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

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Abstract

In this study, we evaluate how pre- and post-migration contextual characteristics are associated with bodyweight among foreign-born individuals in the U.S.. We utilize a cross-classified multi-level model to model clustering in both country of origin and state of residence simultaneously using data from the New Immigrant Survey (n=3,085). The variance in BMI was driven largely by individual differences (86.6%), with country of origin explaining 13.3% of the variance and state of residence explaining 0.1%. Five years later, the variance in BMI was 10.9% for country of origin and 0.005% for state of residence. Country of origin characteristics were consistently associated with bodyweight, particularly animal protein and sweets consumption. We found few state-level characteristics associated with bodyweight. Even after years in the U.S., foreign-born individuals' bodyweight were more strongly associated with country of origin characteristics at the time of their departure, highlighting the role of differential immigrant adaptation by national origin.

1. Introduction

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.[1-3] 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 with the most recent report estimating adult obesity prevalence at 39.8% in the US.[4, 5]

Behavioral changes like shifts in dietary intake and physical activity[6-10] may alter energy balance, and in the longer term may be tied to obesity and related chronic diseases.[11, 12] Uphill environmental, social, and cultural factors appear to play an important role in shaping the more proximate behavioral patterns that give rise to body weight gain.[13] Features of an individual's social and build environment above and beyond the individuals constrain, limit, reward, and induce the behavior of individuals.[13, 14] Anthony Gidden's theoryof structuration is defined as the "active bi-directional process whereby knowledgeable social actors pursue goals within the constraints and opportunities of local environments that are historically and spatially rooted."[15] Efforts to reduce risk by changing behavior may be hopelessly ineffective if there is no clear understanding of the process that leads to exposure.[16] To the extent that obesity is a product of voluntary choices or behaviors, the fact that people are embedded in social networks and are influenced by the evident appearance and behaviors of those around them suggests that weight gain in one person might influence weight gain in others.[17] Spread of obesity may rely less on behavioral imitation than on a change in an individual's general perception of the social norms regarding the acceptability of obesity.[17]

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 and have higher rates of chronic disease and obesity with longer stay in the United States. [18-23] Dietary changes -as any other measure of immigrant adaptation- depends on the practices people engaged in before immigrating, as well as on the context they immigrate to. 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. While people do face different contexts

of "reception" in the United States, social norms and values concerning diet and bodyweight also vary, perhaps even more considerably, across nations/cultures.[24, 25] These norms and values are likely to influence not only individual bodyweight at arrival, but also post-migration changes. In the context of migration, the pre- and post-migration socio-economic context potentially contributes to behavior change and must both be taken into account. Characteristics of the countries of origin may be important after people have resettled in a new place.[26] The presence of local infrastructure and services may enhance resources that improve quality of life.[27] Features of population wellbeing possibly reflect high levels of social capital and capture features of health and wellness in the country.[27]

Foreign-born individuals tend to be in better health on arrival in the US than native-born Americans.[18, 28, 29] However, this health advantage deteriorates with duration of residence in the US.[21, 30] 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.[31] The preponderance of evidence indicates that immigrant health declines, rather than improves, with time in the US.[18] Practitioners and researchers have called for investigations of specific diseases/conditions which can help elucidate the pathways through which immigration might affect health.[32]

Foreign-born children and adults represent about 13% of the U.S. population, ~40 million people.[33] 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%).[34] Based upon data from the New Immigrant Survey (NIS), 12% of foreign-born individuals at the point of legal permanent residence in the US in 2003 -generally obtained after a few years of living in the country- were obese;[35] people from Latin America or the Caribbean, those who were older, had lived in the US for longer, and resided in the Western region of the US had higher odds of obesity.

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.[36, 37] This process entails adoption of new cultural elements and abandonment of cultural elements from the country of origin.[38, 39] These changes in cultural elements manifest in many areas of life such as language usage but can and often includes health behaviors.

Changes in eating patterns are an important consideration to understanding acculturation as well as health, as food and eating are central aspects of culture.[40] Previous studies have found that diets change with time in the United States[41] in ways that are both positive and negative for health; for example, they entail increased fruit and vegetable consumption for some groups, but also increased added/refined sugars.[42] Likewise, recent evidence suggests that foods including relatively high levels of sugars and animal fat and protein, which were once only consumed on special occasions in the country of origin, become routine foods in the post-migration diet.[40, 43] These dietary changes may lead to unhealthy weight gain and be related to the chronic disease patterns noted above.

On the other side, acculturation is shaped by the context of resettlement, including economic opportunities for upward mobility.[44] Theoretically, living in an area with high migrant density could exert both health-promoting and health-demoting influences on obesity risk.[45] Collective social advantage may play a role in generating environmental conditions that are related to population health.[46, 47]The presence of local infrastructure and services may enhance resources that improve quality of life.[47] It is well-established that health outcomes and its associated health behaviors (i.e., fruit and vegetable intake, resulting obesity rates) differ by state,[48] 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 fairly large differences by states with Colorado at the bottom with 20-25% and Alabama at the top with obesity prevalence above 35%.[5] Geographic variation in health behaviors are hypothesized contributors to patterning of obesity among the entire population in the United States and, by extension, foreign-born populations.[49] 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, are unknown in the context of migrant populations.[50]

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 will use country of origin-level and state of residence-level factors to determine how they potentially "induce and constrain health-related behaviors."[13] 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 residence-level factors. We further determine the associations of these multi-level characteristics with bodyweight.

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.[51] Respondents were first sampled between May and November 2003 (*N*=8,573) with a response rate of 68.6 % (NIS-2003-1; Wave 1). On average, the sample had been in the US for 8 years by the time of interview. Interviews were conducted in the language of the respondent's choice as soon as possible after LPR was granted. A follow-up interview (NIS-2003-2; Wave 2) was conducted over six years after the first interview, from June 2007 to December 2009. Re-interview rate was 45.5% for adults resulting in a sample size of 4,059. The NIS instrument includes modules on demographics, pre-immigration experiences, employment, health, income, assets/transfer, social characteristics, and migration history. Due to the large attrition between waves we restrict our sample to those with data on self-reported height and weight at both waves (n= 3,085). The downturn in the economy, rise of anti-immigrant sentiment, and the sharp increase in deportation between waves resulted in a lower response rate than achieved in Wave 1.[52] The strongest predictors of responding to Wave 2 pertained to demographic background, years of education, and intentions for future US residence.[52] Females were significantly more likely than males to respond.

2.2 Variables

We operationalized bodyweight in four 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 *Change in BMI* (Wave 2 – Wave 1). Self-reported height and weight were used to calculate continuous measures of BMI (kg/m^2). For interpretation purposes of models, *BMI* and *BMI 2* were centered at the grand mean. Finally, we also evaluated the odds of being obese at wave 1 (*Obese)*, where being obese was defined as ≥ 30 kg/m^2.[53]

The following variables are a breakdown of individual- and place-level variables both pre- and post-migration (**Figure 1**). Although our primary focus for this study is on place-level characteristics we evaluate a number of individual-level theorized contributors to bodyweight post-migration in foreign-born individuals.

(Figure 1 here)

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). *Gender* was interviewer identified as male/female at the start of the survey. *Age at Time of Survey* was self-report and kept continuous along with an age-squared term. *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 (Country of Origin): All country of origin place-level variables will be treated as level-2a variables and obtained from 1995 World Bank Development Indicators, Human Development Reports or Food Balance Sheets from the Food and Agriculture Organization (FAO) of the United Nations.[54, 55] 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. All of these measures were highly correlated over time (1985-200). Percent of the country population that resided in an urbanized area or urban cluster in 1993 as defined by the World Bank (*Country Urbanicity). Country HDI* is a summary measure of average 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. Both Urbanicity and HDI are possible correlated indicators with obesity based on the framing of an obesogenic environment. The Food Balance Sheets from FAO present a comprehensive picture of the pattern of a country's food supply by year. We estimated the proportion of kcalories per capita per day by country for animal protein and sweets in 1995. The proportion of meats included the kcalories per capita per day from bovine meat, mutton, goat meat, pig meat, poultry meat and meat (other) divided by the total kcalories consumed per capita per day (*Country Animal Protein)*. The measure of animal protein consumption by country may be correlated with obesity due to the connection with

higher animal fat consumption. The proportion of sugars included the kclories per capita per day from sugar and sweeteners divided by the total kcalories consumer per capita per day (*Country Sweets)*. This measure of sweets consumption by country may be correlated with obesity due to the connection of excess calories via sweets and sugars.

2.2.2 Post-Migration:

Individual-Level: *Age at First Migration* was determined by (Date of Birth – Year left country of Birth) and kept continuous. We focus on age at first migration instead of years in the US, because recent work by Van Hook *et al.,* (2018) disentangling age, age at arrival and duration of residence determined that among Mexican immigrants unhealthy diets were associated with arriving during preschool ages and duration of residence was positively associated with healthy eating after accounting for age at arrival.[56] However, we further run sensitivity using years in the US instead of Age at first migration and see similar results and thus present age at first migration. *Marital Status* was measured as a three-category item of single; married or living with a foreign-born spouse or partner; married or living with a native-born spouse or partner. *School-aged Children Living in the Home* was based upon respondent reports of lists of household members and age of each household member (yes/no). *English Fluency* was measured by asking respondents how well they spoke English with choices including: "very well, well, not well, and not at all." These were dichotomized into very well/well versus not well/not at all. Three dietary change variables were used as multiple self-assessment measures of dietary change among foreign-born individuals: 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 and 1 indicating completely different. *Change in Diet* was reverse coded and kept continuous where 10 represented completely different diet from before migration. *Any Abandoned*: "Is there something you ate regularly before coming to the United States that you rarely eat now?" Coded as yes/no. 3) *Any Adopted*: "Is there something you eat a lot now that you rarely ate before you came to the United States. Coded as yes/no.

***Place-Level (State of Residence)*:** All state of residence place-level variables will be treated as level-2b variables. The following level-2 predictors will be obtained from the 2000 Census Bureau: *State Foreign Born*, *State Urbanicity,* and *State Education*.[57] Proportion of the state population that is foreign born

(either naturalized citizen or non-citizen (*State Foreign Born)*. Proportion in an urbanized area or urban cluster in 2000 as defined by the US Census (*State Urbanicity*). Percent of the state population aged 24-65 years with a college education (*State Education*). *State 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 characterize BMI at Wave 1 and BMI/change at Wave 2. Using a cross-classified multi-level model approach, we assessed the extent to which variance in each bodyweight outcome was attributable to country of origin- and state of residence-level factors (i.e., between groups), as opposed to intra-group/cluster variance, assumed to operate mainly at the individual level. We began by exploring the non-hierarchical cross-classified data structure and fit cross-classified multilevel models (CCMM) to examine the relative importance of country of origin and state of residence as sources of variation in our outcomes,[58-60] meaning that the CCMM null model places individuals (denoted i) as simultaneously belonging to two non-nested contexts, here country of origin (denoted j_1) and state of resettlement (denoted j_2). For example, *BMI* at Wave 1 was modeled as:

$$(1)\quad BMI_{i(j_1,j_2)} = \beta_0 + u_{0j_1} + u_{0j_2} + e_{0i(j_1,j_2)}$$

In Equation 1, 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. Intraclass correlation coefficients (ICCs) were obtained 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; finally individual-level post-migration variables. We utilize this approach to move away from the traditional focus of

individual-level factors to more emphasis on the place-impact only. This further allows us to determine how much each level-2 variance are modified by level 2 aggregate variables. Equation 2 presents a proposed final model for *BMI* Wave 1:[1]

$$
\begin{aligned}
(2)\ BMI_{i(j_1,j_2)} = {} & \beta_0 + \beta_1 C\_urban_{1,ij_1} + \beta_2 C\_HDI_{2,ij_1} + \beta_3 C\_animal_{3,ij_1} + \beta_4 C\_sweets_{4,ij_1} \\
& + \beta_5 S\_obesity_{5,ij_2} + \beta_6 S\_education_{6,ij_2} + \beta_7 S\_urban_{7,ij_2} + \beta_8 S\_foreignborn_{8,ij_2} \\
& + \beta_9 social\ standing_{9i} + \beta_{10} urbanicity_{10i} + \beta_{11} education_{11i} \\
& + \beta_{12} age\ at\ time\ of\ survey_{12i} + \beta_{13} gender_{13i} + \beta_{14} age\ first\ migrated_{14i} \\
& + \beta_{15} marital\ stattus_{15i} + \beta_{16} children\ in\ school_{16i} + \beta_{17} english\ fluency_{17i} \\
& + \beta_{18} visa\ type_{18i} + \beta_{19} degree\ of\ change_{19i} + \beta_{20} any\ abandoned_{20i} \\
& + \beta_{21} any\ adopted_{21i} + u_{0j_1} + u_{0j_2} + e_{0i(j_1,j_2)}
\end{aligned}
$$

The same succession of models were done for *BMI* at Wave 2 and change in BMI between waves 1 and 2, with all outcomes using linear regression. Our evaluation of obesity as an outcome used logistic regression with the same succession of models. The BMI 2 model further included wave 1 BMI as a covariate. Significance of variables and variances were assessed at $\alpha = 0.05$ 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 all descriptive analyses and non-response weights were used for all wave 2 outcome descriptive analyses. All regression models excluded survey and non-response weights because we utilized a number of variables in our models which were used to create the non-response and sampling weights. The analytic sample for all models with plausible and non-missing values for bodyweight outcomes was 3,085 with 39 missing on country of origin and 935 with implausible or missing values on self-reported height or weight. At the country of origin level, there were an average of 51.1

[1] For equation purposes, all Country of Origin-level variables have the prefix "C_" and all State of Residence-level variables have the prefix "S_".

respondents from each of the 167 countries, which ranged from 1 to 2,223. At the state of residence level, there were an average of 204 respondents living in the 42 states with a range of 1 to 1,158. We used restricted maximum likelihood (REML) for estimation of variance components and maximum likelihood (ML) to test model fit and the deviances of nested models. REML is the preferred estimation strategy for models with relatively few level 2 units (our State level units) (Appendix Table 2).[61] Respondents were missing data in nine of the individual-level predictors (age, age at migration, degree of change, any abandoned, any adopted, urbanicity, education, social standing, and English fluency) resulting in 13% the total sample with missing data. Multiple imputation was conducted using the "mice" package and all models were estimated using "lme4" package in RStudio 3.6.1.[62, 63] All descriptive analyses were conducted in STATA 16.

3. Results

Participants in the sample came from 168 different countries of origin and requested a green card from 42 different states. An average of 51 foreign-born individuals per country of origin participated in NIS and are in our analytic sample (minimum=1; maximum=1158). In each state of residence, an average of 204 individuals participated (minimum=1; maximum=2223) 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 our analytic sample (n=3,085) as well as the full sample (n=8,573). For our outcome of interest (BMI) in Wave 1, 5% of the sample reported having a BMI categorized as underweight, 51% normal weight, 34% overweight and 11% obese, with mean BMI at 24.7 ± 0.11. By Wave 2, individuals' mean BMI had increased almost a whole point (0.96 kg/m^2) and stood at 25.7 ± 0.11 and 16% were obese. In comparison, based upon BRFSS data of the US population showed an increase of 0.5 BMI units between 2003 and 2003 and 22.4% of individuals were obese in 2003. The majority of the sample are male (54%) and married to a foreign-born spouse (65.5%) with a high school degree on average (12.3 years). Fifty-one percent of respondents reported speaking English very well or well and on average reported migrating to the US around age thirty. On a scale from one to ten, respondents reported that their diet changed since they arrived in the U.S. (5.5). Over half of respondents (53%) reported adopting at least one new food in the U.S. and 47% reported abandoning at least one food. Country of Origin- Human Development Index (HDI), ranged

between 0.229 and 0.883 with an average of 0.61 for the 168 countries in the NIS sample. In comparison, the United States had an HDI of 0.877 in 1995. The proportion of a country's population living in an urban area on average for the NIS sample countries was 54.5% with a range from 9.8 to 100%. The United States in comparison has 77.3% of the population living in an urban area. The average proportion of kcalories per capita per day from meat for the countries of origin in the NIS sample was 7.4% (0.69 – 24.5) with the United States at 11.9% in 1995 based upon FAO repots. The average proportion of kcalories per capita per day from sweets for the countries of origin in the NIS sample was 10.2% (0.88 – 24.5) with the US at 17.3%. The average proportion of the state with a college education for the 42 states included in the NIS was 15.8% in 2000. The average proportion of the state living in an urbanized area or cluster was 76.2%. The average proportion of the state who were foreign-born in 2000 was 8.3%. The average obesity rate for the 42 states in the NIS in 2003 was 22.0% and ranged from 16.0% to 28.4%.

(Table 1 here)

Figure 2 presents the mean BMI at Wave 1 (2003) by country of origin with zero representing the total average for the analytic sample (24.7) adjusted for age at time of survey and gender. Twenty-four countries had an average BMI significantly lower than the full sample average BMI with Vietnam, China and Cambodia over two BMI units below the average. Twenty-two countries had an average BMI significantly higher than the full sample average with Jamaica, Nicaragua, Guatemala, Mexico, and El Salvador over two BMI units above the average. This phenomenon persists and even widens by Wave 2 (Supplemental Figure 1).

(Figure 2 here)

Figure 3 presents the mean BMI at Wave 1 (2003) by state of residence with zero representing the total average for the analytic sample (24.7) adjusted for age at time of survey and gender. Three states had BMI's significantly different from zero. Pennsylvania was significantly lower than the average and California and Washington were significantly higher.

(Figure 3 here)

Table 2 presents the bivariate associations between country of origin and state of residence variables and the bodyweight outcomes keeping the CCMM structure. At Wave 1, Country Sweets was the only level-2 variable pre- or post-migration that was associated with BMI [0.14 (0.08,0.20)]. Country sweets was also the only country of origin variable associated with higher odds of being obese [1.06 (1.03,1.09)]. Five years later at Wave 2, Country HDI and Urbanicity in 1995 were associated with BMI 2 [HDI: -3.37 (-5.80,-0.93); Urbanicity: -0.02 (-0.04,0.0004)]. Change in BMI was associated with all four country of origin measures [HDI: -3.81(-5.36,-2.26); Urbanicity: -0.02 (-0.03,-0.008); Animal Protein: -0.08(-0.13,-0.02); Sweets: -0.08(-0.13,-0.03)].

(Table 2 here)

Table 3 presents the succession of models for Wave 1 BMI. Based upon the null model, and consistent with Figures 1 and 2, the country of origin ICC was 13.3% and state of residence ICC was 0.1%. Due to the small number of clusters at the state of residence (level 2b), we reduced the number of level-2 variables when incorporating individual-level variables to allow the model to converge. In the final model, individuals coming from countries with a higher proportion of kcalories/capita/day coming from animal protein (Country Animal Protein) was associated with lower BMI [-0.08 (-0.15,-0.001)]. Individuals coming from countries with a higher proportion of kcalories per capita per day coming from sweets (Country Sweets) was associated with higher BMI [0.13 (0.07,0.19)]. The country-level variance was reduced by almost half (2.4 vs 1.5) after inclusion of these variables. Individuals who reported more dietary change on a scale from one to ten (degree of change) was associated with higher BMI [005 (0.001,0.10)]. Being male was associated with lower BMI compared to females [-1.14 (-1.41,-0.87)], while being older was associated with higher BMI [0.33 (0.28,0.40)]. Migrating to the US at younger ages was associated with higher BMI [-0.05 (-0.06,-0.03)]. Being married to a foreign-born spouse or partner compared to a native-born spouse or partner was associated with higher BMI [0.68 (0.14,1.22)]. Having school-aged children living in the house was associated with higher BMI [0.45 (0.15,0.76)]. The full model had the lowest deviance of all models and was a reduction of 611.3 from the null

model. Individual-level variance was reduced by 1.6 based upon the inclusion of individual-level variables. Country of origin variance (level 2a) was reduced by 1.2 (50%) after the inclusion of country of origin variables. State of residence variance (level 2b) was reduced to <0.01 after inclusion of individual-level variables (pre- and post-migration).

(Table 3 here)

Table 4 presents the succession of models for Wave 2 BMI. Based upon the null model, the country of origin ICC was 10.9% and state of residence ICC was <0.01%. Due to the small number of clusters at the state of residence (level 2b), we reduced the number of level-2 variables to allow the model to converge. In the final model, individuals coming from countries with a higher proportion of kcalories per capita per day coming from animal protein (Country Animal Protein) was associated with lower BMI [-0.07 (-0.12,-0.02)]. Higher BMI at Wave 1 was associated with higher BMI five years later in Wave 2 [0.76 (0.73,0.79)]. Having above average social standing at age 16 was associated with higher BMI compared to those reporting below average social standing [0.42 (0.07,0.76)]. Being male was associated with lower BMI compared to females [-0.22 (-0.44,-0.01)]. Having more education was associated with lower BMI [-0.107 (-0.10,-0.04)]. Migrating to the US at older ages was associated with higher BMI [0.01 (0.0002,0.03)]. The full model had the lowest deviance of all models and was a reduction of 3458.9 from the null model. Individual-level variance was reduced by 9.5 based upon the inclusion of individual-level variables. Country of origin variance (level 2a) was reduced by 0.5 after the inclusion of all variables. State of residence variance (level 2b) increased to 0.01 after inclusion of individual-level variables (pre- and post-migration).

(Table 4 here)

Table 5 presents the succession of models for Change in BMI over five years (Wave 2 – Wave 1). Due to the small number of clusters at the state of residence (level 2b), we reduced the number of level-2 variables to allow the model to converge. In the final model, individuals coming from countries with a higher proportion of

kcalories per capita per day coming from sweets were less likely to gain weight over further time in the US [-0.04 (-0.08,-0.003)]. Reporting more dietary change on a scale from one to ten (degree of change) at Wave 1 was associated with less weight gain over time [-0.04 (-0.08, -0.004)]. Individuals reporting above average social standing at age 16 had greater weight gain over time compared to those reporting below average social standing [0.50 (0.13,0.86)]. Being younger and having less education was associated with greater change in BMI over time [Age: -0.10 (-0.15,-0.04); Education: -0.06 (-0.09,-0.04)]. Migrating to the US at younger ages was associated with greater change in BMI over time [0.03 (0.01,0.04)]. The full model had the lowest deviance of all models and was a reduction of 342.9 from the null model. Individual-level variance was reduced by 0.4 based upon the inclusion of individual-level variables. Country of origin variance (level 2a) was reduced by 0.3 and state of residence variance (level 2b) increased to 0.02.

(Table 5 here)

Table 6 presents the succession of models for the odds of being obese at Wave 1. Due to the small number of clusters at the state of residence (level 2b), we reduced the number of level-2 variables to allow the model to converge. In the final model, individuals coming from countries with a higher proportion of the population considered urban had lower odds of being obese at wave 1 [0.99 (0.98,0.996)]. Individuals coming from countries with a higher proportion of kcalories per capita per day coming from sweets had higher odds of being obese at Wave 1 [1.08 (1.05,1.12))]. Being male and having more education was associated with lower odds of being obese [Gender: 0.40 (0.36,0.44); Education: 0.98 (0.96,0.99)]. Being older was associated with higher odds of being obese [1.12 (1.10,1.15)]. Migrating to the US at younger ages was associated with higher odds of being obese [0.98 (0.97,0.99)]. Having school children living at home was associated with higher odds of being obese [1.29 (1.14,1.46)]. Speaking English well or very well was associated with higher odds of being obese compared to speaking englih not well or not at all [1.40 (1.22,1.62)]. The full model had the lowest deviance of all models and was a reduction of 803.9 from the null model.

(Table 6 here)

4. Discussion

This study evaluates the amount of variance in foreign-born BMI that can be attributed to individual-, country of origin-, and state of resettlement-level factors. Our results demonstrate that the large share of the variance in BMI at the point of legal permanent residency in 2003 and five years latter (2007-09) is attributable to individual-level factors. Some variance in BMI is also attributable to where an individual was born. Very little difference is seen when regarding state of resettlement-level factors.

Curren theories often discuss changes in bodyweight over extended period of time in the US is based upon post-migraiton location and context of resettlement but our analyses demonstrate different patterns…at least within the US context. The little variation seen at a state-level may have been taken care of through individual-level characteristics and were not impacted by the type of variables we had available at a state-level. Country-level variation may be more indicative of post-migration processes affect people of specific national origins differentially (given that individuals in our sample had been in the counry for eight years on average). Even after years in the U.S., foreign-born individuals' bodyweight were more strongly associated with country of origin characteristics at the time of their departure, highlighting the role of differential immigrant adaptation by national origin.

5. Tables and Figures

Figure 1. Overview of Variables Included at Each Level

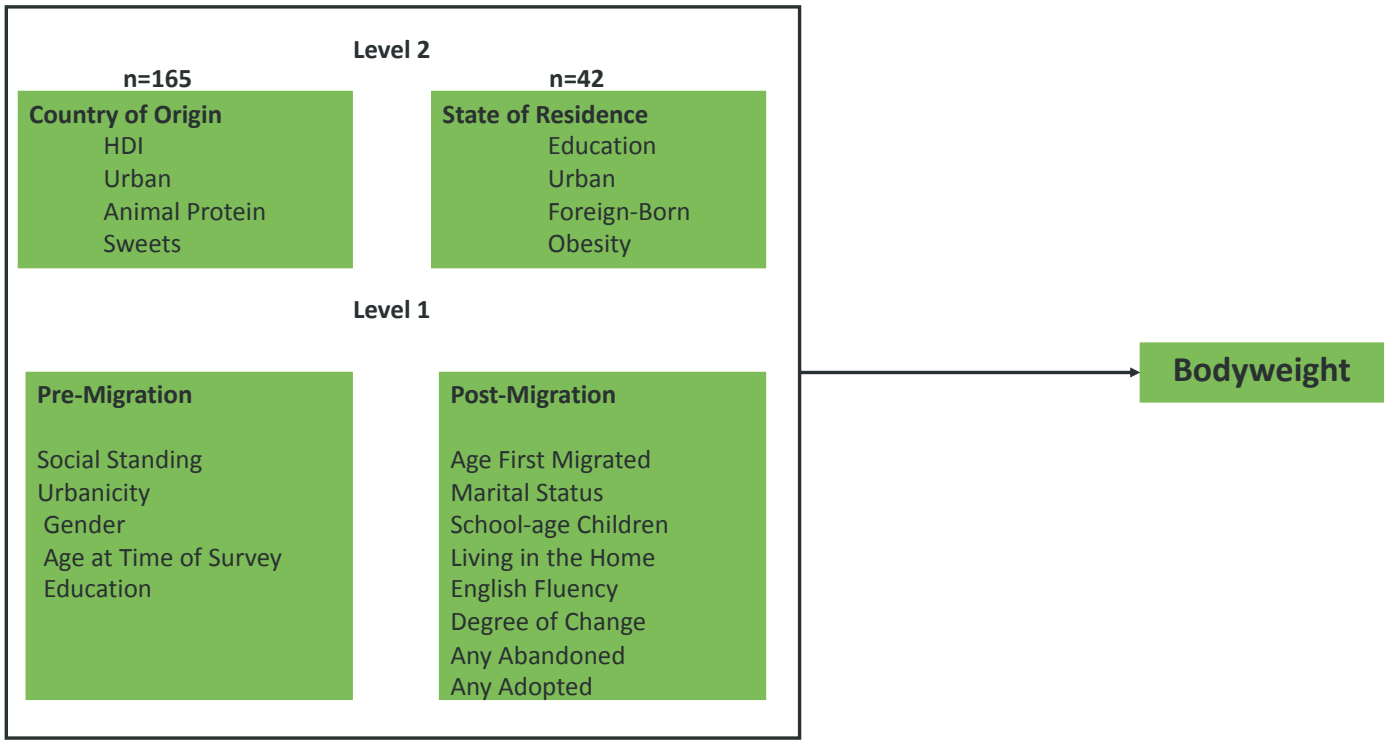
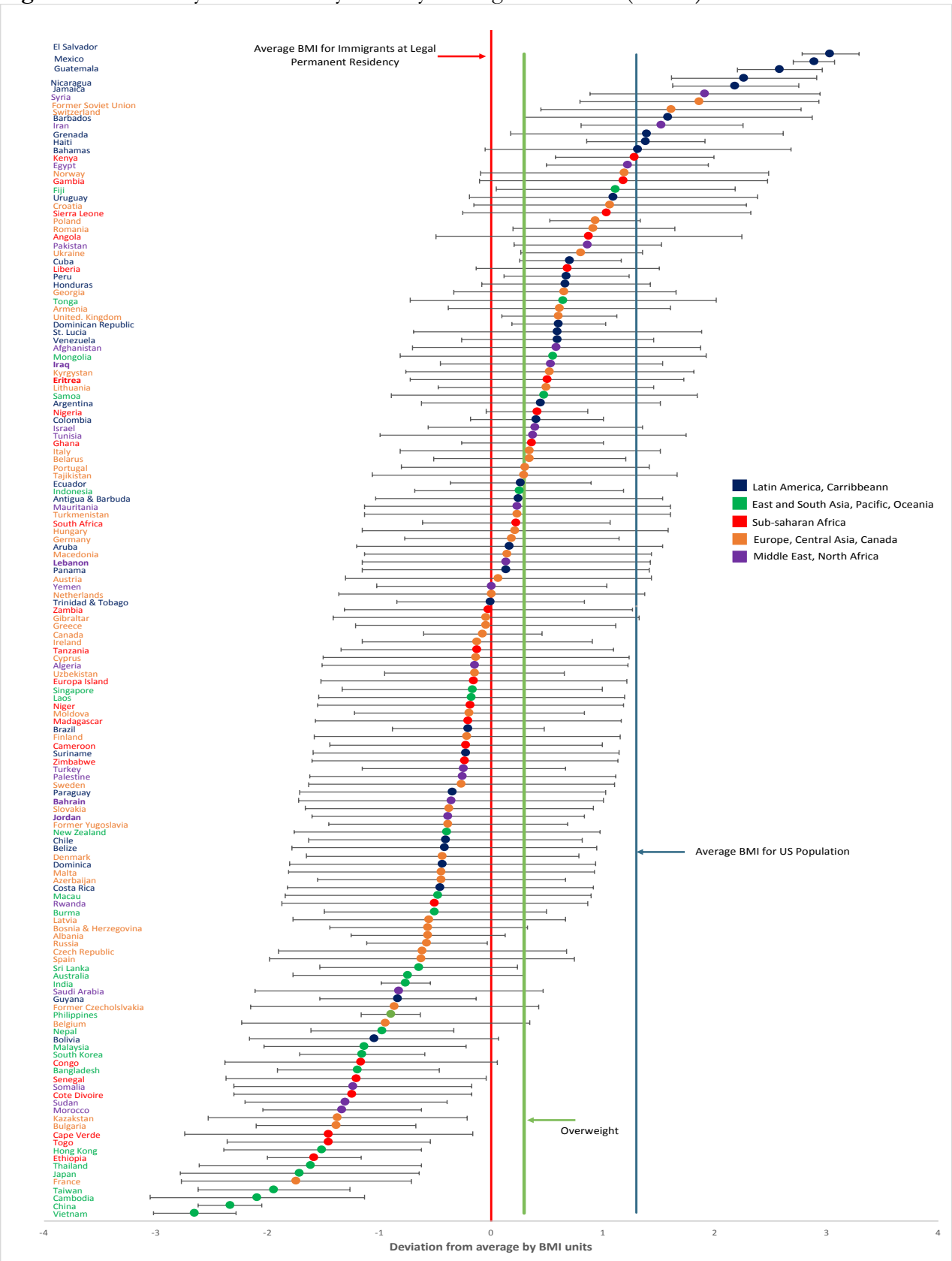


Table 1. Descriptive Characteristics of Foreign-Born Individuals in Analytic Sample (n=3,085) and Full Original Sample (n=8,573)

	Analytic Sample Mean (SE) or %	Full Wave 1 Sample Mean (SE) or %
LEVEL 1		
Bodyweight (kg/m2)		
BMI (continuous)	24.7 (0.11)	24.9 (0.06)
BMI (categories)		
Underweight	4.6%	3.9%
Normal Weight	51.2%	50.8%
Overweight	33.7%	33.3%
Obese	10.5%	11.9%
BMI Wave 2 (continuous)	25.7 (0.11)	25.7 (0.11)
BMI Wave 2 (categories)		
Underweight	3.3%	3.3%
Normal Weight	44.0%	44.0%
Overweight	36.6%	36.6%
Obese	16.1%	15.1%
Change in BMI (Wave 2 - Wave 1)	0.96 (0.07)	0.96 (0.07)
Self-Assessed Dietary Change at Wave 1		
Degree of Change	5.5 (0.07)	5.4 (0.04)
Any Abandoned		
Yes	47.2%	43.9%
Any Adopted		
Yes	53.1%	50.5%
Pre-Migration		
Self-assessed Social Standing at 16		
Below Average	29.4%	28.7%
Average	54.1%	53.1%
Above Average	16.6%	18.2%
Urbanicity at 10		
Urban	60.0%	59.8%
Rural	40.4%	40.2%
Gender		
Female	46.4%	43.6%
Male	53.6%	56.4%
Age at Time of Survey	37.7 (0.35)	39.2 (0.17)
Education	12.3 (0.11)	12.2 (0.06)
Post-Migration		
Age at First Migration	30.5 (0.38)	37.7 (0.19)
Marital Status		
Single/Divorced	19.5%	17.8%
Married to Native-born Spouse	15.1%	14.2%
Married to Foreign-born Spouse	65.5%	68.0%
School Children Living at Home		
Yes	41.3%	44.1%
No	58.7%	55.9%
English Fluency		
Very Well/Well	51.1%	47.7%
Not Well/Not at All	48.9%	52.3%
LEVEL 2	**Mean (Min - Max)**	**United States**
Pre-Migration (Country of Origin)		
Human Development Index (HDI)	0.61 (0.229 - 0.883)	0.877
Urbanicity (%)	54.5 (9.8 - 100)	77.3
Animal Protein (%)	7.4 (0.69 - 24.5)	11.9
Sweets (%)	10.2 (0.88 - 24.5)	17.3
Post-Migration (State of Resettlement)		
Education (%)	15.8 (10.3 - 21.6)	15.5
Urbanicity (%)	76.2 (40.2 - 100.0)	77.3
Foreign-born (%)	8.3 (2.0 - 26.2)	11.1
Obesity (%)	22.2 (16.0 - 28.4)	22.4

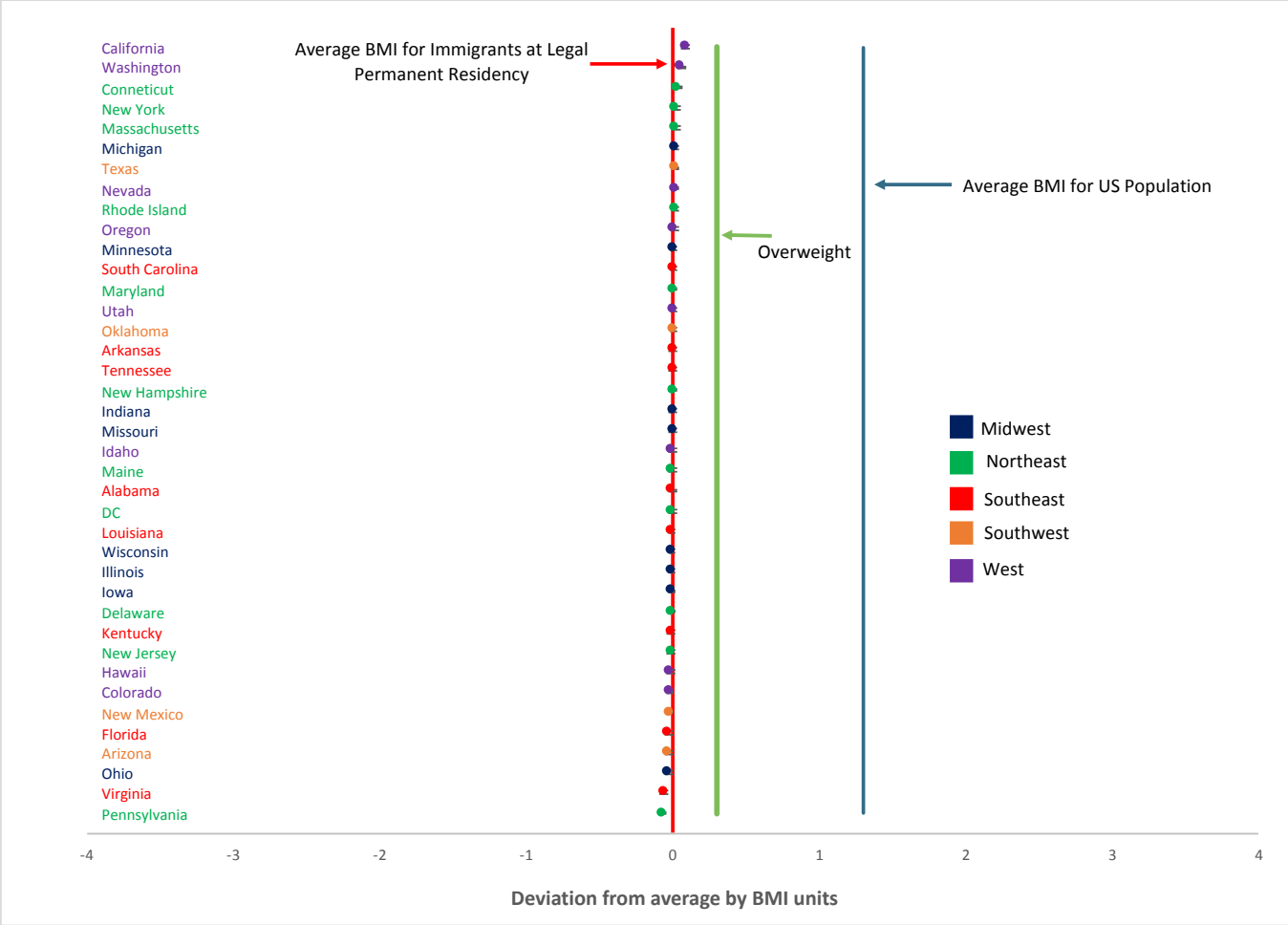
[a] Survey and non-response weights used
[b] Abbreviations: BMI (Body Mass Index); SE (Standard Error)
[c] Level 1 variables all taken from New Immigrant Survey 2003-1 or 2003-2.
[d] Level 2a Country of Origin variables: Human Development Index from HDI reports 1995 (n=153 countries); Urbanicity is proportion of population that is considered urban based on the World Bank definition 1995 (n=158 countries); Meat is defined by the Food and Agriculture Organization (FAO) as proportion of kcalories per capita per day from bovine meat, mutton, goat meat, pig meat, poultry meat, meat (other) in 1995 (n=147 countries); Sweets is defined by the FAO as proportion of kcalories per capita per day from sugar and sweeteners in 1995 (n=147 countries).
[e] Level 2b State of Residence variables: Education was defined as the proportion of the population age 25-64 with a college education based on US Census 2000. Urbanicity is the proportion of the population in an urbanized area or urban cluster in 2000 as defined by the US Census. Foreign-born is the proportion of the state population that is foreign born (either naturalized citizen or non-citizen) based on US Census 2000. Obesity is defined as the adult obesity rate by state obtained from the Behavioral Risk Factor Surveillance System in 2003. All Post-migration variables are based off of the 42 states included in the NIS.

Figure 2. Mean Body Mass Index by Country of Origin at Wave 1 (2003-1)



Note:
[a] n=3085
[b] Centered at the grand mean with red line representing mean BMI for the full sample
[c] BMI = kg/m², based upon self-reported height and weight
[d] Adjusted for age at time of survey and gender
[e] Colors represent regions: [(Blue: Latin America, Carribean); (Green: East and South Asia, Pacific, Oceania); (Red: Sub-Saharan Africa); (Orange: Europe, Central Asia, and Canada); (Purple: Middle East and North Africa)]
[f] Blue line at 1.3 representing the US national average BMI in 2003-04 for adults aged 20-74 based upon NHANES data
[g] Green line at 0.3 representing the start of overweight category based on CDC BMI categories

Figure 3. Mean Body Mass Index by State of Resettlement at Wave 1 (2003-1)



Note:

[a] n=3085
[b] Centered at the grand mean with red line representing mean BMI for the full sample
[c] BMI = kg/m², based upon self-reported height and weight
[d] Adjusted for age at time of survey and gender
[e] Colors represent regions: [(Blue: Midwest); (Green: Northeast); (Red: Southeast); (Orange: Southwest); (Purple: West)]
[f] Blue line at 1.3 representing the US national average BMI in 2003-04 for adults aged 20-74 based upon NHANES data
[g] Green line at 0.3 representing the start of overweight category based on CDC BMI categories

Table 2. Bivariate associations between Country- and State- level Variables and Bodyweight Outcomes

	BMI Wave 1 Beta (95% CI)	Obese Wave 1 OR (95% CI)	BMI Wave 2 Beta (95% CI)	Change in BMI Beta (95% CI)
Pre-Migration (Country of Origin)				
HDI	0.44 (-2.17,3.04)	0.73 (0.25,2.07)	-3.37 (-5.80,-0.93)*	-3.81 (-5.36,-2.26)*
Urbanicity	0.0004 (-0.02,0.02)	0.997 (0.989,1.004)	-0.02 (-0.04,0.0004)*	-0.02 (-0.03,-0.008)*
Animal Protein	0.01 (-0.07,0.10)	0.99 (0.96,1.03)	-0.08 (-0.16,0.003)	-0.08 (-0.13,-0.02)*
Sweets	0.13 (0.06,0.20)*	1.06 (1.03,1.09)*	0.04 (-0.03,0.12)	-0.08 (-0.13,-0.03)*
Post-Migration (State of Residence)				
Urbanicity	0.004 (-0.01,0.02)	1.01 (0.99,1.012)	0.01 (-0.007,0.03)	0.007 (-0.006,0.02)
Education	-0.0008 (-0.09,0.09)	1.02 (0.99,1.06)	-0.01 (-0.10,0.08)	-0.01 (-0.08,0.05)
Foreign born	0.002 (-0.03,0.03)	1.006 (0.99,1.01)	0.01 (-0.02,0.04)	0.01 (-0.008,0.03)
Obesity	-0.005 (-0.08,0.07)	0.997 (0.97,1.02)	0.007 (-0.07,0.08)	0.01 (-0.04,0.06)

Note:

[a] n=3085

[b] Non-response weights used for all outcomes

[c] BMI = kg/m^2, based upon self-reported height and weight

[d] Change in BMI = Wave 1 BMI subtracted from Wave 2 BMI, thus positive values mean an increase in BMI over time

[e] Obese ≥ 30 kg/m^2, based upon self-reported height and weight

[f] Level 2a Country of Origin variables: Human Development Index from HDI reports 1995 (n=153 countries); Urbanicity is proportion of population that is considered urban based on the World Bank definition 1995 (n=158 countries); Meat is defined by the Food and Agriculture Organization (FAO) as proportion of kcalories per capita per day from bovine meat, mutton, goat meat, pig meat, poultry meat, meat (other) in 1995 (n=147 countries); Sweets is defined by the FAO as proportion of kcalories per capita per day from sugar and sweeteners in 1995 (n=147 countries.

[g] Level 2b State of Residence variables: Education was defined as the proportion of the population age 25-64 with college education based on US Census 2000. Urbanicity is the proportion of the population in an urbanized area or urban cluster in 2000 as defined by the US Census. Foreign-born is the proportion of the state population that is foreign born (either naturalized citizen or non-citizen) based on US Census 2000. Obesity is defined as the adult obesity rate by state obtained from the Behavioral Risk Factor Surveillance System in 2003. All Post-migration variables are based off of the 42 states included in the NIS.

Table 3. Cross-classified linear nested models describing association between predictors and Bodyweight in the New Immigrant Survey at Wave 1 (2003).

	Null Model	Model B	Model C	Model D	Model E	Final Model
Fixed effects						
Intercept (SE)	-0.4 (0.19)	-1.5 (0.45)	-0.9 (2.49)	-2.7 (2.67)	-8.5 (1.07)	-8.3 (1.12)
Individual-level						
Self-assessed Dietary Change Wave 1						
Degree of Change (1-10)						0.05 (0.001,0.10)*
Any Abandoned (Y)						-0.03 (-0.34,0.27)
Any Adopted (Y)						0.11 (-0.20,0.42)
Pre-Migration						
Social Standing (Ref: Below Average)						
Average					-0.16 (-0.49,0.18)	-0.14 (-0.47,0.20)
Above Average					-0.32 (-0.77,0.12)	-0.36 (-0.81,0.09)
Urbanicity (Ref: Urban)						
Rural					-0.19 (-0.49,0.10)	-0.16 (-0.46,0.13)
Gender (Ref: Female)						
Male					-1.18 (-1.45,-0.91)*	-1.14 (-1.41,-0.87)*
Age at Time of Survey (years)					0.36 (0.29,0.42)*	0.33 (0.27,0.40)*
Age^2					-0.003 (-0.004,-0.002)*	-0.003 (-0.003,-0.002)*
Education (years)					-0.03 (-0.07,0.003)	-0.04 (-0.08,0.001)
Post-Migration						
Age at First Migration (years)						-0.05 (-0.06,-0.03)*
Marital Status (Ref: Native Spouse)						
Foreign-born						0.68 (0.14,1.22)*
Single/Divorced						0.54 (-0.03,1.12)
School Children Living at Home (Ref: No)						
Yes						0.45 (0.15,0.76)*
English Fluency (Ref: Not at All/Not Well)						
Well/Very Well						-0.17 (-0.37,0.34)
Pre-Migration (Country of Origin)						
Country HDI		-0.004 (-0.01,0.004)		-0.64 (-4.81,3.70)		
Country Urbanicity		-0.002 (-0.02,0.02)		0.0002 (-0.03,0.03)		
Country Animal Protein Consumption		-0.06 (-0.16,0.04)		-0.05 (-0.17,0.05)	-0.08 (-0.16,-0.003)*	-0.08 (-0.15,-0.001)*
Country Sweet Consumption		0.16 (0.08,0.23)*		0.15 (0.08,0.22)*	0.14 (0.08,0.20)*	0.13 (0.07,0.19)*
Post-Migration (State of Residence)						
State Education			-0.02 (-0.12,0.08)	0.003 (-0.09,0.11)		
State Urbanicity			0.01 (-0.03,0.05)	0.11 (-0.03,0.05)	0.003 (-0.01,0.02)	0.002 (-0.02,0.02)
State Foreign Born Population			0.001 (-0.03,0.05)	-0.002 (-0.03,0.04)		
State Obesity Rate			-0.004 (-0.09,0.09)	0.02 (-0.07,0.11)		
Random effects						
Individual	15.6 (3.95)	15.6 (3.95)	15.6 (3.95)	15.6 (3.95)	14.1 (3.76)	14.0 (3.74)
Country	2.4(1.53)	1.5 (1.21)	2.3 (1.52)	1.5 (1.21)	1.4 (1.17)	1.2 (1.09)
State	0.02 (0.15)	0.02 (0.14)	0.03 (0.18)	0.04 (0.19)	0.00 (0.00)	0.008 (0.09)
DIC	17584.8	17177.3	17582.8	17176.7	17018.4	16973.5

Note:

[a] n= 3085; 147 country clusters; 40 state clusters
[b] Multiple imputation used for predictors with missing data (diet measures, social standing, urbanicity, education, age at time of survey, age at first migration, education, and English fluency).
[d] Fixed effect estimates cell entries are parameter (beta) estimates and 95% confidence intervals.
[e] Intercepts presented as a parameter estimate and standard error (SE)
[f] Random effect estimates are presented as estimates and standard errors (SE)
[g] DIC refers to Deviance Information Criteria, a measure of model fit and complexity
[e] Level 2a Country of Origin variables: Human Development Index from HDI reports 1995 (n=153 countries); Animal Protein is defined by the Food and Agriculture Organization (FAO) as proportion of kcalories per capita per day from bovine meat, mutton, goat meat, pig meat, poultry meat, meat (other) in 1995 (n=147 countries); Sweets is defined by the FAO as proportion of kcalories per capita per day from sugar and sweeteners in 1995 (n=147 countries). Urbanicity is the proportion of the population in an urbanized area or urban cluster in 2000 as defined by the US Census (n=42).
[f] Level 2b State of Residence variables: Education was defined as the proportion of the population age 25-64 with a college education based on US Census 2000. Urbanicity is the proportion of the population in an urbanized area or urban cluster in 2000 as defined by the US Census. Foreign-born is the proportion of the state population that is foreign born (either naturalized citizen or non-citizen) based on US Census 2000. Obesity is defined as the adult obesity rate by state obtained from the Behavioral Risk Factor Surveillance System in 2003. All Post-migration variables are based off of the 42 states included in the NIS.

Table 4. Cross-classified linear nested models describing association between predictors and Bodyweight in the New Immigrant Survey at Wave 2 (2007-09).

	Null Model	Model B	Model C	Model D	Model E	Full Model
Fixed effects						
Intercept (SE)	-0.2 (0.18)	-4.1 (0.48)	-1.4 (2.30)	-1.2 (2.33)	-4.7 (1.14)	-17.0 (0.93)
Individual-level						
Wave 1 BMI (continuous)						0.76 (0.73,0.79)*
Self-assessed Dietary Change Wave 1						
Degree of Change (1-10)						-0.03 (-0.07,0.006)
Any Abandoned (Y)						0.10 (-0.14,0.34)
Any Adopted (Y)						0.05 (-0.19,0.29)
Pre-Migration						
Social Standing (Ref: Below Average)						
Average					0.03 (-0.33,0.38)	0.23 (-0.03,0.49)
Above Average					0.09 (-0.39,0.57)	0.42 (0.07,0.76)*
Urbanicity (Ref: Urban)						
Rural					-0.11 (-0.43,0.21)	-0.02 (-0.26,0.21)
Gender (Ref: Female)						
Male					-1.04 (-1.33,-0.75)*	-0.22 (-0.44,-0.01)*
Age at Time of Survey (years)					0.28 (0.21,0.34)*	-0.02 (-0.07,0.04)
Age^2					-0.003 (-0.004,-0.002)*	-0.0002 (-0.0008,0.0004)
Education (years)					-0.10 (-0.14,-0.06)*	-0.07 (-0.10,-0.04)*
Post-Migration						
Age at First Migration (years)						0.01 (0.0002,0.03)*
Marital Status (Ref: Native Spouse)						
Foreign-born						0.27 (-0.15,0.69)
Single/Divorced						0.19 (-0.26,0.64)
School Children Living at Home (Ref: No)						
Yes						-0.04 (-0.28,0.20)
English Fluency (Ref: Not at All/Not Well)						
Well/Very Well						-0.05 (-0.32,0.22)
Pre-Migration (Country of Origin)						
Country HDI		-0.005 (-0.01,0.004)		-4.84 (-9.32,-0.42)*		
Country Urbanicity		-0.01 (-0.04,0.009)		0.005 (-0.02,0.03)		
Country Animal Protein Consumption		-0.10 (-0.21,-0.002)*		-0.04 (-0.16,0.08)	-0.13 (-0.22,-0.05)*	-0.07 (-0.12,-0.02)*
Country Sweet Consumption		0.12 (0.04,0.19)*		0.12 (0.05,0.20)*	0.09 (0.02,0.15)*	-0.009 (-0.05,0.03)
Post-Migration (State of Residence)						
State Education			-0.03 (-0.13,0.08)	-0.01 (-0.12,0.09)		
State Urbanicity			0.02 (-0.02, 0.05)	0.02 (-0.02,0.06)	0.004 (-0.01,0.02)	0.0004 (-0.02,0.02)
State Foreign Born Population			0.005 (-0.04,0.04)	-0.003 (-0.04,0.04)		
State Obesity Rate			0.02 (-0.07,0.11)	0.04 (-0.05,0.13)		
Random effects						
Individual	18.0 (4.25)	18.0 (4.25)	18.0 (4.25)	18.0 (4.24)	17.1 (4.14)	8.5 (2.91)
Country	2.2 (1.47)	1.5 (1.24)	2.1 (1.46)	1.4 (1.17)	1.5 (1.2)	0.5 (0.69)
State	0.0001 (0.01)	0.000 (0.000)	2.35 e-8 (0.0002)	4.3e-8 (0.0002)	0.000 (0.000)	0.01 (0.11)
DIC	18883.2	18451.2	18880.8	18445.3	18451.3	15424.3

Note:

[a] n= 3085; 147 country clusters; 40 state clusters

[b] Multiple imputation used for predictors with missing data (diet measures, social standing, urbanicity, education, age at time of survey, age at first migration, education, and English fluency).

[d] Fixed effect estimates cell entries are parameter (beta) estimates and 95% confidence intervals.

[e] Intercepts presented as a parameter estimate and standard error (SE)

[f] Random effect estimates are presented as estimates and standard errors (SE)

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

[e] Level 2a Country of Origin variables: Human Development Index from HDI reports 1995 (n=153 countries); Animal Protein is defined by the Food and Agriculture Organization (FAO) as proportion of kcalories per capita per day from bovine meat, mutton, goat meat, pig meat, poultry meat, meat (other) in 1995 (n=147 countries); Sweets is defined by the FAO as proportion of kcalories per capita per day from sugar and sweeteners in 1995 (n=147 countries). Urbanicity is the proportion of the population in an urbanized area or urban cluster in 2000 as defined by the US Census (n=42).

[f] Level 2b State of Residence variables: Education was defined as the proportion of the population age 25-64 with a college education based on US Census 2000. Urbanicity is the proportion of the population in an urbanized area or urban cluster in 2000 as defined by the US Census. Foreign-born is the proportion of the state population that is foreign born (either naturalized citizen or non-citizen) based on US Census 2000. Obesity is defined as the adult obesity rate by state obtained from the Behavioral Risk Factor Surveillance System in 2003. All Post-migration variables are based off of the 42 states included in the NIS.

Table 5. Cross-classified linear nested models describing association between predictors and Change in Bodyweight in the New Immigrant Survey between Wave 2 and Wave 1.

	Null Model	Model B	Model C	Model D	Model E	Final Model
Fixed effects						
Intercept (SE)	1.2 (0.12)	2.4 (3.14)	1.3 (1.74)	1.9 (1.91)	5.0 (0.90)	4.9 (0.95)
Individual-level						
Self-assessed Dietary Change Wave 1						
Degree of Change (1-10)						-0.04 (-0.08,-0.004)*
Any Abandoned (Y)						0.11 (-0.14,0.36)
Any Adopted (Y)						0.02 (-0.23,0.28)
Pre-Migration						
Social Standing (Ref: Below Average)						
Average					0.27 (-0.0004,0.54)	0.26 (-0.01,0.53)
Above Average					0.46 (0.10,0.83)*	0.50 (0.13,0.86)*
Urbanicity (Ref: Urban)						
Rural					0.04 (-0.20,0.28)	0.13 (-0.23,0.26)
Gender (Ref: Female)						
Male					0.07 (-0.16,0.29)	0.04 (-0.18,0.26)
Age at Time of Survey (years)					-0.09 (-0.14,-0.04)*	-0.10 (-0.15,-0.04)*
Age^2					0.0006 (0.00003,0.001)*	0.0004 (-0.0002,0.001)
Education (years)					-0.07 (-0.09,-0.04)*	-0.06 (-0.09,-0.03)*
Post-Migration						
Age at First Migration (years)						0.03 (0.01,0.04)*
Marital Status (Ref: Native Spouse)						
Foreign-born						0.11 (-0.33,0.55)
Single/Divorced						0.07 (-0.40,0.53)
School Children Living at Home (Ref: No)						
Yes						-0.16 (-0.41,0.09)
English Fluency (Ref: Not at All/Not Well)						
Well/Very Well						-0.05 (-0.33,0.24)
Pre-Migration (Country of Origin)						
Country HDI		-0.009 (-0.007,0.005)		-4.59 (-7.55,-1.79)*		
Country Urbanicity		-0.01 (-0.03,0.003)		0.005 (-0.01,0.02)		
Country Animal Protein Consumption		-0.04 (-0.10,0.03)		0.03 (-0.05,0.10)	-0.05 (-0.10,0.004)	-0.05 (-0.10,0.0004)
Country Sweet Consumption		-0.03 (-0.08,0.02)		-0.03 (-0.07,0.02)	-0.05 (-0.09,-0.01)*	-0.04 (-0.08,-0.003)*
Post-Migration (State of Residence)						
State Education			0.006 (-0.07,0.08)	-0.01 (-0.10,0.07)		
State Urbanicity			0.004 (-0.02,0.03)	0.009 (-0.02,0.04)	0.0008 (-0.01,0.02)	0.0003 (-0.02,0.02)
State Foreign Born Population			-0.005 (-0.04,0.02)	-0.005 (-0.04,0.03)		
State Obesity Rate			0.03 (-0.04,0.10)	0.03 (-0.05,0.10)		
Random effects						
Individual	9.7 (3.11)	9.7 (3.11)	9.7 (3.11)	9.7 (3.11)	9.4 (3.07)	9.3 (3.06)
Country	0.7 (0.85)	0.5 (0.74)	0.7 (0.85)	0.4 (0.67)	0.4 (0.67)	0.4 (0.59)
State	0.000 (0.000)	0.01 (0.11)	0.01 (0.10)	0.03 (0.17)	0.02 (0.14)	0.02 (0.15)
DIC	16051.1	15687.7	16050.0	15676.8	15728.2	15708.20

Note:

[a] n= 3085; 147 country clusters; 40 state clusters

[b] Multiple imputation used for predictors with missing data (diet measures, social standing, urbanicity, education, age at time of survey, age at first migration, education, and English fluency).

[c] Change in BMI = Wave 1 BMI subtracted from Wave 2 BMI, thus positive values mean an increase in BMI over time

[d] Fixed effect estimates cell entries are parameter (beta) estimates and 95% confidence intervals.

[e] Intercepts presented as a parameter estimate and standard error (SE)

[f] Random effect estimates are presented as estimates and standard errors (SE)

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

[e] Level 2a Country of Origin variables: Human Development Index from HDI reports 1995 (n=153 countries); Animal Protein is defined by the Food and Agriculture Organization (FAO) as proportion of kcalories per capita per day from bovine meat, mutton, goat meat, pig meat, poultry meat, meat (other) in 1995 (n=147 countries); Sweets is defined by the FAO as proportion of kcalories per capita per day from sugar and sweeteners in 1995 (n=147 countries). Urbanicity is the proportion of the population in an urbanized area or urban cluster in 2000 as defined by the US Census (n=42).

[f] Level 2b State of Residence variables: Education was defined as the proportion of the population age 25-64 with a college education based on US Census 2000. Urbanicity is the proportion of the population in an urbanized area or urban cluster in 2000 as defined by the US Census. Foreign-born is the proportion of the state population that is foreign born (either naturalized citizen or non-citizen) based on US Census 2000. Obesity is defined as the adult obesity rate by state obtained from the Behavioral Risk Factor Surveillance System in 2003. All Post-migration variables are based off of the 42 states included in the NIS.

Table 6. Cross-classified linear nested models describing association between predictors and odds of being obese in the New Immigrant Survey at Wave 1 (2003).

	Null Model	Model B	Model C	Model D	Model E	Final Model
Fixed effects						
Intercept (SE)	0.41 (0.35,0.47)	0.32 (0.21,0.49)	0.16 (0.04,0.76)	0.10 (0.02,0.53)	0.03 (0.01,0.06)	0.03 (0.01, 0.07)
Individual-level						
Self-assessed Dietary Change Wave 1						
Degree of Change (1-10)						1.01 (0.99,1.03)
Any Abandoned (Y)						0.91 (0.80,1.03)
Any Adopted (Y)						1.09 (0.97,1.24)
Pre-Migration						
Social Standing (Ref: Below Average)						
Average					0.95 (0.83,1.08)	0.94 (0.82,1.07)
Above Average					0.99 (0.84,1.19)	0.96 (0.70,1.14)
Urbanicity (Ref: Urban)						
Rural					0.91 (0.81,1.02)	0.94 (0.83,1.06)
Gender (Ref: Female)						
Male					0.39 (0.35,0.43)*	0.40 (0.36,0.44)*
Age at Time of Survey (years)					1.12 (1.10,1.15)*	1.12 (1.10,1.15)*
Age^2					0.99 (0.998,0.999)*	0.99 (0.998,0.999)*
Education (years)					0.995 (0.93,1.01)	0.98 (0.96,0.99)*
Post-Migration						
Age at First Migration (years)						0.98 (0.97,0.99)*
Marital Status (Ref: Native Spouse)						
Foreign-born						1.02 (0.82,1.26)
Single/Divorced						0.998 (0.79,1.26)
School Children Living at Home (Ref: No)						
Yes						1.29 (1.14,1.46)*
English Fluency (Ref: Not at All/Not Well)						
Well/Very Well						1.33 (1.16,1.54)*
Pre-Migration (Country of Origin)						
Country HDI		0.55 (0.08,3.51)		0.53 (0.08,3.34)		
Country Urbanicity		0.99 (0.997,1.001)		0.99 (0.98,0.999)*	0.99 (0.98,0.996)*	0.99 (0.98,0.996)*
Country Animal Protein Consumption		0.99 (0.95,1.03)		0.99 (0.95,1.03)		
Country Sweet Consumption		1.08 (1.05,1.12)*		1.08 (1.05,1.12)*	1.09 (1.05,1.13)*	1.08 (1.05,1.12)*
Post-Migration (State of Residence)						
State Education			1.02 (0.99,1.06)	1.04 (0.99,1.08)	1.03 (0.99,1.06)	1.03 (0.99,1.06)
State Urbanicity			1.002 (0.99 , 1.015)	1.004 (0.99,1.02)		
State Foreign Born Population			1.003 (0.99,1.02)	1.0008 (0.99,1.01)		
State Obesity Rate			1.01 (0.98,1.05)	1.02 (0.99,1.06)		
Variance						
Country	0.45 (0.67)	0.37 (0.61)	0.45 (0.67)	0.38 (0.61)	0.42 (0.65)	0.37 (0.06)
State	0.001 (0.04)	0.002 (0.05)	7.30E-10	1.40E-06	3.00E-06	1.4e-8
DIC	8944.3	8658.3	8939.6	8652.4	8228.4	8140.40

Note:

[a] n= 3085; 147 country clusters; 40 state clusters

[b] Multiple imputation used for predictors with missing data (diet measures, social standing, urbanicity, education, age at time of survey, age at first migration, education, and English fluency).
[d] Fixed effect estimates cell entries are parameter (beta) estimates and 95% confidence intervals.
[e] Intercepts presented as a parameter estimate and standard error (SE)
[f] Random effect estimates are presented as estimates and standard errors (SE)
[g] DIC refers to Deviance Information Criteria, a measure of model fit and complexity
[e] Level 2a Country of Origin variables: Human Development Index from HDI reports 1995 (n=153 countries); Animal Protein is defined by the Food and Agriculture Organization (FAO) as proportion of kcalories per capita per day from bovine meat, mutton, goat meat, pig meat, poultry meat, meat (other) in 1995 (n=147 countries); Sweets is defined by the FAO as proportion of kcalories per capita per day from sugar and sweeteners in 1995 (n=147 countries). Urbanicity is the proportion of the population in an urbanized area or urban cluster in 2000 as defined by the US Census (n=42).
[f] Level 2b State of Residence variables: Education was defined as the proportion of the population age 25-64 with a college education based on US Census 2000. Urbanicity is the proportion of the population in an urbanized area or urban cluster in 2000 as defined by the US Census. Foreign-born is the proportion of the state population that is foreign born (either naturalized citizen or non-citizen) based on US Census 2000. Obesity is defined as the adult obesity rate by state obtained from the Behavioral Risk Factor Surveillance System in 2003. All Post-migration variables are based off of the 42 states included in the NIS.

Appendix

Table 1. Correlation Matrices of Level 1 and Level 2 Variables (n=3,085)

Level 1 Correlation

	BMI Wave 1	BMI Wave 2	Degree of Change	Any Abandoned	Any Adopted	Social Standing	Urbanicity	Gender	Age at Time of Survey	Education	Age at First Migration	Marital Status	School Children Living at Home	English Fluency
BMI Wave 1	1.00													
BMI Wave 2	0.74	1.00												
Degree of Change	0.08	0.07	1.00											
Any Abandoned	-0.004	0.02	0.31	1.00										
Any Adopted	0.05	0.06	0.34	0.43	1.00									
Social Standing	-0.15	-0.10	-0.06	0.02	-0.03	1.00								
Urbanicity	0.06	0.05	-0.01	-0.03	0.01	-0.21	1.00							
Gender	-0.14	-0.12	-0.01	-0.04	-0.04	-0.03	0.02	1.00						
Age at Time of Survey	0.17	0.07	-0.11	-0.14	-0.12	-0.12	0.14	0.01	1.00					
Education	-0.18	-0.18	-0.10	0.06	0.01	0.38	-0.34	-0.10	-0.19	1.00				
Age at First Migration	-0.01	-0.04	-0.15	-0.14	-0.16	-0.09	0.12	0.04	0.79	-0.14	1.00			
Marital Status	0.03	-0.004	0.0001	0.002	0.02	0.02	-0.004	0.05	0.16	0.01	0.09	1.00		
School Children Living at Home	0.14	0.10	-0.01	-0.002	0.01	-0.07	0.04	-0.0005	-0.08	-0.03	-0.11	0.20	1.00	
English Fluency	-0.10	-0.10	0.04	0.12	0.07	0.24	-0.22	-0.11	-0.24	0.50	-0.29	0.02	-0.06	1.00

Level 2 Correlations

Pre-Migration (Country of Origin)

	Country HDI	Country Urbanciity	Country Animal Protein	Country Sweets
Country HDI	1.00			
Country Urbanicity	0.83	1.00		
Country Animal Protein	0.69	0.49	1.00	
Country Sweets	0.48	0.65	0.12	1.00

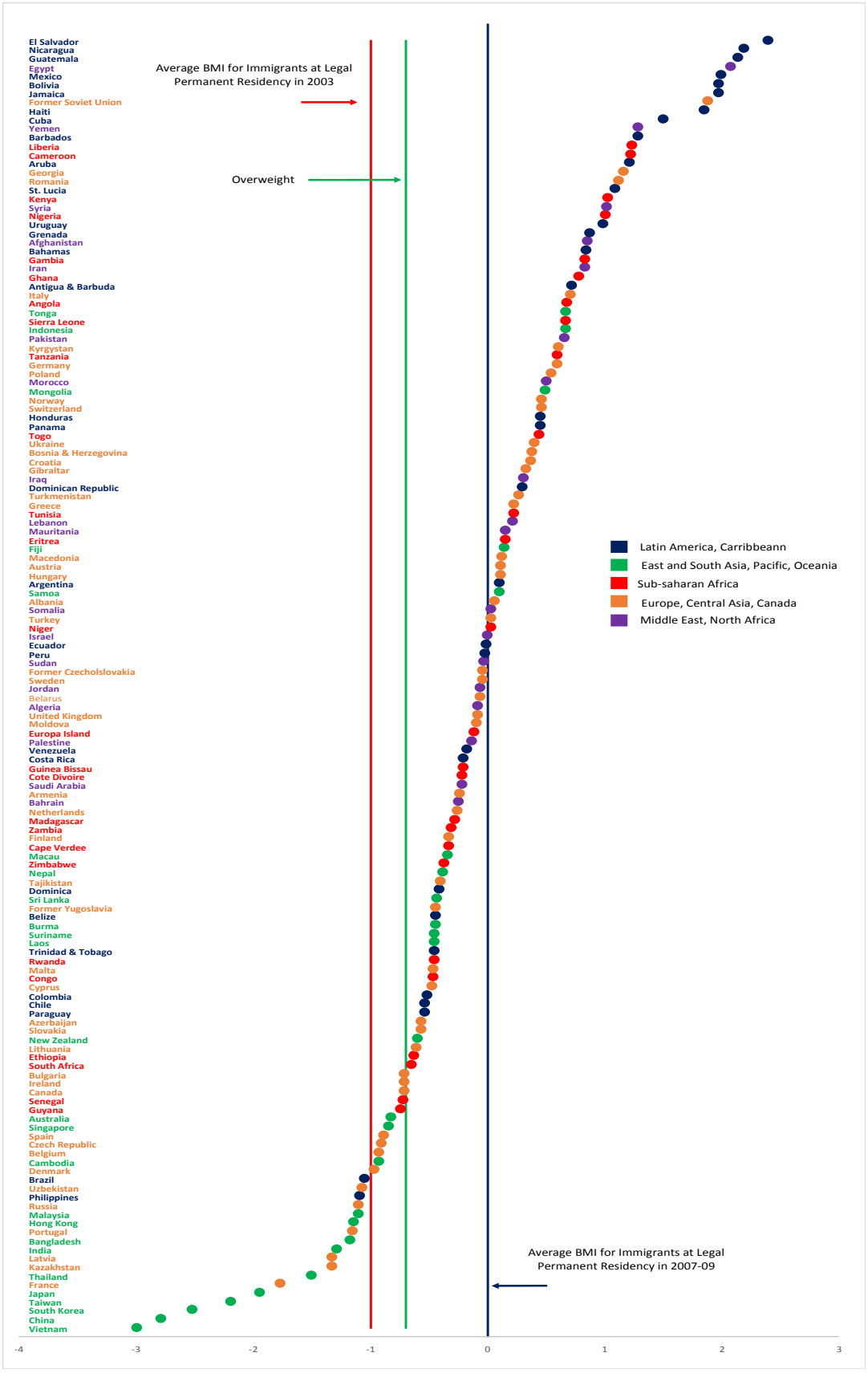
Post-Migrattion (State of Residence)

	State Urbanicity	State Education	State Foreign Born	State Obesity
State Urbanicity	1.00			
State Educatiton	-0.58	1.00		
State Foreign Born	0.82	-0.78	1.00	
State Obesity	-0.29	-0.15	0.03	1.00

Table 2. Mean and Proportion of Sample in each State of Residence Cluster (n=3, 085)

States of Residence	n (%)
AK	3 (0.09%)
AZ	50 (1.52%)
CA	907 (27.56%)
CO	43 (1.31%)
CT	40 (1.22%)
DC	8 (0.24%)
DE	5 (0.15%)
FL	241 (7.32%)
GA	65 (1.98%)
HI	17 (0.52%)
IA	7 (0.21%)
IL	178 (5.41%)
IN	13 (0.40%)
KS	22 (0.67%)
KY	10 (0.30%)
LA	8 (0.24%)
MA	163 (4.95%)
MD	102 (3.10%)
ME	1 (0.03%)
MI	49 (1.49%)
MN	41 (1.25%)
MO	25 (0.76%)
NC	49 (1.49%)
NH	8 (0.24%)
NJ	213 (6.47%)
NM	5 (0.15%)
NV	34 (1.03%)
NY	385 (11.70%)
OH	59 (1.79%)
OK	7 (0.21%)
OR	22 (0.67%)
PA	56 (1.70%)
RI	13 (0.40%)
SC	2 (0.06%)
TN	10 (0.30%)
TX	244 (7.41%)
UT	6 (0.18%)
VA	104 (3.16%)
WA	67 (2.04%)
WI	9 (0.27%)

Figure 1. Mean Body Mass Index by Country of Origin at Wave 2 (2007-2009)



Note:
[a] n=3085
[b] Centered at the grand mean with blue line representing mean BMI for the full sample at Wave 2
[c] Red line at -1 representing the mean BMI for the full sample at Wave 1
[d] BMI = kg/m^2, based upon self-reported height and weight
[d] Adjusted for age at time of survey and gender
[f] Colors represent regions: [(Blue: Latin America, Carribean); (Green: East and South Asia, Pacific, Oceania); (Red: Sub-Saharan Africa); (Orange: Europe, Central Asia, and Canada); (Purple: Middle East and North Africa)]
[g] Blue line at 1.3 representing the US national average BMI in 2003-04 for adults aged 20-74 based upon NHANES data
[h] Green line at 0.3 representing the start of overweight category based on CDC BMI categories

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