on excluded instruments.

as a means to investigate if the occurrence of natural disasters persists over time in the labor market. The results are presented in Table 4, column 2. We see that none of the disaster IVs explain current wages and jointly these variables are insignificant, indicating that historic natural disasters do not affect the future of the labor market. We do see some evidence that the labor market can be affected by natural disasters in the same period as we see that 2002–2005 disasters do explain differences in wages. This result provides further evidence that a measure of contemporary disasters should be included in the second stage of the regression to avoid omitted variable bias.

Lastly, we examine whether our excluded instruments explain obesity status for boys and girls in 2002 (Table 4, columns 3 and 4). If the instruments affected the baseline obesity status of children in 2002, this would be a direct violation of the exclusion restriction. We observe that none of the instruments either individually or jointly have any explanatory power over the obesity rates of boys or girls in 2002.

One may be concerned that there could be a significant lag between a natural disaster and obesity prevalence. For example, it may take several years for the transformation of a food environment as a result of a natural disaster to lead to obesity. To check this possibility, we test the difference in the 2002 obesity rates for boys and girls between communities where the most recent disaster was five years previous and communities that had never had a disaster.[13] Under these assumptions, we fail to reject the null hypothesis that there is no difference between the means of the number of obese or overweight children.

The above tests suggest that disasters before 2002 are unlikely to have systematically affected the change in obesity status of children between 2002 and 2005. However, in order to be good instruments, they must explain migration between 2002 and 2005. To examine their explanatory power, we look at the first stage of the two-stage model in Table 5 for both boys and girls with three different migrant types (all, male, and

[13] Results available upon request.

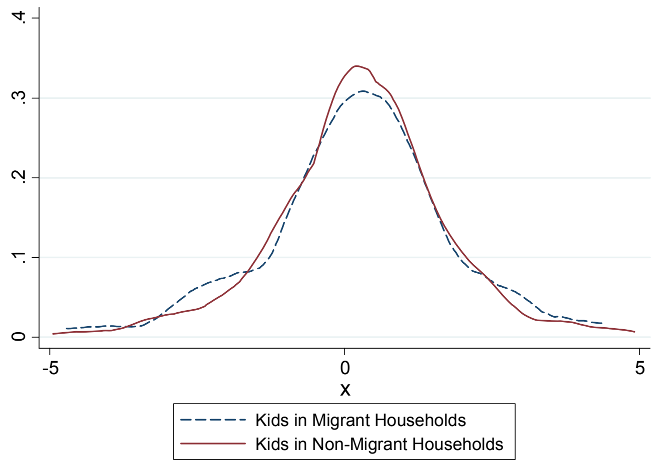

Fig. 1. Kernel density graph for BMI *z*-scores for children in migrant versus nonmigrant households.
Note: Individuals included in this density graph are from both migrant and nonmigrant households ages 4–19.

female). A joint Cragg-Donald Wald *F*-statistic to test the joint significance of the excluded instrument has a value of 12.54 for boys and 12.93 for girls. The Stock–Yogo critical values for three excluded instruments are 13.91 for 5% level and 9.08 for the 10% level. The *P*-value for the *F*-test suggests that the excluded instruments are jointly significant. This statistic is included in all of the tables of interest for each regression. Weak instruments are not a major concern in the main regressions discussed here, but are a concern in some of the secondary regressions. The variable measuring the number of disasters is positive and significant when the male migrates. The time since the most recent disaster is negative and significant in the case of girls. The number of people killed in disasters is negative and significant across regressions. The negative sign on the months since the most recent disaster is intuitive if we think about a natural disaster having a large effect on initial migration, and then this effect decays over time. The number of people killed, measuring the severity of the disaster, is negative and consistent with the idea that if the disaster is bad enough, people use their liquid assets to rebuild rather than send a migrant, or that potential migrants may stay behind to help families rebuild. The signs of these point estimates associated with disasters are generally consistent with findings from both Yang (2008) and Halliday (2006).

5. Results

Initial descriptive analysis indicates that child weight outcomes do vary according to migration status. Kernel density graphs depict the distribution of BMI *z*-scores by migration status for children. Figure 1 represents the aggregate analysis of BMI *z*-scores for all individuals in nonmigrant versus migrant households. We see that the distribution between individuals in migrant and nonmigrant households tracks quite closely. There is some weak evidence that migrant households may be more likely to have greater density at both ends of the BMI *z*-score distribution. However, in Figs. 2 and 3, this same distribution is separated by gender of the children left in Mexico. Several interesting differences emerge. First, we see that the kernel density function for boys in migrant households is situated generally to the right of that for boys in nonmigrant households, and again the density is greater for migrant households at the extremes of the distribution. In the case of the right panel in Fig. 2, for girls, those in migrant households have a kernel density function situated to the left of that for girls in nonmigrant households; however, like in the case of boys, we see higher density generally at the extremes of the distribution.

Table 6 presents results for obesity changes for all boys, ages 4–18, and four subpopulations when a male from the household migrates. These results suggest that for boys, gaining a male migrant in one's home increases the chances of becoming obese, with the coefficient of migration being positive and significant at the 1% level in the 2SLS specification (column 2). To examine a finer segmentation of obesity, four different age/geographic groups are examined. This smaller segmentation suggests that older boys in urban areas and younger boys in rural areas are most likely to become obese when a male member migrates, significant at the 5% level. We see similar results in Table 7, which examines the change in boys' obesity status when a female member migrates. Rural younger boys do not seem to be affected, but we see urban older boys have a positive and significant change in their obesity status when a female migrates.

We see in Tables 8 and 9 (column 2) that neither male nor female migration has a discernible effect on girls' overall weight status. However, analysis of subgroups suggests that migration of both male and female family members may actually decrease the chances of becoming obese in urban older girls. For urban girls ages 12–18, male migration decreases the chance of becoming obese by 1.704 (see Table 8, columns 5) and female migration decreases the chance of becoming obese by 2.212 (see columns 5 in Table 9). Both results are significant only at the 10% level, but it is interesting to note that the magnitude of this change is greater when a female migrates.

Tables 10–16 examine potential pathways by which migration could affect obesity outcomes, namely, changes in monthly household food expenditure across food categories and time use changes for children and adults. In these tables, pathways are specifically examined for urban households and older kids, given that most of the results in Tables 6–9 are applicable to urban older children. Overall, using the same set of control variables as above, there is no change in total weekly food expenditure when a household gains a male or female migrant.[14] Tables 10 and 11 examine the change in household food expenditure (adjusted for equivalence scales) across seven food categories for urban households when either a female (Table 10) or male (Table 11) migrates. Interestingly, we see that having

[14] Results for these regressions are available upon request.

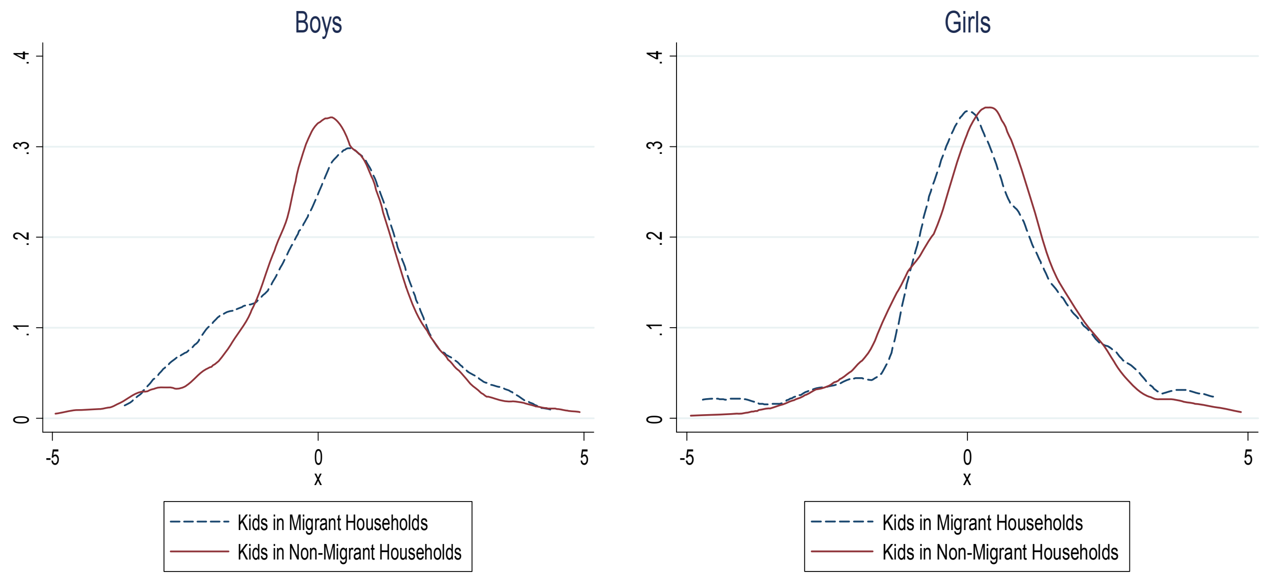

Fig. 2. Kernel density graph for BMI *z*-scores for children in migrant versus nonmigrant households.
Note: Individuals included in this density graph are from both migrant and nonmigrant households ages 4–19, separated by gender.

Table 6
Boys obesity status when male migrates

Variables	(1) 4–18	(2) 4–18	(3) Rural 12–18	(4) Rural 4–11	(5) Urban 12–18	(6) Urban 4–11
	OLS	2SLS	2SLS	2SLS	2SLS	2SLS
Male migrated	0.037	0.748***	0.299	2.002**	1.787**	−0.362
	(0.034)	(0.202)	(0.196)	(0.979)	(0.834)	(0.855)
Constant	1.465**	1.246***	11.106***	11.876	1.081***	1.985**
	(0.611)	(0.315)	(1.529)	(9.740)	(0.185)	(0.829)
Observations	3,110	3,110	810	789	814	697
R^2	0.029	−0.113	0.002	−1.243	−0.528	0.047
Demographic controls	YES	YES	YES	YES	YES	YES
State FE	YES	YES	YES	YES	YES	YES
F-test of IVs		5.026	6.067	1.959	17.27	12.03
Prob > F		0.0035	0.0013	0.132	8.06E-05	0.000363

Note: Standard errors are clustered at the village level and state-level dummies are included. Column titles represent age ranges and geographic location. Results are from a 2SLS instrumental variable regression. Dependent variable is the change in obesity status of boys (ages and geographic regions indicated in column names). Cragg-Donald F-test on excluded instruments is reported with associated P-value. Each regression includes demographic controls as well as a food price index, control for total household expenditure, number of disasters in the community between 2002 and 2005, and state-level fixed effects. Robust standard errors are in parentheses.
***$P < 0.01$, **$P < 0.05$.

a migrant does change weekly expenditure allocations across food categories in urban areas. When an urban household, in Table 10, gains a female migrant, they decrease their expenditure on processed foods and fruits and vegetables. The magnitudes of the expenditure reductions suggest that households are allocating resources strongly away from fruits and vegetables and processed food in nearly equal proportions. In Table 11, it appears that there is a larger and more varied shift in food expenditure across categories when a male migrates. Households decrease their spending on food-away-from-home, fruits and vegetables, and meat and significantly increase their spending on dairy and eggs. There is no change in spending on processed food, soda, or cereal and grains. These results do not provide a strong and consistent story of changing food preferences and expenditures that lead to obesity in migrant households. There is some evidence that diets may be transitioning to less healthful food (i.e., transitioning away from fruits and vegetables) but these results are not enough to conclusively state that a nutrition transition is the main driver of changes in obesity status after migration. One weakness of these results is that it is impossible to determine the diets of children within the household since expenditures are measured at the household level. It is possible

Table 7
Boys obesity status when female migrates

Variables	(1) 4–18	(2) 4–18	(3) Rural 12–18	(4) Rural 4–11	(5) Urban 12–18	(6) Urban 4–11
	OLS	2SLS	2SLS	2SLS	2SLS	2SLS
Female migrated	−0.013	2.914	−1.853	−1.819	1.425***	−0.712
	(0.049)	(3.149)	(2.328)	(1.117)	(0.177)	(1.165)
Constant	1.477**	1.334***	11.078***	29.021**	1.413***	1.982**
	(0.611)	(0.417)	(2.080)	(14.794)	(0.324)	(0.815)
Observations	3,110	3,110	810	789	814	697
R^2	0.028	−1.098	−0.528	−0.464	−0.19	0.008
Demographic controls	YES	YES	YES	YES	YES	YES
State FE	YES	YES	YES	YES	YES	YES
F-test of IVs		0.885	0.303	1.899	12.58	20.07
Prob > F		0.454	0.823	0.141	0.000384	2.44E-05

Note: Standard errors are clustered at the village level and state-level dummies are included. Column titles represent age ranges and geographic location. Results are from a 2SLS instrumental variable regression. Dependent variable is the change in obesity status of boys (ages and geographic regions indicated in column names). Cragg-Donald F-test on excluded instruments is reported with associated P-value. Each regression includes demographic controls as well as a food price index, control for total household expenditure, number of disasters in the community between 2002 and 2005, and state-level fixed effects. Robust standard errors are in parentheses.
***$P < 0.01$, **$P < 0.05$.

Table 8
Girls obesity status when male migrates

Variables	(1) 4–18	(2) 4–18	(3) Rural 12–18	(4) Rural 4–11	(5) Urban 12–18	(6) Urban 4–11
Male migrated	0.02	−0.161	0.05	0.356	−1.704*	−1.103
	(0.028)	(0.261)	(0.262)	(0.386)	(0.919)	(0.691)
Constant	0.107	0.142	1.658***	2.557	−1.233***	1.180***
	(0.471)	(0.106)	(0.392)	(2.640)	(0.184)	(0.223)
Observations	3,204	3,204	869	781	833	721
R^2	0.029	0.016	0.024	−0.038	−0.66	−0.222
Demographic controls	YES	YES	YES	YES	YES	YES
F-test of IVs		3.426	2.225	0.885	11.36	20.51
Prob > F		0.0226	0.0965	0.455	0.000481	3.29E-05

Note: Standard errors are clustered at the village level and state-level dummies are included. Column titles represent age ranges and geographic location. Results are from a 2SLS instrumental variable regression. Dependent variable is the change in obesity status of girls (ages and geographic regions indicated in column names). Cragg-Donald F-test on excluded instruments is reported with associated P-value. Each regression includes demographic controls as well as a food price index, control for total household expenditure, number of disasters in the community between 2002 and 2005, and state-level fixed effects. Robust standard errors are in parentheses.
***$P < 0.01$, *$P < 0.1$.

that diets vary within the household that may explain changes in obesity, but it is not possible to parse out these changes with these data. Food diary data for individual household members are needed to understand these subtleties.

Given that dietary changes do not provide a strong causal pathway to changes in obesity, Tables 12–16 examine time use changes for both children and adults after a migration event. The inclusion of adults in this analysis is important because it captures intrahousehold substitution of labor after migration which we could not adequately capture when excluding adult time use changes.

Table 12 examines the change in time dedicated to work for urban boys and girls age 12–18 years when any family member, male member, or female member migrates. The results are limited to this subsample since this is the population where there seems to be a change in obesity status when a family member migrates. We see that girls increase their weekly hours of work significantly when any migration takes place. The largest increase in girls work hours occurs when a female migrates, which is consistent with the reduction in obesity status of older girls being the largest when a female migrates. These urban teen girls, who become less obese with migration, as shown in Tables 8 and 9, are working[15] 31 hours more a week (Table 12, column 4) when a male migrates and 77 more hours a week when a female migrates, primarily doing housework and tending to elderly household members. Boys also seem to increase work hours when a female migrates, but the magnitude is much

[15] Work is defined as the sum of hours per week dedicated to housework, elderly care, collecting firewood or water, or agricultural work.

Table 9
Girls obesity status when female migrates

Variables	(1) 4–18	(2) 4–18	(3) Rural 12–18	(4) Rural 4–11	(5) Urban 12–18	(6) Urban 4–11
Female migrated	0.03	−0.289	0.17	−0.801	−2.212*	−2.139
	(0.042)	(1.177)	(0.550)	(0.975)	(1.311)	(1.674)
Constant	0.108	−0.134	1.635***	3.058	−0.968***	1.329***
	(0.471)	(0.094)	(0.418)	(3.044)	(0.246)	(0.265)
Observations	3,204	3,204	869	781	833	721
R^2	0.029	0.007	0.014	−0.048	−0.529	−0.583
Demographic controls	YES	YES	YES	YES	YES	YES
F-test of IVs		0.545	2.643	1.311	13.62	4.057
Prob > F		0.654	0.0591	0.281	0.000195	0.0308

Note: Standard errors are clustered at the village level and state-level dummies are included. Column titles represent age ranges and geographic location. Results are from a 2SLS instrumental variable regression. Dependent variable is the change in obesity status of girls (ages and geographic regions indicated in column names). Cragg-Donald F-test on excluded instruments is reported with associated P-value. Each regression includes demographic controls as well as a food price index, control for total household expenditure, number of disasters in the community between 2002 and 2005, and state-level fixed effects. Robust standard errors are in parentheses.
***$P < 0.01$, *$P < 0.1$.

Table 10
Urban household food expenditure when female migrates

Variables	(1) Processed food	(2) Food away from home	(3) Soda	(4) Fruit and vegetables	(5) Meat	(6) Dairy and eggs	(7) Cereal grains and beans
Female migrated	−53.004***	−8.677	−22.166	−56.988***	−49.76	133.185	−19.801
	(11.809)	(18.027)	(61.603)	(22.011)	(94.993)	(115.628)	(16.744)
Constant	−2.583	29.269***	136.307**	43.357***	139.762***	54.744**	−8.677
	(6.087)	(8.963)	(54.098)	(3.880)	(42.606)	(24.436)	(7.501)
Observations	1,717	1,715	1,641	1,711	1,694	1,545	1,715
R^2	−0.018	0.046	0.059	0.029	0.091	0.132	0.041
F-test of IVs	11.25	11.18	13.18	11.27	10.51	7.906	11.28
Prob > F	0.000505	0.00052	0.00023	0.0005	0.000697	0.00296	0.000498

Note: Standard errors are clustered at the village level and state-level dummies are included. Column titles represent the category of food expenditure. Results are from a 2SLS instrumental variable regression. Dependent variable is change in expenditure on each food category. The sample includes only households with children used in the change in obesity regressions. Cragg-Donald F-test on excluded instruments is reported with associated P-value. Each regression includes demographic controls as well as a food price index, control for total household expenditure, number of disasters in the community between 2002 and 2005, and state-level fixed effects. Robust standard errors are in parentheses.
***$P < 0.01$, **$P < 0.05$.

smaller than that of girls (11 hours per week for boys—see Table 12, column 6). Further, when a male migrates, boys do not change their number of work hours. This likely explains why girls seem to reduce their chances of becoming obese when someone migrates, given that teen girls increase their strenuous activities. Results in Table 13 also suggest that boys are reducing their leisure time when migration occurs. However, as mentioned above, "leisure" is defined quite specifically as cultural activities, lessons, active playing, and reading. As such this measurement does not capture things like socializing with friends, etc. When we restrict leisure activities to only include playing, there is no significant change in either boys or girls play hours after migration. Results in Table 14 suggest that girls are watching much more TV when a family member migrates. However, given that the magnitude of this coefficient is similar to their increase in work, it could very well be that these girls are both working in the house and watching TV at the same time. Boys seem to decrease their screen time particularly when a female migrates.

The last set of regressions in Tables 15 and 16 address the question of why teen girls might be increasing their work hours to such a large extent after migration. These tables measure adult participation in housework and wage labor as 0/1. Evidence suggests that after male migration, adult females reduce their housework participation and increase the likelihood of wage labor participation significantly. This is likely the reason we see teen girls' housework hours increase after male migration. Not surprisingly the change in housework or wage labor participation in Mexico does not change when a female migrates. However, we see teen girls take up much of the housework hours after a female migrates. Interestingly, in Table 16, we see the exact opposite trend for male time allocation after migration. After migration of a family member, and particularly a male family member, adult males are less likely to participate

Table 11
Urban household food expenditure when male migrates

Variables	(1) Processed food	(2) Food away from home	(3) Soda	(4) Fruit and vegetables	(5) Meat	(6) Dairy and eggs	(7) Cereal grains and beans
Male migrates	−17.436	−73.700**	6.024	−88.925***	−191.477***	458.798**	−21.944
	(16.808)	(31.624)	(106.954)	(30.373)	(71.621)	(213.230)	(13.767)
Constant	−1.158	29.010*	134.991**	44.845***	140.665***	54.023	−8.278*
	(2.547)	(15.144)	(57.221)	(13.997)	(24.986)	(45.129)	(4.942)
Observations	1,717	1,715	1,641	1,711	1,694	1,545	1,715
R^2	0.04	−0.057	0.06	−0.114	−0.103	−0.252	0.036
F-test of IVs	10.6	10.64	10.2	10.41	10.09	9.383	10.55
Prob > F	0.000671	0.00066	0.000804	0.000732	0.000847	0.00145	0.000686

Note: Standard errors are clustered at the village level and state-level dummies are included. Column titles represent the category of food expenditure. Results are from a 2SLS instrumental variable regression. Dependent variable is change in expenditure on each food category. The sample includes only households with children used in the change in obesity regressions. Cragg-Donald F-test on excluded instruments is reported with associated P-value. Each regression includes demographic controls as well as a food price index, control for total household expenditure, number of disasters in the community between 2002 and 2005, and state-level fixed effects. Robust standard errors are in parentheses.
***$P < 0.01$, **$P < 0.05$, *$P < 0.1$.

Table 12
Hours worked by kids in migrant households (urban older kids)

Variables	(1) Boys	(2) Girls	(3) Boys	(4) Girls	(5) Boys	(6) Girls
Family member migrated	4.275	24.401***				
	(4.703)	(6.653)				
Male family member migrated			−5.088	30.571***		
			(16.932)	(11.612)		
Female family member migrated					10.657**	76.848***
					(5.403)	(17.781)
Constant	−10.659***	17.470	−10.495***	18.692	−9.075***	9.603
	(3.340)	(19.864)	(3.856)	(19.513)	(2.767)	(21.694)
Observations	814	833	814	833	814	833
R^2	0.082	0.035	0.084	0.006	0.081	−0.391
F-test of IVs	14.73	12.81	17.27	11.36	12.58	13.62
Prob > F	0.000179	0.000266	8.06e-05	0.000481	0.000384	0.000195

Note: Standard errors are clustered at the village level and state-level dummies are included. Column titles indicate type of activity by location. Results are from a 2SLS instrumental variable regression. Dependent variable is change in hours for boys/girls ages 12–18 between 2002 and 2005. Cragg-Donald F-test on excluded instruments is reported with associated P-value. Each regression includes demographic controls as well as a food price index, control for total household expenditure, number of disasters in the community between 2002 and 2005, and state-level fixed effects. Robust standard errors are in parentheses.
***$P < 0.01$, **$P < 0.05$.

in wage labor and more likely to participate in housework after any type of migration. These results substantiate the assertion that an important pathway to changes in teen obesity after migration results from changes in adult time use and resulting intrahousehold changes in labor allocations. In particular, teen girls seem to be picking up much of the unattended housework when adult women enter the wage labor force or migrate themselves. This change reduces girls' obesity outcomes, whereby boys do not seem to increase the strenuous activities. Both boys and girls do seem to face some dietary changes, which importantly include a reduction in fresh fruits and vegetables, but caloric expenditure or lack thereof, seems to be a more important determining factor in urban teen obesity outcomes resulting from migration.

6. Conclusions

This article investigates the effect of international migration from Mexico to the United States on obesity outcomes for children who remain in Mexico. Given the dramatic and increasing obesity rates in Mexico, understanding factors that contribute to obesity is an important policy area. Establishing causality between migration and obesity outcomes is challenging since migrants do not randomly select into migration and unobservable factors that may increase (or decrease) the chances of migration may also increase (or decrease) the probability of household members becoming obese. In this study, historical natural disasters at the community level are used to identify migration choices. Very few studies have studied the relationship

Table 13
Leisure hours by kids in migrant households (urban older kids)

Variables	(1) Boys	(2) Girls	(3) Boys	(4) Girls	(5) Boys	(6) Girls
Family member migrated	−23.057***	25.350*				
	(7.189)	(14.353)				
Male family member migrated			−68.981***	32.472*		
			(23.476)	(18.356)		
Female family member migrated					−34.799***	12.828
					(10.463)	(27.043)
Constant	20.128*	39.258***	24.784*	40.531***	15.231	38.908***
	(10.662)	(7.442)	(14.057)	(8.003)	(9.740)	(6.021)
Observations	814	833	814	833	814	833
R^2	0.028	−0.047	−0.388	−0.084	0.034	0.041
F-test of IVs	14.73	12.81	17.27	11.36	12.58	13.62
Prob > F	0.000179	0.000266	8.06e-05	0.000481	0.000384	0.000195

Note: Standard errors are clustered at the village level and state-level dummies are included. Column titles indicate type of activity by location. Results are from a 2SLS instrumental variable regression. Dependent variable is change in hours for boys/girls ages 12–18 between 2002 and 2005. Cragg-Donald F-test on excluded instruments is reported with associated P-value. Each regression includes demographic controls as well as a food price index, control for total household expenditure, number of disasters in the community between 2002 and 2005, and state-level fixed effects. Robust standard errors are in parentheses.
***$P < 0.01$, *$P < 0.1$.

Table 14
Screen time hours by kids in migrant households (urban older kids)

Variables	(1) Boys	(2) Girls	(3) Boys	(4) Girls	(5) Boys	(6) Girls
Family member migrated	−8.798**	38.737***				
	(3.466)	(7.927)				
Male family member migrated			−6.970	69.108***		
			(10.921)	(13.167)		
Female family member migrated					−17.623***	89.302***
					(5.353)	(17.767)
Constant	73.886***	64.097***	74.550***	66.116***	71.319***	55.425***
	(3.868)	(7.986)	(3.574)	(10.424)	(4.261)	(8.485)
Observations	814	833	814	833	814	833
R^2	0.164	−0.126	0.169	−0.515	0.151	−0.496
F-test of IVs	14.73	12.81	17.27	11.36	12.58	13.62
Prob > F	0.000179	0.000266	8.06e-05	0.000481	0.000384	0.000195

Note: Standard errors are clustered at the village level and state-level dummies are included. Column titles indicate type of activity by location. Results are from a 2SLS instrumental variable regression. Dependent variable is change in hours for boys/girls ages 12–18 between 2002 and 2005. Cragg-Donald F-test on excluded instruments is reported with associated P-value. Each regression includes demographic controls as well as a food price index, control for total household expenditure, number of disasters in the community between 2002 and 2005, and state-level fixed effects. Robust standard errors are in parentheses.
***$P < 0.01$, **$P < 0.05$.

between obesity and migration and none to our knowledge have established a causal relationship between the two. As such, this study fills a distinct gap in this literature.

Results indicate that migration does affect obesity outcomes in both boys and girls; however, it affects them in different ways. In the case of boys, the migration of a family member to the United States increases the chances of obesity in urban teen boys. However, urban girls are less likely to become obese when a household member migrates. The difference in the change in obesity status for boys versus girls after migration is a surprising finding. The regressions investigating causal pathways offer some clues as to why this difference might occur.

Both changes in food expenditure and children's time use induced by migration are investigated to identify causal pathways to obesity. Results suggest changes in activity levels for girls after migration change their weight outcomes. Girls increase their housework hours after a female migrates, and to a lesser extent after a male migrates, since adult females enter the wage labor force. Boys, on the other hand, reduce their leisure hours but do not have the same increase in work hours. Boys may, although this is not measured in the survey, increase their time "relaxing" or socializing leading to more sedentary behavior. These activity changes along with some changes in the household food expenditures tell at least a partial story of why we see differential obesity outcomes for boys and girls after migration. If over a quarter of the household food expenditure is going toward soda, processed food, bakery, and sugar items, as it is for these households, one could surmise that relative changes

Table 15
Urban adult female time allocation

	Adult female housework			Adult female wage labor		
Variables	(1)	(2)	(3)	(4)	(5)	(6)
Family member migrated	−0.377			0.487*		
	(0.293)			(0.292)		
Male family member migrated		−0.944*			1.266**	
		(0.559)			(0.569)	
Female family member migrated			−0.333			0.375
			(0.507)			(0.485)
Constant	0.652***	0.503**	0.705***	−0.275	−0.070	−0.346**
	(0.211)	(0.252)	(0.205)	(0.174)	(0.212)	(0.171)
Observations	3,915	3,915	3,915	3,915	3,915	3,915
R^2	−0.000	−0.081	0.014	−0.004	−0.146	0.017
Demographic controls	YES	YES	YES	YES	YES	YES
F-test of IVs	15.60	12.32	22.30	15.60	12.32	22.30
Prob > F	2.33e-05	0.000105	1.93e-06	2.33e-05	0.000105	1.93e-06

Note: Standard errors are clustered at the village level and state-level dummies are included. Column titles indicate type of activity by location. Results are from a 2SLS instrumental variable regression. Dependent variable is change in activities (0/1) for adult females between 2002 and 2005. Cragg-Donald F-test on excluded instruments is reported with associated P-value. Each regression includes demographic controls as well as a food price index, control for total household expenditure, number of disasters in the community between 2002 and 2005, and state-level fixed effects. Robust standard errors are in parentheses.
***$P < 0.01$, **$P < 0.05$, *$P < 0.1$.

Table 16
Urban adult male time allocation

	Adult male housework			Adult male wage labor		
Variables	(1)	(2)	(3)	(4)	(5)	(6)
Family member migrated	0.427***			−0.509**		
	(0.106)			(0.242)		
Male family member migrated		0.818**			−1.355**	
		(0.326)			(0.651)	
Female family member migrated			0.713***			−0.554
			(0.199)			(0.356)
Constant	0.028	0.168	0.081	0.579***	0.283	0.596***
	(0.082)	(0.152)	(0.095)	(0.109)	(0.231)	(0.116)
Observations	2,844	2,844	2,844	2,844	2,844	2,844
R^2	−0.166	−0.379	−0.149	0.000	−0.210	0.036
F-test of IVs	13.29	8.112	11.95	13.29	8.112	11.95
Prob > F	0.000221	0.00224	0.000376	0.000221	0.00224	0.000376

Note: Standard errors are clustered at the village level and state-level dummies are included. Column titles indicate type of activity by location. Results are from a 2SLS instrumental variable regression. Dependent variable is change in activities (0/1) for adult males between 2002 and 2005. Cragg-Donald F-test on excluded instruments is reported with associated P-value. Each regression includes demographic controls as well as a food price index, control for total household expenditure, number of disasters in the community between 2002 and 2005, and state-level fixed effects. Robust standard errors are in parentheses.
***$P < 0.01$, **$P < 0.05$.

in activity levels could result in important changes in obesity outcomes.

These findings are generally consistent with the theory presented in Section 2. When migration occurs, households likely increase their unearned income through remittances, and more leisure is consumed. The increase in girls' work at home suggests that intrahousehold labor substitution after migration likely leads urban girls to increase their caloric expenditure through strenuous work. This finding is consistent with previous studies that have documented the change in labor allocation after migration (Acosta, 2011; Amuedo-Dorantes and Pozo, 2006; Funkhouser, 1992; Hanson, 2007; Rodriguez and Tiongson, 2001). Further, these results are also weakly consistent with Popkin (1999) and Asfaw's (2011) findings that a nutritional transition is occurring and that migration may be encouraging this transition to happen faster than it otherwise would have. This article brings these two strands of literature together and suggests that the migration-induced labor reallocation and nutrition changes are having deleterious health effects especially for boys and girls in urban areas.

Policies and programs to reduce obesity have been met with limited success in the United States, and this is likely to be the case in Mexico as well. However, given the importance of migration in the Mexican context and how migration affects the obesity status of boys, policies to actively fight obesity need to be considered. Specifically, reaching out to teen boys to provide safe places to engage in physical activity seems to be an important first step. One could imagine using a consequence of migration, remittances, to build infrastructure and programs that might stave off rising obesity in migrant households. In this way, migration may, on net, decrease obesity outcomes if more opportunities for a healthier lifestyle are provided with migrant remittances. Mexico has a well-established mechanism to invest remittances into community public goods. Using these funds to reduce an obesogenic environment could effectively reduce obesity outcomes in high migration communities, especially since this study suggests that teen boys in migrant households are at a greater risk of becoming obese than those from nonmigrant households.

In sum, the rising obesity rates in developing countries are only just beginning to be understood. This study provides some evidence toward contributing factors. These findings can help identify some of the causal pathways to childhood obesity and hopefully contribute to informed policy formulation aimed at stemming the tide of rising obesity rates in Mexico and identifying individuals who may become vulnerable to weight gain given a change in household composition resulting from migration.

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