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Do Mexican immigrants "import" social gradients in health behaviors to the US?

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Abstract

Greater educational attainment is consistently associated with lower mortality rates and better health behaviors in the US, a pattern known as the social gradient in health. However, recent research suggests that Mexican-origin adults in the US have weak or flat gradients, in contrast to steep gradients for non-Hispanic whites. In this study we evaluate one possible explanation for this finding: that the relative weakness of education gradients in health behaviors observed among Mexican-origin adults in the US is due to weak gradients in the sending population. We test this "imported gradients" hypothesis with data from two large nationally-representative datasets: the US National Health Interview Survey (NHIS) and the Mexican National Health Survey (ENSA 2000). We compare the education gradients in smoking and obesity for recently-arrived Mexican immigrants in the US to the corresponding gradients in high-migration regions of Mexico. Results partially support the imported gradients hypothesis and have implications for health education and promotion programs targeted to immigrant populations to reduce racial and ethnic disparities in health in the US.

Better social position, as measured by education, income, and occupational status, is generally associated with lower mortality risks and better health at all levels of the socioeconomic ladder. This "social gradient" in health has been found in a wide range of populations and for many health outcomes (Adler & Ostrove, 1999; Goldman, 2001; Marmot, Ryff, Bumpass, Shipley, & Marks, 1997). In the US and other developed countries, higher income and greater educational attainment are consistently associated with lower mortality rates and better health behaviors. The situation for the Latino population in the US, and for Mexican-origin adults in particular, is more complex, however. Using three distinct data sets, Goldman et al. (2006) demonstrated that education gradients in health outcomes and behaviors are relatively weak for Mexican-origin[1] adults in the US compared with the steep gradients observed for non-Hispanic whites.

Weak or flat social gradients in health would be socially desirable if all socioeconomic groups within a population experience good health and exhibit few unhealthy behaviors. However, if flat gradients occur at poor levels of health or for unhealthy behaviors, then the situation is more problematic. In this case, weak gradients would imply that the Mexican-origin population may face greater barriers than other ethnic groups in the US to improvement in health or health behaviors even as socioeconomic status improves—in effect, trapping Mexican-origin individuals at poorer levels of health. From a policy perspective, then, it is important to understand the origins of weak gradients.

In this study we investigate the hypothesis that these atypically flat gradients among Mexican-Americans are due, at least in part, to the "importation" of social gradients in health behaviors by immigrants from Mexico. There are two foundations for this hypothesis. First,

[1] In this paper, "Mexican-origin" refers to individuals who were born in Mexico as well as those born in the United States who identify themselves as Mexican in origin.

some health behaviors, such as smoking, overeating, and a sedentary lifestyle, require at least a minimum amount of disposable income or are associated with higher status occupations. Thus, in poor countries the well-off may be better able to smoke heavily or become obese. A recent study of smoking and obesity risk confirms this relationship in Mexico by showing that gradients in health behaviors are flat, or reversed, for some subgroups (Buttenheim, Wong, Goldman, & Pebley, forthcoming).

The second premise that underlies the imported gradients hypothesis is that many health behaviors, including smoking, diet, and exercise, are adopted early in life and tend to persist throughout adulthood (Janson, 1999; Kelder, Perry, Kleppe, & Lytle, 1994; Lantz, 2003; Mikkila, Rasanen, Raitakari, Pietinen, & Viikari, 2005). Thus, the imported gradients hypothesis suggests both that Mexican immigrants to the US have grown up in a setting in which obesity and smoking are at least as common among higher-status as compared with lower-status individuals, and that they bring the behaviors adopted early in life with them when they migrate.

In this study we use large, nationally-representative datasets from both Mexico and the US to test the imported gradients hypothesis and to extend the work of Goldman and colleagues in important ways. First, their finding of weak gradients for Mexican-Americans was based on two unrealistic assumptions: (1) that the gradients are the same for men and women; and (2) that the education-health relationship is linear. Here we analyze men and women separately and use a more flexible specification for education that allows for a non-linear relationship, as has been identified in both the US (Kimbro, Bzostek, Goldman, & Rodriguez, 2008) and in Mexico (Buttenheim et al., forthcoming). Second, we add to a small number of studies that use data from both Mexico and the United States to address health disparities in Hispanic populations (Crimmins, Soldo, Kim, & Alley, 2005; Wong, Ofstedal, Yount, & Agree, 2008). Unlike these previous cross-border studies, we focus on prime-age rather than older adults and incorporate explicit statistical tests of the equality of social gradients in Mexico and the US.

We focus our discussion of social gradients in health on two specific health-related behaviors, smoking and obesity[2], that are strongly correlated with chronic disease and that contribute significantly to the burden of disease and mortality in both Mexico and the US (Mokdad, Marks, Stroup, & Gerberding, 2004; Stevens et al., 2008). Urbanization, food and tobacco marketing, and income growth have produced rapid changes in dietary habits and tobacco use in Mexico (Franco-Marina, 2007; Popkin, 2001, 2006). These changes have a direct impact on the United Status: Because people of Mexican descent are the most rapidly-growing segment of the US population (Guzman, 2001), the social patterning of health behaviors generally, and smoking and obesity specifically, will have important implications for the burden of chronic disease in the US in coming decades.

Explaining a weak SES-health behavior relationship in the Mexican-origin population

Goldman and colleagues (2006) found smaller education differentials in health for Mexican-American adults compared to whites for a wide range of health behaviors and outcomes including smoking, heavy or binge drinking, overweight/obese status, work limitations, and depressive symptoms. The weak education-health associations were particularly evident for foreign-born compared to US-born Mexicans. Other studies have also found weaker social gradients in obesity (Chang & Lauderdale, 2005; Khan, Sobal, & Martorell, 1997; Martorell, Khan, Hughes, & Grummer-Strawn, 1998) and mortality (Turra & Goldman, 2007) for Mexican-Americans.

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[2] In this study we refer to obesity as a health behavior, although obesity is the result of a complex set of health behaviors (including diet and physical activity) and genetic endowments.

Goldman and colleagues proposed three hypotheses to explain weak gradients for the Mexican-origin population in the US. First, if Mexico-US migration is selective on good health, particularly among lower SES Mexicans, then this selection could attenuate the expected relationship between socioeconomic status and health among Mexicans in the US. While this "healthy migrant" hypothesis seems logical and is consistent with findings of mildly positive migrant selection on education (Chiquiar & Hanson, 2005; Crimmins et al., 2005; Feliciano, 2005), Rubalcava et al. (2008) find very weak evidence for health-related migration from Mexico to the US based on a national longitudinal study in Mexico.

Second, "acculturation" to the US social and economic climate (Lara, Gamboa, Kahramanian, Morales, & Bautista, 2005) or "segmented assimilation" of migrants into poorer segments of US society (Landale, Oropesa, Llanes, & Gorman, 1999) may have disproportionately negative effects on US-born Mexicans. These hypotheses suggest that either exposure to US society in general or exposure to particular segments of US society lead Mexican immigrants to adopt poorer health behaviors over time and across generations.

The third hypothesis, which is the central focus of this paper, suggests that immigrants "import" social gradients to the US from Mexico. Evidence from our recent study of social gradients in smoking and obesity among adults in Mexico (Buttenheim et al., forthcoming) shows that education gradients are weak but in the expected direction for male smoking and female obesity, flat for male obesity, and reversed for female smoking. If these patterns apply to Mexican immigrants in the US as well, they could account for the observed weak relationship between education and health behaviors among the Mexican-origin population in the US.

Why would SES-health behavior differentials in Mexico be weaker than in the US? As discussed above, weak or "reversed" gradients may result from the fact that both smoking and obesity may require a minimum level of income and/or occupational status. The shift in social gradients from "reversed" (i.e., higher smoking associated with higher socioeconomic status) or flat (i.e., smoking rates equal across all strata) to the standard gradients observed in developed countries (i.e., higher smoking associated with lower socioeconomic status) is likely to be part of the larger process of socioeconomic development and the health transition. For example, in the case of the tobacco epidemic, regular smoking may be initially affordable only to the elite and may be seen as a status symbol. In later stages of the epidemic, dissemination of information on the health consequences of smoking may encourage more educated individuals to avoid or quit smoking (Pampel, 2002). If gradients are observed at the midpoint of this transition, they will appear flat. Thus, the reason we may observe flatter gradients in Mexico is that the country is in the midst of a nutritional and epidemiologic transition that would be likely to produce such weak gradients. This would in turn contribute to an observed weak relationship between education and health behaviors among Mexican migrants in the US.

We evaluate the imported gradients hypothesis through three research questions. First, we examine whether weak or flat gradients for the Mexican-origin population in the US as a whole are also observed when the sample is stratified by gender and when we use a more flexible education specification. We also distinguish between recently-arrived and longer-term Mexican immigrants to facilitate our explicit test of imported gradients.

Our second research question tests for differences in social gradients in health behaviors between regions of Mexico with low and high levels of migration to and from the US. Well-established migration patterns have produced specific regions in Mexico from which migrants to the US originate disproportionately (Fussell, 2003; Fussell & Massey, 2004; Wong, Pérez, & Martiñón, 2006). Migration to the US is a common livelihood strategy in these communities.

Established social networks in receiving communities and extensive information about jobs and living conditions in the US in sending communities make the costs of cross-border migration particularly low. With frequent seasonal and circular migration, we expect that consumption patterns and other cultural influences in Mexico are more like those in the US than in non-migrant sending areas.[3] Thus, comparing Mexico as a whole to the Mexican-origin population in the US may mask the fact that health behavior gradients in migrant-sending communities are different than other Mexican communities and more similar to the US. If we ignore potential differences between migrant-sending and other communities in Mexico, we may conclude that Mexican immigrants in the US are not importing gradients in health behaviors from Mexico, when in fact they are.

Third, we evaluate the central tenet of the imported gradients hypothesis: Are social gradients in health behaviors for recently-arrived Mexicans in the US similar to the patterns in high-migration regions in Mexico? If so, this evidence would provide support for the imported gradients hypothesis.

Methods

Data and measures

Data for the study are drawn from two large nationally-representative datasets: the National Health Interview Survey (hereafter, NHIS) in the United States and the 2000 Mexican National Health Survey (hereafter, ENSA) in Mexico. The NHIS is an annual cross-sectional survey of the civilian, non-institutionalized US population, sampling approximately 35,000 households and 75,000 individuals each year (National Center for Health Statistics, 2006) . We pooled six waves

[3] Similarly, areas in the US receiving large numbers of Mexican immigrants may have patterns more similar to Mexico than other US communities.

of the NHIS (2000-2005) to generate a sufficiently large sample of foreign-born Mexicans. We restrict the sample to 94,595 adults age 25 to 64 in order to minimize both the number of adults who are still in school and recall and survivor biases among older respondents. We also exclude pregnant women. The pooled sample is weighted according to the NHIS sampling scheme.

The dependent variables in the analysis are dichotomous measures of current smoking and obesity. In the NHIS, current smoking is self-reported and is defined as having ever smoked a total of 100 cigarettes and currently smoking "every day" or "some days". We exclude 640 respondents with missing data on smoking from the smoking analyses. Obesity is defined as having a BMI ≥ 30.0 kg/m^2, calculated in the NHIS from self-reported height and weight. The obesity analyses exclude 6,798 cases with missing or extreme outlier BMI values, the latter defined as more than twice the interquartile range below the first quartile or above the third quartile (Larson 2006).

The focal variables of interest are educational attainment and ethnicity/nativity. Like other studies of social gradients, we use educational attainment as our measure of socioeconomic status. Educational attainment has the advantage of being stable over time (after education is completed in late adolescence or early adulthood) and, once completed, is not influenced by the migration process. Setting aside concerns about the potential differences in economic returns to education acquired in the US vs. Mexico (Jackson, Pebley, & Goldman, 2008), we define educational attainment as a continuous variable representing years of completed schooling in the United States or in Mexico. The variable ranges from 0 to 21.

Ethnicity/nativity distinguishes native-born whites from three different groups of Mexican-origin adults: US-born Mexican origin, foreign-born Mexicans who have been in the US for ten or more years (hereafter, long-stay Mexican), and foreign-born Mexicans who have been in the US for less than ten years (hereafter, short-stay Mexican). We exclude foreign-born whites from the analysis. Age in years is included in the models as a control variable.

The second dataset used in the analysis is the 2000 Mexican National Health Survey (ENSA 2000). ENSA 2000 sampled 47,360 households from a sampling frame of basic geographical statistical units maintained by the National Institute of Geography and Statistics (INEGI). The stratified multistage sample of households is representative of the Mexican population at the state level. Sample weights adjust for nonresponse and design effects (Valespino et al., 2003). Detailed descriptions of the ENSA study and results are available elsewhere (Olaiz et al., 2003; Sánchez-Castillo et al., 2005; Sanchez-Castillo et al., 2003; Valespino et al., 2003; Velazquez-Monroy et al., 2003). Within sampled households, one adult (age 20 or older) was selected from each household to answer detailed questions about education, employment, health risk factors, health care services utilization, and other topics. Trained anthropometrists weighed and measured each respondent. We focus on 33,284 adults ages 25-64, again excluding pregnant women.

In ENSA 2000, current smoking is reported by the respondent as a dichotomous measure, with 855 respondents missing data on this measure. Obesity is defined as having a BMI $\geq$ 30.0 kg/m^2; however, in ENSA 2000, respondent height and weight are measured rather than reported. We again use two times the interquartile range to identify extreme outliers, excluding 1,961 respondents with missing or outlier BMI values from the obesity analysis.

In the ENSA analysis we classify respondents based on the level of migration in the *municipio* (comparable to a US county) of residence. The level of migration in the *municipio* is calculated for all 2,443 Mexican *municipios* using data from the 2000 Mexican census, and is defined as the number of *municipio* residents migrating to or from the United States between

1995 and 2000. The 321 *municipios* included in the ENSA 2000 sample were then categorized into “high” or “low” migration areas based on the percentile ranking of level of migration relative to all *municipios*. In the analysis shown below, high migration *municipios* are those above the 80th percentile of all Mexican *municipios* in number of residents migrating, and low migration areas are those at or below the 80th percentile.

Analytic approach

The first step of our analysis is the estimation of the log odds of smoking and of being obese for each of the six subpopulations of interest: four ethnicity/nativity groups in the US and two migration groups in Mexico. Separate models are estimated for men and women, for a total of twelve models. In each model we introduce age and education using regression splines.[4] To ease interpretation of results, we then use the coefficients from the logistic regression models to generate predicted probabilities of smoking or of being obese by age and educational attainment.

The predicted probabilities are used in three different sets of comparisons. First, we graph these predicted probabilities to show the relative strength or weakness of the education-health relationship for each subpopulation with age held constant at 40 years, about the median age in our samples. To focus the comparison on portions of the education distribution where all groups have sufficient sample sizes, we plot predicted probabilities only between the 2.5th and the 97.5th percentiles of each group’s education distribution, although all respondents are used in the underlying estimations. The graphs allow for a first visual examination of the differences in gradients across groups.

[4] Splines are piecewise polynomial functions, with each polynomial defined between a series of two knots but constrained to have the same value and derivative where it meets the next polynomial. Splines are a very flexible modeling tool and are known to be better behaved than higher-order polynomials. Here we use a natural cubic spline for education so that the curvature approaches zero at both tails of the education distribution, where data are sparse. Knots are at 0, 6, 9, 12, 15 and 21 years of schooling. For age we use a cubic spline with knots at 25, 35, 43, 52, and 64 years. This approach retains more information from the data than the common alternative of treating age and education as categorical variables.

Next, we use two statistical tests for differences in gradients. The first is a Wald test of the equality of the education coefficients for each of six selected pairs of ethnicity/nativity groups (listed in Table 2), for each gender and health behavior. We use a conservative threshold p-value of .01 to account for the fact that we are performing multiple pair-wise tests[5] which increases the probability of finding a significant test.

The second statistical test compares education-health gradients at a specific point in the education distribution. We choose 12 years of education, representing completion of high school, as a meaningful level of educational attainment in both the US and Mexican educational systems. The statistic we derive represents the rate of change in the log odds of smoking or being obese per year of schooling, evaluated at the completion of high school. This statistic can be compared across ethnicity/nativity groups, with threshold p-values again equal to .01 to compensate for performing multiple tests.

Using these tests we examine each research question in turn. First, we reexamine the previous finding of flat or weak gradients in health behaviors among Mexican-origin populations in the US. Next, we compare gradients in high vs. low migration *municipios* in Mexico. Finally, we focus explicitly on the imported gradients hypothesis by comparing education gradients for short-stay Mexicans in the US to gradients in high migration regions of Mexico. A finding of no significant differences between these two groups would provide strong support for the imported gradients hypothesis.

Results

Smoking and overweight prevalence in the US and Mexico

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[5] A formal Bonferroni correction would yield a threshold p-value of .05/6 = .0083 (based on six pair-wise tests)—we round to .01 for simplicity.

Descriptive statistics for each of the six subpopulations (four from the NHIS and two from ENSA) are presented in Tables 1A (for men) and 1B (for women). Note that the short-stay Mexicans (those living less than 10 years in the United States) are the youngest group for both men and women. Educational attainment ranges from an average of 6.3 years for Mexican men in low-migration regions to 13.8 years for US whites. Women show a similar variability in education levels across the subgroups, but with lower attainment than men in Mexico.

In our US sample, smoking prevalence ranges from 21% for short-stay Mexican men to 27% among white men, and from 6% for short-stay Mexican women to 25% for white women. These figures are consistent with published estimates of current smoking for whites and Hispanics from the 2000-2005 NHIS (Pleis & Lethbridge-Cejku, 2006; Pleis, Schiller, & Benson, 2003). The descriptive tables also indicate a smoking prevalence of 40% for men in high-migration regions of Mexico and 31% for men in low-migration regions. Smoking prevalence for Mexican women shows a similar pattern for high- vs. low-migration regions (14% vs. 5%). These data correspond to published reviews of smoking prevalence in Mexico (e.g., Valdés-Salgado, Lazcano-Ponce, & Hernández-Avila, 2005).

The patterns of obesity prevalence contrast sharply with those for smoking. In the US, prevalence is highest among US-born Mexicans (37% of men and 36% of women), a pattern that has been true for the last decade (Flegal, Carroll, Kuczmarski, & Johnson, 1998). For men, obesity is lowest among short-stay Mexicans, and, for women, among both short-stay Mexicans and whites. It is important to note that these estimates from the NHIS are lower than comparable estimates from the NHANES, in which height and weight were measured rather than self-reported. In general, obesity prevalence has been rising at an alarming rate in the US, increasing from 11% and 16% (male and female) in 1960 to 28% and 34% (male and female) in 2000 (Hedley et al., 2004; Ogden et al., 2006).

Obesity is also increasing in Mexico, with even more dramatic recent increases due to a rapid nutritional transition to high-calorie, low-nutrient diets (Popkin, 2006; Popkin & Gordon-Larsen, 2004). Estimates from our sample indicate that 16% of men are obese in low migration region of the country vs. 22% in high-migration regions. For women, the corresponding estimates are even higher: 28 and 32%. While Mexico used to have a high prevalence of underweight women, particularly in rural areas, this is no longer the case: In both urban and rural areas, overweight and obese women far outnumber underweight women by a factor of 20 or 30 (Mendez, Monteiro, & Popkin, 2005), with obesity rates only slightly lower in rural than urban areas (Fernald et al., 2004). A study of 36 developing countries found Mexico to have the third-highest prevalence of female overweight and obesity, after Jordan and Egypt (Mendez et al., 2005).

Are social gradients in health behaviors weaker for Mexican-origin adults in the US compared to whites?

Smoking

The graphs in Figure 1 depict the predicted probability of smoking at age 40 for males and females (the first two columns) and of obesity at age 40 for males and females (the third and fourth columns), by ethnicity and nativity. The varied and sometimes irregular shapes of the splines underscore the limitations of the linearity assumption used by previous researchers to model the association between education and health behaviors (e.g., Goldman et al., 2006).

In the first graph, the weakness of the education-smoking relationship for short-stay and long-stay Mexican men (the two bottom lines) compared to US-born Mexican men and whites is striking. While the probability of smoking declines steeply for white men from 10 years of schooling through 20 years, the two Mexican-born groups show no such decline between 0 and 15 years of schooling. For US-born Mexicans, both smoking prevalence and the strength of the education-smoking relationship generally lie between those of the Mexican-born groups and whites. A similar pattern is evident for women in the second graph: a steep decline in the predicted probability of smoking for white women as educational attainment increases, with a less steep decline for US-born Mexicans and almost no variation in smoking levels by education for the two Mexican-born groups.

In Table 2 we test the statistical significance of these visual comparisons. The table reports p-values from Wald tests of the equality of the set of education coefficients from two different models. For example, the p-value of .003 in top left cell of Table 2 indicates that we would reject the hypothesis that the coefficients on the education spline terms for US-born Mexicans and US whites are equal to each other in models predicting the log-odds of smoking for men. White males can also be statistically distinguished from long-stay and short-stay Mexican men ($p < .001$ for both comparisons). In contrast, we cannot reject the hypothesis that US-born Mexican and short-stay Mexicans have equal gradients. A similar pattern emerges for the analysis of smoking for women (second column): gradients differ between whites and all other groups, but we fail to reject the hypothesis that US-born Mexican and short-stay Mexicans have the same gradients. The top row of Figure 2 confirms these findings of weaker gradients (represented as shorter bars) for foreign-born Mexicans compared to whites and US-born Mexicans at 12 years of education.

Obesity

We now turn to the parallel set of analyses for obesity in the US. For men (Figure 1, Panel I, third graph), the gradients for short-stay and long-stay Mexicans in the US vary little by years of schooling, whereas the white gradient slopes downward. The curve for US-born Mexican men stands out both for its higher prevalence of obesity and for its inverted-U shape, with the highest predicted probability at about 12 years of completed schooling. However, the Wald tests (Table 2, third column and Figure 2) indicate that these gradients are not significantly different from each other.

For women, the story is quite different. The fourth graph in Figure 1, Panel I shows a declining prevalence of obesity for all groups as education increases, with the notable exception of short-stay Mexican women with 11 years or more of education—here the likelihood of obesity increases sharply with additional schooling.[6] Table 2 confirms that the education-obesity relationship for short-stay Mexican women is distinct from those for whites and US-Born Mexicans. Figure 2 depicts the unique slope for short-stay Mexican women: a strong relationship between more schooling and obesity at the completion of high school. We conclude that Goldman et al.'s analysis, which is based on a linear specification of the education-health relationships and combines men and women, masked this U-shaped relationship for recently-arrived Mexican women. The patterns also support a general finding in the literature that male obesity is less responsive than female obesity to socioeconomic status (Chang & Lauderdale, 2005; McLaren, 2007; Monteiro, Conde, & Popkin, 2001).

[6] The "hockey-stick" shape of this curve does not appear to be overly influenced by small sample sizes at the upper end of the education distribution, as more than 30% of the 1,310 women in this analysis have 12 or more years of education.

In sum, we find strong evidence of a significant difference in the relationship between education and smoking for foreign-born Mexicans in the US compared to whites. These results confirm the Goldman et al. (2006) finding that the education-health relationship is weaker among Mexican-origin populations in the US compared to whites, for both men and women. For obesity, it appears that men of all ethnicity/nativity groups have a weak education gradient, while recently-arrived Mexican women have a distinct U-shaped relationship between education and obesity that stands in contrast to the expected gradient for other groups.

Do social gradients in health behaviors in Mexico differ between high-migration and. low-migration regions?

Our second question concerns social gradients in health in two different populations in Mexico: those in regions with large migration streams to the US, and those with comparatively smaller streams. A finding of distinct gradients between these two groups is of substantive interest for many reasons, but also offers us a more refined test of the imported gradients hypothesis through a comparison of recently-arrived Mexicans in the US to Mexicans in the main sending regions for immigration to the US, if the low and high sending areas are substantially different.

The education gradients in health behaviors in high- and low-migration regions of Mexico are shown in the second panel of Figure 1. Results for smoking in the first two graphs suggest that while prevalence is higher in high-migration regions, the general shape of the associations is similar. This is confirmed in Table 2, Panel II by the large (i.e., non-significant) p-values for the Wald tests of equality of the coefficients for high and low-migration regions. Figure 2 supports the general finding of similar gradients between the two regions for male smoking at the completion of high school. For women, the gradient for smoking in high-migration regions is near flat at this level of schooling, while in low-migration regions it is noticeably upward-sloping. The obesity analyses in the third and fourth graphs of Panel II reveal flat gradients in both high- and low-migration regions for both men and women, also confirmed by the Wald tests in Table 2 and by the graphs in Figure 2. We conclude that there is little evidence that gradients in either smoking or obesity differ in high- vs. low-migration regions of Mexico, although the prevalence of smoking is higher in high-migration regions.

Do migrants import gradients?

Finally, we turn to the third research question of the study: Can the distinct social gradients in health behaviors among Mexican-origin adults in the US be explained by importation of gradients from Mexico? If migrants import gradients, we would expect gradients among short-stay Mexicans in the US to mirror gradients in high-migration regions of Mexico. At the same time we recognize that even if the imported gradients hypothesis were the major explanation for flat gradients among Mexican-origin adults in the US, we would still expect some differences between the two groups in the prevalence of these health behaviors and the socioeconomic differentials in the behaviors due to selective migration and to acculturation, particularly given our 10-year cutoff for "short-stay" Mexicans in the US.

We find some support for the imported gradients hypothesis for male smoking: the gradient for short-stay Mexicans cannot be distinguished from the gradient in high-migration regions in Mexico (Table 2, p=.289). The similarity of the gradients among the Mexican-born populations in both NHIS and ENSA is also clear from the first graph of Figure 1, Panel III and the top left graph in Figure 2. However, this finding is complicated by the stark difference in *levels* of smoking between the two groups: the predicted probability of smoking is higher at every educational level among the men in high-migration regions of Mexico compared to short-stay Mexicans in the US. We discuss possible reasons for this prevalence gap below. The imported gradients hypothesis is also supported to some degree by women's smoking patterns. The gradients for short-stay Mexican women and the women in high-migration regions of Mexico cannot be distinguished statistically, and at twelve years of schooling, gradients for all Mexican-born groups are reversed (in contrast to US-born Mexicans and whites).

The patterns for male obesity provide more dubious support for the imported gradients hypothesis, in part because men on both sides of the border show minimal association between education and obesity. All of our tests indicate that gradients are similar for recently-arrived Mexicans in the US and men in high-migration regions of Mexico. However, these gradients are also similar to those for whites and long-stay Mexican men in the US.

The results for female obesity are the most challenging to interpret. Certainly the "hockey-stick" shape of the gradient for short-stay Mexican women in the US in Figure 1 looks very different from the pattern for women in high-migration regions of Mexico, particularly above 12 years of schooling, although the Wald test does not confirm a statistically significant difference at $p<.01$. Figure 2 also confirms that, at 12 years of schooling, education is associated with a higher probability smoking for short-stay Mexican women in contrast to women in Mexico. This finding suggests that recently-arrived Mexican women in the United States at the upper end of the education distribution do not resemble women of similar educational attainment in Mexico. This could result either from selective migration even among the most educated women in Mexico, or from changes in diet and physical activity behaviors after arriving in the US.

Discussion

We have investigated the hypothesis that Mexican immigrants bring social patterns of health behaviors with them when they come to the US and that this "importation" of gradients accounts for the relatively weak or flat gradients in health behavior behaviors among Mexican-origin populations in the US. We find at least partial support for the imported gradients hypothesis in the case of smoking for both men and women. Results are less clear for obesity, in part because SES-obesity relationships are generally weaker for men (an empirical regularity found in many countries) and in part because the education-obesity curve for recently-immigrated Mexican women in the US has a unique shape. The findings suggest that other factors, such as selective migration, acculturation, and segmented assimilation, may also be contributing to weak gradients in health behaviors.

As we argue above, flat or weak social gradients in health and health behaviors are less of a concern if the population in question has excellent health or very healthy behaviors. However, the existence of weak gradients for a population with poorer health or health behaviors suggests that even with improvements in social status, the population's health or health behavior will remain poor. For example, flat or positive education gradients for high-prevalence unhealthy behaviors suggest that even Mexican immigrants with relatively high SES may not realize the health benefits that increased status offers the white population. US-born and long-stay Mexican men and short-stay Mexican women exhibit this pattern for obesity in which improvements in educational attainment do not appear to reduce the prevalence of obesity. This is a significant concern for policy makers and health practitioners because it may suggest, if cross-sectional patterns persist longitudinally, that the Mexican-origin population in the US will continue to experience a high prevalence of obesity. In the case of men's smoking, on the other hand, the low smoking prevalence among both immigrant populations suggests that flat or weak gradients are less of a concern, at least among this group. However, smoking rates are higher for US-born Mexicans vs. Mexican migrants, suggesting that policy makers and practitioners need to understand what happens to second and subsequent generations.

Our findings that social gradients vary across different subpopulations and time periods raise important questions for the design and targeting of health promotion programs and health-related policies. For example, since smoking prevalence *increases* with educational attainment for Mexican-origin women, how should we design smoking cessation or tobacco control programs for these women? How can programs counter the ethnic-based targeted marketing efforts of tobacco companies built on their keen understanding of different patterns of tobacco use and tobacco related attitudes among immigrant populations (Acevedo-Garcia, Barbeau, Bishop, Pan, & Emmons, 2004)? Given a very different regulatory environment and attitudes towards smoking in Mexico, can US policymakers assume that Mexican-origin adults will respond to tobacco control policies in the same way that white or black populations do (Martinez-Donate et al., 2007; Martinez-Donate et al., 2008)?

This last question is particularly relevant in addressing the finding that there is a large gap in smoking prevalence between Mexican men in high-migration regions and short-stay Mexican men in the US. Although the gradients are similarly flat, prevalence is much higher in Mexico—an odd finding given our previous emphasis on the early establishment and persistence of health behaviors such as smoking. We suggest three plausible reasons for the gap in smoking prevalence between these two populations. First, the gap may be due to differences in the definition of the current smoking in NHIS vs. ENSA—ENSA has a slightly broader definition that does not require having ever smoked 100 cigarettes, and does not specify smoking "every day" or "some days" in the question on current smoking. Low-intensity and low-frequency smokers in ENSA may have responded "yes" to a current smoking question while a Mexican-origin smoker with similar habits in the US may have answered "no". A second cause of the gap may be selective migration, with smokers less likely than non-smokers to move from Mexico to the US. While previous work has found little if any selection on general health measures for Mexican migrants (Rubalcava et al., 2008), selection has not been tested for smoking or other health behaviors *per se*.

A third potential source for the gap is that overall prevalence of smoking may drop for Mexican men living in the US independent of the level of schooling. This drop in prevalence could result from more restrictive anti-smoking regulations in the US (e.g., smoke-free workplaces). A study of smoking behavior among Mexican-origin adults in San Diego, California compared to Tijuana and Guadalajara, Mexico found that the tobacco control environment in the US does reduce smoking rates for Mexican-Americans (Martinez-Donate et al., 2008). Migrant smokers of all education levels may also respond to higher relative prices of cigarettes in the US by smoking less. For example, when expressed in purchasing power parity units pegged to the price of a Big Mac, cigarettes are more than twice as expensive in the US relative to Mexico (Guindon, Tobin, & Yach, 2002). Smokers in high-migration areas of Mexico, meanwhile, may enjoy relatively high incomes due to remittances from the US. The peculiar gap in smoking prevalence between these two groups certainly warrants additional research.

Our study has several limitations. First, while height and weight were measured by field workers in the ENSA dataset, we rely on self-reports for the NHIS data. Obesity prevalence may therefore be underestimated in the NHIS data but to an unknown extent. Second, a three- or five-year cutoff rather than the 10-year cutoff used to define the short-stay Mexican group would have been a better approximation of immigrants who are recent arrivals, but sample sizes did not permit us to use this shorter period of time. Third, social gradients in health behaviors may vary by the measure of socioeconomic status considered. In earlier work, we found smoking to be positively associated with household income but negatively associated with education for men in urban and rural areas (Buttenheim et al., forthcoming). Fernald (2007) found a positive relationship between income and obesity, explained in part by higher consumption of sugar beverages. Thus, our results for educational attainment are only one piece of a larger picture.

Fourth, our inferences are limited by our use of cross-sectional data rather than longitudinal data. Ideally, we would like to observe the pre-migration health behavior of the Mexican-origin adults in the US, and follow the health behaviors of the ENSA sample over time as some of the sample migrates to the US. Our use of a community-level measure of migration in Mexico is an admittedly rough proxy for these dynamic processes.

Our results provide at least partial support for the imported gradients hypothesis. Thus, we would expect that the social patterns of health for Mexican-origin adults in US will continue to reflect the complex SES-health relationship in Mexico. As Mexico experiences epidemiological and socioeconomic change, patterns in the US will likely change as well. At the same time, selective migration from Mexico and integration processes once migrants reach the US will continue to shape the SES-health behavior relationship for Mexican Americans. Successful behavioral and structural interventions to improve health and reduce chronic disease burden in the US must account for this complex web of social determinants of health, and be sensitive to the gradients that accompany migrants across borders.

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Table 1. Descriptive statistics, US and Mexican adults ages 25-64, 2000-2005.

1A. Men

	US (NHIS 2000-2005)			Mexico (ENSA 2000)		
	US-Born NHW	US-Born Mexican-origin	Mexican-born, ≥10 years in US	Mexican-born, <10 years in US	Residents of high-migration regions	Residents of low-migration regions
Age in years (mean) [Standard error]	43.9 [.071]	39.9 [.244]	40.5 [.235]	33.2 [.316]	39.1 [.195]	39.5 [.249]
Completed schooling in years (mean) [Standard error]	13.8 [.026]	12.4 [.068]	8.8 [.101]	8.5 [.143]	8.6 [.100]	6.25 [.128]
Current smoker (%)	27	26	22	21	40	31
Unweighted N	36,690	2,566	2,806	1,267	6,214	3,568
Obese (BMI≥30) (%)	25	37	24	15	22	16
Unweighted N	35,857	2,470	2,702	1,156	6,026	3,477

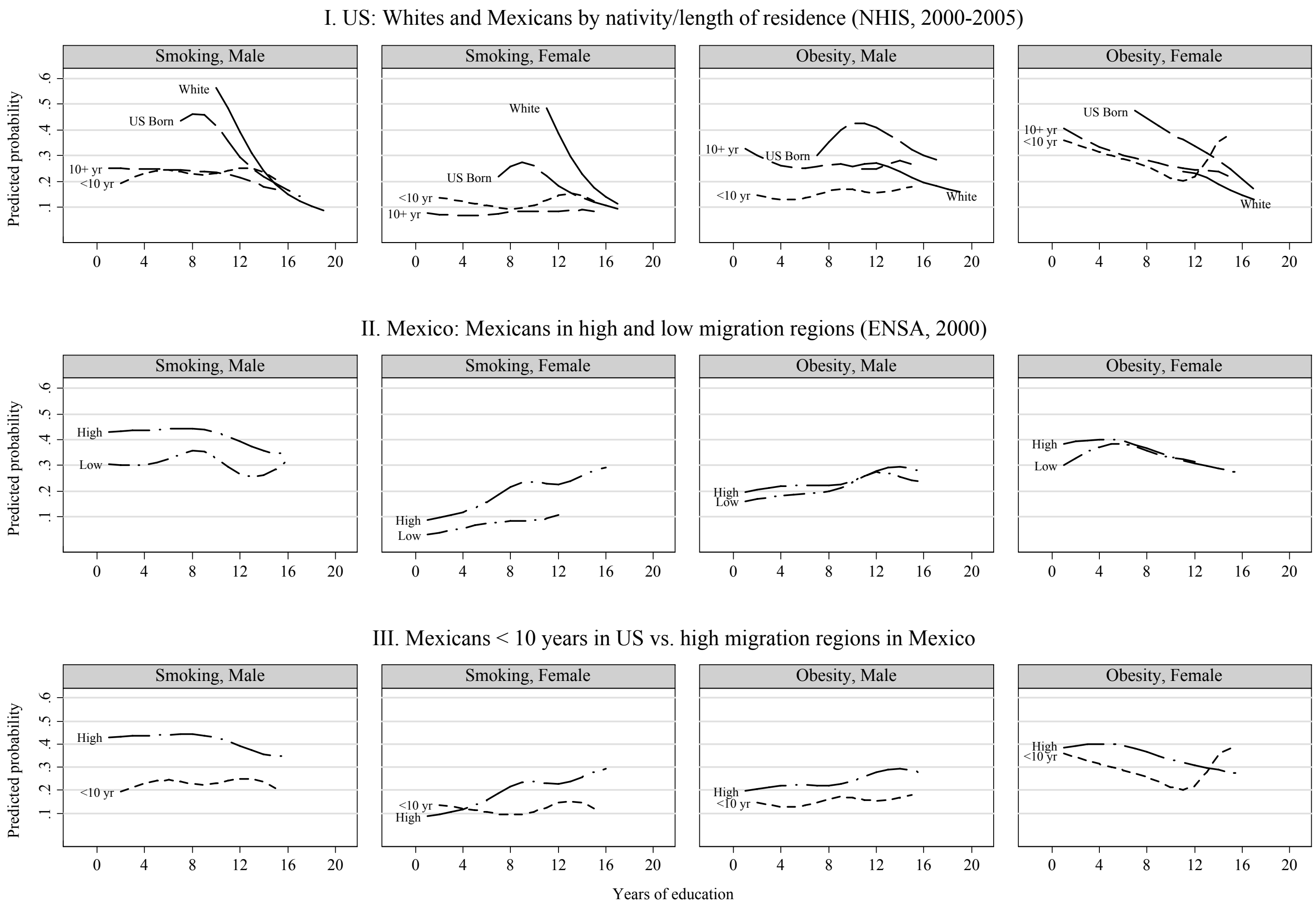
1B. Women

	US (NHIS 2000-2005)			Mexico (ENSA 2000)		
	US-Born NHW	US-Born Mexican-origin	Mexican-born, ≥10 years in US	Mexican-born, < 10 years in US	Residents of high-migration regions	Residents of low-migration regions
Age in years (mean) [Standard error]	44.1 [.064]	40.5 [.232]	41.3 [.206]	34.0 [.279]	39.1 [.137]	39.2 [.196]
Completed schooling in years (mean) [Standard error]	13.8 [.024]	12.5 [.063]	8.8 [.094]	8.5 [.145]	7.5 [.081]	5.1 [.112]
Current smoker, %	25	16	7	6	14	5
Unweighted N	42,721	3,529	3,056	1,320	14,426	8,221
Obese (BMI≥30 kg/m^2), %	21	36	30	21	32	28
Unweighted N	38,618	3,119	2,793	1,082	13,837	7,983

Table 2. Results (p-values) from Wald tests of the equality of coefficients on education spline terms from models predicting the log odds of smoking/obesity, Mexican and US adults ages 25-64, 2000-2005.

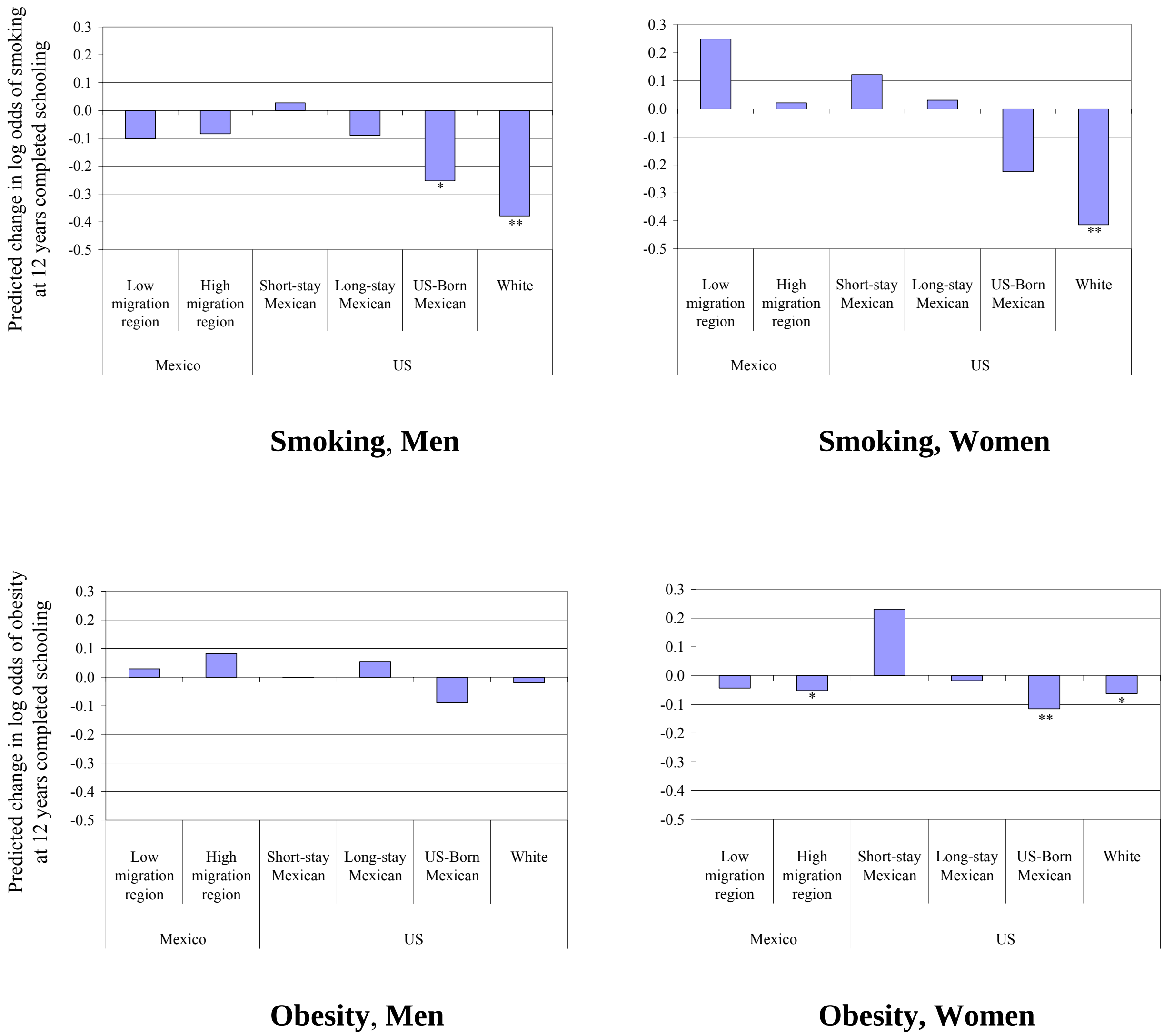
	Smoking		Obesity	
	Men	Women	Men	Women
I. Do gradients differ by ethnicity /nativity in the US?				
A. White vs. US-Born Mexican	.003	<.001	.051	.183
B. White vs. Long-stay Mexican	<.001	<.001	.233	.029
C. White vs. Short-stay Mexican	<.001	<.001	.171	<.001
D. US-Born Mexican vs. Short-Stay Mexican	.018	.084	.637	.001
II. Do gradients differ by level of migration in Mexico?				
E. High-migration regions vs. Low-migration regions	.475	.119	.779	.093
III. Is the imported gradients hypothesis supported?				
F. Short-stay Mexican (US) vs. High-migration regions (Mexico)	.289	.025	.740	.031

Figure 1. Predicted probability of poor health behaviors by education and ethnicity/nativity



Source: Authors calculations based on National Health Interview Survey (US) and ENSA (Mexican National Health Survey).

Figure 2. Predicted change in the log odds of smoking/obesity around completion of high school, Mexican and US adults ages 25-64, 2000-2005.



Source: Authors calculations based on National Health Interview Survey (US) and ENSA (Mexican National Health Survey).
Bars show the predicted change in the log odds of smoking/obesity associated with a year of schooling at completion of high school (12 years).
Asterisks show results from pairwise Wald tests of the equivalence of the change in the log odds of smoking/obesity for short-stay Mexican vs. all other groups. ** Significantly different from short-stay Mexican at p< .001. * Significantly different from short-stay Mexican at p <.01.