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Immigration and The American Obesity Epidemic*

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Abstract

Immigration is an important population dynamic at work in the U.S. but we know little about its impact on American obesity. Built on nutrition transition and immigration theories, the paper provides explanations for immigrants' initial body composition advantage, its partial erosion over time, and the gender difference in the erosion. We find evidence that the American obesity epidemic would be much more severe without the mass immigration that began in 1965. In addition to confirming the erosion in immigrants' body composition advantage, we further find that this erosion is weaker for men than for women. Once immigration's impact is teased out, racial/ethnic disparities in body composition greatly differ from what appear. This study provides gender-specific estimates for the differences in obesity by nativity and residence duration and the net level of Hispanic-white and Asian-white disparities at the mean body mass index (BMI) as well as the overweight, Stage-1 and Stage-2 obesity cutoffs. Our findings suggest that immigration must be taken into account when addressing public health concerns.

Introduction

The past three decades have seen a trend of increasingly unhealthy body composition of the American population, referred to as the obesity epidemic. The American obesity trend appears to coincide with the increasing influx of post-1965 immigrants. This paper argues that the epidemic would have been much worse without the waves of immigration. It also argues that racial/ethnic disparities are obscured by failing to account for immigration's impact. Drawing from theories on nutrition transition and immigration, the paper posits that two sets of forces act in opposite directions. Immigrants' advantage in body composition is driven by the selection of healthy people to immigrate to the U.S. and the selection of unhealthy people to return to their home country. Immigrants' initial body composition advantage, however, is gradually eroded by the exposure to the high risk of obesity in the U.S. An empirical question is which set of forces dominates to determine immigration's impact on American obesity.

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The empirical literature on immigration and health often examines mortality, chronic diseases, health-risky behaviors and perceived health status (e.g., Palloni and Arias 2004; Uretsky & Mathiesen 2007). When obesity is examined, much research looks at specific immigrant groups (e.g., Flegal et al. 2004; Lauderdale & Rathouz 2000), which does not provide an overall picture. The population approach in this paper draws data from a recent, nationally representative sample of American men and women aged 25 to 54 in the National Health Interview Survey (NHIS 2005). It examines immigration's impact on the mean body mass index (BMI) and the three BMI cutoffs for overweight, Stage-1 obesity, and Stage-2 obesity defined by the Centers for Disease Control (CDC). Our study seeks to (1) identify immigrants' initial body composition advantage by contrasting recent immigrants' BMI against natives' and earlier immigrants'; (2) compare the effect of out-migration selection by males and females; and (3) estimate the racial/ethnic disparities controlling for immigrant status and residence duration. Findings from this study provide comprehensive evidence for immigration's impact on the American obesity epidemic.

The American Obesity Epidemic

Unhealthy body compositions are defined by CDC using the body mass index (BMI), defined as the weight in kilograms divided by the height in meters squared.[1] The CDC-defined cutoffs are 25 for overweight, 30 for Stage-1 obesity, and 35 for Stage-2 obesity.[2] We can view these cutoffs as weights for men and women of typical height, since adults do not grow in height. For a typical American man of 176 cm tall, the weight is about 77 kg at the overweight cutoff, 93 kg at the Stage-1 obesity cutoff, and 108 kg at the Stage-2 obesity cutoff. For a typical American woman of 165 cm tall, the corresponding weight at the three BMI cutoffs is about 68, 82 and 95 kg, respectively. A person' health risk increases if his/her BMI exceeds the overweight cutoff. Stage-1 and Stage-2 obesity elevate the risk of type II diabetes, hypertension, heart disease, strokes, and osteoarthritis, often irreversible conditions requiring life-long medical care (CDC 2008). The Surgeon General's Call to Action to Prevent and Decrease Overweight and Obesity (CDC 2008) states that the direct and indirect costs of obesity totaled approximately $117 billion in 2000. The majority of these costs are due to obesity-associated health problems.

When the majority of people maintain their body composition within the normal range of BMI, the population BMI is stable and at equilibrium. However, the prevalence of obesity among Americans rapidly increased over the last three decades of the 20th century and has since remained high, leading to an epidemic of obesity with over 30% of the American adults classified obese in 2003 (CDC 2008).

Obesity disparities are large among major social groups. Gender differences in BMI are not only biomedical (e.g., childbearing) but also social. For example, compared to men, women are less likely to hold high occupational status, which is a protective factor for BMI (Wardle, Waller and Jarvis 2002). Racial/ethnic disparities in BMI are well recognized. According to the measured BMI from the National Health and Nutrition Examination Survey (NHANES)

[1]In the U.S. measurement system, BMI=703·(weight in pounds)/(height in inches)^2.

[2]Another BMI cutoff (18.5) is for normal BMI.

1999–2000, about 40 percent of non-Hispanic blacks, 33 percent of Mexicans, and 29 percent of non-Hispanic whites were obese. BMI is also stratified by socioeconomic groups. A curvilinear relationship is found between education and obesity (Zhang and Wang 2004). Hofferth (2004) suggests that people in deep poverty do not have enough food and may be underweight, whereas people with moderate income may have the highest BMI because of their excessive exposure to fast food, limited access to affordable fresh vegetables and fruits, and lack of medical insurance. In addition, age grading in BMI is mostly attributable to biomedical factors but also to changing life cycle stages. BMI is likely to increase until age 60 and decline afterwards (Wang and Beydoun 2007).

The majority of post-1965 immigrants are Hispanic and Asian, generating increasing research interest in immigrants' health. Acculturation, a process of adapting to the new environment and culture in the host society, speeds up the adoption of the western lifestyle, resulting in an increasingly unhealthy body composition (Nielsen et al. 2002). Many studies examine the body composition of immigrants of specific racial/ethnic and nationality origins (e.g., Kaplan et al. 2004; Flegal et al. 2004; Lauderdale & Rathouz 2000). Using data on recent legal immigrants, Jasso et al. (2004) find that immigrants have a lower BMI than the native born. Goel et al. (2004) also find that immigrants as a whole have lower BMI than natives and further document that immigrants who have spent less than 10 years in the U.S. have a significant lower BMI than those with a longer duration of residence, adjusted for age, gender, education, and income.

In most previous studies, explanations for the residence duration effect are mainly from the acculturation perspective, without considering that gendered return migration patterns may play a role in differentiating the effect of residence duration by gender. Furthermore, even with the large proportion of Hispanics and Asians among immigrants, the degree to which racial/ethnic disparities in BMI are masked is seldom assessed in the literature. Finally, previous research usually examines mean BMI which does not indicate any of the CDC-defined obesity cutoffs.

Theoretical Consideration

To investigate how immigration impacts American obesity, we start with the literature on the Hispanic health paradox. Compared to non-Hispanic whites, Hispanics have a lower socioeconomic profile but also a lower mortality rate, referred to as the epidemiological paradox (Abraido-Lanza et al. 1999). Palloni and Arias (2004) summarize three potential explanations for the paradox. First, selective immigration to the U.S. and selective out-migration from the U.S. reduce the mortality rate of Hispanic immigrants. Under the healthy-immigrant effect healthier people self select to migrate (Jasso and Rosenzweigh 1990) and by the "salmon-bias" effect immigrants return to their home country after periods of poor health (Sorlie et al. 1993). As a result of both in- and out-migration selections, disproportionately healthy Hispanic immigrants remain in the U.S. Second, Hispanics' social and cultural practices are partially preserved during the acculturation process, thereby preventing a rapid adoption of unhealthy behavior and lifestyle of the native born (Sorlie et al. 1993; Abraido-Lanza et al. 1999). Thus, even over a considerable duration in the U.S., Hispanic immigrants may retain partial health advantage over whites. Finally, there is a possibility that the paradox is created by a data artifact, resulting from the use of different data sources to calculate the mortality rate.

Empirical research has yet to provide consistent and complete evidence to support these explanations. Jasso et al. (2004) support the healthy-migrant hypothesis. Palloni and Arias (2004) offer support for the healthy-immigrant effect among foreign-born non-Cuban Hispanics and the salmon-bias effect among foreign-born Mexicans, but no support for the cultural buffering hypotheses. Abraido-Lanza et al. (1999) partially support the cultural buffering effect.

From the Hispanic paradox literature we draw three theoretical explanations: the healthy immigrant effect, the salmon-bias effect, and the cultural buffering effect. We integrate them with principles from nutrition transition theories to derive empirical implications for immigration's impact on American body composition. In this extension, we separate the factors leading to immigrants' *initial* body composition advantage from those leading to the post-migration *erosion* of this advantage.

Favorable Initial Body Compositions among Immigrants

Two independent factors—global nutrition transition and self selection of immigrants—shape the favorable initial body composition among immigrants. The continuous large inflows of immigrants to the U.S. fuel the substantial presence of recent immigrants, making this initial advantage an important aspect of immigration's impact on Americans' body composition

Global nutrition transition—The nutrition transition is defined as a series of changes in diet and physical activity (both at work and during leisure time), reflected in nutrition outcomes such as body composition. There exists great heterogeneity across countries during any time period, as Popkin (2002:93) points out that "over the last three centuries, the pace of dietary and activity change appears to have accelerated to varying degrees in different regions of the world." He classifies five broad nutrition patterns: the first two patterns describe hunting-gathering and pre-industrial societies; the third pattern refers to receding famine and increasing consumption of fruits, vegetables and animal protein, resulting in less malnourishment and more normal body composition; the fourth pattern features the "Western diet", a diet high in saturated fat, sugar and refined foods and low in fiber, associated with a high level of obesity together with a decline in physical activities; and finally the fifth pattern involves institutional and individual efforts to develop a lifestyle that prolongs health.

Concerning the U.S. and its immigrant sending countries, we focus on the last three patterns which currently coexist. The third pattern fits most immigrant sending countries in Asia (such as India, China, and South and Southeast Asian countries). The fourth pattern is a characteristic of the U.S. and portions of the population in many Latin American countries. The fifth pattern is emerging in the U.S. and involves educated native-born professionals, a small segment of the population.

The region of Latin America deserves special attention since the majority of immigrants are from that part of the world, particularly Mexico. While many countries in Latin America entered the fourth nutrition pattern early last century, the U.S. has been in the fourth nutrition pattern for a longer time (Popkin 2002). Pelletier and Rahn's meta analysis (1998) based on almost 1500 empirical studies of developing countries' BMI trend reveals a significant increase in mean BMI between 1957 and 1994 in all major regions of the developing world. During that period, the average of BMI means reported in previous studies is around 23 with a standard deviation of 1.9 for Latin American and Caribbean countries. In comparison, between the early 1960s and 1999–2002 the mean U.S. BMI increased from just over 25 to almost 28 for adult American men and from almost 25 to just over 28 for adult American women (Costa and Steckel 1997; Ogden et al 2004). Rivera et al. (2002) show that Mexico exhibits a later shift with marked increases in obesity in a very short period of time. Overall, Latin American countries have not advanced as deep in the fourth nutrition pattern and have not experienced its cumulative effect to the same degree as the U.S.

In sum, American obesity prevalence has been a step ahead of that of the Latin American countries and several steps ahead of Asian countries. Thus, even if immigrants were randomly selected from their home population rather than self-selected as found in the literature, immigrants at arrival would be more likely to have lower BMI than natives because of the imbalanced global nutrition transition across countries.

Self selection of immigrants—International migration is a serious decision and the move itself is a challenging event, both of which contribute to the self selection of people with favorable health traits. This self-selection is influenced by the relative economic and social situations in the home and host country (Massey et al. 1993; Portes and Rumbaut 2006; Jasso and Rosenzweig 1990). High wage differentials, under-developed market economies, long distances between the sending and receiving countries, and employment-seeking motives all lead to self-selection on observed and unobserved traits including good health. Jasso et al.'s (2004) study of a representative sample of permanent residents highlight the significant advantages of immigrants over natives in regards to a wide range of chronic diseases.

Erosion of Immigrants' Body Composition Advantage

While immigrants bring initial body composition advantage with them, this advantage is eroded with their longer years in the U.S. Two sets of forces operate in opposite directions. In one direction is the widespread exposure to the American lifestyle and the acculturation to this lifestyle among immigrants. In the opposite direction, cultural buffer and return migration slow down the erosion. While exposure, acculturation, and origin cultural buffer are unlikely to differ significantly between men and women, return migration is likely to affect men more strongly than women.

Speedy nutrition transition in the U.S—By virtue of entering the U.S., immigrants cross two worlds of very different economic development levels. Simultaneously, Asian immigrants make a quick transit from the third to the fourth nutrition pattern and Latino immigrants quickly advance within the fourth pattern. This speedy transition involves different aspects all leading to greater risk of obesity. Lakdawalla et al. (2005) suggest that the strenuousness of work, food consumption, and leisure physical activities are related to economic development. The technological advancement in the U.S. causes a decline in the demand for physical strenuousness in industries like construction and household services, which heavily employ immigrant workers. The U.S. has also seen a decline in the relative price of food and a rise in the relative price of physical exercise. For immigrants, while the western diet is a sign of affluence back in the home country, it is affordable with U.S. earnings. At the same time, it is a luxury for immigrants to do physical exercises in leisure time. In addition, as a large proportion of people are heavy in the U.S., obesity may be more socially acceptable (Levy 2002). These aspects contribute to immigrants' speedy nutrition transition and greater risk of obesity.

Immigrants residing in low-income neighborhoods are particularly exposed to fast food and alcohol through heavy advertisements and easy accessibility. As a result, these immigrants quickly lose their initial advantage in body composition. At the same time, professional workplaces expose high-skilled immigrants to the emerging lifestyle of the fifth nutrition pattern that prevents obesity. This influence may stall the erosion of the body composition advantage for a relatively small percentage of immigrants.

Delayed acculturation and cultural buffering—Upon arrival in the U.S., immigrants start their journey of acculturation. However, the speed of acculturation depends on how strongly the origin culture is preserved. With respect to obesity, origin cultures brought from Asia and Latin America feature ethnic diets high in fiber and fresh vegetables and fruits as well as high levels of leisure physical activities (even for Latin American immigrants already in the fourth nutrition pattern). Moreover, most first-generation immigrants maintain a strong identity of their home country (Portes and Rumbaut 2006), which helps preserve the origin culture and slow down acculturation (Abraído-Lanza et al. 1999; Sorlie et al. 1993). Thus, delayed acculturation and cultural buffering hold back the erosion of immigrants' initial advantage.

The salmon-bias effect—This metaphor refers to return migration after a period of poor health. As return migration has a gendered pattern, we expect a gendered salmon-bias effect. Immigrant men often act as pioneers by coming first to the U.S. to find employment opportunities and once this is accomplished, the wife and children follow (Massey et al. 1993). Although economic restructuring and the expansion of the service and health care industries in the U.S. have attracted women migrant pioneers (Houstoun et al 1984), women immigrants are generally more likely to be family-based than men immigrants (Jeffreys 2005).

Pioneer immigrants are more likely to exhibit salmon-like behavior than family-based immigrants. If a pioneer does not find employment in the host society, he returns home and looks for opportunity elsewhere. When women arrive on a permanent residence visa for family unification, the family has usually decided on a permanent stay. The ultimate purpose of permanent immigration is to improve children's life chances (Portes and Rumbaut 2006). Because children are likely to live with their mothers, women immigrants have stronger

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motives to stay in the host society to raise children and help them realize the American dream. Therefore, immigrant women are more likely than men to stay rather than return even when facing a long period of unhealthy conditions.

In addition, the transformation of the American family and the women's movement since the 1970s have empowered American women offering them with greater employment opportunities and freedom than for women in developing countries (Pedraza 1991). Women immigrants from developing countries are thus reluctant to return to the subordinate position in their home country. In contrast, immigrant men regain power by returning to the home country (Grasmuck and Pessar 1991). The fact that over time there are more foreign-born women than foreign-born men indicates the lower return migration rate for women than for men (Jasso and Rosenzweig 1990). Overall, stronger incentives to stay produce a weaker salmon-bias effect for women than for men.

Hypotheses

The above reasoning incorporates nutrition transition theories and immigration theories to explain immigrants' initial advantage in BMI and the convergence to natives' body composition over time at different rates by gender. It stresses how immigration may affect population health in three ways. First, based on the immigrant self selection and the imbalanced global nutrition transition, we hypothesize that immigrants within a short duration after arrival have a body composition advantage over the native born. Continuously incoming immigrants are the necessary condition under which immigration can effectively reduce the American obesity prevalence.

Second, immigrants' speedy nutrition transition within the U.S. and acculturation suggests an inevitable erosion of immigrants' initial body composition advantage. We hypothesize that, while being eroded, the immigrant advantage still remains significant after a considerable time in the U.S. because of origin culture buffer and return migration. In particular, immigrant men may exhibit stronger immigrant advantage and a weaker erosion than immigrant women after a long duration of U.S. residence because of the gendered salmon-bias effect.

Third, the assessment of the impact of immigration on the population as a whole is incomplete without examining group disparities after immigration factors are taken into account. Because the native born have been exposed to the gradual advancement within the fourth nutrition pattern for their whole life whereas the foreign born have experienced a speedy transition or advancement, the causes of obesity disparities by race/ethnicity should differ by nativity. Therefore we need to know the net level of racial/ethnic obesity disparities by comparing the patterns with and without considering immigration's impact. The high minority composition among immigrants increases within-race variations while reducing between-race variations, particularly for the Hispanic and Asian groups (Hao 2007). Thus, the healthier Hispanic immigrants attenuate the overall Hispanic-white unhealthy disparities. By the same token, the healthier Asian immigrants exaggerate the Asian-white healthy disparity in BMI. Our third hypothesis states that the Hispanic-white unhealthy disparity in obesity may be more severe than it appears whereas the Asian edge over whites may not be as large as it appears.

Data and Measures

This study draws data from the 2005 National Health Interview Survey (NHIS), a nationally representative survey conducted by the National Center for Health Statistics. The NHIS is chosen for its two advantages over other data such as National Health and Nutrition Examination Survey (NHANES). It contains key information required for this study, including foreign-born status, ethnic origin, and year of arrival. Second, the large NHIS sample size permits separate analyses of men and women and investigations into nativity/duration and race/ethnicity differences within gender groups. One key limitation of the NHIS is that body weight and height are self reported. For the purpose of our paper, the two advantages outweigh the limitation. We will be cautious in interpreting our findings, focusing more on group comparisons that minimize the self-reporting problem.

Out of the 38,509 households surveyed in the NHIS, one adult per household was randomly selected to answer detailed questions on topics regarding demographic, socioeconomic, and health conditions. Our sample includes respondents aged 25 to 54 years old to focus on the prime-age population.[3] The resulting sample includes 7,169 men and 8,461 women. In the male sample, 21% are foreign born and the corresponding number for the female sample is 19%.

The dependent variable is BMI, measured by the ratio of weight in kilograms to the squared height in meters. This variable was created by the National Center for Health Statistics and extremely high values are top-coded to protect the confidentiality of respondents. The quantile regression model used in this paper produces estimates robust to top coding. The two sets of key explanatory variables are immigration and race/ethnicity. Immigrant status is defined by foreign birth status. Duration of U.S. residence is measured with two categories: less than 10 years and 10 years and longer, with the native born as the reference.[4] Race/ethnicity is measured by a set of dummy variables indicating Hispanic, non-Hispanic Asian, and non-Hispanic black with non-Hispanic white as the reference. Class position is indicated by education and income-to-needs ratio. Educational attainment levels distinguish among high school, some college, college, and beyond college, with lower than high school as the reference. Categories of income-to-needs ratios (income relative to the poverty line of the family) are between 1.0 and 1.5, between 1.5 and 2.5, between 2.5 and 3.5, and above 3.5, with below 1.0 as the reference. Life cycle is measured by age and age-squared. Family characteristics include number of children and marital status, which distinguishes among married, divorced/widowed/separated, never-married, and cohabiting. We measure welfare participation with the use of Food Stamp Program. See Appendix Table 1 for the descriptive statistics for variables used in the analysis for the man and woman subsamples.

[3]Pregnant women are excluded from the sample.

[4]Although more detailed information about U.S. residence duration is available, we use two categories to avoid small cell sizes of longer duration categories.

Analytic Strategies

Taking advantage of the full BMI distribution, we first use the ordinary least square (OLS) model to estimate the conditional mean BMI and then use the quantile regression (QR) model to estimate the conditional quantiles corresponding to the three BMI cutoffs for overweight, Stage-1 obesity, and Stage-2 obesity. The term quantile is a general expression for the ordered values of a variable, such as percentiles and deciles. For our study, the overweight cutoff corresponds to the 29th percentile of U.S. men's BMI and the 47th percentile of U.S. women's BMI, and is denoted by Q_p ($Q_{.29}$ for men and $Q_{.47}$ for women), where $0 < p < 1$. Stage-1 obesity is $Q_{.76}$ for men and $Q_{.75}$ for women and Stage-2 obesity is $Q_{.94}$ for men and $Q_{.90}$ for women. The mean BMI is 27.4 ($Q_{.56}$) for men and 26.7 ($Q_{.59}$) for women. Thus, the mean BMI does not correspond to any CDC-defined BMI cutoffs for either men or women. In addition, while the quantile corresponding to Stage-1 obesity cutoff is similar for men and women, the quantile corresponding to Stage-2 obesity differs moderately between men and women. A more dramatic gender difference is found in the quantile for the overweight cutoff. This fact suggests that modeling only the mean BMI does not fully address the obesity concern. To address this limitation, we use the QR model. The QR model is a natural extension of the OLS, first introduced by Koenker and Bassett (1978) and recently disseminated to social science researchers by Hao and Naiman (2007).

Let y_i be the BMI and x_i a vector of covariates (including the constant term) for individual i. The familiar OLS model can be expressed as $y_i = \beta' x_i + \varepsilon_i$. The OLS model predicts the conditional mean BMI: $E(y_i \mid x_i) = \beta' x_i$. In a similar manner, the QR model predicts conditional quantiles: $Q_p(y_i \mid x_i) = \beta_p' x_i$ where β_p is a vector of parameters specific for the p^{th} quantile Q_p. We will estimate three sets of parameters for the three quantiles corresponding to the conditional BMI cutoffs for overweight, Stage-1 and Stage-2 obesity.

Extending the OLS model to the QR model offers two advantages. The QR model allows us to estimate precisely the effects of covariates on the three BMI cutoffs rather than just the mean and also identify where the effect is the strongest. Moreover, the robust property of QR models is attractive for this study because the estimates are not sensitive to either the potential underreporting problem in people's weight relative to their height or the top-coding practice used with survey data (Koenker 2005; Hao and Naiman 2007). In contrast, OLS regression estimates are sensitive to these issues.

For both OLS and QR, we specify two models. In the baseline model BMI is a function of race/ethnicity, class position (education and income-to-needs), life cycle (age and age-squared), family characteristics (marital status and number of children), and Food Stamp participation. This model assumes no immigration effect. In the full model, we include immigration variables measuring immigrant status and length of U.S. residence. Each model is specified separately for men and women. This gives us a total of eight sets of results: two types of regression analysis (OLS and QR) for both the baseline and full models within each gender group.

Descriptive Analysis

We examine the histogram of BMI for men and women in Figure 1, which imposes the normal curve to make clear the skewness. To see the different locations of the mean and the CDC-defined cutoffs, we mark them as vertical lines. The mean BMI falls between overweight and Stage-1 obesity for both men and women, i.e., typical men and women are overweight in the U.S. The BMI distribution for women is more right-skewed than men's, with higher densities over the normal weight range and the Stage-2 obese range.

Based on the density function in Figure 1, we make the cumulative probability function and then take its inverse to create the quantile function. Figure 2 compares the quantile function between men and women. The y-axis indicates the BMI quantiles (the ordered values of BMI) and the x-axis indicates the cumulative proportion of the population (p) having BMI below the corresponding quantile. The solid curve is for men and the dashed curve for women. Figure 2 shows how markedly two of the three CDC-defined cutoffs differ between men and women. For example, corresponding to the overweight cutoff (25 in BMI), the cumulative probability is much less for men than for women (more women have normal weight than men). The quantile functions for men and women converge after the Stage-1 obesity cutoff and then depart in an opposite direction: more women than men are stage-2 obese. The gendered patterns of quantiles corresponding to the BMI cutoffs suggest that separate QR analyses are necessary to identify immigration's effect on BMI cutoffs specifically for men and women.

Four body composition statuses are defined by the three CDC cutoffs: (1) normal (between the normal cutoff of 18.5 and the overweight cutoff of 25), (2) overweight (between the overweight cutoff and the Stage-1 obesity cutoff of 30), (3) Stage-1 obese (between the Stage-1 obesity cutoff and the Stage-2 obesity cutoff of 35), and (4) Stage-2 obese (above the Stage-2 obesity cutoff).[5] Figure 3 shows the racial patterns in these four statuses for men and women with a focus on white, Hispanic and Asian. Note that each racial/ethnic group includes both native born and foreign born. Among men and women, Asians have a much healthier body composition distribution than the other two groups. White men, Hispanic men, and Hispanic women appear to be at high risk because over half of them are overweight, Stage-1 obese, or Stage-2 obese. Only Asian women have a majority in the normal weight range.

Figure 4 shows the percentage distribution of the four BMI statuses for each nativity/residence-duration group separately for men and women. Among men, immigrants arriving within 10 years have the healthiest BMI. A smaller immigrant advantage over the native born remains for immigrant men who have stayed in the U.S. for 10 years or longer. The percentages for State-1 and Stage-2 obesity are lower for immigrants than for natives so the immigrant advantage appears to be in these categories but not in the overweight category. Immigrant women with shorter residence lengths also exhibit an advantage, again in the Stage-1 and Stage-2 obesity categories. However, a long U.S. residence cancels this advantage and immigrant women become similar to native-born women in all BMI

[5]We do not discuss malnourishment in this paper.

categories. These patterns suggest that both immigrant men and women have an initial advantage in body composition but the erosion of this advantage is more severe for women than for men. We now turn to examine whether these patterns hold in multivariate analysis.

Multivariate Analysis

Estimates from the full model allow us to test the hypotheses about immigrants' initial BMI advantage and its erosion over time. Comparing the baseline model and the full model tests the third hypotheses about immigration's impact on the racial/ethnic BMI patterns. In estimating the baseline model and the full model, we first perform the conventional OLS analysis as a bridge to the existing empirical work and then the QR analysis to allow for differential effects on the BMI cutoffs for overweight and Stage-1 and Stage-2 obesity. In presenting our results for testing each hypothesis, we examine OLS before QR and men before women within OLS and QR.

Immigration's Impact: Initial Advantage and Erosion Over Time

OLS results—Column 1 of Table 1 presents the estimates for immigration effects on the conditional mean BMI from the full model, which includes immigration variables in addition to a set of demographic and socioeconomic covariates. Presented are the estimates for immigration variables, two dummy variables indicating two groups of immigrants defined by lengths of U.S. residence (less than 10 years vs. 10 years and longer), with natives as the reference. The significant results show that immigrant men who arrived in the U.S. within 10 years have a mean BMI 1.737 lower than their native-born counterparts, all else equal. Substantively this coefficient means that a typical native-born man has a mean BMI at 27.4 whereas a typical immigrant man has a mean BMI at 25.7 (almost in the normal range). We can also translate this coefficient into a measure of weight for men at the typical height. Column 1 of Table 2 shows that for a typical native-born man who is 176 cm tall (5′8″), the weight at the men's mean BMI is about 85 kg (187 lb). Being an immigrant within 10 years of arrival is estimated to reduce the weight by 5.4 kg (12 lb) to 79.5 kg (175 lb). Immigrants' initial advantage declines with a longer stay in the U.S. Immigrant men who have stayed in the U.S. for 10 years or longer retain a smaller but still significant advantage (−1.039) over native men.

A similar pattern is found for women from the OLS estimates: a strong initial advantage and an erosion of this advantage over time but their advantage remains over natives. The bottom panel of Column 1 in Table 2 shows that for a typical native-born women who is 165 cm tall (5′4″), the weight at the women's mean BMI is 73 kg (160 lb). Foreign born status and residence duration less than 10 years can reduce the weight by 5.4 kg (12 lb) to 67 kg (148 lb). Given the shorter stature of women than men, the initial immigration advantage appears larger for women than for men.

Table 1 also presents the percentage of initial advantage that is eroded for immigrants who have been in the U.S. for 10 or more years. The percent eroded is much greater for immigrant women than immigrant men (52.9% vs. 40.2%). Because the model controls for a set of factors including race/ethnicity, family factors, and life cycle, the effects of acculturation and origin cultural buffer are unlikely to differ by gender significantly. Thus the greater erosion for women than for men supports our second hypothesis: the gendered erosion of immigrant initial advantage is likely because of the weaker salmon bias effect for women than for men. It suggests that not only biomedical factors but also population dynamics shape the complex gender difference in obesity.

Quantile regression results—Columns 2–4 in Table 1 show the QR results. The sign of QR estimates agree with the OLS estimates showing immigration's effect. For men, the initial advantage, the erosion over time, and the retained advantage for 10 years or longer duration are all significant at the three cutoffs. However, QR estimates show significantly different *magnitudes* of immigration's effect, increasing from the overweight cutoff, to the Stage-1 obesity cutoff, and to the Stage-2 obesity cutoff. Translated to the weight measure shown in Columns 2–4 in Table 2, the weight reduction due to the initial immigrant advantage for a typical-height man is 3 kg (6.6 lb) at overweight, 7 kg (15.4 lb) at Stage-1 obesity, and 11 kg (24.3 lb) at Stage-2 obesity.

The degree of erosion, moreover, declines from the Stage-1 obesity cutoff to the Stage-2 obesity cutoff from 43% to 32%. Both the greater initial advantage and the milder erosion at Stage-2 obesity suggest that immigration's impact on obesity is the strongest at Stage-2 obesity as both recent and earlier immigrant men are less likely to become Stage-2 obese.

While in general the male patterns obtained from the QR analysis hold for women, e.g., the initial immigrant advantage concentrated in the obesity-related regions, a number of important gender differences are notable. First, the initial advantage of women immigrants is greater than that of men immigrants, e.g., at Stage-1 obesity, the immigrant advantage is estimated to be −2.834 for women, as compared to −2.246 for men. Again translated to the weight measure shown in Table 2 (bottom panel), the weight reduction due to the initial immigrant advantage for a typical-height woman is 4 kg (9 lb) at overweight, 7.7 kg (17 lb) at Stage-1 obesity, and 11 kg (24.3 lb) at Stage-2 obesity. These weight reductions indicate a greater effect of the immigrant initial advantage for women than for men given the relatively shorter stature among women than men.

Second, the erosion is faster for women than for men at Stage-1 and Stage-2 obesity cutoffs, 56.9% and 56.2%, respectively (bottom of Table 1). So while women immigrants start off with a greater advantage over native-born women than in the men's case, with a stay of 10 years or longer their relative advantage becomes similar to men's at Stage-1 obesity and less than men's at Stage-2 obesity. This gendered erosion pattern further supports our second hypothesis that immigrant women with unhealthier body composition are more likely to stay in the U.S. than immigrant men, i.e., a weaker salmon-bias effect for women than for men.

The QR results characterize more precisely immigration's effects that are meaningful for public health. Compared to the OLS estimates, the QR estimates not only capture a much stronger immigration effect but also identify the location where the immigrant advantage concentrates and how the erosion differs by gender. Both types of analysis find that immigration has reduced the severity of American obesity, and the identified gender differences suggest the contribution of gendered immigration and return migration to the complex gender patterns of BMI.

Immigration Effects on the Native Born: Racial/Ethnic Disparities

In this part of analysis we focus on the Hispanic-white and Asian-white disparities. While black obesity is also a public health concern, immigration should not have a large impact on blacks' BMI because of the relatively small volume of black immigrants. The prevalence of obesity in the Hispanic population is expected to be higher when accounting for immigration. Similarly, native-born Asians' BMI may not be as healthy as currently thought. These expectations are based on (a) the fact that about a half of the Hispanic population and about three quarters of the Asian population in the U.S. are foreign born and (b) our earlier findings that immigrants, including those staying for 10 years or more, are healthier than the native born. We estimate the net level of racial/ethnic disparities, which can be conceived as racial/ethnic disparities at the same SES level and other covariates' levels, for either immigrants or natives.

We examine the degree to which immigration impacts racial/ethnic disparities in BMI by comparing the estimates for the racial variables between the baseline model (controlling for all covariates except for the immigration variables) and the full model (controlling for all covariates including the immigration variables). Table 3 shows the results.

OLS results—Column 1 of Table 3 shows the OLS results. In the top panel for men, being Hispanic increases one's BMI from .459 points higher in the baseline model to 1.147 points higher in the full model. This indicates greater BMI for male Hispanics when immigration variables are controlled. In other words, native-born Hispanic men have a BMI 1.147 points higher than native-born white men at the conditional mean BMI. In addition, foreign-born Hispanic men within 10 years of arrival are actually healthier than native-born whites, which is calculated as 1.147−1.737=−0.59 by summing the Hispanic coefficient (1.147 shown in Table 3) and the recent immigrant coefficient (−1.737 shown in Table 1).

Native-born Asian men's healthier body composition than white men's is overstated by the baseline model when foreign-born status and residence duration are not controlled. In the full model, native-born Asian men's advantage drops by over one half to −.85 from −1.788. Thus, native-born Asian men have a BMI −.85 points lower than native-born white men at the conditional mean BMI. The composite effect for foreign-born Asian men within 10 years of arrival is calculated as −.85−1.737=−2.587.

The basic story about the immigration effect on racial/ethnic disparities among women (the bottom panel of Column 1 in Table 3) is similar to that for men: introducing immigration variables reveals greater Hispanic-white unhealthy disparities and smaller Asian-white healthy disparities.

Quantile regression results—Examining the QR estimates, we see that the Hispanic effect is suppressed and the Asian effect is inflated by failing to control for immigration. For men, the Hispanic-white disparity estimated by the baseline model is significant only at the overweight cutoff and close to zero at Stage-1 and Stage-2 obesity cutoffs. However, when immigration variables are controlled, the Hispanic-white disparity not only exists at all three cutoffs but is more severe at the Stage-1 and Stage-2 obesity cutoffs than that at the overweight cutoff. Thus the fact that immigrants are healthier obscures the net level of

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Hispanic-white disparity at Stage-1 and Stage-2 obesity cutoffs. The Asian-white disparity is affected in an opposite way. The baseline model yields significantly more favorable body composition among Asian men than white men at all three cutoffs with a larger gap at the two obesity cutoffs. Once immigration's impact is controlled, Asian men's advantage falls and becomes non-significant at the Stage-2 obesity cutoff. The decline in Asian men's advantage is greater at the obesity cutoffs.

For women, the QR estimates reveal a similar pattern when immigration variables are included. There is one difference in the results between men and women. While Asian men and white men are similar at the Stage-2 obesity cutoff, Asian women and white women are similar at the overweight cutoff.

In sum, both the OLS and QR results support our third hypotheses about immigration's impact on racial/ethnic disparities. The QR estimates further identify the net level of Hispanic-white and Asian-white disparities at the overweight, Stage-1 and Stage-2 obesity cutoffs.

Conclusions

Immigration is an important population dynamic at work in the U.S. but we know little about its impact on American obesity. Unlike most studies on immigration and health that focus on specific immigrant groups, this paper takes a population approach. Built on nutrition transition and immigration theories, the paper provides explanations for immigrants' initial body composition advantage, its partial erosion over time, and the gender difference in the erosion. We find evidence that the American obesity epidemic would be much more severe without the mass immigration that began in 1965. In addition to confirming the erosion in immigrants' body composition advantage, we further find that this erosion is weaker for men than for women. Once immigration's impact is teased out, racial/ethnic disparities in body composition greatly differ from what we observe. This study provides estimates for the differences in obesity by nativity and residence duration and the net level of Hispanic-white and Asian-white disparities at the mean BMI as well as the overweight, Stage-1 and Stage-2 obesity cutoffs. Our findins suggest that public health interventions should differentially address the prevalence of obesity for the native born versus the foreign born. If the observed growth in obesity in the U.S. is already alarming, our findings call for greater concern.

The most straightforward policy implication is to help delay the erosion of immigrant initial advantage. The less straightforward policy implications can be drawn from immigration's impact on American obesity. In many aspects (recent and earlier immigrants' BMI as well as racial/ethnic disparities in BMI) immigration's impact is stronger on the two obesity cutoffs than on the overweight cutoff. The prominent BMI disparity between Hispanics and whites at the same socioeconomic level calls for effective intervention programs. Similarly the decline in Asians' favorable BMI deserves policy attention to preserve their advantage.

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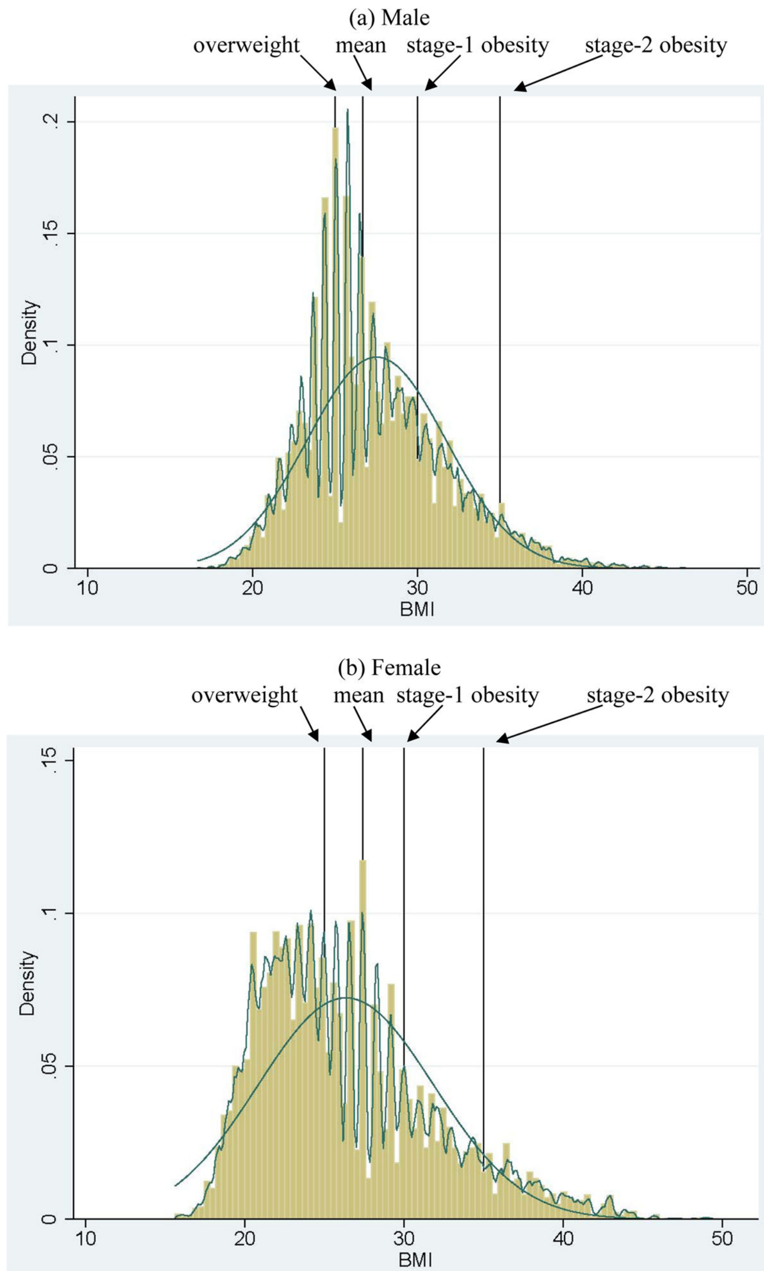

Figure 1.
Histogram for Body Mass Index (BMI) by Gender: 2005 American Population

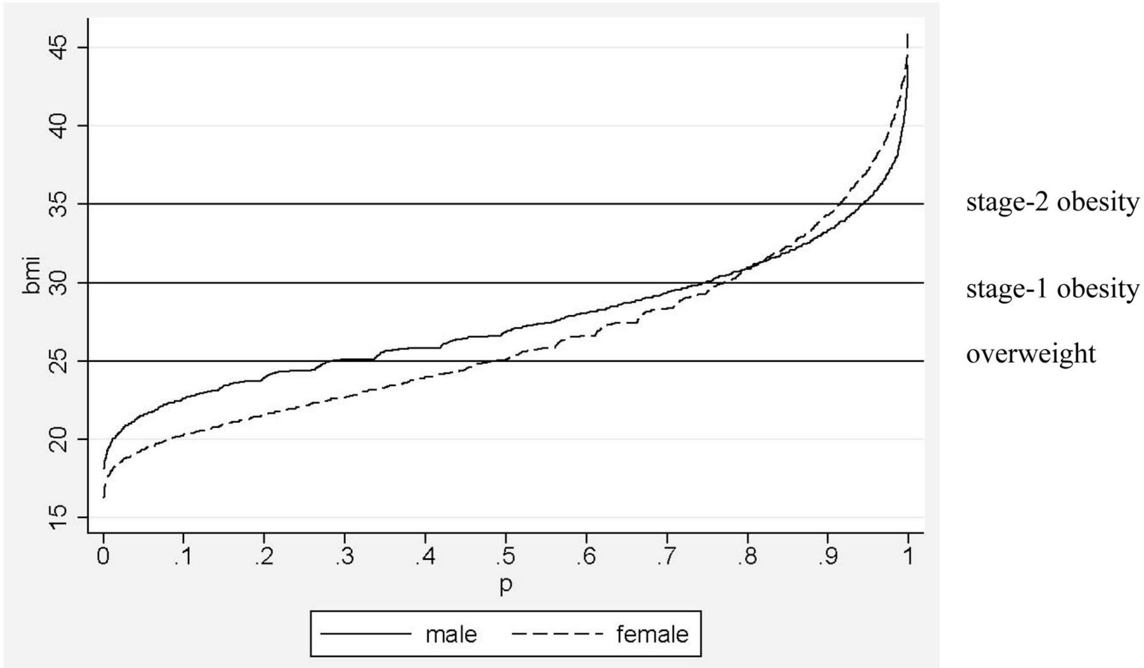

Figure 2.
BMI Quantile Functions by Gender: 2005 American Population

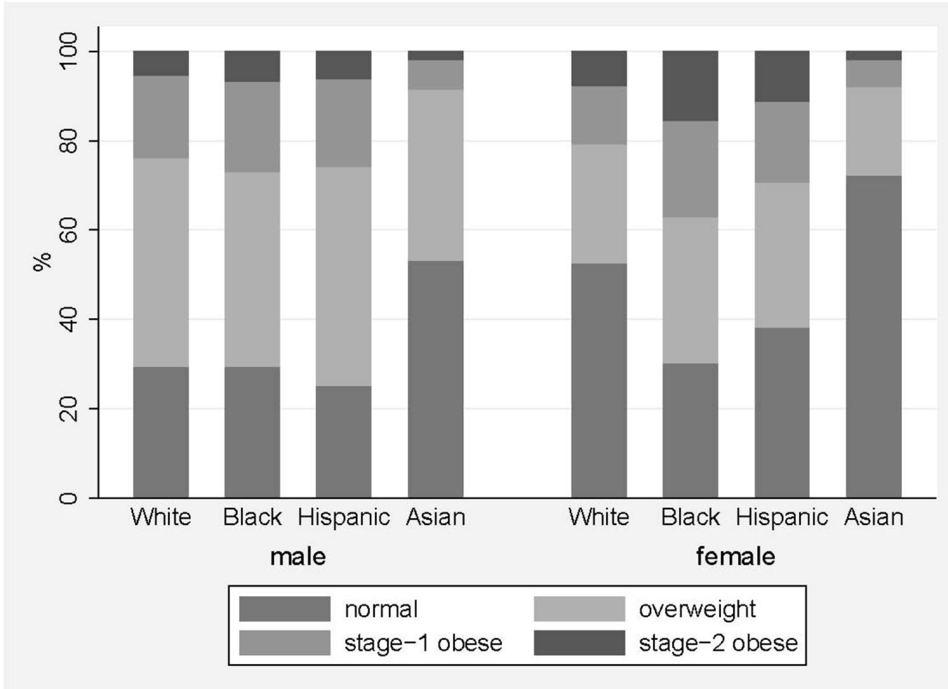

Figure 3.
Percentage Distribution of BMI Status by Race/Ethnicity and Gender: 2005 American Population

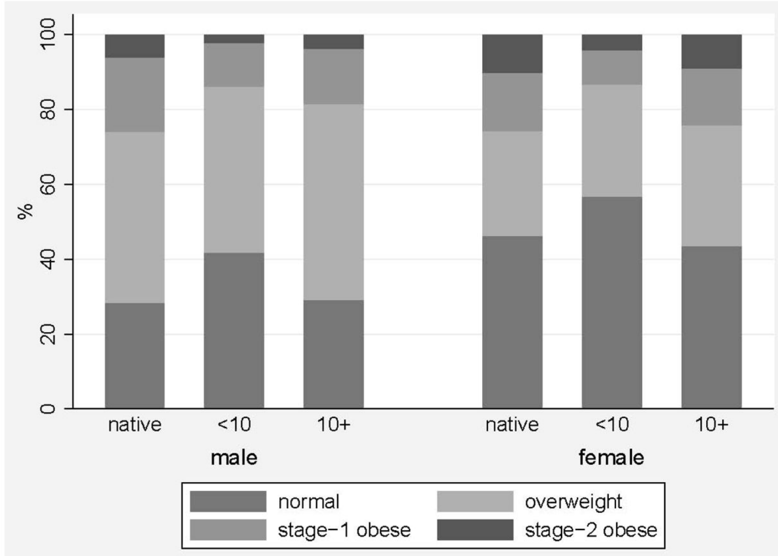

Figure 4.
Percentage Distribution of BMI Status by Nativity/U.S.-Residence and Gender: 2005 American Population

Table 1

Impact of Immigration on Body Mass Index (BMI): 2005 American Population

Variable	OLS		Quantile Regression	
	Mean BMI	Overweight cutoff	Stage-1 obesity cutoff	Stage-2 obesity cutoff
Male				
Immigrant U.S. residence (native-born as reference)				
< 10 years	−1.737**	−0.975**	−2.246** [a]	−3.546** [b c]
10+ years	−1.039**	−0.558**	−1.289** [a]	−2.398** [b c]
Erosion (%)	40.2	42.8	42.6	32.4
Female				
Immigrant U.S. residence (native-born as reference)				
< 10 years	−1.984**	−1.517**	−2.834** [a]	−4.040** [b c]
10+ years	−0.934**	−0.859**	−1.222**	−1.768** [b]
Erosion (%)	52.9	43.4	56.9	56.2

Note: Presented are estimates from the full model, separately for men and women. The full model includes race/ethnicity, age, age-squared, education, income-to-needs, number of children, marital status, and Food Stamp participation, the coefficients of which are not shown in the table.

The superscripts (a, b, and c) indicate that the difference in coefficients are significant between Stage-1 obesity cutoff and overweight cutoff (a), between Stage-2 obesity cutoff and Stage-1 obesity cutoff (b), and between Stage-2 obesity cutoff and overweight cutoff (c).

* $p < .05$

** $p < .01$

Table 2

Interpretation of Initial Immigrant Advantage in BMI in terms of Weights of Typical Men and Women

	Mean BMI	Overweight	Stage-1 Obesity	Stage-2 Obesity
Typical men with height = 176 cm				
BMI score	27.4	25	30	35
Weight (in kilogram)	84.9	77.4	92.9	108.4
Change in BMI score (OLS and QR coefficient)	−1.737	−0.975	−2.246	−3.546
New weight (in kilogram)	79.5	74.4	86.0	97.4
Change in weight (in kilogram)	−5.4	−3.0	−7.0	−11.0
Typical women with height = 165 cm				
BMI score	26.7	25	30	35
Weight (in kilogram)	72.7	68.1	81.7	95.3
Change in BMI score (OLS and QR coefficient)	−1.984	−1.517	−2.834	−4.040
New weight (in kilogram)	67.3	63.9	74.0	84.3
Change in weight (in kilogram)	−5.4	−4.1	−7.7	−11.0

Table 3

Immigration's Impact on Racial/Ethnic Disparities in BMI: 2005 American Population

Variable	OLS		Quantile Regression	
	Mean BMI	Overweight cutoff	Stage-1 obesity cutoff	Stage-2 obesity cutoff
Male				
Baseline model: w/o immigration variables				
Hispanic vs. white	0.459**	0.631**	0.122 [a]	−0.032
Asian vs. white	−1.788**	−1.293**	−2.562** [a]	−3.228* [b]
Full model: with immigration variables				
Hispanic vs. white	1.147**	1.076**	0.960**	1.387**
Asian vs. white	−0.850**	−0.771**	−1.375**	−1.616
Female				
Baseline model: w/o immigration variables				
Hispanic vs. white	1.240**	1.377**	1.306**	0.709
Asian vs. white	−1.892**	−1.112**	−2.556** [a]	−4.442** [b c]
Full model: with immigration variables				
Hispanic vs. white	1.838**	2.015**	2.184**	1.849**
Asian vs. white	−0.879*	−0.415	−1.067* [a]	−2.810** [b c]

Note: Both models control for age, age-squared, education, income-to-needs, number of children, marital status, and Food Stamp participation, the coefficients of which are not reported in the table.

The superscripts (a, b, and c) indicate that the difference in coefficients are significant between Stage-1 obesity cutoff and overweight cutoff (a), between Stage-2 obesity cutoff and Stage-1 obesity cutoff (b), and between Stage-2 obesity cutoff and overweight cutoff (c).

* $p < .05$

** $p < .01$

Appendix Table 1

Descriptive Statistics of Variables Used in Analysis

Variable	Male		Female	
	Mean	SD	Mean	SD
BMI	27.4	4.2	26.7	5.6
Race/Ethnicity				
Black	0.124	0.330	0.165	0.371
Hispanic	0.203	0.402	0.208	0.406
Asian	0.037	0.189	0.031	0.174
Immigrant status & U.S. residence				
native-born	0.791	0.407	0.813	0.390
< 10 years	0.069	0.253	0.061	0.239
10+ years	0.140	0.347	0.126	0.332
Education				
no high school	0.179	0.383	0.176	0.381
high school	0.247	0.431	0.229	0.420
some college	0.275	0.447	0.301	0.459
college	0.209	0.407	0.196	0.397
beyond college	0.090	0.286	0.099	0.299
Income-to-needs				
<1.0	0.094	0.292	0.146	0.353
1.0–1.5	0.071	0.257	0.091	0.288
1.5–2.5	0.168	0.374	0.180	0.384
2.5–3.5	0.169	0.375	0.148	0.355
>=3.5	0.498	0.500	0.435	0.496
Age	39.7	8.4	39.5	8.5
Age-squared	1645	671	1634	676
Marital status				
married	0.536	0.499	0.540	0.498
not married	0.166	0.372	0.223	0.416
never married	0.234	0.424	0.187	0.390

Variable	**Male**		**Female**	
	Mean	**SD**	**Mean**	**SD**
cohabiting	0.064	0.244	0.051	0.219
Number of children				
0	0.577	0.494	0.420	0.494
1–2	0.332	0.471	0.435	0.496
3–10	0.091	0.287	0.145	0.352
Food Stamp participation	0.051	0.221	0.111	0.314
% of population	0.459		0.541	