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Changes in health selection of obesity among Mexican immigrants: A binational examination

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ABSTRACT

Health selection is often measured by comparing the health of more recent immigrants to the native born of their new host country. However, this comparison fails to take into account two important factors: (1) that changes in the health profile of sending countries may impact the health of immigrants over time, and (2) that the best comparison group for health selection would be people who remain in the country of origin. Obesity represents an important health outcome that may be best understood by taking into account these two factors. Using nationally-representative datasets from Mexico and the US, we examined differences in obesity-related health selection, by gender, in 2000 and 2012. We calculated prevalence ratios from log-binomial models to compare the risk of obesity among recent immigrants to the US to Mexican nationals with varying likelihood of migration, in order to determine changes in health selection over time. Among men in 2000, we found little difference in obesity status between recent immigrants to the US and Mexican non-migrants. However, in 2012, Mexican men who were the least likely to migrate had higher obesity prevalence than recent immigrants, which may reflect emerging health selection. The trends for women, however, indicated differences in obesity status between recent Mexican immigrants and non-migrants at both time points. In both 2000 and 2012, Mexican national women had significantly higher obesity prevalence than recent immigrant women, with the biggest difference between recent immigrants and Mexican women who were least likely to migrate. There was also indication that selection increased with time for women, as the differences between Mexican nationals and recent immigrants to the US grew from 2000 to 2012. Our study is among the first to use a binational dataset to examine the impact of health selectivity, over time, on obesity.

1. Introduction

When compared to people born in the United States (US), immigrants routinely exhibit better health across a variety of measures, including body weight, hypertension, heart disease, and mortality (Antecol and Bedard, 2006; Jasso et al., 2004; Singh and Miller, 2004). This "healthy migrant effect" is largely attributed to health selection. Healthier individuals are more likely to migrate because they have fewer physical restrictions and stand to benefit the most economically from migration. Yet migrants are also coming from countries that are undergoing unprecedented changes in population health. Macro-level trends in nutrition, globalization, and urbanization have contributed to drastic shifts in the country-level health profiles of non-communicable disease (NCD) risk in just a matter of decades (Hawkes, 2006; Leeder et al., 2003; Leon, 2008; Popkin, 1999). A prime example of this is obesity. In 1980, the prevalence of obesity worldwide was 4.8% for men and 7.9% for women; these figures nearly doubled by 2008, to 9.8% for men and 13.9% for women. These trends were mirrored in Latin America and Asia, two important sending regions for US immigrants (Finucane et al., 2011).

It is unclear what impact changing health conditions in sending countries should have on the comparative health advantage migrants display relative to their non-migrating peers. Labor-market based migration theories suggest that health

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selection may increase as the health of the sending country declines because migrants remain positively selected on health while their non-migrating counterparts become unhealthier. Jasso et al. (2004) characterized the decision to migrate as a function of costs related to individual skills, labor supply, and skill transferability. Given the associated costs, there is a minimal level of health that will make migration worthwhile. Not only is good health necessary for migration, individuals most likely to migrate may make behavioral choices that positively affect their future health because of the potential economic benefit from migration, differentiating them further from the non-migrating population (Kennedy et al., 2006). Population health trends also underpin country-level differences in productivity and skill transferability, which are key determinants of the magnitude of health selection. As applied to the example of obesity, the obesity differential between migrants and non-migrants (i.e., health selection) should increase as the obesity level of the sending country increases.

Other processes that instead emphasize the global integration of people and products across borders suggest alternative patterns for health selection. Globalization is a driving force behind the rise in NCD risk worldwide (Prentice, 2006). In the case of obesity, people who are most likely to migrate are also those who may have the most exposure to cross-national processes related to increased NCD risk. For example, individuals in active migrant networks are likely to receive remittances from abroad, which have been associated with higher consumption and correlated with higher rates of obesity for non-migrants. Creighton et al. (2011) found that Mexican children living in households with more migrant networks had an increased risk of weight gain. In this case, health selection should decrease, as we would anticipate immigrant sending communities and households would have a higher likelihood of obesity than their non-sending counterparts.

The current methods of assessing health selection have limited ability to consider such dynamic shifts in sending countries, however. The majority of the existing work has been conducted on US datasets in which health selection is indirectly assessed by comparing immigrants to the US-born. After controlling for socioeconomic and demographic characteristics, the residual protective effect of nativity is seen as evidence of health selection (Argeseanu Cunningham et al., 2008). To accurately assess health selection, however, a more appropriate comparison would be between migrants and non-migrants who stayed behind in the country of origin. Evidence for health selection would be more direct if migrants, on average, have better health status than their non-migrating counterparts. Other studies that have used these types of comparison groups have examined disability, self-rated health, and mental health, and found some support that migrants display more favorable health across certain outcome measures than individuals still residing in the home country (Breslau et al., 2011; Guendelman et al., 2013; Mehta and Elo, 2012).

Our study builds upon this emerging literature to examine health selection trends over time using a country of origin comparison group. Given the rapid increase in obesity globally in recent years, it can be a particularly illustrative health marker to gauge how changes in the health of sending countries impact differences in health status between US migrants and non-migrants in the sending country. Obesity also has important health implications that factor into migration-related selection. First, it is highly correlated with serious chronic diseases, such as diabetes (Stein and Colditz, 2004). Second, it can restrict opportunities in the receiving country through stigma and discrimination (Puhl and Heuer, 2010).

Comparing migrants to non-migrants requires additional consideration of who is likely to migrate in the sending countries. Migration is not only health-selective, but is patterned according to social and demographic features, such as gender, age, education, employment, and place of residence (Van Hook et al., 2012). By identifying the likelihood of migration, we can account for social and economic differences between migrants and their non-migrating counterparts, as well as other unmeasured constructs that can underlie both migration and health. This brings us closer to answering the counterfactual question of whether migrants would display similar health patterns had they not migrated.

The best comparison for health selection, then, is between migrants in a receiving country and non-migrating individuals in the respective sending country who vary by their migration likelihood. If there is very little health selection, there should also be little difference between recent migrants and non-migrating individuals across different likelihoods of migration. If migration becomes more health-selective, the differences between recent immigrants and non-migrants should follow a pattern whereby the smallest difference is between recent migrants in the receiving country and those with the highest migration likelihood in the sending country and the largest difference is between recent migrants and those with the lowest migration likelihood in the sending country.

1.1. Obesity trends in Mexico and health selection

This paper focuses on obesity among adults and the Mexican case. Given the importance of Mexican immigrants to the US, in terms of geographic proximity, the percentage of immigrants who are Mexican, and health inequities, understanding the changing Mexican context is of particular importance. Mexico has seen drastic increases in obesity in recent years. By 2008, 32.8% of the Mexican population was obese, making it the most obese country among the world's most populous nations. Mexico's obesity prevalence now surpasses that of the US, which is 31.8% (UNFAO, 2013). Between 2000 and 2012, the prevalence of obesity increased from 28.2% to 37.4% for Mexican women, and from 18.6% to 26.9% for Mexican men (Barquera et al., 2013).

In general, studies that have compared Mexican migrants to non-migrants have found migration to be associated with better health. Migrants are more likely to be taller (a proxy for early life health) (Crimmins et al., 2005), have better child self-assessed health (Ullmann et al., 2011), and fewer physical limitations (Bostean, 2013). Patterns for health selection in self-rated health and mental health are not as strong (Akresh and Frank, 2008; Bostean, 2013; Breslau et al., 2011).

Specific to obesity, there is currently little evidence that Mexican immigrants have different body weights than the general Mexican population, or that this pattern has changed over time. Guendelman et al. (2013) found no difference in obesity status between Mexican women and Mexican immigrant women in the US. Rubalcava et al. (2008) utilized prospective data and found no baseline differences in overweight between Mexicans who migrated at a later time point and those who did not. Van Hook et al. (2012) differentiated across the Mexican population by migration likelihood and found that children with the highest propensity of having parents who migrate actually displayed lower obesity prevalence than children of US immigrants. Yet all of these studies were limited in key ways: they compared migrants to non-migrants at one time point, did not differentiate among Mexican natives by migration likelihood, did not differentiate among Mexican immigrants by length of US residence, or only examined a specific population (i.e., children).

When considering changes in obesity-related health selectivity, Antecol and Bedard (2006) found the difference in obesity prevalence between the US-born and Latino immigrants who entered the US before 1980 to be slightly larger than the difference between the US-born and Latino immigrants who entered in 1991–1995. In contrast, Albrecht et al. (2013) found no significant changes in the difference in BMI or waist circumference between the US born and recently-arrived Mexican immigrants across three waves of nationally representative data spanning 20 years (1988–2008). Neither of these studies can make firm conclusions about selection patterns, however, as neither included a sample of Mexican nationals.

Our current study examines whether population-level changes in health, measured through obesity, are reflected in differences in obesity levels among Mexican immigrants compared to Mexican non-migrants at two time points, 2000 and 2012. We utilize nationally-representative datasets from Mexico and the US to compare the obesity status of recently-arrived Mexican immigrants to their non-migrating counterparts still in Mexico. In 2000, if health selection was occurring, we would expect that recent Mexican immigrants to the US would display a lower prevalence of obesity compared to Mexican nationals. Obesity levels should follow a pattern whereby those with the highest migration likelihood would have similar obesity levels as recent immigrants. As migration likelihood decreases, the difference from recent immigrants should grow larger, with the non-migrants with the lowest migration having the highest obesity levels. In 2012, if rising obesity in Mexico increases health selection, we would expect a larger gap in obesity levels between Mexican immigrants and their non-migrating counterparts than in 2000. On the other hand, if rising obesity in Mexico decreases health selection (due to the impact of global networks), we would expect more similar levels of obesity among Mexican immigrants and non-migrants in Mexico.

We also consider these patterns separately for men and women. The global obesity epidemic is largely fueled by environmental factors that can impact men and women differently (Popkin, 2002; Prentice, 2006). For example, women tend to be more sedentary, which can put them at increased risk for weight gain in light of country-level shifts to more energy dense-foods. There are also biologic differences in weight gain across sex, such as menopause and childbearing (Kanter and Caballero, 2012). In Mexico, women have been consistently heavier than men (Ford and Mokdad, 2008), suggesting that the obesity epidemic differs across gender. If Mexican women are more vulnerable to obesogenic environments, we should see more obvious changes in health selection between the two time points for women than men.

2. Methods

2.1. Data and sample

We utilized three datasets for our analyses: the 2000 Mexican National Health Survey (ENSA), the 2012 Mexican National Health and Nutrition Survey (ENSANUT), and the 1999/2000 and 2011/2012 waves of the US National Health Interview Surveys (NHIS).

The ENSA is a nationally-representative, cross-sectional, household survey conducted from September 1999 to March 2000 (Olaiz et al., 2003; Valdespino et al., 2003). A total of 45,870 Mexican households were interviewed, with a total of 45,269 individual questionnaires completed for adults ages 20 and older.

The ENSANUT is a nationally representative, cross-sectional, household survey conducted between October 2011 and May 2012 (Gutierrez et al., 2012). A total of 50,528 households were sampled and 50,596 individual surveys were completed for adults ages 20 and older. A subset of the sample had anthropomorphic measurements taken, including measured height and weight.

The NHIS is a nationally-representative US survey of households conducted annually by the National Center for Health Statistics. Each year, between 35,000 and 40,000 households are sampled (NCHS, 2012). To ensure that we had a sizeable immigrant sample, we combined two NHIS waves to correspond to the ENSA and ENSANUT years (i.e., 1999–2000 and 2011–2012). We only included respondents who indicated they were Mexican or Mexican-American. All NHIS waves were downloaded from the Integrated Health Interview Series (IHIS) (MPC, 2012).

For all datasets, our sample was limited to people of working age (20–64 years old), as health selection may operate differently at older ages (Jasso et al., 2004). We excluded respondents whose body mass index (BMI) was missing or was under 6.6 or over 85.78, to correspond to the valid BMI range of the NHIS respondents. These represented 4.4%, 4.4%, 4.7%, and 0.1% of the initial 1999/2000 NHIS, 2011/2012 NHIS, ENSA and ENSANUT samples, respectively. In the NHIS, respondents with missing BMI data were more likely to be female, unemployed and lower educated. Respondents with missing data in the ENSA were more likely to be male, younger, unmarried, unemployed and higher educated.

We also excluded individuals in the ENSA who were missing migration likelihood values (detailed below). This represented an additional 1% of the ENSA sample size after the BMI missing cases were removed. There were no additional missing cases in the ENSANUT. Finally, we excluded pregnant women. Our final sample size was 5073 for the 1999/2000 NHIS, 5733 for the 2011/2012 NHIS, 36,777 for the ENSA and 32,813 for the ENSANUT.

We utilized the person weights for each respective dataset and accounted for clustering with robust standard errors. For the NHIS, we adjusted the person weights to reflect the combined waves.

2.2. Variables

2.2.1. Obesity

We calculated BMI using the standard formula (weight in kilograms/height in m^2). Obesity was a dichotomous variable that indicated a BMI of 30 kg/m^2 or higher. In the ENSA and ENSANUT, height and weight were measured by study staff. In contrast, height and weight were self-reported in the NHIS. To adjust for the potential self-reporting bias in the NHIS, we estimated correction factors from the National Health Examination and Nutrition Survey (NHANES), as the latter survey contains both self-reported and measured BMI (Gorber et al., 2008). We utilized this adjusted BMI to calculate obesity in our analyses.

2.2.2. Migration status

Respondents were identified as being (1) US-born Mexicans, (2) Mexican immigrants to the US with more than 10 years of residence, (3) Mexican immigrants to the US with less than 10 years of residence, or (4) non-migrants still residing in Mexico with five levels of migration likelihood (very high, high, medium, low, very low).

The US-born Mexicans and immigrants were from the NHIS. We used the country of birth variable and number of years spent in the US variable to code people into their respective migration statuses. Non-migrants were from the ENSA and ENSANUT. We divided them into quintiles based on their likelihood to migrate (detailed below).

2.2.3. Covariates

We included age, marital status (married or in union versus all others), education (less than primary, primary, secondary, university completed), and employed (yes/no) as covariates in our regression models.

2.3. Migration likelihood

We divided Mexican respondents in the ENSA and ENSANUT into quintiles based on their likelihood of migrating. These datasets do not contain migration information, so we estimated migration likelihood using data from the 2000 Mexican Census for the ENSA and the 2010 Mexican Census for the ENSANUT. Both waves of the Mexican Census were downloaded from the Integrated Public Use Microdata Series (IPUMS) International (MPC, 2014).

The Mexican Census contains information on household international migration in the past five years. If respondents answered yes to whether someone in their household had gone to live in another country in the past five years, they were additionally asked to identify the destination country. We coded for household migration if respondents answered yes to the question and identified the US as the destination country.

This household migration variable has previously been used to approximate migration propensity in other studies (Buttenheim et al., 2010). While the Mexican Census does measure individual migration, this variable actually captures return migration, as the respondent must have migrated and returned by the time the census was administered. Return migration is a unique process that has its own health and economic predictors (Abraído-Lanza et al., 1999). We determined that household migration is highly correlated with individual migration by estimating the likelihood of migration given household migration utilizing the Mexican Family Life Survey, a longitudinal and nationally-representative dataset collected in Mexico in 2002 and again in 2005 (Rubalcava and Teruel, 2006). We found that residing in a household with someone who had previously migrated to the US at Wave 1 was highly predictive of US migration at Wave 2 (results available upon request).

In each Mexican Census dataset, we regressed household migration on age, age squared, gender, marital status, education, employment, state-level GDP, municipio-level migration rate, and urbanicity. These covariates have been associated with migration in previous studies (Massey and Espinosa, 1997; Van Hook et al., 2012). We used a logistic regression model with robust standard errors (Appendix Table A1).

We took the coefficients and error terms for the resulting regression equation and used them to calculate the log-odds of migration for respondents in the ENSA and ENSANUT. We created quintiles of predicted migration status within the ENSA and ENSANUT based on the weighted samples (Appendix Tables A2 and A3).

2.4. Analysis

We began with a bivariate analysis of obesity prevalence and migration likelihood (ENSA and ENSANUT) and migration status (NHIS) separately for each dataset. We then combined the 1999/2000 NHIS waves with the ENSA (hereafter, the 2000 wave) and the 2011/2012 NHIS with the ENSANUT (hereafter, the 2012 wave) and conducted a series of log-binomial regression models in the two combined datasets. We used the Poisson family and log link with robust standard errors, with Taylor series linearization for variance estimation. The models adjusted for age, marital status, education and employment.

We then combined all datasets and conducted two log-binomial regression models. The first had migration status, covariates, and an indicator variable for period (2000 versus 2012), the second model added interaction terms between migration status and period. We conducted an *F*-test with seven degrees of freedom to test the significance of the joint interaction in the second model. We also graphed the predicted probabilities for obesity by period to display the interaction. Finally, we conducted post-hoc contrast tests to examine whether the predicted prevalence of obesity was significantly different across the different migration likelihood categories and survey years. All analyses were stratified by gender. All analyses also included person weights for the respective surveys to account for the weighted designs.

3. Results

3.1. Sample characteristics

The US-born Mexican and immigrant Mexican respondents in the NHIS (hereafter, US Mexicans) were similar in age to their Mexican national counterparts in the ENSA and ENSANUT (Table 1). US Mexicans had higher secondary educational levels and higher levels of employment than Mexican nationals. In 2000, 43.9% of US Mexicans had completed secondary education, while only 19.5% of Mexican nationals had the same level of education; in 2012, 51.9% of US Mexicans had a secondary degree compared to 21.2% of Mexican nationals. Over 70% of US Mexicans were employed in 2000 and 2012, compared to 54.1% and 59.2% of Mexican nationals, respectively.

Table 1
Selected characteristics of survey participants from 2000 Mexican ENSA, 2012 Mexican ENSANUT and 1999–2000 and 2011–2012 US NHIS.

Unweighted *N*'s (weighted percents)	ENSA 2000	NHIS 1999–2000	ENSANUT 2012	NHIS 2011–2012
N[a]	36,777	5073	32,813	5733
Age; weighted mean (SD)	35.9 (11.9)	36.4 (11.5)	38.5 (12.3)	37.7 (11.8)
% Male sex	48.3	52.9	47.1	54.5
% Marital status				
Married or in a union	72.5	70.7	69.8	66.8
All others	27.5	29.3	30.2	233.2
% Education				
<Primary	6.8	10.7	4.9	6.3
Primary completed	63.7	39.1	59.1	32.3
Secondary completed	19.5	43.9	21.2	51.9
University completed	10.0	6.3	14.8	9.5
% Employed				
Yes	54.1	74.3	59.2	70.7
No	45.9	25.7	40.8	29.3
% Urbanicity[b]				
Urban	62.9		79.0	
Rural	37.1		21.0	
% Migration likelihood among Mexican nationals (*n*)				
Very low	19.8 (8845)		20.0 (7389)	
Low	19.9 (4270)		19.9 (3645)	
Medium	20.0 (5508)		20.0 (5326)	
High	20.1 (8118)		20.0 (7125)	
Very high	20.2 (10,036)		20.0 (9298)	
% Nativity and duration (*n*)				
US-born Mexican		44.7 (2307)		44.2 (2484)
Foreign-born Mexican recent (<10 years)		20.1 (867)		9.9 (560)
Foreign-born Mexico long-term (≥10 years)		35.3 (1722)		45.9 (2646)

[a] *n* is only valid person weights (not zero, not missing), valid BMI, valid migration probabilities.
[b] Urban defined as ≥15,000 for ENSA 2000 and ≥2500 for ENSANUT 2012.

Table 2
Prevalence of obesity among Mexican nationals with varying likelihood of migration, Foreign-born Mexicans in the US, and US-born Mexicans, 2000 and 2012.

	Obesity (weighted prevalence, SE)		
	All	Men	Women
2000			
All Mexican nationals	23.87 (0.003)	18.94 (0.01)	28.49 (0.004)
Mexican nationals by migration likelihood			
Very low	21.93 (0.01)	19.48 (0.01)	26.65 (0.01)
Low	21.50 (0.01)	16.92 (0.01)	26.74 (0.01)
Medium	25.93 (0.01)	20.81 (0.01)	29.40 (0.01)
High	24.63 (0.01)	19.22 (0.01)	28.72 (0.01)
Very high	25.33 (0.01)	18.55 (0.01)	29.72 (0.01)
All Mexicans in US	29.35 (0.01)	29.58 (0.01)	29.10 (0.01)
Foreign-born Mexicans in the US			
<10 years in US	18.03 (0.02)	17.25 (0.02)	18.92 (0.02)
≥10 years in the US	28.02 (0.01)	27.93 (0.02)	28.16 (0.02)
US-born Mexicans	36.36 (0.01)	38.38 (0.02)	34.41 (0.02)
2012			
All Mexican nationals	33.16 (0.004)	27.91 (0.01)	37.82 (0.01)
Mexican nationals by migration likelihood			
Very low	37.40 (0.01)	33.37 (0.01)	44.34 (0.01)
Low	33.11 (0.01)	27.25 (0.02)	37.63 (0.02)
Medium	32.36 (0.01)	25.66 (0.01)	38.10 (0.01)
High	32.41 (0.01)	27.13 (0.01)	36.33 (0.01)
Very high	30.50 (0.01)	23.36 (0.01)	35.20 (0.01)
All Mexicans in US	37.81 (0.01)	38.13 (0.01)	37.43 (0.01)
Foreign-born Mexicans in the US			
<10 years in US	23.87 (0.02)	23.79 (0.03)	23.97 (0.03)
≥10 years in the US	36.45 (0.01)	36.46 (0.02)	36.45 (0.02)
US-born Mexicans	42.44 (0.01)	43.38 (0.02)	41.34 (0.02)

In the US samples, more than 40% of study participants were US-born. Recent immigrants made up a greater proportion of US Mexicans in 2000 than in 2012; 20.1% in 2000 compared to 9.9% in 2012.

3.1.1. Bivariate obesity trends

Table 2 displays the weighted obesity prevalence by migration status and gender. Looking first at the 2000 trends, all US Mexicans (both US-born and immigrants) had higher prevalence of obesity than Mexican nationals (29.4% versus 23.9%). The group with the highest obesity prevalence was US-born Mexicans (36.4%). Mexican national men had much lower prevalence of obesity than all US Mexicans (18.9% versus 29.6%), although there was little difference between the two populations for women. In Mexico, women were considerably more obese than men (28.5% compared to 18.9%). In 2012, the trends were the same across countries and gender. However, the prevalence of obesity increased among all groups.

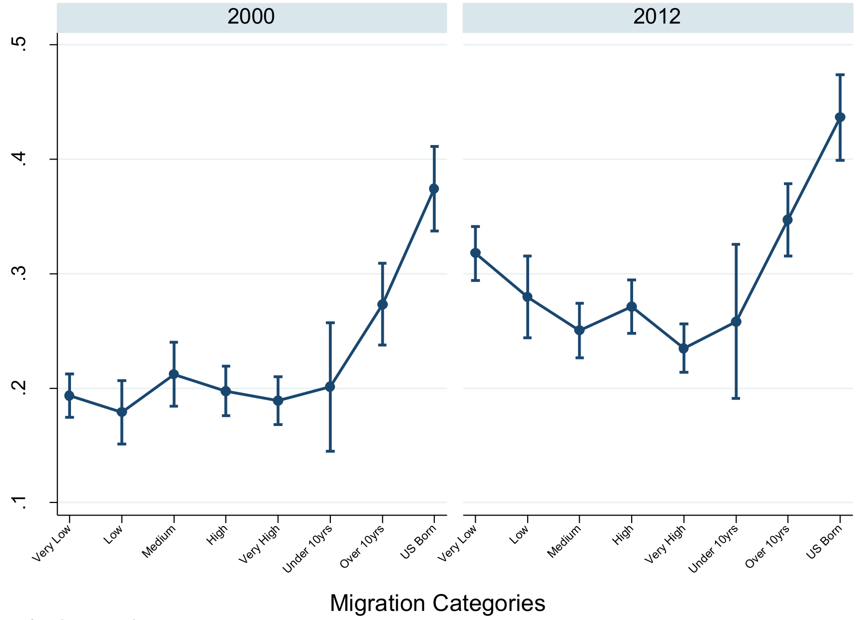
In 2000, recent Mexican immigrants (under 10 years US residence) had lower obesity prevalence than Mexican nationals with the highest likelihood of migration. This was more obvious among women (18.9% versus 29.7%), with a smaller difference among men (17.3% versus 18.6%). In 2012, the prevalence of obesity increased for all populations. Among women, recent Mexican immigrants in the US still had lower prevalence of obesity than Mexican nationals with the highest likelihood of migration (24.0% versus 35.2%). Among men, however, recent Mexican immigrants had very similar obesity levels compared to Mexican nationals with the highest migration likelihood (23.8% versus 23.4%).

3.1.2. Multivariable obesity trends

Table 3 provides the results of the multivariable analyses in the combined NHIS and ENSA/ENSANUT samples for men. The reference group was recent Mexican immigrants with less than 10 years of US residence. Mexican nationals with the highest likelihood of migration had lower obesity than recent immigrants in both 2000 and 2012, but these differences were not statistically significant (PR = 0.86, 95% CI 0.64–1.17 in 2000; PR = 0.93, 95% CI 0.71–1.23 in 2012). In 2000, Mexican nationals with very low and low likelihoods of migration had lower risk for obesity than recent

Table 3
Prevalence ratio (PR) of migration likelihood and US migration status associated with higher obesity for men, 2000 and 2012.

	2000			2012			Combined years					
	Adjusted for age, marital status, education, employment			Adjusted for age, marital status, education, employment			Adjusted for age, marital status, education, employment, year			Adjusted for age, marital status, education, employment, year interaction of year and each migration category (p-value)		
	PR	(95% CI)		PR	(95% CI)		PR	(95% CI)		PR	(95% CI)	
Mexican nationals – Very low likelihood of migration	0.89	0.66	1.19	1.28	0.97	1.68	1.13	0.92	1.38	0.96	0.72	1.29
Mexican nationals – Low likelihood	0.84	0.61	1.16	1.11	0.83	1.49	1.00	0.81	1.24	0.89	0.65	1.22
Mexican nationals – Medium likelihood	0.96	0.71	1.32	1.00	0.76	1.33	0.99	0.80	1.21	1.05	0.77	1.44
Mexican nationals – High likelihood	0.91	0.67	1.23	1.08	0.82	1.42	1.02	0.83	1.25	0.98	0.73	1.32
Mexican nationals – Very high likelihood	0.86	0.64	1.17	0.93	0.71	1.23	0.91	0.74	1.12	0.94	0.70	1.27
Foreign-born Mexicans with <10 years in US	Ref.			Ref.			Ref.			Ref.		
Foreign-born Mexicans with ≥10 years in the US	1.22	0.90	1.66	1.40	1.06	1.85	1.33	1.08	1.63	1.36	1.00	1.85
US-born Mexicans	1.65	1.23	2.23	1.75	1.33	2.31	1.73	1.41	2.11	1.86	1.38	2.50
2012 Wave (Baseline 2000)							1.36	1.29	1.44	1.28	0.88	1.88
Mexican nationals – Very low * 2012										1.28	0.86	1.91
Mexican nationals – Low * 2012										1.22	0.79	1.87
Mexican nationals – Medium * 2012										0.92	0.61	1.39
Mexican nationals – High * 2012										1.07	0.71	1.60
Mexican nationals – Very high * 2012										0.97	0.64	1.45
Foreign-born Mexicans with <10 years in US * 2012										Ref.		
Foreign-born Mexicans with ≥10 years * 2012										0.99	0.66	1.49
US-born Mexicans * 2012										0.91	0.61	1.36
Joint test of interaction										$p = 0.03$		



p for interaction = 0.03

Fig. 1. Predicted prevalence of obesity by Mexican migration likelihood and US migration status for men, 2000 and 2012.

immigrants (PR = 0.89, 95% CI 0.66–1.19 and PR 0.84, 95% CI 0.61–1.16, respectively). In 2012, this pattern reversed: Mexicans with the lowest likelihood of migration had higher obesity risk than recent Mexican immigrants (PR = 1.28, 95% CI 0.97–1.78) and the risk for obesity decreased with increasing migration likelihood.

US-born Mexican men consistently had higher obesity risk compared to recent immigrants across both time points (PR = 1.65, 95% CI 1.23–2.23 for 2000; PR = 1.75, 95% CI 1.33–2.31 for 2012). In 2000, there was no statistically significant difference between the recent and longer-term Mexican immigrants, but in 2012 the longer-term immigrants had higher prevalence of obesity compared to the recent immigrants (PR = 1.40, 95% CI 1.06–1.85).

In the models with both waves combined, respondents from 2012 had higher obesity risk than those from 2000, indicating the rising obesity trend with time (PR = 1.36, 95% CI 1.29–1.44). The joint test for interaction for year and migration categories was significant ($p = 0.03$), suggesting that there was some difference in the distribution of obesity across the different migration categories—and thus, health selection—between the two time points. Fig. 1 displays the predicted probability of obesity according to migration categories resulting from the interaction model. Between 2000 and 2012, the groups with lower migration likelihood experienced the largest increases in obesity, driving the stronger negative relationship between obesity and migration likelihood (i.e., lower migration likelihood, higher obesity) at the later time point. Post-hoc contrast tests confirmed that there were no differences across the non-migrants in 2000. In 2012, however, the predicted prevalence of obesity for the very high migration likelihood category was significantly lower than all other migration groups except the medium likelihood group (results available upon request).

Table 4 provides the same results for women. In 2000, Mexican women with the highest likelihood of migration had higher obesity than recent immigrants, but this difference was not statistically significant. Differences were more pronounced among Mexican women with very low, low, and medium likelihood of migration, who all had significantly higher obesity than recent Mexican immigrants (PR = 1.28, 95% CI 1.02–1.59; PR = 1.34, 95% CI 1.07–1.68; PR = 1.33, 95% CI 1.07–1.66, respectively). In 2012, the differences between these groups and recent immigrants became larger. All Mexican non-migrants had significantly higher obesity than recent immigrants. The differences followed a pattern whereby those with the lowest likelihood of migration had the highest prevalence of obesity relative to recent immigrants, and the prevalence decreased as migration likelihood increased.

As with men, US-born Mexican women had higher obesity compared to recent immigrants in both years (PR = 1.65, 95% CI 1.30–2.08 for 2000; PR = 1.76, 95% CI 1.35–2.29 for 2012). In 2000, there was no statistically significant difference between the recent and longer-term Mexican immigrants, but in 2012 the longer-term immigrants had higher obesity risk compared to the recent immigrants (PR = 1.32, 95% CI 1.01–1.72).

In the combined sample, we saw significantly higher obesity risk in 2012 than in 2000, mirroring the rising obesity trend (PR = 1.28, 95% CI 1.24–1.33). In the final model, the interaction between migration status and period was significant ($p < 0.0001$), suggesting that health selection patterns were different between the two time points. Fig. 2 illustrates the results. Like men, the groups with the lowest migration likelihood saw the biggest jump in obesity among Mexican nationals, and the negative relationship between migration likelihood and obesity prevalence was clearer in 2012 than in 2000. The post-hoc contrast tests indicated that in 2000, the very high migration likelihood group had significantly lower predicted obesity prevalence than the medium likelihood group. In 2012, the very high migration likelihood group had significantly lower predicted obesity prevalence than the very low, low and medium likelihood groups (results available upon request).

Table 4
Prevalence ratio (PR) of migration likelihood and US migration status associated with higher obesity for women, 2000 and 2012.

	2000			2012			Combined years					
	Adjusted for age, marital status, education, employment			Adjusted for age, marital status, education, employment			Adjusted for age, marital status, education, employment, year			Adjusted for age, marital status, education, employment, year interaction of year and each migration category (*p*-value)		
	PR	(95% CI)		PR	(95% CI)		PR	(95% CI)		PR	(95% CI)	
Mexican nationals – Very low likelihood of migration	1.28	1.02	1.59	1.73	1.33	2.23	1.56	1.32	1.85	1.32	1.06	1.65
Mexican nationals – Low likelihood	1.34	1.07	1.68	1.45	1.11	1.88	1.40	1.17	1.66	1.37	1.09	1.73
Mexican nationals – Medium likelihood	1.33	1.07	1.66	1.41	1.09	1.83	1.38	1.16	1.63	1.39	1.11	1.74
Mexican nationals – High likelihood	1.19	0.96	1.48	1.36	1.05	1.76	1.31	1.10	1.55	1.27	1.02	1.59
Mexican nationals – Very high likelihood	1.18	0.95	1.46	1.29	1.00	1.66	1.26	1.06	1.49	1.27	1.02	1.58
Foreign-born Mexicans with <10 years in US	Ref.			Ref.			Ref.			Ref.		
Foreign-born Mexicans with ≥10 years in the US	1.16	0.91	1.48	1.32	1.01	1.72	1.26	1.05	1.51	1.23	0.96	1.57
US-born Mexicans	1.65	1.30	2.08	1.76	1.35	2.29	1.72	1.44	2.05	1.69	1.34	2.14
2012 Wave (Baseline 2000)							1.28	1.24	1.33	1.22	0.88	1.70
Mexican nationals – Very low * 2012										1.29	0.92	1.81
Mexican nationals – Low * 2012										1.04	0.73	1.47
Mexican nationals – Medium * 2012										0.99	0.71	1.40
Mexican nationals – High * 2012										1.05	0.75	1.48
Mexican nationals – Very high * 2012										1.00	0.71	1.39
Foreign-born Mexicans with <10 years in US * 2012										Ref.		
Foreign-born Mexicans with ≥10 years * 2012										1.05	0.73	1.51
US-born Mexicans * 2012										1.04	0.73	1.47
Joint test of interaction										$p < 0.0001$		

3.2. Sensitivity analyses

We re-ran our analysis using area-level migration to verify the appropriateness of the household migration variable to approximate migration likelihood. In the ENSA and ENSANUT, we categorized respondents into quintiles based on municipio-level (i.e., county-level) household migration. Individuals with the highest migration likelihood were thus living in municipios that were in the top 20% of household migration. This strategy was employed by Buttenheim and colleagues (2010) to estimate migration likelihood. This analysis produced similar results as the original analysis.

We also reduced the cutoff for recent and longer-term immigrants to be over and under 5 years. The results are in the same directions as the original analysis with the 10-year cutoff. We maintained the 10-year cutoff for our main analysis because the small sample sizes for immigrants under 5 years make these

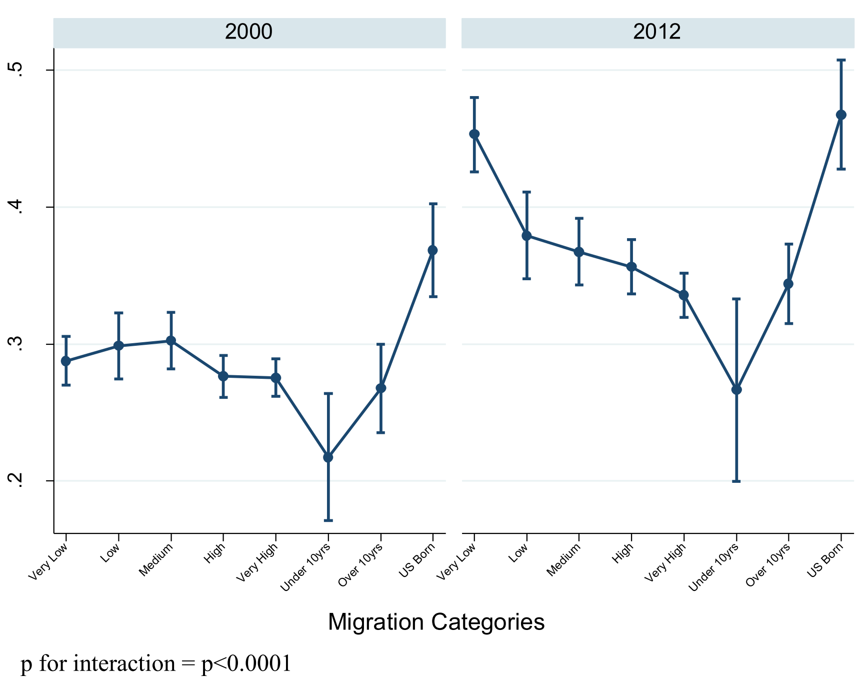


Fig. 2. Predicted prevalence of obesity by Mexican migration likelihood and US migration status for women, 2000 and 2012.

estimates less stable. We also reran our analysis using fixed ranges for the migration likelihood categories (very high, high, medium, low, very low) across the two time points. The categories in our original analysis represented the quintiles for predicted migration in 2000 and 2012, and thus the range for each category differed across the two waves. We created alternative categories for migration likelihood by taking the midpoint of the ranges for each category between 2000 and 2012. Again, results were qualitatively the same as the original analysis. Finally, we used BMI as our outcome measure and found similar results to those presented here for obesity. All results for the various sensitivity analyses are available upon request.

4. Discussion

This paper investigated whether health selection among immigrants to the US was impacted by changing health circumstances in Mexico, the country of origin. We compared the obesity prevalence of recent Mexican immigrants to the US with Mexican nationals who had varying migration likelihood at 2000 and 2012. There was little evidence that Mexican immigrant men were selected on obesity in 2000. By 2012, however, there were emerging differences between immigrant and non-migrant men. Specifically, Mexican men who were the least likely to migrate had significantly higher obesity prevalence than recent immigrants. For women, however, there was a clear trend in health selection at both time points. In both 2000 and 2012, Mexican national women had significantly higher obesity prevalence than recent immigrant women. There was also indication that women were more positively selected on obesity over time as recent Mexican immigrants had lower obesity risk compared to Mexican nationals in 2012 than in 2000.

Our paper adds to the existing literature on health selection in Mexico in several ways. First, we compared Mexican immigrants to non-migrants still residing in Mexico, which is an arguably better comparison to examine health selection. The bulk of other research on Mexican and Hispanic immigrants and obesity-related health selection has compared immigrants to the US born (Albrecht et al., 2013; Antecol and Bedard, 2006; Sanchez-Vaznaugh et al., 2008). Among the emerging literature that has utilized a non-migrant sample to examine health selection, our results add to the growing evidence that Mexican immigrants are positively selected on physical health features, such as early child health and physical limitations (Bostean, 2013; Crimmins et al., 2005; Ullmann et al., 2011).

Our study also suggests the health differential between migrants and non-migrants is sensitive to changes in the health environment of the sending country. Our findings are distinct from other studies that did not find body weight differences between Mexican migrants and non-migrants (Guendelman et al., 2013; Rubalcava et al., 2008). These studies, however, used data from the first part of the 2000s. If we had only examined the 2000 data, we may have also concluded that health selection in obesity was weak, especially for men. A single time point does not provide insight into the role of dynamic health trends in the country of origin.

Our results imply that health selection increased alongside the rising obesity rates in Mexico. Although all Mexican non-migrants had higher obesity prevalence in 2012 than in 2000, the differences between the recent immigrants to the US and Mexican non-migrants grew during this time period. This is contrary to what would have been expected if remittances and US exposure contributed to both higher rates of obesity as well as migration likelihood. Other research suggests that in regard to obesity, connection to global networks and the associated cultural exposure is distinct from migration processes. Creighton et al. (2011) found that children in communities with higher migration were less likely to become overweight or obese. In contrast, children were more likely to gain weight if they lived in communities with higher remittances. Our results seem to align better with labor market theories of migration and health selection, which propose a migrant health advantage as the health patterns of the sending country change.

It is possible that the results we see for higher obesity with lower likelihood of migration do not reflect migration status, per se, but the socioeconomic conditions that are correlated with migration status. In other words, migration likelihood could be a proxy for socioeconomic status (SES) such that those with a low migration likelihood have low SES and those with a high migration likelihood have high SES. If this were true, the results could merely be reflecting the social transition of obesity; as low- and middle-income countries become more urban and more developed, obesity becomes concentrated among people of lower SES (McLaren, 2007). We do not believe, however, that migration likelihood is an indicator of individual-level SES. First, we found that people with higher education levels were actually less likely to migrate than people with lower education levels at both time points. What is more, our migration prediction included many variables that are not necessarily individual-markers of SES (e.g., state-level GDP). Finally, if our results for migration likelihood and obesity were due to social patterning, we would expect the migration patterns to mirror the social patterning of obesity by education. We examined the relationship between education and obesity in the ENSA and ENSANUT datasets and found that the educational patterns of obesity differ from the migration likelihood patterns in key respects. For women, education was negatively associated with obesity. However, migration likelihood and obesity showed the opposite pattern: people with a higher likelihood of migration (i.e., those with lower education) had lower obesity than people with a lower likelihood of migration (i.e., those with higher education). The association between SES and obesity was more complex for men in the ENSA and ENSANUT data; there was a positive association between education and obesity in rural areas, but no association in urban areas. However, the relationship between education and obesity was very consistent between the two time points. If migration was indeed a proxy for SES, we would have expected similar consistency in the migration likelihood and obesity relationship across the two waves for men, but this was not the case.

An additional possibility is that our findings reflect the differences in obesity and migration patterns between people living in urban versus rural areas. The processes related to increases in obesity generally occur first in urban areas (Chaudhari et al., 2013; Popkin et al., 2012). We found that people living in urban areas were also less likely to migrate; therefore, the higher prevalence of obesity among those with the lowest likelihood of migration may be partly due to the higher obesity seen among people living in urban areas in Mexico. Other evidence, however, suggests that urban/rural differences may not wholly explain our findings, especially considering differences in health selection based on gender and urbanicity. Using data from the early 2000s, Rubalcava et al. (2008) found that rural men were more likely to migrate to the US if they had lower body weights, whereas urban men saw no relationship between weight status and migration. Weight status did not impact migration for rural or urban women. This suggests that we should have seen lower obesity prevalence among men with a higher likelihood of migration in 2000, as they were predominantly from rural areas, and few differences among women.

However, these patterns were not reflected in our data for 2000, leading us to conclude that our findings are not the product of urban/rural differences.

Finally, migration from Mexico declined substantially following the economic downturn in 2008 (Passel et al., 2012). Mexican immigrants in 2012 may represent a uniquely selected population in terms of migration circumstances as well as health. The migration predictors were similar in 2000 and 2012, however, suggesting that while there may have been fewer immigrants in 2012, they had similar demographic profiles to those in 2000. We ultimately cannot disentangle the effects of an exogenous economic event from rising country-level obesity in this dataset.

While our findings on health selection do not necessarily address post-migration health, there were interesting duration patterns across the two time points. We found no evidence of higher obesity among longer-term immigrants compared to recent immigrants in 2000. In 2012, however, longer-term immigrants showed higher obesity risk than recent immigrants. We would have expected smaller differences between recent and longer-term immigrants in 2012 because Mexico and the US had more comparable obesogenic environments at this later time point. Recent immigrants in 2012 should have already been exposed to similar Westernized diets and environmental obesity risks in Mexico as their longer-term immigrant counterparts in the US. If anything, our findings suggest that even though immigrants were more highly selected compared to their non-migrating Mexican counterparts in 2012, they were still heavier than at earlier times and seem to be getting more obese with longer US residence. We encourage additional research that explores why duration patterns change at different time points.

5. Conclusions

Our study is among the first to use a binational dataset to examine the impact of health selectivity, over time, on obesity. Mexican immigrant women were selected on obesity, and this selection increased as the Mexican obesity prevalence increased. Mexican men were not initially selected on obesity, but the increase in the Mexican obesity prevalence has started to influence health selection.

There were some limitations. First, we cannot infer causal relationships among migration, obesity, and selection using repeated cross-sectional data. Second, we could not directly ascertain individual migration status, and instead used a proxy measure of household migration. Yet our sensitivity analysis with the Mexican Family Life Study corroborated our assumption that household migration is strongly associated with individual migration, and we feel confident that we have captured migration likelihood appropriately. Third, although we statistically adjusted for the self-report of BMI in the NHIS, we acknowledge that the differences in measurement may limit comparability between the US-based migrants and non-migrants in Mexico. Finally, although we speak of health selection in general terms, our findings are specific to obesity and may not necessarily represent patterns related to other health markers, especially infectious diseases.

Our findings emphasize the importance of using an appropriate comparison group when studying health selectivity. We encourage future use of binational datasets to investigate other markers of health selectivity and migration between countries.

Appendix Tables

Table A1
Logged odds of Migrating, Mexican Census 2000 & 2010.

	2000 Census			2010 Census	
	Coef.	$P>\|z\|$		Coef.	$P>\|z\|$
Male	−0.15	0.00	Male	−0.10	0.00
Age	−0.04	0.00	Age	−0.04	0.00
Age squared	0.00	0.00	Age squared	0.00	0.00
Employed	−0.10	0.00	Employed	−0.04	0.00
Married	−0.29	0.00	Married	−0.08	0.00
Urban	−0.23	0.00	Urban	−0.36	0.00
Municipo-level household migration	8.43	0.00	Municipo-level household migration	11.25	0.00
Education			Education		
Primary completed	−0.08	0.00	Primary completed	−0.01	0.48
Secondary completed	−0.24	0.00	Secondary completed	−0.11	0.00
College completed	−0.31	0.00	College completed	−0.07	0.00
State GDP			State GDP		
Tlaxcala	−0.55	0.00	Colima	−0.02	0.56
Baja California Sur	−0.86	0.00	Baja California Sur	−0.59	0.00
Colima	0.04	0.34	Nayarit	0.07	0.05
Zacatecas	−0.20	0.00	Zacatecas	0.04	0.11
Campeche	−1.48	0.00	Aguascalientes	0.05	0.26
Aguascalientes	−0.10	0.00	Morelos	0.02	0.61
Durango	−0.19	0.00	Durango	0.02	0.73
Tabasco	−1.76	0.00	Yucatán	−0.82	0.00
Hidalgo	−0.31	0.00	Quintana Roo	−0.73	0.00
Morelos	−0.02	0.48	Guerrero	−0.07	0.01
Yucatán	−1.26	0.00	Hidalgo	−0.13	0.00
Quintana Roo	−1.23	0.00	Oaxaca	−0.23	0.00
Oaxaca	−0.45	0.00	Querétaro de Arteaga	−0.23	0.00
Chiapas	−1.56	0.00	San Luis Potosí	−0.05	0.09
Guerrero	−0.15	0.00	Chiapas	−0.66	0.00
San Luis Potosí	−0.17	0.00	Sinaloa	−0.48	0.00
Querétaro de Arteaga	−0.21	0.00	Michoacán de Ocampo	0.07	0.00
Sinaloa	−0.29	0.00	Sonora	−0.37	0.00
Michoacán de Ocampo	−0.08	0.00	Baja California	−0.50	0.00
Sonora	−0.81	0.00	Chihuahua	−0.13	0.00
Coahuila de Zaragoza	−0.44	0.00	Coahuila de Zaragoza	−0.38	0.00
Tamaulipas	−0.36	0.00	Tamaulipas	−0.32	0.00
Guanajuato	−0.09	0.00	Puebla	−0.03	0.33
Baja California	−0.48	0.00	Tabasco	−1.09	0.00
Puebla	−0.45	0.00	Guanajuato	−0.07	0.00
Veracruz-Llave	−0.54	0.00	Veracruz-Llave	−0.32	0.00
Chihuahua	−0.20	0.00	Campeche	−1.17	0.00
Jalisco	−0.04	0.10	Jalisco	0.01	0.81
Nuevo León	−0.45	0.00	Nuevo León	−0.69	0.00
México	−0.43	0.00	México	−0.43	0.00
Distrito Federal	−0.50	0.00	Distrito Federal	−0.40	0.00
Intercept	−2.13	0.00	Intercept	−2.47	0.00

Table A2
Range of migration likelihood by quartile, ENSA 2000 and ENSANUT 2012.

	2000 ENSA		2012 ENSANUT	
	Minimum	Maximum	Minimum	Maximum
Very low likelihood of migration	0.4%	2.3%	0.6%	1.8%
Low likelihood of migration	2.4%	3.1%	1.8%	2.2%
Medium likelihood of migration	3.1%	4.1%	2.2%	3.1%
High likelihood of migration	4.1%	6.5%	3.1%	4.4%
Very high likelihood of migration	6.5%	67.4%	4.4%	62.1%

Table A3
Descriptive characteristics by migration likelihood.

	Very low	Low	Med.	High	Very high	<10 years in the US	≥10 years in the US	US born	Very low	Low	Med.	High	Very high	<10 years in the US	≥10 years in the US	US born
	2000 All								**2012 All**							
Age	34	33	36	38	39	30	40	38	39	37	39	38	38	31	41	35
Education																
Less than Primary	5	2	6	9	13	15	18	2	3	3	4	5	9	7	12	1
Primary	49	56	70	69	75	56	48	23	48	56	57	63	71	51	33	15
Secondary	28	28	17	15	9	26	29	65	30	24	22	18	12	34	39	69
College	18	13	8	8	3	4	4	9	19	17	17	14	8	7	5	15
Mean BMI	27.2	26.8	27.2	27.3	27.2	26.6	28.1	28.9	29	28	28	28	28	27	29	30
Employed	71	59	48	49	44	67	76	77	74	60	59	55	48	71	71	71
Married	85	74	69	68	68	67	80	65	79	65	67	67	70	65	77	56
Male	66	53	40	43	39	53	57	49	63	44	46	43	40	57	54	54
	2000 Men								**2012 Men**							
Age	34	34	37	37	39	29	40	37	39	37	39	38	38	31	41	35
Education																
Less than Primary	2.7	2.2	5.4	6.4	11.3	13.6	19.25	2.2	3	3	4	4	8	6	12	1
Primary	48	57.7	68.1	70.9	73.9	60.05	47.09	23.1	49	58	55	65	73	53	43	17
Secondary	28	23.8	14.7	13.2	10	23.31	28.23	65.6	28	21	23	16	11	33	41	69
College	21	16.4	11.8	9.5	4.8	3.03	5.4	9.1	20	18	19	15	8	8	4	14
Mean BMI	27	26.3	26.7	26.6	26.3	26.9	28.3	29.2	29	27	28	28	27	28	29	30
Employed	94	86	83	82	82	90	92	83	90	78	84	81	81	89	85	75
Married	87	62	66	68	69	58	84	66	83	56	74	69	73	60	80	57
	2000 Women								**2012 Women**							
Age	34	32	35	38	39	31	40	37	38	38	39	38	38	34	41	36
Education																
Less than Primary	10	1	6	10	13	16	17	3	4	3	5	5	9	9	11	1
Primary	49	55	71	67	76	50	50	23	46	55	59	61	70	49	46	13
Secondary	28	34	18	17	9	30	30	65	34	26	21	20	12	35	38	70
College	13	10	5	6	2	4	3	10	16	16	15	14	8	7	5	16
Mean BMI	28	27	28	28	28	26	28	29	30	29	29	29	28	27	29	30
Employed	29	28	24	24	19	41	55	70	45	46	38	36	26	47	54	67
Married	82	87	71	67	67	77	75	65	74	72	61	66	69	72	74	55

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