Health Implications of Migration: Cross-Classified Multilevel Models to Disentangle Country of Origin and State of Resettlement Effects of Bodyweight

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Abstract

Objectives: Pre- and post-migration environments have differing demographic, social and economic characteristics which can affect health. What level of variance in bodyweight is attributable to individual-, country of origin-, and state of resettlement-level factors?

Methods: We test what portion of the variance (as captured through intra-cluster correlations (ICCS)) in bodyweight is attributable to multi-level factors. Data come from the New Immigrant Survey (NIS), a nationally representative, longitudinal study of international migrants. The outcomes of interest is BMI (kg/m^2) at Wave 1 (n=7,450) and Wave 2 (n=3,140). We utilize a cross-classified multi-level model approach (CCMM), where clustering in both country of origin and state of resettlement are modeled simultaneously using Bayes estimation.

Results: Preliminary results are based upon the public version of the NIS, which condenses states of resettlement into 15 states/regions and countries of origin into 27 countries/regions. In the null model the between-level variance in BMI at Wave 1 was driven largely by the country of origin (2.4) and not by the state of resettlement (0.08). In the CCMM, the country ICC was 9.2% and the state ICC was 0.25% indicating that state-level variance was minimal. Throughout, estimates for CCMM are closely aligned with estimates in the country-only model, further indicating that country-level variance is playing a larger part than state-level variance in individual-level BMI after being in the country for eight years on average. Five years later, the between-level variance in BMI at Wave 2 was still driven by the country of origin (2.8) and even less by the state of resettlement (0.03). In the CCMM, the country ICC was 13.6% and the state ICC was 0.2%.

Conclusions: The large share of the variance in BMI at the point of legal permanent residency in 2003 is attributable to individual-level factors. Some variance in this baseline BMI and BMI five years later is also attributable to where an individual was born. This research helps contribute to our understanding of how environments shape health behaviors.

1. Introduction

Foreign-born individuals tend to be in better health on arrival in the US than native-born Americans.[1-3] However, this health advantage deteriorates with duration of residence in the US.[4-5] Between 1999-2001, male and female immigrants to the US experienced 23% and 16% lower all-cause mortality than native-born Americans and a longer life expectancy by 3.4 years.[6] The preponderance of evidence indicates that immigrant health declines, rather than improves, with time in the US.[1] Practitioners and researchers have called for investigations of specific diseases/conditions which can help elucidate the pathways through which immigration might affect health.[7]

Obesity is a serious public health problem and contributes to the burden of chronic health conditions such as diabetes, cardiovascular disease and certain forms of cancer.[8-10] Using data from the National Health and Examination Survey (NHANES), Hales *et al.* (2017) estimated the prevalence of obesity amongst adults in the US continues to increase.[11] The recent report from 2015-2016 estimates the prevalence of obesity to be 39.8% among adults in the US.[11-12] Hispanic and non-Hispanic black adults had a higher prevalence of obesity than non-Hispanic whites (47%, 46.8%, and 37.9% respectively).

Foreign-born children and adults represent about 13% of the U.S. population, ~40 million people.[13] They are over-represented among groups at high risk for obesity: racial and ethnic minority (52 vs. 22% in the U.S. born population), those with only high-school education (31 vs. 11%), and those living in poverty (18 vs. 14%).[14] Based upon data from the New Immigrant Survey (NIS), 45% of foreign-born individuals at the point of legal permanent residence in the US in 2003 were either overweight or obese;[15] people from Latin America or the Caribbean, those who were older, had lived in the US for longer, and resided in the West region of the US had higher odds of obesity.

Foreign-born people are a diverse group migrating from a number of different countries of origin with varying levels of economic development. However, upon arrival to the U.S. foreign-born people on average tend to have limited access to health care and preventive care, but they tend to be in better health than native-born people.[1-3] However, many foreign-born people have higher rates of chronic disease and obesity with longer stay in the United States.[1, 4, 16-19] A leading explanation for experiences of chronic disease among foreign-born people has been acculturation. Acculturation is the process through which foreign-born people adopt ideas, values, and behaviors that are associated with their country of reception.[20-21] This process entails adoption of new cultural elements and abandonment of cultural elements from the country of origin.[22-23] These changes in cultural elements manifest in many areas of life such as language usage but also include health behaviors. They may affect energy balance, by entailing changes in dietary intake and physical activity,[24-28] and in the longer term may be tied to obesity and related chronic diseases. It is well-established that health outcomes and even health behaviors (i.e., fruit and vegetable intake) differ by state,[29] but less has been done in evaluating how states potentially play a role in the variance of health outcomes nationally. In the context of obesity, the most recent estimates of the prevalence of obesity in the US from 2015-2016, reports differences by states with Colorado reporting a prevalence between 20 and 25% versus Alabama with an obesity prevalence above 35%.[11] The extent to which values and behaviors change may be determined in part by social and economic context, including characteristics of the communities of resettlement.[30]

Changes in eating patterns are an important consideration to understanding acculturation as well as health, as food and eating are central aspects of culture.[31] Previous studies have found that diets changes with time in the United States[32] in ways that are both positive and negative for health; for example, they entail increased fruit and vegetable consumption but also increased added sugars.[33] Recent qualitative data suggests that foods once only consumed for special occasion in the country of origin, often including animal protein, fats, and sugars, become routine foods in the post-migration diet[31, 34] These dietary changes may be related to the chronic disease patterns noted above.

Social norms and values concerning diet and bodyweight vary considerably across nations/cultures.[35-36] These norms and values are likely to influence individual diet and subsequently bodyweight changes. As foreign-born individuals straddle two cultural contexts, that of their origin country and receiving state, national structural and integration measures in their country of origin and similar measures within their state of resettlement may shape their diet and bodyweight.

There is increasing interest in understanding multilevel phenomena, that is, how features of the physical and social environment in which individuals live, learn, work, and play influence their health and behavior.[37-38] Features of the social and built environment above the individual (familial, community, organizational and societal levels), constrain, limit, reward, and induce the behavior of individuals.[39-40] Consensus has grown for the need to further the study of behavior and health in order to capture the role of social structure to a greater degree. In the context of migration, focusing on the influence of individual-level factors on foreign-born health assumes no variation above the individual. In the context of a country of destination such as the US, there is a large degree of variability in health behaviors, economic, and social factors by state.[8, 41] State of resettlement can be a rough proxy for the general status of these smaller environments, particularly in regards to the policies that regulate them.

In this study, we evaluate how pre- and post-migration contextual characteristics are associated with bodyweight among foreign-born individuals in the United States. We use the nationally representative New Immigrant Survey (NIS), which is generalizable to people who were granted legal permanent residency in the U.S. in 2003. We estimate the amount of variance in foreign-born Body Mass Index (BMI) that can be attributed to individual-, country of origin- and state of resettlement-level factors.

2. Materials and Methods

2.1 Data Resources and Study Population

We used data from the NIS, a nationally representative longitudinal study of international migrants, sampled at the point of receiving permanent residence status.[42] The adult sample consisted of 8,573 respondents in 2003/2004 and 4,363 in 2007/2009. Due to the nature of the population, there is quite a bit of attrition between waves, however we run sensitivity analyses to evaluate those who have both waves of data as well to check the robustness of our results.

2.2 Variables

We measured bodyweight in three ways: body mass index (*BMI*) in Wave 1 (average 8 years in the U.S.), *BMI 2* in Wave 2 (average 13 years in the U.S.), and reported weight changes over the previous 2 years in Wave 2 (*Weight Change).* Self-reported height and weights was used to calculate continuous measures of *BMI* and *BMI 2* (kg/m^2). Sensitivity analyses included evaluation of standard cut-off categories: underweight defined as < 18.5 kg/m^2, normal-weight as 18.5-24.9 kg/m^2, overweight as 25.0-29.9 kg/m^2, and obesity as ≥ 30 kg/m^2.[43] Further sensitivity analyses included Asian-specific cut-points for BMI classification for those appropriate.[44] For interpretation purposes of models, *BMI* and *BMI 2* were centered at the grand mean. *Weight Change* is a four-categorical variable based upon the NIS Wave 2 question: “Have you gained or lost ten or more pounds in the last 2 years?” with categories as follows: Gained, Lost, Fluctuated, or No Change.

The main exposures of interest were three diet variables: All respondents were asked to compare the similarity in their diet to their diet in their home country on a scale from 1 to 10 with 10 indicating completely the same. *Change in Diet* will be categorized into <5 versus >= 5, identifying those who report substantial dietary change. 2) *Abandoned foods*: "Is there something you ate regularly before coming to the United States that you rarely eat now?" Coded as yes/no. 3) *Adopted foods*: "Is there something you eat a lot now that you rarely ate before you came to the United States. Coded as yes/no.

The following variables are a breakdown of individual- and place-level variables both pre- and post-migration (**Figure 1**).

2.2.1 Pre-Migration:

Individual-Level: *Social Standing* was measured in response to the question, "Thinking about the time when you were 16 years old, compared with families in the country where you grew up, would you say your family income during that time was far below average, below average, average, above average, or far above average?" For the current analyses, responses of "far below average" and "below average" were designated as "below average," and "far above average" and "above average" were designated as "above average," creating a three-category variable. *Urbanicity* was measured in response to the question, "Were you living in a rural area when about age 10" (yes/no). *Age* was self-report and kept continuous along with an age-squared term. *Sex* was interviewer identified as male/female at the start of the survey. *Education* was coded as years of school completed (continuous). Both education and urbanicity were classified as pre-migration characteristics because less than 3% of the sample migrated before age 16.

Place-Level: All country of origin place-level variables will be treated as level-2 variables and obtained from 1995 World Bank Development Indicators or Human Development Reports.[45-46] We chose 1995 because the average time in the US for our sample is 8 years meaning on average individuals left their country of origin in 1995. We further ran sensitivity analyses for these variables using data from 1991-1999. Percent of the country population that resided in an urbanized area or urban cluster in 1993 as defined by the World Bank (*C_Urban).*[1] Percent of the country population that is unemployed modeled as an International Labour Organization (ILO) estimate by the World Bank (*C_Employment). C_HDI* is a summary measure of average

[1] All place-level pre-migration variables will have the prefix C to denote a country of origin-level variables. Place-level post-migration variables will have the prefix S to denote state of resettlement-level variables.

achievement in key dimensions of human development: life expectancy at birth, mean years of schooling, and GNI per capita. The composite measure ranges from 0 to 1 with 1 being greater development.

2.2.2 Post-Migration:

Individual-Level: *Visa Type* originally included 10 different categories but will be recoded into 5 major groupings: (1) family reunification (includes all family reunion possibilities, including spouse of the US citizen, spouse of the legal permanent resident, parents of the US citizen, child of the US citizen, family fourth preference, etc), (2) employment, (3) diversity, (4) refugee, and (5) legalization.[2] *Age First Migrated* was determined by (Date of Birth – Year left country of Birth) and kept continuous. *Social Connectivity* was measured by if an individual reported attending religious services (yes/no). *Language Fluency* was measured by asking respondents how well they spoke English with choices including: "very well, well, not well, and not at all."

***Place-Level*:** All state of resettlement place-level variables will be treated as level-2 variables. S_*Traditional* destinations will be defined as the 7 states with a longer history of accepting immigrants (California, Texas, New York, Florida, New Jersey, Illinois, Massachusetts). The following level-2 predictors will be obtained from the 2000 Census Bureau: *S_Urban, S_Income,* and *S_Education*.[47] Proportion in an urbanized area or urban cluster in 2000 as defined by the US Census (S_*Urban*). Percent of the state population aged 24-65 years with less than high school education (S_*Education*). We further obtained median state income levels in 2000 (S_*Income*). S_*Obesity* will be defined as the adult obesity rate by state obtained from the Behavioral Risk Factor Surveillance System in 2003.

2.3 Statistical Analysis:

We first conducted descriptive analyses to assess correlations between outcomes of interest and predictors. We tested what level of variance in each bodyweight outcome was attributable to individual-, country of origin-, and state of resettlement-level factors. To do this we utilized a cross-classified multi-level model approach. We began by exploring the non-hierarchical cross-classified data structure and fit cross-classified multilevel models to examine the relative importance of country of origin and state of resettlement as sources of variation in our outcomes.[48-50] For example, for the outcome *BMI* at Wave 1, we began by fitting

[2] Visa Type is not in the current models or results due to lack of access because part of private version of NIS. Will be incorporated into future models once access is granted.

three separate null models. The first two null models used a standard two-level multilevel model: one is a "country-only" multilevel model and the other is a "state-only" multilevel model. The third null model is a cross-classified multilevel model (CCMM) with both country of origin and state of resettlement. The two-level "country-only" multilevel model, where the outcome for a person (denoted *i*) nested in a given country of origin (denoted j_1) was modeled as:

$$(1)\ \ BMI_{ij_1} = \beta_0 + u_{0j_1} + e_{0ij_1}$$

In Equation 1, the fixed parameter β_0 refers to the overall mean outcome BMI across all countries of origin. The random effect parameter u_{0j_1} refers to the random effect for countries and e_{0ij_1} refers to the random effect of the individual. Then the same model will be run using state of resettlement (denoted j_2) only in place of country of origin:

$$(2)\ \ BMI_{ij_2} = \beta_0 + u_{0j_2} + e_{0ij_2}$$

The third model we fit was the CCMM. In a CCMM, individuals (denoted *i*) simultaneously belong to two non-nested contexts, here country of origin (denoted j_1) and state of resettlement (denoted j_2). Thus, our outcome *BMI* at Wave 1 was modeled as:

$$(3)\ \ BMI_{i(j_1,j_2)} = \beta_0 + u_{0j_1} + u_{0j_2} + e_{0i(j_1,j_2)}$$

In Equation 3, which presents a null or intercept-only CCMM, the fixed parameter β_0 refers to the overall mean outcome across all states of resettlement and countries of origin. u_{0j_1} refers to the random effect of countries of origin, u_{0j_2} refers to the random effect for the states of resettlement, and $e_{0i(j_1,j_2)}$ refers to the random effect for the individual with the combination of j_1 country of origin and j_2 state of resettlement. Interclass correlation coefficients (ICCs) were obtained for Equations 1, 2, and 3 to determine the amount of variance attributable to each level. We further calculated an intracell correlation, referring to the correlation in outcome of two individuals who live in the same state of resettlement and came from the same country of origin. The CCMM was extended to include predictors at each level of analysis with a succession of nested models starting with place-level pre-migration variables; then place-level post-migration variables; then individual-level pre-migration variables;[3] finally individual-level post-migration variables. Equation 4 presents a proposed final model for *BMI* Wave 1:

$$
\begin{aligned}
(4)\ BMI_{i(j_1,j_2)} = {} & \beta_0 + \beta_1 C\_urban_{1,ij_1} + \beta_2 C\_employment_{2,ij_1} + \beta_3 C\_HDI_{3,ij_1} + \beta_4 S\_urban_{4,ij_2} \\
& + \beta_5 S\_obesity_{5,ij_2} + \beta_6 S\_education_{6,ij_2} + \beta_7 S\_income_{7,ij_2} + \beta_8 S\_traditional_{8,ij_2} \\
& + \beta_9 social\ standing_{9i} + \beta_{10} urbanicity_{10i} + \beta_{11} education_{11i} + \beta_{12} age_{12i} + \beta_{13} sex_{13i} \\
& + \beta_{14} visa\ type_{14i} + \beta_{15} social\ connectivity_{15i} + \beta_{16} age\ first\ migrated_{16i} \\
& + \beta_{17} marital\ status_{17i} + \beta_{18} english\ fluency_{18i} + u_{0j_1} + u_{0j_2} + e_{0i(j_1,j_2)}
\end{aligned}
$$

The same succession of models will be done with the other specified outcomes (*BMI 2* and *Weight Change*) with both BMI outcomes using linear regression and weight change as a multinomial logistic regression. All analyses were conducted in STATA 15. BMI 2 and Weight Change further include BMI at Wave 1 as a predictor. All modeling analyses were conducted using *mixed* command with Bayes estimation. Significance of variables and variances were assessed at α = 0.05 level and 95% credibility intervals. Model fit was assessed using deviance scores. For each model, the reduction in level-1 variance, level-2 intercept variances, and level-2 slope variances was assessed in comparison to the simplest model including the respective random effects as descriptives of the model's predictive ability. Survey weights were used for descriptive statistics, however since the NIS sampling frame was created using age and immigration category (discussed in this proposal as visa type) and both of these variables are included in the model we will not be using survey weights for the model component of this analysis**.** The analytic sample for baseline BMI models with plausible and non-missing values for BMI and dietary assessment variables is 7,385. The analytic sample for the BMI Wave 2 and Weight Change models with plausible, non-missing values BMI and dietary assessment variables is 3,140. We also ran sensitivity analysis on BMI at Wave 1 using the sample who have data at both waves (n=3,140).

[3] This is finalized order of models, however current results report only the incorporation of individual-level predictors.

The preliminary results presented below are based upon the public version of the NIS dataset which condenses states of resettlement into 15 states/regions (California, Florida, Illinois, New Jersey, New York, Texas, New England, Middle Atlantic, South Atlantic, East South Central, West North Central, West South Central, Mountain, Pacific, and Territories) and countries of origin into 27 countries/regions (Canada, China, Colombia, Cuba, DR, El Salvador, Ethiopia, Guatemala, Haiti, India, Jamaica, Korea, Mexico, Nigeria, Peru, Philippines, Poland, Russia, Ukraine, United Kingdom, Vietnam, Europe and Central Asia, East Asia, Latin America, African Sub-Saharan, Middle East, and Oceania). We are applying for the restricted access dataset, which will allow for expanding both level 2 clusters to include specific states and countries; this will increase estimation capability and allow for incorporation of level 2 variables discussed above. The analytic sample size will not change but we will re-run the models presented below to assess if there are any changes in the individual-, country- and state- level estimates and variances based on the increasing number of clusters for both country of origin and state of resettlement. Due to the small number of state-level clusters (n=15), the Weight Change models were unable to converge and are not reported below. We will run these and incorporate into the paper once the private version of NIS has been obtained. Model fit will be more clearly discussed with each subsequent model and incorporation of proportion of variance changes. Further subsequent models with state and country level predictors will also be added as previously discussed.

3. Preliminary Results

To first determine if cross-classification modeling is necessary, we evaluated if individuals from the same country of origin all resettled in the same state or vice versa. An average of 315 foreign-born individuals per country of origin participated in NIS (minimum=31; maximum=1158). In each state of resettlement, an average of 564 individuals participated (minimum=3; maximum=2182) with 343 different combinations of country and state contexts. Thus, there was no clear hierarchical nesting of individuals coming all from one country to resettle in one state and a cross-classified modeling approach is appropriate.

Table 1 presents descriptive on individuals in the BMI Wave 1 analytic sample (n=7450). For our outcome of interest (BMI), 4% of the sample reported having a BMI categorized as underweight, 51% normal weight, 33% overweight and 12% obese. With the mean BMI at 25.0 ± 0.06. The majority of the sample are male (56%) and married (82%) with a high school degree on average (12.2 years). Twenty-one percent of respondents reported speaking English very well and having been in the US for an average of 7.5 years. On a scale from one to ten, respondents reported that their diet changed somewhat since they arrived in the U.S. (5.25). About half of respondents (49%) reported adopting at least one new food in the U.S. and 43% reported abandoning at least one food.

In Table 2, we show individual-level pre- and post-migrations characteristics stratified by BMI category. They were older, with the mean age of those who were obese being 41.0 years old, and those who were normal-weight being 36.9 years old. Women more often experienced overweight compared to men (43% vs. 26%). Respondents who were married or living with a partner were less likely to be obese compared to respondents who were single/divorced (38% vs. 35%). Those categorized as being obese had one less year of schooling on average. No differences in reported abandoned foods but those categorized as obese were less likely to report adopting new foods post-migration.

Table 3 presents the results of the initial models for the country-only MLM, state-only MLM, and the CCMM predicting BMI at Wave 1. In the null model (Table 3, Model 1), the random effects for the country-only (1.9) and the state-only (0.2) were not similar and in the CCMM, the between-level variance in BMI was driven largely by the country (1.8) and not by the state (0.05). Comparable ICC values were obtained for the country-only (9.6%) and state-only multi-level model (1.0%), indicating that the majority of the variability was attributable to individual characteristics. In the CCMM, the country ICC was 9.2% and the state ICC was 2.5%.

From here on we only present the CCMM. When the predictors of interest were added to all three models (Table 3, Model 2), the between-level variance changed very little if at all [CCMM: (Country: 1.9) (State: 0.04=5)]. Reporting no abandonment of foods from one's country of origin was associated with higher BMI in. When incorporating pre-migration characteristics at the individual level (Table 3, Model 3), abandoned foods was no longer significant, but reporting big dietary changes post-migration was associated with higher BMI. Being female was significantly associated with lower BMI compared to being male. Increased age was significantly associated with higher BMI. However, as people get older this effect lessens. Having less education was significantly associated with higher BMI. With the addition of post-migration individual characteristics (Table 3, Model 4), all significant associates of pre-migration characteristics held consistent. Migrating to the US at a younger age was associated with higher BMI. Being married/living with a partner was significantly associated with higher BMI, compared to individuals who were single, divorced or widowed. Being socially connected, measured here as regularly attending religious services, was associated with a higher BMI. Table 3 presents the results of the same models for BMI at Wave 1 but only for those who also have data at Wave 2 (n=3,140). The diet variables and social connectivity were no longer significant.

Table 5 presents the results of the initial models for the CCMM predicting BMI at Wave 2 (n=3,140). In the null model (Table 4, Model 1), the random effects for the country-only (2.7) and the state-only (0.2) were not similar and in the CCMM, the between-level variance in BMI was driven largely by the country (2.8) and not by the state (0.03). In the CCMM, the country ICC was 13.6% and the state ICC was 0.2%, indicating that the large majority was attributable to individual-level variance. BMI at Wave 1 was significant with the effect lessoning at the tails. When the predictors of interest were added, none of the dietary variables at either wave were significant. When incorporating pre-migration characteristics at the individual level (Table 3, Model 4), having more years of education was associated with lower BMI.

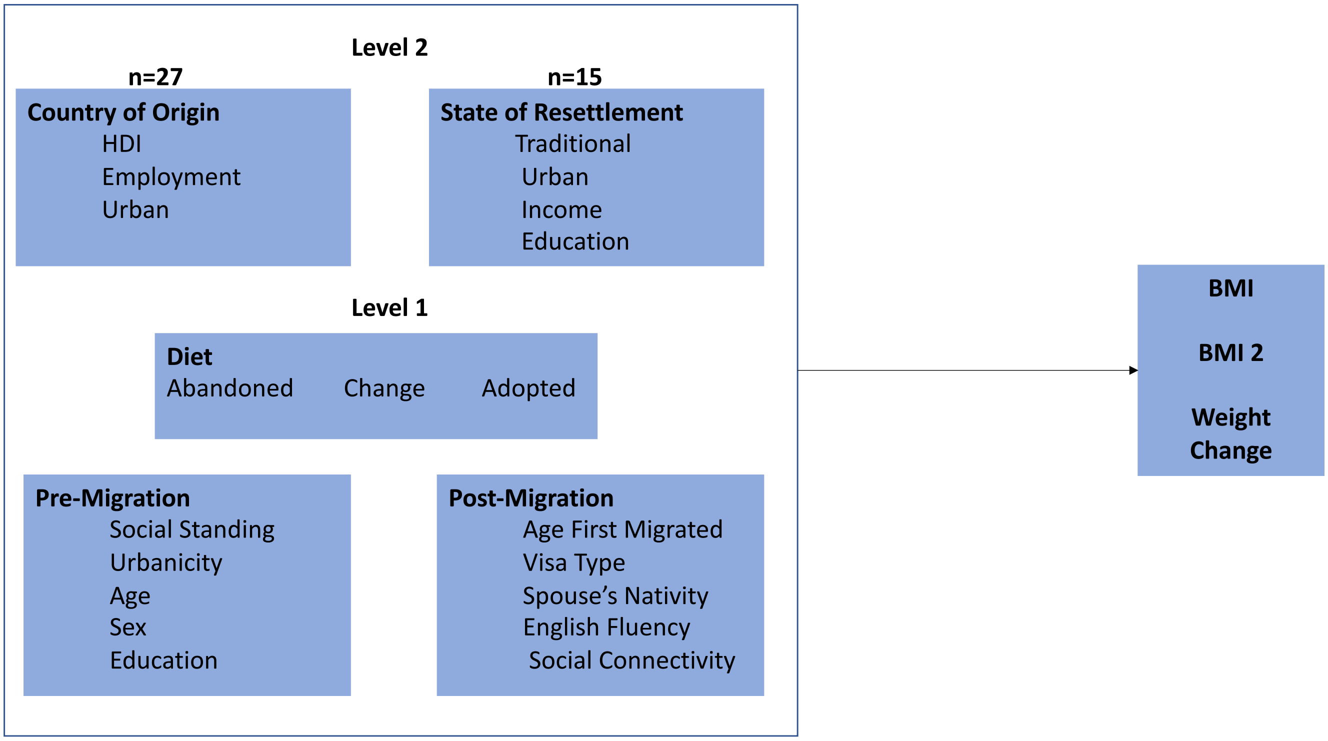
With the addition of post-migration individual characteristics (Table 3, Model 5), all significant associates of pre-migration characteristics held consistent with the incorporation of post-migration variables and having some type of social standing in your country of origin was associated with higher BMI compared to below average social standing. Migrating to the US at a younger age was associated with lower BMI. Having any level of higher English fluency compared to none at all was associated with lower BMI at wave 2.

Discussion

Due to the current state of this working paper we are hesitant to discuss any overarching conclusions prior to the addition of our planned analysis with the private version of NIS and incorporation of country- and state-level variables. However, we can conclude that the large share of the variance in BMI at two time points amongst immigrants to the U.S. are attributable to individual-level factors. Our initial findings further demonstrate that both pre- and post-migration characteristics at the individual level are associated with BMI over time in the US.

Tables and Figures

Figure 1. Overview of Variables Included at Each Level



Note: Visa Type is a part of the private version of NIS and will be included but currently unavailable.

Table 1. Individual-level Characteristics of Foreign-Born Individuals in Analytic Sample for NIS Wave 1- 2003 (n=7,385)

	Mean (SE) or %
Bodyweight (kg/m2)	
BMI (continuous)	25.0 (0.06)
BMI (categories)	
Underweight	3.9%
Normal Weight	50.8%
Overweight	33.3%
Obese	11.9%
BMI2 (continuous)	25.7 (0.11)
BMI2 (categories)	
Underweight	3.3%
Normal Weight	44.0%
Overweight	36.6%
Obese	16.1%
Diet	
Dietary Change > 5 (%)	5.4 (0.04)
Yes	51.7%
No	48.3%
Abandoned (%)	
Yes	43.9%
Adopted (%)	
Yes	50.5%
Pre-Migration	
Social Standing (%)	
Below Average	28.7%
Average	53.1%
Above Average	18.2%
Urbanicity (%)	
Urban	59.8%
Rural	40.2%
Gender (%)	
Female	43.6%
Male	56.4%
Age, mean (SE)	39.2 (0.17)
Education, mean (SE)	12.2 (0.06)
Post-Migration	
Age First Migrated, me	31.7 (0.19)
Marital Status (%)	
Single/Divorced	17.8%
Married or marri	82.2%
Social Connectivity (%)	
Yes	20.9%
No	79.2%
English Fluency (%)	
Very Well	21.4%
Well	26.3%
Not Well	31.6%
Not at All	20.8%

[1] Weighted to sampling design
[2] Abbreviations: BMI (Body Mass Index); SE (Standard Error)

Table 2. Characteristics of Foreign-Born Individuals by BMI Category for NIS 2003/2004 (n=7,450)

Variables	BMI- Wave 1				
	Underweight	**Normal Weight**	**Overweight**	**Obese**	***p***
Diet					
Dietary Change > 5 (%)					**0.0001**
Yes	4.1	53.2	32.5	10.2	
No	3.7	48.7	34.0	13.6	
Abandoned (%)					0.8797
Yes	3.9	50.7	33.4	12.0	
No	3.9	51.1	33.2	11.8	
Adopted (%)					**0.0303**
Yes	3.8	52.2	33.4	10.7	
No	4.1	49.7	33.0	13.2	
Pre-Migration					
Social Standing (%)					**<0.00001**
Below Average	2.6	42.5	38.4	16.5	
Average	4.3	54.1	31.8	9.9	
Above Average	4.6	54.4	30.4	10.5	
Urbanicity (%)					**< 0.00001**
Urban	4.2	53.3	31.3	11.2	
Rural	3.5	47.1	36.5	13.0	
Gender (%)					**<0.00001**
Female	1.7	44.0	42.6	11.7	
Male	5.7	56.4	25.8	12.1	
Age, mean (SE)	33.9 (0.92)	36.9 (0.24)	39.9 (0.29)	41.0 (0.51)	a, b, c, d, e, f
Education, mean (SE)	12.9 (0.29)	13.1 (0.08)	12.1 (0.11)	10.6 (0.20)	b, c, d, e, f
Post-Migration					
Age First Migrated, mean (SE)	30.4 (1.01)	30.4 (0.27)	31.3 (0.33)	30.8 (0.60)	d
Marital Status (%)					**0.0468**
Single/Divorced	2.1	29.6	30.6	37.7	
Married or marriage-like relationship	1.6	30.5	28.5	35.4	
Social Connectivity (%)					**< 0.00001**
Yes	2.9	45.9	37.3	13.9	
No	4.2	5.2	32.3	11.4	
English Fluency (%)					**< 0.00001**
Very Well	4.2	55.0	31.6	9.2	
Well	4.3	53.7	31.4	10.6	
Not Well	3.8	49.7	34.0	12.6	
Not at All	3.8	44.7	35.7	15.9	

[1] Weighted to sampling design

[2] Two sample T-tests was used to calculate differences in continuous variables. Chi-squared test of proportions was used to calculate the p-value for categorical variables.

[3] a: Underweight versus Normal Weight
b: Underweight versus Overweight
c: Underweight versus Obese
d: Normal Weight versus Overweight
e: Normal Weight versus Obese
f: Overweight versus Obese

Table 3. Nested Models Describing Association Between Predictors and Body Mass Index in the New Immigrant Survey 2003/2004 (N=7,450).

	Model 1- null models			**Model 2- Self Assessed Dietary Change**	**Model 3- Individual Pre-Migration**	**Model 4- Individual Post-Migration**
	Country only	State only	Cross-classified	Cross-classified	Cross-classified	Cross-classified
Fixed effects						
Intercept (SE)	0.05 (0.30)	-0.19 (0.17)	-0.04 (0.25)	0.03 (0.27)	-6.48 (0.54)	-6.67 (0.60)
Individual-level						
Diet						
Big Change (>5)				0.20 (-0.001,0.41)	0.30 (0.10,0.50)*	0.29 (0.07,0.50)*
Abandoned (Y)				-0.34 (-0.56,-0.12)*	-0.21 (-0.42,0.003)	-0.23 (-0.46,0.001)
Adopted (Y)				0.02 (-0.20,0.24)	0.16 (-0.05,0.37)	0.10 (-0.13,0.33)
Pre-Migration						
Social Standing						
Below Average					ref	ref
Average					-0.17 (-0.41,0.07)	-0.24 (-0.50,0.01)
Above Average					-0.11 (-0.42,0.19)	-0.20 (-0.52,0.13)
Urbanicity						
Urban					ref	ref
Rural					-0.11 (-0.32,0.10)	-0.06 (-0.28,0.16)
Gender						
Male					ref	ref
Female					-0.99 (-1.17,-0.80)*	-1.14 (-1.34,-0.93)*
Age					0.32 (0.28,0.36)*	0.36 (0.31,0.41)*
Age Squared					-0.003 (-0.003,-0.002)*	-0.003 (-0.004,-0.003)*
Education (years)					-0.06 (-0.08,-0.03)*	-0.09 (-0.12,-0.06)*
Post-Migration						
Age First Migrated (years)						-0.03 (-0.04,-0.01)*
Marital Status						
not Married						ref
Married or Marriage Like Relationship						0.54 (0.27,0.81)*
Social Connectivity						
Yes						0.35 (0.09,0.60)*
No						ref
English Fluency						
Not at All						ref
Not Well						0.29 (-0.16,0.74)
Well						-0.01 (-0.42,0.39)
Very Well						-0.06 (-0.41,0.30)
Random effects						
Individual	17.8 (0.30)	19.7 (0.33)	17.8 (0.30)	17.7 (0.29)	16.3 (0.28)	15.7 (0.28)
Country	1.9 (0.60)	-	1.8 (0.58)	1.9 (0.60)	1.8 (0.57)	1.6 (0.52)
State	-	0.2 (0.14)	0.05 (0.04)	0.05 (0.04)	0.03 (0.03)	0.04 (0.03)
DIC	-	-	42370.5	41690.6	40330.5	33934.06

[a] Bayes estimation and 95% credibility intervals

[b] Fixed effect estimates cell entries are parameter (beta) estimates and credible intervals.

[c] Intercept presented as a parameter estimate and standard error (SE)

[d] Random effect estimates are presented as estimates and credible intervals

[e] DIC refers to Deviance Information Criteria, a measure of model fit and complexity

Table 4. Nested Models Describing Association Between Predictors and Body Mass Index in the New Immigrant Survey 2003/2004 for those with Wave 2 data (N=3,291).

	Model 1- null models			**Model 2- Self Assessed Dietary Change**	**Model 3- Individual Pre-Migration**	**Model 4- Individual Post-Migration**
	Country only	State only	Cross-classified	Cross-classified	Cross-classified	Cross-classified
Fixed effects						
Intercept (SE)	-0.0001 (0.33)	-0.14 (0.18)	-0.11 (0.32)	-0.09 (0.34)	-7.6 (0.82)	-7.2 (0.06)
Individual-level						
Diet						
Big Change (>5)				0.11 (-0.19,0.42)	0.20 (-0.10,0.50)	0.19 (-0.12, 0.51)
Abandoned (Y)				-0.19 (-0.51,0.13)	-0.06 (-0.37,0.25)	-0.09 (-0.42,0.23)
Adopted (Y)				0.12 (-0.20, 0.45)	0.19 (-0.13,0.50)	0.03 (-0.31,0.38)
Pre-Migration						
Social Standing						
Below Average					ref	ref
Average					-0.17 (-0.53,0.17)	-0.22 (-0.59,0.15)
Above Average					-0.39 (-0.85,0.07)	-0.41 (-0.89,0.06)
Urbanicity						
Urban					ref	ref
Rural					-0.18 (-0.48,0.12)	-0.20 (-0.53,0.12)
Gender						
Male					ref	ref
Female					-1.18 (-1.47,-0.90)*	-1.37 (-1.67,-1.10)*
Age					0.36 (0.30,0.43)*	0.42 (0.35,0.50)*
Age Squared					-0.003 (-0.004,-0.003)*	-0.004 (-0.005,-0.003)*
Education (years)					-0.03 (-0.06,0.01)	-0.07 (-0.11,-0.03)*
Post-Migration						
Age First Migrated (years)						-0.05 (-0.07,-0.03)*
Marital Status						
not Married						ref
Married or Marriage Like Relationship						0.38 (-0.01, 0.79)
Social Connectivity						
Yes						-0.02 (-0.38,0.34)
No						ref
English Fluency						
Not at All						ref
Not Well						0.04 (-0.60,0.69)
Well						-0.28 (-85,0.30)
Very Well						-0.15 (-0.65,0.36)
Random effects						
Individual	16.1 (0.41)	18.5 (0.47)	16.1 (0.41)	16.1 (0.42)	14.7 (0.38)	14.2 (0.39)
Country	2.4 (0.77)	-	2.4 (0.79)	2.4 (0.80)	2.3 (0.75)	1.9 (0.64)
State	-	0.3 (0.17)	0.08 (0.07)	0.08 (0.07)	0.05 (0.06)	0.06 (0.06)
DIC	-	-	23005.0	17401.5	16905.5	14512.292

[a] Bayes estimation and 95% credibility intervals

[b] Fixed effect estimates cell entries are parameter (beta) estimates and credible intervals.

[c] Intercept presented as a parameter estimate and standard error (SE)

[d] Random effect estimates are presented as estimates and credible intervals

[e] DIC refers to Deviance Information Criteria, a measure of model fit and complexity

Table 5. Nested Models Describing Association Between Predictors and Body Mass Index in the New Immigrant Survey at Wave 2 (N=3,291).

	Model 1- null models			**Model 2**	**Assessed Dietary Change**	**Model 4- Individual Pre-Migration**	**Model 5- Individual Post-Migration**
	Country only	State only	Cross-classified	Cross-classified	Cross-classified	Cross-classified	Cross-classified
Fixed effects							
Intercept (SE)	-0.09 (0.34)	-0.16 (0.16)	-0.18 (0.35)	-21.2 (1.17)	-22.2 (1.20)	-21.0 (1.31)	-21.0 (1.38)
Individual-level							
BMI Wave 1				0.94 (0.77,1.11)*	1.00 (0.83,1.17)*	1.03 (0.85,1.20)*	1.06 (0.88,1.25)*
BMI^2				-0.004 (-0.007,-0.0005)*	-0.005 (-0.008,-0.001)*	-0.005 (-0.008,-0.002)*	-0.006 (-0.009,-0.002)
Diet Wave 1							
Big Change (>5)					-0.15 (-0.38,0.09)	-0.15 (-0.39,0.08)	-0.18 (-0.43,0.07)
Abandoned (Y)					0.15 (-0.10,0.39)	0.18 (-0.07,0.43)	0.16 (-0.10,0.43)
Adopted (Y)					0.002 (-0.25,0.26)	-0.008 (-0.26,0.25)	0.06 (-0.21,0.32)
Diet Wave 2							
Big Change (>5)					0.14 (-0.09,0.36)	0.14 (-0.08,0.37)	0.05 (-0.19,0.29)
Abandoned (Y)					-0.10 (-0.33,0.13)	-0.09 (-0.32,0.14)	-0.01 (-0.26,0.24)
Adopted (Y)					0.17 (-0.06,0.41)	0.20 (-0.04,0.43)	0.26 (-0.0001,0.51)
Pre-Migration							
Social Standing							
Below Average						ref	ref
Average						0.14 (-0.13,0.41)	0.31 (0.02,0.61)*
Above Average						0.22 (-0.13,0.58)	0.50 (0.11,0.89)*
Urbanicity							
Urban						ref	ref
Rural						-0.03 (-0.27,0.21)	-0.08 (-0.34,0.17)
Gender							
Male						ref	ref
Female						-0.15 (-0.37,0.08)	-0.18 (-0.43,0.06)
Age (years)						-0.01 (-0.07,0.04)	-0.04 (-0.11,0.02)
Age^2						-0.0001 (-0.0007,0.0005)	0.0003 (-0.0007,0.000
Education (years)						-0.08 (-0.11,-0.05)*	-0.06 (-0.10,-0.03)*
Post-Migration							
Age First Migrated (years)							0.02 (0.007,0.04)*
Marital Status							
Not Married							ref
Married or Marriage-like Relationship							0.03 (-0.29,0.35)
Social Connectivity							
Yes							0.09 (-0.20, 0.38)
No							ref
English Fluency							
Not at All							ref
Not Well							-0.92 (-1.44,-0.39)*
Well							-0.63 (-1.10,-0.17)*
Very Well							-0.62 (-1.01,-0.22)*
Random effects							
Individual	17.8 (0.45)	20.1 (0.51)	17.8 (0.45)	8.8 (0.22)	8.7 (0.23)	8.4 (0.22)	8.4 (0.24)
Country	2.7 (0.91)	-	2.8 (0.92)	0.53 (0.21)	0.51 (0.20)	0.44 (0.18)	0.55 (0.23)
State	-	0.2 (0.13)	0.03 (0.03)	0.02 (0.02)	0.02 (0.02)	0.02 (0.02)	0.02 (0.02)
DIC	-	-	19142.0	15684.8	14446.2	14173.8	12293.88

[a] Bayes estimation and 95% credibility intervals

[b] Fixed effect estimates cell entries are parameter (beta) estimates and credible intervals.

[c] Intercept presented as a parameter estimate and standard error (SE)

[d] Random effect estimates are presented as estimates and credible intervals

[e] DIC refers to Deviance Information Criteria, a measure of model fit and complexity

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