MOVING TO THE LAND OF FROSTED CAKES AND FRIED FOOD: IMMIGRANT OBESITY IN THE U.S.

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Abstract

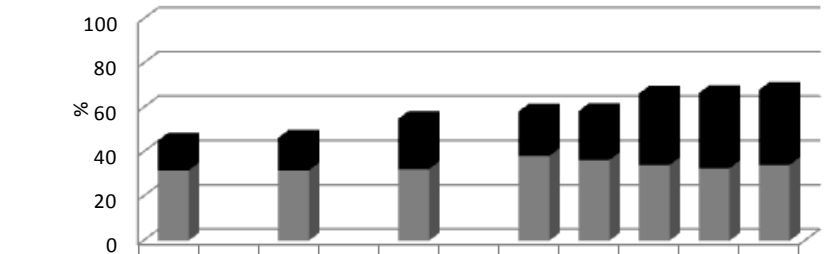
The paper focuses on body weight gain among immigrants in the US. The emphasis is on disentangling different time lines that are relevant in the context of immigration and acculturation, namely length of exposure to the high obesity culture, age at immigration, year of immigration and aging. Using data from the National Latino and Asian American Study (NLAAS), we find that (1) acculturation is associated with higher BMIs for the 1st generation, but not the 1.5 generation; (2) immigration at an early age (before 12) facilitates acculturation progress and drives BMI convergence to natives; (3) the effect of sojourn length in the host country is unstable across model specifications; (4) BMI differences between Asian and Latino immigrants are partly due to effect size differences in the acculturation variables.

Keywords: Immigration, Obesity, Acculturation

JEL classification: I10, J15

1. Introduction

The prevalence of overweight and obesity[1] among the US population has increased since the 1960s (Figure 1). The rise was slow at first, increasing by about 10 percentage points in the 30-year period from 1960 to 1990, followed by a 13 percentage point increase in just 18 years from 1990 to 2008. Concern over these epidemic trends are rooted in the fact that overweight, and especially obesity, are major risk factors for chronic diseases such as diabetes and cardiovascular diseases. Today, two thirds of the US population are overweight and about half of them are obese, prompting the 2010 OECD report on obesity to declare that **"**[s]oaring obesity rates make the US the fattest country in the OECD." Extending the basis of comparison to all countries, US obesity prevalence also ranks higher than that of almost all other countries, although lack of data precludes a precise ranking.



	early 60s	late 70s	~ 1990	2000	2002	03-4	05-6	07-8
BMI > 30	13.5	14.7	22.7	20.1	22.1	32.2	33.9	33.8
BMI 25 - 30	31.7	31.7	32.3	38.2	36.4	34.1	32.7	34.2

Data Source: http://apps.who.int/bmi/index.jsp

Figure 1. US trends in overweight and obesity rates

By implication, immigrants coming to the US almost inevitably originate from countries where obesity prevalence is lower, in some cases even drastically lower. Figure 2 shows obesity prevalence rates for selected origin countries. The contrast with the US is particularly strong for the three Asian countries from which the US receives large shares of its immigrants. India, for example, where less than five percent of the population were obese in 2005, accounted for more than one third of new (permanent) immigrants in the US in 2005. For immigrants from Latin America the contrast is less severe, especially for Mexican immigrants. Moreover, most individuals coming to the US enjoy the so-called healthy immigrant effect, succinctly summarized by Malmusi et al. (2010) stating that "recently arrived immigrants (usually from

[1] Overweight and obesity are defined as a body mass index (BMI) exceeding 25 and 30, respectively. The BMI is a weight-for-height index defined as a person's weight in kilograms divided by the square of the height in meters [kg/m2].

poor areas) have generally better health than the native population, or at least better than expected for their socioeconomic characteristics" (p. 1611). The healthy immigrant effect is even strengthened when taking into account that international migration is highly selective with respect to health, wealth, and education (McDonald and Kennedy 2004).

	India 2005/6	China 2002	Philippines 2003	Mexico 2000	Cuba 2001	USA 2000	USA 2008
BMI > 30	3	3	4.3	23.6	11.8	20.1	33.8

Data Source: http://apps.who.int/bmi/index.jsp

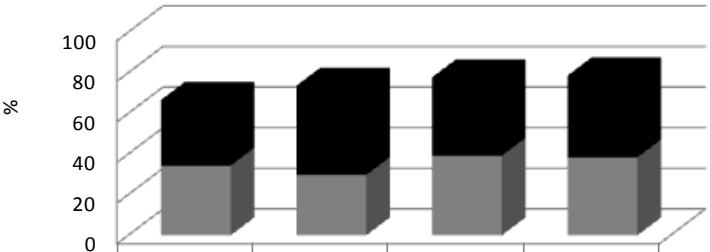
Figure 2. Overweight and obesity rates in selected countries

As immigrants settle and extend their stay in the US, they are exposed to the food culture and life-style that contribute to overweight and the associated poor health outcomes. A sedentary life-style (few calories expended) coupled with a diet based on high intakes of energy dense food, rich in fat and sugar (many calories consumed), creates the energy imbalance ultimately responsible for weight gain. Not surprisingly, thus, studies have found increased obesity among immigrants as their time spent in the United States increases (Singh and Miller 2004) and immigrant obesity has become an issue drawing public attention in the United States. The rising interest in this topic is partly due to what could be called the 'obesity trajectory' within the immigrant community where 2nd-generation immigrants have a particularly high prevalence of overweight (Popkin and Udry 1998; Allen et al. 2007; Bates et al. 2008). Descendants are carrying more extra weights than their foreign-born parents, with environmental and cultural factors rather than genetics being responsible for this obesity trajectory among immigrants.[2]

The obesity trajectory is initiated with immigrants' own acculturation to the American lifestyle and diet (Gordon-Larsen et al. 2003; WHI 2004). The observable outcome – change in body weight – is influenced by a large number of factors (Geol et al. 2004; Kaplan et al. 2004; Rosin 2008; Sanchez-Vaznaugh et al. 2008). As a result, the likelihood of being obese may differ

[2] While there is strong evidence that genetics is a partial cause of obesity (Maes et al. 1997, Herbert et al. 2006.), it is not likely to play a role for the generational obesity trajectory as the widespread diffusion of a genetic variation within such a short span is impossible.

among immigrants by gender, ethnicity, level of acculturation, the disparity between own culture and American culture, and the motivation for leaving the own culture behind. Identifying these dissimilarities will shed light on risk factors attributable to unhealthy BMI for different immigrant subgroups and help target strategies to tackle the far reaching consequences of the obesity epidemic.



	non-Hisp White	non-Hisp Black	Hispanic	Mex-Am
BMI > 30	32.4	44.1	38.7	40.4
BMI 25 - 30	34.3	29.7	39.2	38.4

Data Source: http://apps.who.int/bmi/index.jsp

Figure 3. Racial/ethnic variation in overweight and obesity rates, US 2008

This paper focuses on the unhealthy assimilation of immigrants and one negative health outcome – body weight gain among immigrants in the US. The emphasis is on disentangling different time scales that are relevant in the context of immigration and acculturation, namely length of exposure to the high obesity culture, age at immigration, year of immigration and aging. Within this broad realm, we aim at identifying systematic differences between immigrants of different cultural background, namely Asian and Latinos. As shown in Figure 2, the BMI disparity between the US and the home country differs substantially for these two groups and may influence the speed of acculturation and weight gain following immigrants' settlement in the US. Moreover, as the US society is highly segregated along economic and racial/ethnic lines – two key predictors of obesity – the microcosm in which immigrants find themselves will differ. In particular, Latinos, more so than Asian immigrants, will likely have more exposure to the ethnic population groups with the highest obesity prevalence, namely the Hispanic population originating in Mexico. As shown in Figure 3, almost 80 percent of Mexican-Americans are estimated to be overweight.

The paper is divided into four parts. Following this introduction, the second section provides a literature review of obesity among the immigrant population. The third section

presents the empirical analysis, with subsections on data, models, and results. The paper ends with a summary and conclusions.

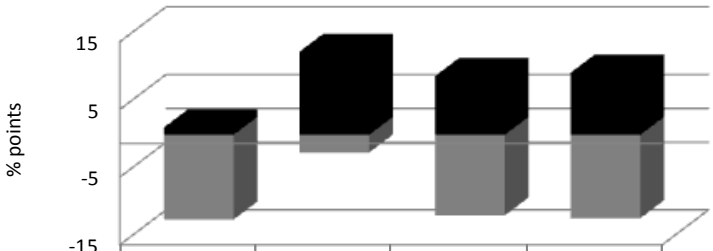
2. Background

Upon arrival in the US, immigrants face a high obesity culture, where consuming high-calorie, low-nutrient food and beverages has become the norm. Immigrants are flooded with a tsunami of advertisements for cheap food of questionable nutritional value, encounter the abundance of fast food, and learn about unhealthy eating patterns at their jobs and at school. The children of immigrants are at particular risk (van Hook and Balistery 2007) as they learn these behaviors quickly through school lunches and vending machines in school cafeterias.

Not surprisingly, the literature suggests that obesity rates among the immigrant population increases as immigrants extend their stay in the US. The general argument is that the acculturation of immigrants steadily advances over time, with weight gain being one of the outcomes as immigrants adapt the American life style and behaviors. Kaplan et al. (2004) find that the prevalence of obesity among Hispanic immigrants steadily increases with increasing length of stay in the US. Using a small sample of women from Puerto Rico, Fitzgerald et al. (2006) find that obesity prevalence is related to the degree of acculturation. Khan et al. (1997) use generation and language preference as indicators of acculturation among Hispanics in the US and find that the second and third generations had higher BMIs than first generation immigrants. Moreover, among women a greater preference for English language use is linked to lower BMIs. A closely related line of research looks at the link between immigrants' obesity-inducing behaviors and acculturation. Unger et al. (2004) find that acculturation to US society, as measured by English language use and the standard AHIMSA acculturation scale, is a risk factor for obesity-related behaviors among Asian-American and Hispanic adolescents. Hai et al. (2003) look specifically at dietary patterns and find a link with acculturation and obesity.

However, the empirical evidence is somewhat mixed as the duration effect does not apply universally. For example, Kaushal (2009) only finds a duration effect for immigrants without a college degree but not for immigrants with a bachelor's degree, and Van Hook and Balistery (2004) cannot find an acculturation effect for immigrant children. Park et al. (2009) analyze cohorts of immigrants and native-borns and find rising obesity for both, but also find that the rise is faster for native-borns. They conclude that there is no convergence and that past research too narrowly focused on a duration effect without taking into consideration other changes taking place over time. Iversen et al. (2010) analyze BMI changes among immigrants in Norway and support the symmetric convergence hypothesis. That is, independent of the immigrants' initial weight and of their duration of stay, acculturation (measured as proficiency in Norwegian) is associated with immigrants' BMI approaching that of the native population.

In this study we propose an obesity production function where an immigrant's BMI is hypothesized to depend on several inputs, broadly categorized into two groups: inputs describing the immigrant's demographic and economic situation in the US and inputs describing the context of the immigration experience. The demo-economic components refer to socio-economic status, life-style and behavioral factors, such as smoking, and factors linked to the genetic endowment, such as gender and age. Many of these factors have previously been linked to BMI.



	non-Hisp White	non-Hisp Black	Hispanic	Mex-Am
BMI > 30	1.1	12.3	8.7	9.2
BMI 25 - 30	-12.5	-2.6	-11.9	-12.3

Data Source: http://apps.who.int/bmi/index.jsp

Figure 4. Gender gap (female BMI – male BMI) in overweight and obesity rates, US 2008

For example, Figure 3 shows racial/ethnic variations in overweight and obesity rates in the US, and Figure 4 shows the gender gap in overweight and obesity prevalence in the US. Among women, the propensity to be overweight (but not obese, i.e., BMI between 25 and 30) is lower than for men; the propensity to be obese (BMI > 30), however, is higher for women than for men. This gender gap in obesity rates is particularly large for Hispanics and non-Hispanic Blacks. While the comparison shown in Figure 4 refers to immigrants and native-borns, similar results have also been found when concentrating on the immigrant populations only. Van Hook and Balistery (2004) find that among adolescent immigrants, boys have a higher obesity prevalence rates than girls. However, some empirical results regarding the personal characteristic of immigrants are puzzling. Higher socio-economic status is generally inversely related to BMI, but Khan et al. (1997) find that BMI was not associated with the socio-economic status of Hispanic women.

Factors associated with the immigration context may contribute to immigrants' weight gain as migrating to another country is a profound biographical disruption with inevitable adjustments in migrants' lives. These factors thus speak to the timing of migration within the migrant's life course, the exposure time to the obese culture (duration), the disparity between origin and destination, and the degree of acculturation.

The different time lines that are implicitly included in the input factors of the obesity production function are difficult to disentangle. For instance, persons who immigrated in 1980 were initially exposed to a less obese population than the cohort entering in 1990 but had a much longer exposure time to the American life style and diet than the cohort immigrating at a later point in time. Moreover, while both cohorts share the experience of the onset of the obesity epidemic in the 1990s, they will – at that time – only be of the same age if they immigrated at different ages, in which case they were exposed to different environments (e.g., school versus labor force) during the critical initial phase of acculturation. The empirical analysis reported below explicitly takes these different time lines into account.

3. Empirical Analysis

3.1 Data

The data used for this study are drawn from the National Latino and Asian American Study (NLAAS) of 2,554 Latino immigrants and 2,095 Asian American immigrants in the US who are of age 18 or older. The data were collected between May 2002 and November 2003. The objective of the survey was to obtain information on the prevalence of psychiatric disorders and use of mental health services among the immigrant population. However, the survey also elicited important information on the immigration context, the socio-economic and demographic position of immigrants and – most important for this study – the respondent's height and weight.

The respondents selected for this study exclude persons who were born in the US, and persons who were older than 65 at the time of the survey. It also excludes those with extreme[3] BMI values and those with missing values for salient variables. In total, 2,780 respondents are analyzed in this study, 51.9% of them are of Asian origin. The respondents are assigned to two subsamples depending on the age at which they immigrated to the US. The subsample of those who immigrated as adults (1st generation) is comprised of n = 1,911 respondents, and the subsample of those who immigrated as children or adolescents (1.5 generation) included n = 869 respondents.

Table 1 shows the definitions of the variables used in the study, and Table 2 shows the summary statistics, calculated separately for the sample of first generation immigrants (immigrated as adults) and the sample of 1.5 generation immigrants (immigrated as child or adolescent). The variable of interest is the respondent's BMI. In both samples, the average BMI

[3] Persons falling into the 1% highest and 1% lowest BMI quantile were excluded so as to avoid the estimation results being unduly affected by outliers. Moreover, extreme BMI values are also measured imprecisely since both the height and the weight variable used to calculate the person's BMI were top-and bottom-coded. Height was bottom coded at 57 inches (1.45 meters) and top-coded at 75 inches (1.91 meters). Weight was bottom coded at 100 pounds (45.45 kg) and top-coded at 300 pounds (136.36 kg).

is slightly above the "overweight threshold" of 25 kg per square meter, but the standard deviation is bigger for the 1.5 generation than for the first generation immigrants.

Table 1. Variable Definitions

Variable	Definition
Dependent variable	
BMI	Body Mass Index [kg/m^2]
Demo-economic Attributes	
AGE	Age [yrs]
AGESQ	Squared age
FEMALE	1 if female; 0 otherwise
SINGLE	1 if single (never-married); 0 otherwise
HHINC	Household income [USD 1,000]
LOWEDU	1 if low educational attainment level (< 12 yrs of schooling); 0 otherwise
SMOKE	1 if smoker; 0 otherwise
Immigration Context	
ASIAN	1 if country of origin is Asian; 0 otherwise
MEXICAN	1 if country of origin is Mexico; 0 otherwise
RECENT	1 if immigrated within the last five years; 0 otherwise
ASKID	1 = immigrated at age < 12; 0 = immigrated at age between 12 and 18
ASYOUNG	1 = immigrated between the age of 18 and 34; 0 = immigrated at 35 and above
ENGLISH	English proficiency index, ranges between 0 (worst) and 1 (perfect)
JOB	1 if immigrated for job; 0 otherwise

Two types of explanatory variables are considered. The first type includes personal variables that describe the demographic and economic position of the respondents; the second type characterizes the respondents' immigration experience and will be in the center of the discussion. Not surprisingly, respondents of the 1.5 generation are, on average, younger than those of the 1st generation sample. Differences between the two subsamples in the remaining demo-economic attributes are also expected, given the 10-year age difference between the two samples. Compared to the (on average younger) 1.5 generation, the 1st generation respondents have higher shares of women and of poorly educated persons, but a smaller share of never-married persons. Moreover, 1st-generation immigrants tend to live in households that are less wealthy than those of the 1.5 generation respondents. The income gap amounts to about $4,880 or 8.3 percent of the average 1st generation income. Finally, the prevalence of smoking is higher among 1.5 generation respondents than among 1st generation immigrants.[4]

[4] Note that the smoking prevalence rate among the 1.5 generation is similar to that of the US population in 2004 (see: http://www.cdc.gov/tobacco/data_statistics/state_data/data_highlights/2006/sections/index.htm)

Table 2. Summary Statistics

	1st Generation Sample: *n*=1,911 (immigrated as adults)					1.5 Generation Sample: *n*=869 (immigrated as children/adolescents)				
Variable	Mean	Std.dev.	Min	Max	r *)	Mean	Std.dev.	Min	Max	r *)
Dependent variable										
BMI	25.02	3.89	17.97	37.51		25.64	4.66	18.01	40.19	
Demo-economic Attributes										
AGE	43.04	11.12	19	65	0.12	33.26	11.06	18	65	0.25
FEMALE	0.54	0.50	0	1	-0.15	0.50	0.50	0	1	-0.10
SINGLE	0.10	0.30	0	1	-0.08	0.30	0.46	0	1	-0.21
HHINC	58.95	54.15	0	200	-0.09	63.83	56.60	0	200	-0.04
LOWEDU	0.31	0.46	0	1	0.12	0.23	0.42	0	1	0.20
SMOKE	0.17	0.38	0	1	0.03	0.21	0.41	0	1	0.04
Immigration Context										
ASIAN	0.58	0.49	0	1	-0.42	0.39	0.49	0	1	-0.36
MEXICAN	0.12	0.33	0	1	0.22	0.21	0.40	0	1	0.20
RECENT	0.23	0.42	0	1	-0.04	0.05	0.21	0	1	-0.12
ASYOUNG	0.76	0.43	0	1	-0.03					
ASKID						0.64	0.48	0	1	0.04
ENGLISH	0.51	0.25	0.25	1	-0.13	0.73	0.25	0.25	1	-0.16
JOB	0.63	0.48	0	1	0.10					

*) bivariate correlation with BMI

Six variables are used to describe the immigration context. The dummy variables ASIAN and MEXICAN are used to distinguish three origin regions, namely Asia, Mexico and Latin-America without Mexico. As discussed above, there are vast differences in the BMIs of these three regions and it is expected that these differences are maintained when people move to the US. Thus, it is expected that the variable ASIAN has a negative effect and the variable MEXICAN a positive effect on immigrants' BMI. The variable RECENT is a dummy variable that distinguishes immigrants who have stayed in the US for less than five years from immigrants who have stayed in the US for more than five years and thus arrived before 1997/98. We do not have any prior expectation regarding the direction of the effect of RECENT on BMI as there are likely two opposing forces: (1) a BMI-increasing effect due to recent newcomers entering a more obese culture than those who have already been in the US for more than five years, and (2) a BMI-lowering effect due to recent immigrants having a shorter time of exposure to the obese culture in the US.

Three variables are used to describe the immigrant's acculturation. First, age at immigration is hypothesized to be a salient feature in the acculturation process as those who migrate at an older age have been more deeply shaped by the culture in their home country and need to invest more effort and time into adapting the norms and values of the host society. Note that age at immigration is coded as dummy variable. For the 1st-generation sample, we defined the dummy ASYOUNG to flag immigrants who were younger than 35 at the time of immigration. Since immigration is highly age-selective, it is not surprising that 76 percent of the 1st generation sample immigrated before their 35th birthday. For the 1.5 generation sample, we defined the dummy ASKID to separate respondents who entered the US at a young age (under age 12) from those who were older at the time of immigration. In total, 64 percent of the sampled 1.5 generation respondents immigrated to the US before their 12th birthday. It is expected that the dummies ASYOUNG and ASKID have a positive impact on BMI.

Second, the variable ENGLISH measures respondents' proficiency in English. The expectation is that English language proficiency signals the intensity of contact with the host society and the willingness/eagerness to adopt the host culture. Thus, it is expected that ENGLISH will have a BMI-increasing effect. Finally, the variable JOB indicates whether the respondent's move to the US was strongly motivated by job considerations. Job orientation requires and intensifies acculturation with the host society and thus is expected to have a BMI-increasing effect. Note that the variable JOB is not included in the 1.5 generation models as children and adolescents are assumed to be tied movers following their parents.

With respect to the immigration context variables, the two samples show some vast differences. Compared to the 1.5 generation sample, the 1st generation immigrants have a substantially higher (+19 percentage points) share of Asians, but a lower (-9 percentage points)

share of immigrants of Mexican descent, are more likely to have recently arrived[5] in the US (less than five years ago) and are, on average, not as proficient in English.

Table 2 also shows the bivariate correlation coefficients between BMI and the explanatory variables. For both samples, the immigrant's origin emerges as a strong predictor of BMI with correlations of -0.424 and -0.361 for the 1st and 1.5 generation Asians, respectively. For 1st-generation immigrants, the remaining variables are only weakly linked to BMI. 1.5 generation immigrants moderately strong (bivariate) BMI predictors include age at the time of the survey, marital status (never-married respondents tend to have a lower BMI) and education level (low educational attainment is associated with a higher BMI).

3.2 Methods

To address the research questions, two sets of models are estimated. The first set of models (Models 1 to 3) refers to the 1st generation, and the second set (Models 4 to 6) refers to the 1.5 generation. For both types of models, we start off by estimating a multiple regression model representing the obesity production function. The base model takes on the form:

$$\mathbf{BMI} = \mathbf{X}\beta + \mathbf{Z}\gamma + \varepsilon.$$

Thus, the dependent variable **BMI** is expressed as a linear function of the demo-economic variables, **X**, and immigration context variables, **Z**. The vectors of parameters β and γ are the effects of **X** and **Z** on **BMI**, respectively, and ε represents the vector of error terms. In subsequent steps, we expand the model by including interaction terms with the variables ASIAN and FEMALE, thereby allowing the effects β and γ to systematically vary by origin and by gender.

3.3 Results

The estimation results are summarized in Table 3 and Table 4 for the 1st generation and 1.5 generation samples, respectively. Turning first to the sample of 1st generation immigrations, the base model explains almost a quarter of the BMI variation across the 1,911 immigrants. The estimated parameters suggest that only three of the demo-economic variables systematically affect immigrants' BMI, namely age, gender and marital status. Model 1 suggests that BMI increases with age, but does so at a decreasing rate. Ceteris paribus, it is estimated that the BMI of a 30-year old is 1.64 kg/m^2 higher than that of a 20-year old immigrant, but only 1.04 kg/m^2 lower than the BMI of a 40-year old immigrant. Immigrants at age 52 are estimated to have the highest BMI.

[5] The comparison is somewhat lop-sided as respondents in the 1.5 sample are at least 18 years old. Thus, all those who immigrated as child (< 12 years old, ASKID = 1) cannot also be recent immigrants.

Model 1 also suggests that on average, the BMI of male immigrants exceed that of immigrant women by 1.131kg/m^2. Remarkably, some of the variables that typically show up as powerful BMI predictors are not significant, namely the income variable HHINC, the education variable LOWEDU, and the behavioral variable indicating whether or not the person smokes.

Table 3. Estimation Results*) for 1st Generation Models

	Model 1		Model 2		Model 3	
Variable	b	SE_b	b	SE_b	b	SE_b
Intercept	**18.466**	1.434	**21.175**	2.107	**20.244**	2.020
AGE	**0.314**	0.060	**0.205**	0.089	**0.343**	0.085
AGESQR	**-0.003**	0.001	*-0.002*	0.001	**-0.003**	0.001
FEMALE	**-1.131**	0.163	**-6.391**	2.876	**-1.005**	0.249
SINGLE	*-0.474*	0.281	-0.279	0.400	-0.455	0.423
HHINC	0.001	0.002	**0.005**	0.003	-0.006	0.003
LOWEDU	0.016	0.199	-0.265	0.299	-0.448	0.273
SMOKE	-0.173	0.214	-0.007	0.259	-0.329	0.310
ASIAN	**-3.454**	0.193	**-3.200**	0.289	**-6.507**	2.873
MEXICAN	**1.064**	0.284	**0.815**	0.407	**0.824**	0.303
RECENT	**0.588**	0.231	0.257	0.344	0.058	0.345
ASYOUNG	0.133	0.230	0.120	0.346	-0.124	0.351
ENGLISH	**1.431**	0.423	0.442	0.616	**-2.016**	0.774
JOB	**0.402**	0.164	**0.562**	0.245	*0.388*	0.262
Interactions between [ ] and:			*[FEMALE]*		*[ASIAN]*	
AGE			*0.211*	0.121	-0.024	0.120
AGESQR			-0.002	0.001	0.000	0.001
FEMALE					-0.268	0.330
SINGLE			-0.516	0.567	-0.011	0.564
HHINC			**-0.009**	0.003	**0.008**	0.004
LOWEDU			0.528	0.402	**0.822**	0.399
SMOKE			-0.606	0.469	0.193	0.427
ASIAN			-0.501	0.391		
MEXICAN			0.470	0.568		
RECENT			0.604	0.464	*0.717*	0.464
ASYOUNG			0.028	0.463	**0.408**	0.463
ENGLISH			**1.946**	0.850	4.818	0.928
JOB			-0.243	0.330	-0.149	0.336
R^2	0.243		0.251		0.263	

*) Parameters in bold (italics) are significantly different from zero at $\alpha = 0.05$ ($a = 0.1$)

The variables describing the immigration context do, however, have a powerful impact on BMI. First, the country of origin has a significant and substantial impact on immigrants' BMI. Ceteris paribus, Asian immigrants' BMI is 3.454 kg/m^2 lower than that of non-Asian immigrants. Moreover, being from Mexico adds 1.064 kg/m^2 to a person's BMI.

Second, the model suggests that the first few years after immigration are crucial to controlling immigrant obesity. On average, the BMI of immigrants who arrived in the US less than five years ago (i.e., RECENT = 1), is 0.588 kg/m^2 higher than for comparable immigrants who have been in the US for a longer time. This suggests that the immediate cultural disruption associated with the move across the US border imposes a high weight gain risk that dominates

any potential BMI-increasing effect associated with length-of-exposure to the US obesity culture. Finally, the other acculturation variables do have the expected positive effects. Having immigrated for job opportunities and improved English proficiency are indicators of immigrants' adoption of US culture; both factors are – not surprisingly – estimated to be associated with an elevated BMIs.

Models 2 and 3 paint a more nuanced picture of the factors influencing immigrants' BMI. Model 2 focuses on the differences between male and female immigrants. Just like Model 1, it is estimated that the BMI increases with age, and household income, and varies by country of origin. Furthermore, Model 2 suggests that, in addition to the overall gender gap (the variable FEMALE has a significantly negative coefficient), the effects of some BMI predictors vary significantly between men and women.[6] For immigrant men, but not for immigrant women, rising income is associated with an increasing BMI. In contrast, improved English proficiency has no impact on men's BMI but increases women's BMI significantly. The magnitude of the gender gap thus depends on the specific attributes. For example, the BMI of a 30-year old, never-married male immigrant from Asia with a household income of $30,000, who did not complete high school, immigrated for job opportunities less than five years ago, smokes and is fluent in English, is 0.946 kg/m^2 higher than that of his female counterpart.

Model 3 suggests that the BMI disparities between Asians and Latinos operate through both effect differences (slopes) and differences in the overall level (intercepts). Most remarkable, the model suggests that income and education do not contribute to the BMI variation of Latino immigrants, but do matter strongly for Asians immigrants. Rising income and low educational attainment levels are associated with elevated BMIs among the Asian immigrants. Origin-specific effect differences are also estimated for English proficiency. Latinos whose English is fluent have a significantly lower BMI than those without English proficiency. The difference in estimated BMI amounts to -2.016 kg/m^2. For Asians, however, the estimated difference is positive (-2.016 + 4.818= 2.802) but not significant.

[6] A joint F-test on all the interaction coefficients rejected the hypothesis that the parameters of the interaction terms are all zeroes.

Table 4. Estimation Results*) for 1.5 Generation Models

	Model 4		Model 5		Model 6	
Variable	b	SE_b	b	SE_b	b	SE_b
Intercept	**23.609**	1.851	**23.827**	2.665	**23.403**	2.264
AGE	*0.156*	0.093	0.193	0.132	*0.205*	0.114
AGESQR	-0.001	0.001	-0.002	0.002	-0.002	0.001
FEMALE	**-1.198**	0.293	-0.308	3.687	**-0.844**	0.371
SINGLE	-0.608	0.382	**-1.524**	0.545	-0.259	0.495
HHINC	0.001	0.003	0.005	0.004	0.003	0.004
LOWEDU	**0.937**	0.428	0.131	0.640	**1.054**	0.487
SMOKE	-0.177	0.358	-0.201	0.452	-0.407	0.451
ASIAN	**-2.550**	0.343	**-2.467**	0.483	-2.054	3.955
MEXICAN	0.540	0.429	0.764	0.617	0.314	0.439
RECENT	-1.097	0.778	-0.903	1.023	**-1.971**	0.985
ASKID	**0.966**	0.346	**1.136**	0.491	0.617	0.446
ENGLISH	-1.159	0.777	-1.115	1.164	**-1.947**	0.960
Interactions between [ ] and:			*[FEMALE]*		*[ASIAN]*	
AGE			-0.148	0.186	0.002	0.003
AGESQR			0.003	0.002	-0.880	0.602
FEMALE					-0.750	0.802
SINGLE			**1.543**	0.764	-0.005	0.006
HHINC			-0.009	0.006	-1.533	1.097
LOWEDU			*1.470*	0.858	0.754	0.748
SMOKE			0.067	0.748	2.101	1.609
ASIAN			-0.164	0.683		
MEXICAN			-0.225	0.855		
RECENT			-0.012	1.569	2.542	1.546
ASKID			-0.212	0.693	1.005	0.704
ENGLISH			-0.090	1.558	2.434	1.649
R^2	0.208		0.234		0.223	

*) Parameters in bold (italics) are significantly different from zero at $\alpha = 0.05$ ($\alpha = 0.1$)

Turning now to the second set of models reveals that BMI variations among the 1.5 generation are governed by different determinants than the BMI variations of 1st generation immigrants. Model 4 suggests immigrant origin does play a role but the estimated magnitude is comparatively small: the estimated ASIAN effect is reduced to -2.55 kg/m^2 compared to -3.454 kg/m^2 for 1st generation immigrants and the Mexico effect is not significant for the 1.5 generation immigrants. This indicates that the BMI of later generation immigrants tend to converge, despite the distinct difference that existed among their parental generation. Furthermore, unlike in Model 1 where the age at immigration (captured by variable ASYOUNG) was insignificant, Model 4 suggests that moving at an early age (captured by the variable ASKID) has a BMI-increasing effect on the 1.5th generation: the BMI of those who came as a young child (under age 12) is, on average, 0.966 kg/m^2 higher than of those who entered the US as adolescents. Finally, the estimation result of Model 4 is in line with the well-known negative association between education and the risk of being overweight. Immigrants without high school education have a significantly higher BMI – on average +0.937 kg/m^2 – than the well-educated immigrants.

Model 5 (Model 6) allow the effect sizes to vary by FEMALE (ASIAN). Interestingly, the estimations do not yield significant sex-specific or origin-specific effect sizes. The only exception is the impact of marital status. Model 5 finds that being single is associated with a low BMI among male but not among female immigrants.

The reason why we may see significant interaction effects for the 1st generation but not for the 1.5 generation is that the sample size for the 1.5 generation is smaller than that of the 1st generation sample. Other things being equal, the power of the test is higher as sample size increases. Another possibility is that the 1.5 generation immigrant – by definition – arrived in the US at an early age, which makes it easier to accept the norms, values and behaviors of US society. As a result, the process of adaptation is comparatively smooth and the BMI response to the change of lifestyle tends to be more homogeneous, rather than showing a lot of variation by gender and origin as we found for the first generation immigrants.

4. Summary and Conclusions

This paper estimated obesity production functions for immigrants of the 1st generation and the 1.5 generation using 2002/03 NLAAS data. The research aimed at identifying the linkages between immigrants' acculturation and obesity and to shed light on the relative importance of the different time scales that are relevant in the context of immigration and acculturation, namely age at immigration, biological age, the length of exposure to the high obesity culture, and the year of immigration.

The research design accounted for whether or not immigrants arrived in the US as adults by separately analyzing the 1st and the 1.5 generation immigrants. We found that the BMI predictors operate differently for the two samples. In particular, origin disparities that are quite strong for 1st generation immigrants are less pronounced for 1.5 generation immigrants. Moreover, within the 1.5 generation, a very young age at arrival in the US has a BMI enhancing effect. In contrast, the BMI of 1st generation immigrants is unaffected by whether they arrived during early or late adulthood. For the effect of biological age on BMI, the two generations also differ. Among 1st generation immigrants but not among 1.5 generation immigrants, older ages are associated with a higher BMI.

We find that the BMI of recent arrivals to the US is significantly higher than the BMI of immigrants with a longer (more than five years) sojourn. This suggests that it is the initial exposure to US culture that has a significant BMI-enhancing effect and may even allude to possible nonlinearities of immigrants' overweight trajectory. However, longitudinal data are needed to investigate this issue further. Longitudinal data are also required to get a better

understanding of the possible period effects. In particular, it should be noted that the variable RECENT does not just capture the cohort effect but also a period effect.

The models also suggest that the BMI of Asian immigrants differ significantly from that of Latinos, and the differences are partly due to Asian-Latino differences in effect sizes. English language proficiency and job orientation – used to capture immigrant acculturation – turn out to be salient predictors of immigrants' BMI. Overall speaking, more acculturation is associated with higher BMI, but the mechanism is different by gender and country of origin. Among the first generation, labor-market-oriented immigration is a dominant indicator of the male immigrant's acculturation level; while for the female, English skill is a more representative acculturation indicator closely related to BMI increase. Although we find English proficiency performs as a force that drives BMI convergence to the natives, the magnitude and significance of the language skill variable drop when it comes to the 1.5 generation. This is sensible since early exposure to the English-speaking environment can boost language skills, such that no matter where the interviewee is originally from, progress in acculturation is less hampered by language difference, and the variation of BMI associated with English proficiency will be reduced.

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