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Are Recent Immigrants Larger than Earlier Ones at Their Arrival? Cohort Variation in Initial BMI among US Immigrants, 1989–2011

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Abstract Studies have reported that newly-arrived immigrants to the US often have better health outcomes, including lower body mass index (BMI) than established ones. This study tests the hypothesis about variation in initial BMI among immigrants who have come to the US during different time periods. Using 1989–2011 data from NHIS, we found that recent immigrants in general were larger at their time of arrival than the earlier ones. However, we also observed variations in initial BMI across racial and ethnic origin groups. For example, we found the trends for Hispanic and Asian immigrants to have increased during the study period. The average initial BMI for recent Hispanic immigrant cohorts surpassed the upper limit for normal weight. While earlier cohorts of Asian immigrants had much lower initial BMI than other immigrant groups, the estimated annual increase among Asians was the most rapid. Our findings support the observation about the rising body weight and obesity rates worldwide. The policy implications of our findings were also discussed.

Keywords BMI · Overweight · Obesity · Cohort variation

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Introduction

Obesity, which is currently defined as a body mass index (BMI) of 30 or greater by the Centers for Disease Control and Prevention [4] is considered a major public health issue around the world. According to the World Health Organization (WHO), about 475 million adults worldwide were classified as obese in 2013. Not only that, another 1.0 billion people were considered overweight (adults who have a BMI of 25 or more) [11, 28]. Given the links that researchers have made between obesity and several poor health conditions, including diabetes, heart diseases and other chronic ailments [23], it is not surprising that the discourse about obesity has ramped up, attracting significant attention by researchers, policy makers and health advocates alike. For example, in the United States, Mrs. Obama (the First Lady) has launched a campaign with a focus on reducing childhood obesity [15].

The United States is no exception to the worldwide obesity threat. For example, several recent studies have reported that more than two-thirds (68.8 %) of American adults either overweight or obese [9, 16–18]. Researchers have concluded that the recent figures are much higher than those observed prior to the 1980s. For example, according to the Center for Disease Control, no American state had an obesity rate that was higher than 15 % during the 1980s. However, since the 1990s, this trend seems to have been reversed. Indeed as of 2010, 35 states had obesity rates that were 25 % or higher, and 12 other states had rates that were equal to or in excess of 30 % [5]. More importantly, it has also been observed that the rates of extreme obesity cases (BMI of 40 or more) have risen among both American adults and children [4, 5].

Even though obesity rates in America have increased in recent years, it has also been observed that the reported

patterns of obesity vary greatly among social groupings and sub-populations. Higher levels of obesity have been reported, for example, among the poor and those with less or limited education [3]. Equally important, differential obesity rates have also been reported among new and established immigrants [8, 10]. For example, existing studies have concluded that newly-arrived immigrants to the US tend to have better health outcomes and have lower BMI than well-established immigrants (those who have been living in the US for a long time). These findings have been found to be true after researchers have controlled for aging and other relevant factors [14].

Though the reasons that have been offered by researchers to account for the rising obesity rates are widely debated in the academic and non-academic circles, one of popular explanations in obesity or weight gain among established and non-established immigrants have to do with lifestyle differences [1]. According to this perspective, many immigrant sending countries are less likely to produce overweight people by virtue of their lifestyles and cultural practices (e.g., food habits) in comparison to those found in the US. Not surprisingly, exposure to the sedentary American culture and its diet which is heavy in saturated fats and sugary products, for example, is commonly blamed for the gradual dissipation of weight advantages among immigrants.

One major weakness of existing studies on established and non-established immigrants is their methodological approaches. For the most part, previous studies have used two indicators of immigrants' exposure to American culture: (1) the effect of duration in America, and (2) generations in America [6, 8, 24]. Relying mainly on cross-sectional data, these studies have reported that longer duration in US and later generations in US were associated with higher BMI, the so called "unhealthy acculturation effects." As Borjas [2] and Pitkin and Myers [19] have argued, the use of cross-sectional data to analyze longitudinal trends made such studies vulnerable to the "cross-sectional fallacy."

The problem with this methodological approach is that since the various immigrants in America who are identified in cross-sectional surveys arrived during different time periods, it is reasonable to argue that the earlier immigrant arrivals are those who have been resident in the country longer than their more recent counterparts. As a result, if one find in cross-sectional data that there is an association between length of stay (longer duration in America) and BMI, it is not easy to conclude that such an association is due to more exposure to American culture or the result of selectivity (that is, earlier cohorts of immigrants to America may have been selected on the basis of different criteria than recent immigrants). Indeed it is nearly impossible to separate acculturation effects and the cohort differences in cross-sectional surveys. Thus, if earlier arrival cohorts have a lower or higher BMI than more recent cohorts at the time of their arrival in America, these cohort differences would attenuate or exaggerate the negative effect of exposure to American diet and lifestyle. The result would be an inaccurate understanding of changes in immigrants' health status in America.

One major source of cohort variation in initial body weight concerns the pre-migration experiences of these immigrants to America in their countries of origin. Overall, obesity rates in the less developed countries (LDCs), where most immigrants to America have come from during the past few decades have historically been lower than those found in the more developed countries (MDCs). One major reason for this pattern has to do with the fact that the LDCs are at an earlier stage of their nutrition transition [7, 20]. The nutrition transition, researchers note, involves a shift in diet and activity patterns which in turn shape health outcomes such as body weight [21]. While developed countries have long been used to the so called "Western" diet regime [10]; one that is based on refined foods, meat and dairy products containing high levels of saturated fats, many people in the LDCs have just begun to transit towards this trend [21]. At the moment, it is reasonable to suggest that the nutrition transition is increasingly evident among middle- and lower-income countries as their standard of living improves [7]. As Chopra et al. [7] have reported, rapid urbanization in the developing world is bringing about changes in lifestyle; toward more sedentary ones with reduced physical activities. This shift in diet and lifestyle have contributed in no small way to the rising incidence rates of obesity and non-communicable diseases globally as Chopra et al. [7] have pointed out.

Although Asians generally have a much lower BMI level than many Europeans a few decades ago, this pattern is changing [30]. More recent data from the WHO have noted, for instance, that obesity rates in China almost doubled between 1980 and 2008. A similar pattern (rising levels of obesity) has also been reported for India [25] and Latin American countries [22].[1] Given the fact that most post-1965 immigrants are from Asia and Latin America, we suspect that this rapid increase in overweight and obesity in Asia and Latin America would be evident among the immigrants they send to US. While other researchers have also suspected that recent immigrants are larger than earlier ones at their time of arrival [6, 10], for the lack of empirical studies, we know very little about cohort variations in initial weight status of immigrants to America.

[1] 1. For country specific BMI rates, see http://www1.imperial.ac.uk/publichealth/departments/ebs/projects/eresh/majidezzati/healthmetrics/metabolicriskfactors/metabolic_risk_factor_maps/.

In this study, we tested the hypothesis that recent immigrants to America have higher BMI at their time of arrival than earlier ones. Using data from National Health Interview Survey (NHIS) that has measures on immigrants' weight and height, we provided some insights into BMI levels among various immigrant cohort groups. Such a study has theoretical and policy implications. At the theoretical-level, findings from the study could contribute to the discourse on the diet and nutrition transition that is going on in many developing countries where most recent immigrants to America come from. In terms of policy, the findings could also be used for preventive efforts geared towards reducing the obesity related health issues facing recent and established immigrants in America.

Methods

Study Design, Data Sources and Sample Selection

We used repeated cross-sectional design to investigate trends in immigrants' initial weight status during the past two decades. The data came from the NHIS conducted between 1989 and 2011 [12]. NHIS was conducted by the National Center for Health Statistics which used a complex, multistage probability design to select a representative sample of the civilian non-institutionalized population in the US. In general, the response rate for the annual NHIS exceeded 85 % [12]. The NHIS is one of the few national representative surveys with information on immigration status, their length of residence, and weight and height measures. These measures provide an opportunity for us to examine changes in the initial weight of US immigrants over a 23 years period.

We tested our hypothesis about immigrants' initial BMI by restricting our sample to the foreign born population. Next, we selected those who were aged 18 and above and had been in the US for less than a year at the time of the survey. Because information on years in the US was not available in earlier survey years, we excluded surveys that were conducted prior to 1989 from the analyses. After these exclusions, we were left with a final sample that included 3,118 respondents. We used weight in all our analysis to account for the complex sampling scheme used in the NHIS survey. All data used were based on self-reports, including information about the respondent's height and weight information.

Measures

Consistent with existing studies, our measures of overweight were based on the widely used BMI. BMI was calculated as weight in kilograms divided by the respondent's height in meters squared (kg/m^2). Using these criteria, we defined an overweight person (adult) as anyone with a BMI equal to or more than 25.[2] Any respondent whose BMI level was equal to, or more than, 30 was considered obese. Those with a BMI of less than 18.5 were classified as underweight.

The NHIS data, from which we derived our measures, did not provide exact information on year of immigration. Rather, the data categorized immigrants into five groups based on how long they have been in the US (i.e. <1; 1–4; 5–9; 10–14 years; 15 and more years), making it difficult to identify which year an immigrant specifically came to the US except for those who have just arrived in the country (i.e., those under 1 year). In addressing this methodological problem, we focused on those immigrants who reported that they arrived within the past 12 months prior to the survey year. Thus, survey year was used as proxy for the year of arrival to differentiate between the various arrival cohorts. Year of arrival was centered at 1989 so that the intercepts in the regression analysis represented the predicted BMI for immigrants who came to America in 1989.

Racial and ethnic origin groups were coded as follows: non-Hispanic whites, Hispanics, Asians, and other (this includes the small number of non-Hispanic blacks who were surveyed). Although information on place of origin was not available in NHIS before the 2000 survey year, for immigrants who have just arrived in America, the above racial and ethnic categories provided us with a rough measure for capturing the regions of origin of these immigrants. Because BMI changes as an individual ages, we also included age in our analyses. Age was centered at 18. We included a dummy variable for gender (1 = males and 0 otherwise) in our models. Marital status was also dummy-coded (married versus all others). Educational attainment was measured by years of formal schooling. For the regression models, listwise deletion techniques were used to handle all the missing data cases.

Data Analysis

The data were analyzed using SAS 9.3. We first report observed cohort trends in BMI and prevalence of being underweight, overweight, and obese. To show these cohort trends, we used three-year moving average smoothing technique to report our observations. We averaged our observations of BMI over successive 3 year periods to smooth out some of the random fluctuations. This methodological approach is useful in revealing more clearly the underlying trends in BMI. In all the figures we reported, we displayed the crude trends without any adjustment for age and gender. This would not affect our substantive findings

[2] Note that the overweight category includes obese individuals.

Table 1 Descriptive statistics for key variables

	Mean	SD	Percentage	Min.	Max.	Valid n
Body Mass Index (BMI)	23.60	5.50		11.10	58.50	3,118
Underweight (BMI < 18.5)			6.71			209
Overweight (BMI ≥ 25)			31.40			979
Obese (BMI ≥ 30)			6.36			198
Age	32.44	18.06		18.00	94.00	3,118
Gender						3,118
Male			50.62			1,578
Female			49.38			1,540
Marrital status						3,118
Married			56.10			1,749
Other			43.90			1,369
Education	12.16	5.79		0.00	17.00	3,078
Race/Ethnicity						3,099
Hispanic			36.89			1,397
Non-Hispanic White			26.35			662
Asian			28.89			804
Other			7.75			238

given that the immigrants sampled tended to be young. Moreover, literature has documented that both males and females were equally likely to migrate during the period under investigation [29]. Before reporting our results, we used sensitivity analysis to compare the crude trends and the age-sex adjusted trends on BMI levels and found no noticeable differences among the two.

Second, we used ordinary least squares (OLS) regression analysis to examine whether or not the trends reported in initial BMI is related to changes in other human capital factors for different immigrant cohorts. We further examined differential trends across racial and ethnic origin groups. Third, because conditional means in BMI (estimated in OLS models) are sensitive to extreme values, we also analyzed trends in underweight, overweight and obesity using binary logistic regression models.

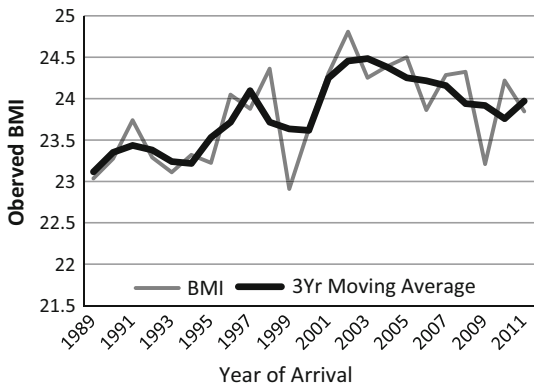

Fig. 1 Trends in observed BMI at entry, 1989–2011. *Note*: Pearson r: 0.08, $p < .000$

Results

Descriptive statistics for the key variables used in our study were reported in Table 1. Of the 3,118 adult immigrants surveyed between 1989 and 2011 and reported been in the US for less than a year, their average BMI was 23.6. This figure fell within the normal BMI range for an average adult. Although most of the new immigrants had a normal BMI of 23.6, we also observed that about 7 % of the respondents had a BMI of less than 18.5. The latter were considered underweight by existing standards. Additionally, another 31 % were overweight, and 6 % were considered obese according to their reported weight and height. Overall, 51 % of the immigrants interviewed were males, and 56 % were married. The mean age of those surveyed was about 32 years. On average, they had about 12 years of education. In terms of race/ethnicity, 37 % of those surveyed self-identified as Hispanics, 26 % as non-Hispanic white, 29 % as Asians, and 8 % as Others.

Figure 1 examines year-specific mean BMI and the three-year moving averages for the respondents. The lighter line in this figure represents the average BMI for each year, while the darker one deals with the three-year moving averages. As can be seen from Fig. 1, although there were some year to year fluctuations in reported BMI, we detected an increasing trend in BMI levels for the new immigrants who arrived between 1989 and 2011. Though

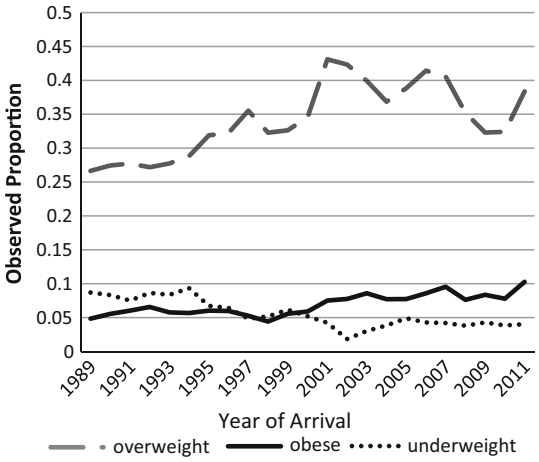

Fig. 2 Trends in observed prevalence in underweight, overweight and obesity at entry (3-year moving averages). *Note*: overweight: r = 0.09, $p < .001$; obese: r = 0.04; $p < .05$; underweight: r = −0.07, $p < .001$

we still observed some fluctuations when we focused our attention on the 3-year moving averages, the increasing levels of BMI over time appeared to be clearer than with the 1 year averages. Moreover, the average BMI levels seemed to have gone up: towards the upper end of the normal BMI range. We calculated Pearson's correlation coefficient to quantify the association between the observed BMI and the year of arrival and found the coefficient (r = .08) was statistically significant.

Because mean BMI is sensitive to outliers, we also examined the trends (3-year moving averages) in underweight, overweight, and obesity for the period under investigation (Fig. 2). As reported in Fig. 2, it appeared that the number of people identified as underweight was on the decline, while those for overweight and obese people continued to rise. The correlation between underweight and year of arrival (r = −0.07), however, suggested a mild decreasing trend. The same coefficient for the prevalence of overweight and obesity was 0.09 and 0.04, respectively, indicating mild increasing trends. Overall, all the correlation coefficients were found to be statistically significant.

The findings in Fig. 2 on weight status were consistent with our expectations. They provided further evidence to support our hypothesis that recent cohorts of immigrants were larger at their arrival than earlier ones. One may ask: Are these increasing trends due to the changes of the mix of country of origin over time as suggested in the literature [2]? Second, how are the trends different when we consider race/ethnic origin groups? In answering these questions, we used OLS regression to analyze the trends in immigrants' initial BMI overtime (Table 2).

Model 1 of Table 2 examines the gross cohort variation in BMI. Because the variable "year of arrival" was centered at 1989, the intercept of Model 1 provides information about our estimated BMI for immigrants who arrived

Table 2 OLS regression analysis on initial BMI among US immigrants

.	Model 1 Coef. (SE)	Model 2 Coef. (SE)	Model 3 Coef. (SE)
Intercept	23.23***	24.18***	22.49***
	(0.11)	(0.21)	(0.35)
Year of arrival	0.05***	−0.02	0.00
	(0.01)	(0.02)	(0.02)
Hispanic		−0.22	0.12
		(0.27)	(0.28)
Asian		−2.91***	−2.70***
		(0.28)	(0.28)
Other		0.03	0.37
		(0.42)	(0.41)
Hispanic × year of arrival		0.08**	0.04
		(0.03)	(0.03)
Asian × year of arrival		0.12***	0.12
		(0.03)	(0.03)
Other × year of arrival		0.07	0.06
		(0.05)	(0.05)
Age			0.06***
			(0.01)
Male			1.20***
			(0.14)
Married			0.58***
			(0.14)
Education			−0.03+
			(0.02)
R^2	0.01	0.08	0.16

+ $p < .10$; * $p < .05$; ** $p < .01$; *** $p < .001$

in 1989. Disregarding the fluctuations, we observed a yearly increase in BMI of about .05. This finding suggested that 22 years after 1989, the predicted BMI for these immigrants was 24.33 in 2011, and was approaching 25, the threshold for one to be considered overweight.[3]

The above analysis indicated that immigrants were larger at their time of arrival than earlier ones. However, the overall patterns might hide differences among different immigrant groups. Figure 3 displays the observed trends in initial BMI for the different immigrant groups focusing on their race/ethnic identities. It seemed that at the end of 1980s and during the beginning of the 1990s, Hispanic immigrants had similar levels of initial BMI as non-Hispanic white immigrants. The trend for white immigrants, as observed in

[3] While the Pearson correlation showed how strong BMI was associated with year of arrival, the regression coefficient for "year of arrival" helped us to quantify the annual increase in BMI across arrival cohorts. The R^2 of Model 1 (0.0064 rounded to 0.01 in Table 2) was the same as the square of Pearson correlation coefficient reported in Fig. 1 (0.08 × 0.08 = 0.0064).

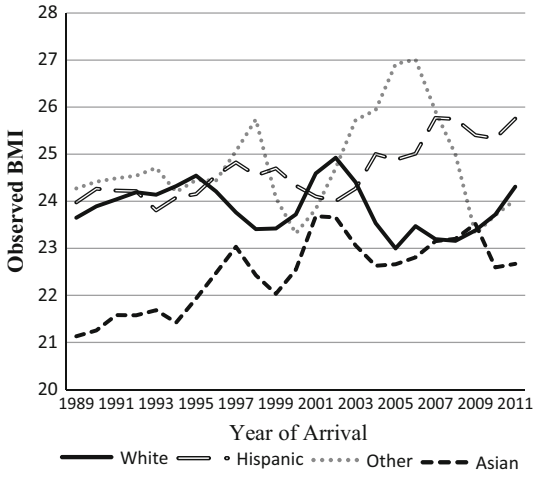

Fig. 3 Trends in observed BMI at entry by racial/ethnic groups 3-year moving averages)

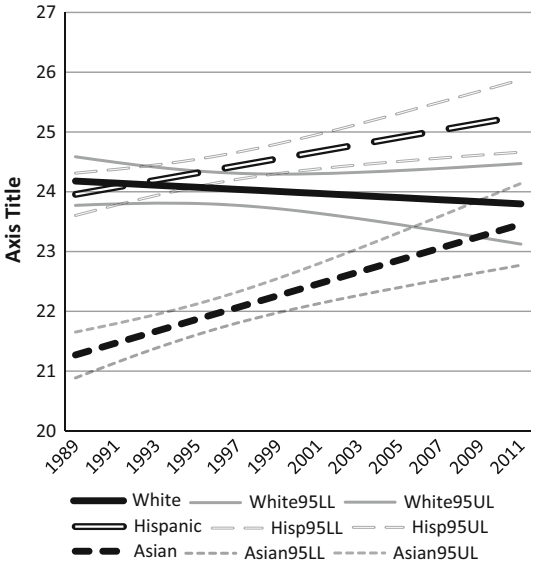

Fig. 4 Predicted trends in BMI at entry by racial/ethnic groups

the 3-year moving averages, seemed to fluctuate around a constant level (BMI = 24). However, we found that the trends for Hispanic immigrants were rising which suggest that the earlier cohorts of Hispanic immigrants were not that different form non-Hispanic whites at the time of their arrival, but their recent cohorts tended to have a higher BMI. The average initial BMI for recent Hispanic immigrant cohorts was higher than the upper limit for normal weight. On the other hand, although earlier cohorts of Asian immigrants had much lower initial BMI than other immigrant groups, the recent cohorts had initial BMI levels similar to those of non-Hispanic white immigrants. It was difficult to tell if the trend for "other" immigrants was increasing or decreasing due to the large fluctuations.

To make inferences and test the statistical significance of group differences in these trends, interaction effects between race and ethnic origin groups and "year of arrival" were included in Model 2 of Table 2.[4] In Model 2, the intercept represented the initial BMI for non-Hispanic whites (the reference group) in 1989, and the main effect for "year of arrival" captured the trend or the rate of change in initial BMI across arrival cohorts for non-Hispanic whites during the study period. The main effect for each racial group indicated the difference between the corresponding group and non-Hispanic whites with respect to their initial BMI in 1989. The interaction effect between each racial group and "year of arrival" captured the difference between the corresponding group and non-Hispanic whites with respect to their rate of change in initial BMI over time. Evidently, we found that the estimated initial BMI for non-Hispanic whites in 1989 was 24.18 and the trend was relatively flat (annual increase in initial BMI = −0.02, not statistically significant). Compared to non-Hispanic whites, Hispanics had a similar initial BMI at 1989, and their weights have increased since then. There was a greater increasing trend of initial BMI across successive cohorts of Hispanic immigrants (annual increase in initial BMI = 0.08–0.02 = 0.06) than that for non-Hispanic whites over the study period. Asian immigrants had a significantly lower BMI in 1989. However, their annual rate of increase in BMI was the most rapid (0.12–0.02 = 0.10) among the various groups.

Based on the coefficients reported in Model 2, we estimated linear trends in initial BMI and their 95 % confidence interval for the different immigrant groups in Fig. 4. While new Hispanic immigrants became larger and larger, recent non-Hispanic white immigrants have about the same initial BMI levels as compared to their earlier counterparts. Asian immigrants who arrived a few decades ago had much lower initial BMI than other immigrants who arrived at the same time. Their advantage has diminished among recent arrivals. Overall, the differences between non-Hispanic white and Asian immigrants have reduced overtime.

In Model 3 (Table 2), we controlled for age, gender, marital status, and educational attainment to see if the differences across race/ethnic origin groups were due to different demographic characteristics or human capital attributes that they brought with them to America.[5] Adding

[4] In supplementary analysis, we controlled for other covariates and found similar interaction effects.

[5] Due to the high level of missing on income and poverty measures (missing 643 cases), income variable was not included in the main analysis. However, in sensitivity analysis, we considered income and poverty variables. We found that poverty status, but not income, was associated with higher BMI and the effect was marginally significant ($p < .10$).

Table 3 Logistic regression analysis on initial weight status among US immigrants

	Underweight				Overweight				Obese			
	Coef. (SE)	Odds ratio			Coef. (SE)	Odds ratio			Coef. (SE)	Odds ratio		
		Point est.	95%LL	95%UL		Point est.	95%LL	95%UL		Point est.	95%LL	95%UL
Intercept	−1.65***				−1.33***				−2.68***			
	(0.33)				(0.16)				(0.28)			
Year of arrival	0.03	1.03	0.99	1.07	0.02**	1.03	1.01	1.04	0.00	1.00	0.97	1.04
	(0.02)				(0.01)				(0.02)			
Hispanic	−0.37	0.69	0.37	1.27	−0.05	0.95	0.75	1.21	0.08	1.08	0.71	1.65
	(0.31)				(0.12)				(0.22)			
Asian	2.07***	7.92	4.97	12.71	−1.50***	0.22	0.17	0.29	−2.49***	0.08	0.04	0.18
	(0.24)				(0.14)				(0.39)			
Other	0.09	1.09	0.47	2.52	0.42*	1.52	1.09	2.12	0.13	1.14	0.64	2.01
	(0.43)				(0.17)				(0.29)			
Hispanic × year of arrival	−0.05	0.95	0.89	1.01	0.00	1.00	0.98	1.03	0.02	1.02	0.98	1.06
	(0.03)				(0.01)				(0.02)			
Asian × year of arrival	−0.12***	0.89	0.84	0.93	0.05***	1.05	1.02	1.08	0.12***	1.13	1.06	1.20
	(0.03)				(0.01)				(0.03)			
Other × year of arrival	−0.06	0.94	0.85	1.05	0.00	1.00	0.96	1.04	0.04	1.04	0.98	1.10
	(0.05)				(0.02)				(0.03)			
Age	−0.04***	0.96	0.95	0.98	0.03***	1.03	1.03	1.03	0.03***	1.03	1.02	1.04
	(0.01)				(0.00)				(0.00)			
Male	−1.36***	0.26	0.20	0.34	0.67***	1.95	1.74	2.22	−0.25*	0.78	0.62	0.97
	(0.13)				(0.06)				(0.11)			
Married	−0.34**	0.71	0.56	0.90	0.41***	1.51	1.32	1.71	0.03	1.03	0.82	1.29
	(0.12)				(0.06)				(0.12)			
Education	−0.04*	0.96	0.93	0.99	−0.03***	0.97	0.95	0.98	−0.03^{+}	0.97	0.95	1.00
	(0.02)				(0.01)				(0.01)			

$^{+}$ $p < .01$; * $p < .05$; ** $p < .01$; *** $p < .001$

these variables explained away the differences between Hispanic immigrants and non-Hispanic white immigrants but not for Asian immigrants.

In general, older immigrants, males, and married adults were more likely to report higher BMI than their younger, female and non-married counterparts. Though education, a measure of socioeconomic status (SES) has been found to be an important protective factor for obesity among Americans [3], our analyses show that the effect of education on initial BMI was not statistically significant. However, the relationship between SES and weight was different and more complicated in developing countries than those observed among the more developed nations. In many poor countries, higher SES may lead to more access to "modernized" diet and lifestyle and could in turn elevate their weight gains [26].

The results from the logistic regression models on being underweight, overweight and obese were reported in Table 3. For whites, we did not observe any significant increasing or decreasing trends in the log odds of being underweight or obese as indicated by the coefficients for year of arrival. However, their log odds of being overweight increased across the successive arrival cohorts. Asian immigrants who came to America in 1989 had an odds of being underweight that was about 8 times those of white immigrants who arrived at the same time (odds ratio = 7.92). However, we observed that underweight across cohorts of Asian immigrants was on a rapid decreasing trend. On the other hand, the odds of being overweight and obese were much lower for Asian immigrants who came to US in 1989 compared to their white counterparts; the successive cohorts following them were catching up. The rates of increase in the log odds of being overweight and obese were fastest among Asian immigrants. For example, the odds of obesity for Asian immigrants who came to US in 1989 were less than one tenth of that for non-Hispanic white immigrants who came around the same time (odds ratio = 0.08). After 21 years of

differential rates of increase, the odds of being obese for Asian immigrants who came in 2010 were about the same as that for their white counterparts (odds ratio = 1.03).[6] The trends for Hispanics and other immigrants in all three weight statuses were not differentiable from white immigrants when demographic and human capital variables were controlled.

In general, older immigrants were less likely to be underweight but more likely to be overweight and obese than younger immigrants. Female immigrants were much more likely to be underweight than their male counterparts. The latter finding was consistent with what has been reported in the literature [13, 27]. In general, education seems to serve as a protective mechanism against unhealthy weight status.

Discussion

It has been reported that obesity rates for immigrants in America have increased in recent years [24]. Previous studies have often explained this increase as resulting from their exposure to American culture. The changing nutrition patterns in the immigrant sending countries are mostly ignored in this discourse. Moreover, the possibility that recent cohorts of immigrants who have come to America are larger than their earlier counterparts at their time of arrival has not been well investigated.

Using data from the 1989–2011 NHIS, we found that recent immigrants were on average larger at their time of arrival in America than the earlier immigrant groups. Our findings indicated that the well-recognized unhealthy acculturation effect that has been reported in the literature may be confounded by cohort variations if the study uses cross-sectional data. Immigrant weight status at arrival reflects a nutrition transition that is occurring in the sending countries. Thus, our findings are consistent with the observation about the rising body weight and obesity rates worldwide, especially in the fast developing regions of Asia. It is therefore not surprising that Asian immigrants in America have become larger and larger over the years.

Because of the well-established relationship between weight and many chronic diseases, the different initial weight status across arrival cohorts might imply differential health trajectories and assimilation patterns after immigration. Unfortunately, as a result of data limitations, we were unable to investigate this possibility of cohort specific assimilation patterns. This was especially the case since we restricted our sample to those who have stayed in the US for less than a year. It would have been desirable to compare different cohorts after 5 years, 10 years, or 15 years in US, but the lack of information on the exact year of immigration has prevented us from conducting these comparisons.

Though our findings provide some insights into BMI among immigrant cohorts, the study has its limitations. First, our BMI measure was based on self-reported height and weight which were subject to reporting errors. Second, the NHIS data contained many missing cases on self-reported weight and height. As a result, among the 4,977 respondents who met our criteria for sample selection, 1,859 did not have a valid BMI score. We conducted sensitivity analysis to compare those who had a valid score on BMI and those who did not and found that Hispanic immigrants, and immigrants who were married or have lower levels of education were more likely to have missing data on BMI. Not only that, the amount of missing data appears to be more pronounced in recent than earlier years. This is particularly true for Hispanic immigrants. Given our findings that Hispanic immigrants were more likely to have higher BMI, we suspected that the missing pattern could attenuate the observed increasing trends in average BMI and prevalence of obesity and overweight rather than exaggerate them.

Third, we were unable to exclude pregnant women from the sample because the person file in the NHIS data that we used did not report the pregnancy status of the respondents. As a result, though we speculated that differential fertility rates across origin groups might confound the reported group differences, we were unable to test this hypothesis. In addition, we classified ethnic and racial origin into broad groups which could hide any within group variations. For example, it has been documented that obesity patterns in Mexico are quite different from those in Cuba and other Latin American countries. Unfortunately, the small sample size of new arrivals did not permit us to refine race and ethnic origin groups for our comparisons.

Finally, by focusing on immigrants only, the study evaluated the differences across arrival cohorts. Further studies are needed, for example, to evaluate how the observed trends among immigrants differ from those among native born Americans (changes in immigrant versus native-born American BMI gap over time).

[6] The log odds of being obese for non-Hispanic white immigrants who came to US in 1989 was -2.68 with an annual increase of 0.0026. After 21 years, the log odds of being obese for non-Hispanic white immigrants who came to US in 2010 was -2.625 (calculation: $(-2.68) + 0.0026 \times 21 = -2.625$). The corresponding odds was 0.072 (calculation: $e^{-2.625} = 0.072$). The log odds of being obese for Asian immigrants who came to US in 1989 was -5.17 (calculation: $-2.68 - 2.49 = -5.17$) with an annual increase of 0.1226 (calculation: $0.0026 + 0.12 = 0.1226$). After 21 years, the log odds of being obese for new Asian immigrants who came to US in 2010 was -2.595 (calculation: $(-5.17) + 0.1226 \times 21 = -2.595$). The corresponding odds was 0.075 (calculation: $e^{-2.595} = 0.075$). The ratio between the two odds was 1.03 (calculation: $0.075/0.072 = 1.03$) in 2010.

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