The Interaction Between an Individual's Acculturation and Community Factors on Physical Inactivity and Obesity: A Multilevel Analysis

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Objectives. We examined whether the interactions between primarily speaking English at home and community-level measures (median household income and immigrant composition) are associated with physical inactivity and obesity.

Methods. We pooled the 2005 and 2007 Los Angeles County Health Survey data to construct a multilevel data set, with community-level median household income and immigrant density as predictors at the community level. After controlling for individual-level demographic variables, we included the respondent's perceived community safety as a covariate to test the hypothesis that perceived public safety mediates the association between acculturation and health outcomes.

Results. The interaction between community median household income and primarily speaking English at home was associated with lower likelihoods of physical inactivity (odds ratio [OR] = 0.644; 95% confidence interval [CI] = 0.502, 0.825) and obesity (OR = 0.674; 95% CI = 0.514, 0.882). These odds remained significant after we controlled for perceived community safety.

Conclusions. Resources in higher-income areas may be beneficial only to residents fully integrated into the community. Future research could focus on understanding how linguistic isolation affects community-level social learning and access to resources and whether this differs by family-level acculturation. (*Am J Public Health.* 2015;105:1460–1467. doi:10.2105/AJPH.2014.302541)

Immigrants face the challenge of assimilating into their host country while maintaining values, beliefs, and behaviors from their homelands. Both acculturation and ethnic identity can influence health, and the construct of acculturation has been included in more and more health studies.[1,2] Despite long-standing sociocultural theories of behavior that suggest that one's behavior is the result of a dynamic interplay between internal, individual-level factors and social-cultural context,[3–6] few public health studies have explored this interaction.[7] A critical review noted that studies of acculturation tend to

> separate culture from the larger social structure and the dynamic social processes in which behavior and beliefs are generated, and to relegate consideration of the socio-economic challenges associated with immigration, poor English language skills, and poverty, to their effects as separate or confounding variables.[8(p981)]

For an immigrant, the interaction between acculturation status and the larger social structure in the host society could be important for health, as an inadequate level of acculturation in some contexts might result in reduced access to resources. In particular, undocumented immigrants have no federal coverage of health care under the Affordable Care Act. Therefore, access to resources may differ by legal status. However, in some settings, ethnic identity may buffer and even be protective against public health challenges in the United States (e.g., immigrants may maintain their dietary customs, which often include more whole foods, despite the excessive availability of processed foods in the United States).[9] From a methodological perspective, multilevel models can provide a better understanding of this kind of interaction, whereby community-level factors, individual-level acculturation, and the cross-level interaction effects between the two can all be included as regressors of the outcome variable. However, very few public health studies have considered the cross-level interaction between acculturation and community-level factors on health behaviors and health outcomes. In an attempt to fill this research gap, we used population-based survey data to explore the cross-level interaction between community-level factors (median household income and immigrant composition) and individual-level linguistic acculturation (language preference at home).

This study includes 2 independent variables that have been infrequently considered in previous studies of immigrant health: community immigrant composition and perceived community safety. Among various community-level factors that could influence residents' health outcomes, community immigrant composition has begun to receive academic attention.[10] Aside from individual-level acculturation indicators such as language preference and place of birth, living in a community with a high proportion of immigrants may be an independent predictor of one's level of acculturation since people who are less acculturated may choose to live in ethnic enclaves.[11] Perceived community safety has been shown to be a strong predictor of individual-level health outcomes such as having a mental health disorder or being overweight.[12–15] The causal pathways between an unsafe community and negative health outcomes such as obesity could operate through reduced physical activity[16–20] or through stress, which can disrupt energy metabolism and food intake regulation.[21–24]

Because acculturation has been shown to be associated with one's perception of community safety[25] and predicts many different health

behaviors and health outcomes,[1,2] it is likely that an individual's level of acculturation could modify the impact of community-level factors on health outcomes. Because understanding of these causal mechanisms is still far from conclusive, a study of the interaction between individuals' level of acculturation and community-level factors could help reveal the complex pattern of acculturation and health. From the perspective of public health interventions, a good understanding of acculturation, perceived safety, and health could inform intersectoral collaboration between public safety, K-12 (kindergarten through 12th grade) and adult education, immigrant services, and public health agencies.

METHODS

We obtained individual-level data from the 2005 and 2007 Los Angeles County Health Survey, which is a population-based survey of Los Angeles County, California, residents. Approximately 8000 households participate, out of nearly 10 million county residents. The sample size was chosen to produce estimates for gender and racial/ethnic groups and the 8 Service Planning Areas in the county.[26] The survey procedures include the identification of a random sample of landline household telephones using a random-digit-dial sampling method. A majority of the Los Angeles County population (99.2%, according to the 2010 US Census) resides in urban areas. For both survey years, additional adult surveys were conducted in Antelope Valley, as it is the least populated Service Planning Area in the county.[27,28] For the adult survey, interviews were conducted with 1 adult from each household. The adult response rates for the 2005 and 2007 surveys were 23% and 18%, respectively.[27,28]

Respondents who were born outside the United States (n = 5975) reported their country or region of origin. Approximately 100 unique places were reported, with the number of respondents per country ranging from 1 to 269. Because of the small number of participants by country, we did not conduct the present analyses separately. As part of the survey, respondents also provided zip codes for their place of residence. We then matched the survey data to Zip Code Tabulated Area data from the 2000 US Census to derive community-level measures (immigrant composition and income). The analytic sample consisted of 290 zip codes with a total sample size of 15 471 respondents.

Variables

Physical inactivity and obesity were the dependent variables. We classified physical inactivity as a binary outcome: active or some activity (coded 0) and minimal to no activity (coded 1). We determined the activity levels in the data set from questions about the frequency and duration of moderate and vigorous physical activity, which could include activities done at work or home or for recreation or exercise. For obesity, we dichotomized respondents into those who were obese (body mass index [BMI; defined as weight in kilograms divided by the square of height in meters] ≥ 30 kg/m^2; coded 1) and all others (coded 0). We included language spoken at home as the main measure of acculturation and length of time in the United States as an alternative measure. The 2 measures of acculturation were related to each other: nearly all US-born respondents (98%) spoke English at home, and immigrants were more likely to speak English at home the longer they had been in the country (18%, 21%, and 43% for <5 years, 5–10 years, and ≥ 10 years in the United States, respectively). We coded perceived community safety as "community perceived as unsafe or somewhat unsafe" (coded 1) and "community perceived as very safe or safe" (coded 0). We included and coded age, gender, race/ethnicity, educational attainment, and household income as individual-level control covariates.

Of the 290 zip codes in the data sets, 143 (49.31%) had small sample sizes (<50 respondents), whereas previous studies have suggested that multilevel logistic models require a sample size of at least 50 groups and 50 individuals per group to produce unbiased estimates.[29,30] To ensure adequate statistical power, we created larger geographic units by merging sparsely populated contiguous zip codes with similar median household incomes and racial makeups into areas larger than a zip code. We used ArcGIS 10.0 (ESRI, Redlands, CA) to identify the contiguous zip codes with insufficient sample sizes. We categorized both the zip code–level median household income and the zip code–level percentage of White residents into quartiles, and used the quartiles for the following 2-step merging procedure: (1) if 2 small contiguous zip codes fell into the same quartile in median household income and percentage of White residents, we merged them into 1 larger community; and (2) if 1 small zip code was adjacent to a large zip code, and they were in the same or neighboring quartiles of median income and percentage of Whites, we merged the small zip code with the larger one. As a result, we created 72 areas and combined them with 62 zip codes that already contained more than 50 respondents, yielding a total of 134 areas for multilevel analyses.

For community-level covariates ("community" here is operationalized as the "area" as described in the previous paragraph), we selected the percentage of immigrants in the community and community median household income. We obtained both measures at the zip code level from the 2000 US Census[31] and then aggregated them into the area level as weighted by the zip code's population share of the area. We used percentage of immigrants in the community to measure community composition, and median household income served as a proxy for community socioeconomic status. The mean percentage of immigrants in a community was 35.7% (range = 10.0%–68.1%). The mean median household income was $20 760 (range = $7720–$75 965). We created 2 interaction terms: language spoken at home × percentage of immigrants and language spoken at home × median household income.

Statistical Analysis

Our first objective in the analysis was to test whether acculturation was associated with perceived community safety, and whether this association was modified by community-level factors. Because the data had a hierarchical structure, we applied multilevel logistic regression on the dependent variable of perceived community safety to estimate the odds ratios of the individual-level and community-level variables and the cross-level interaction terms.

In a model with interaction terms, collinearity between the main effects and the interactions can inflate the estimated coefficients.[32] Thus, we centered the community-level variables around the grand mean. We log-transformed

TABLE 1—Characteristics of Study Participants, by Level of Perceived Community Safety: Los Angeles County Health Survey, California, 2005 and 2007

Characteristic	Perceived Their Community to Be Safe (n = 12 875), No. (%)	Perceived Their Community to Be Unsafe (n = 2596), No. (%)	P[a]
Language spoken at home			< .001
English	10 230 (79.46)	1 471 (56.66)	
Non-English	2 645 (20.54)	1 125 (43.34)	
Time in US, y			< .001
US-born	8 428 (65.46)	1 238 (47.69)	
0–4	333 (2.59)	111 (4.28)	
5–10	514 (3.99)	193 (7.43)	
≥ 10	3 530 (27.42)	1 040 (40.06)	
Age, y			< .001
18–34	2 753 (21.38)	844 (32.51)	
35–49	3 819 (29.66)	892 (34.36)	
50–64	3 390 (26.33)	553 (21.30)	
≥ 65	2 913 (22.63)	307 (11.83)	
Gender			< .001
Male	6 298 (48.92)	1 124 (43.30)	
Female	6 577 (51.08)	1 472 (56.70)	
Race/ethnicity			< .001
Non-Hispanic White	5 742 (44.60)	585 (22.53)	
Hispanic	4 322 (33.57)	1 457 (56.12)	
African American	1 017 (7.90)	280 (10.79)	
Asian	1 413 (10.97)	229 (8.82)	
Others	381 (2.96)	45 (1.73)	
Educational attainment			< .001
Less than high school	2 063 (16.12)	846 (32.98)	
High school diploma	2 458 (19.21)	567 (22.11)	
Some college	3 352 (26.20)	643 (25.07)	
College degree or above	4 922 (38.47)	509 (19.84)	
Household income, % of FPL			< .001
≤ 100	2 140 (16.62)	901 (34.71)	
≤ 200	2 521 (19.58)	779 (30.01)	
≤ 300	2 133 (16.57)	367 (14.14)	
> 300	6 081 (47.23)	549 (21.15)	
% of immigrants in community[b]			< .001
≥ 50	1 683 (13.07)	636 (24.50)	
< 50	11 192 (86.93)	1 960 (75.50)	
Median household income in the community, $[b]			< .001
< 13 338.34 (< 25th percentile)	2 611 (20.28)	1 185 (45.65)	
13 338.34–18 596 (25th–50th percentile)	3 098 (24.06)	810 (31.20)	
18 597–26 532 (50th–75th percentile)	3 482 (27.04)	409 (15.76)	
> 26 532 (> 75th percentile)	3 684 (28.61)	192 (7.40)	
Physical activity			< .001
Minimal or none	4 774 (36.95)	1 066 (41.35)	
Vigorous or moderate	8 147 (63.05)	1 512 (58.65)	

Continued

median household income to adjust for its skewed distribution.

Our second objective was to test whether perceived community safety was a significant mediator in the relationship between linguistic acculturation and the health outcomes (physical inactivity and obesity), and whether the cross-level interaction between linguistic acculturation and community-level factors significantly predicted health after adjustment for perceived community safety. We estimated multilevel logistic regression models with perceived community safety, linguistic acculturation, other individual-level variables, and community-level variables, as well as cross-level interactions.

We produced all of the multilevel logistic regression models with random effects, assuming an independent variance–covariance matrix, using the XTMELOGIT command in Stata version 12.0 (StataCorp LP, College Station, TX). We performed all statistical significance tests at the $\alpha = .05$ level.

RESULTS

Table 1 provides the descriptive statistics of variables used in the analysis. Of the 15 471 respondents, 2596 (16.78%) reported that they felt unsafe or somewhat unsafe in their community. Among those who felt safe, 79.46% primarily spoke English at home, whereas among those who reported feeling unsafe only 56.66% primarily spoke English at home ($P < .001$). Among US-born respondents, a higher proportion felt safe (65.46%) than unsafe (47.69%; $P < .001$). The distribution of age and gender varied significantly by perceived community safety ($P < .001$). For the categories race/ethnicity, educational attainment, and household income, those most likely to feel safe in their communities were non-Hispanic Whites (44.60%), those with a college degree or more (38.47%), and those with a family income of more than 300% of the federal poverty level (47.23%), respectively. Among those who felt safe in their communities, only 13.07% lived in immigrant-dominant communities (≥ 50% immigrant), whereas among those who felt unsafe in their communities, 24.50% lived in immigrant-dominant communities. The frequency distribution of health outcomes, including physical inactivity and obesity, varied significantly across levels of perceived community safety ($P < .001$).

TABLE 1—*Continued*

Obesity			< .001
Yes	3 538 (27.20)	1 013 (38.87)	
No	9 471 (72.80)	1 593 (61.13)	
Hypertension			
Yes	3 613 (27.88)	680 (26.21)	.083
No	9 346 (72.12)	1 914 (73.79)	

Note. FPL = federal poverty level. Percentages might not sum to 100 because of rounding.
[a]*P* values were produced by the χ^2 test.
[b]Data were derived from the 2000 US Census.

Table 2 presents results of the multilevel logistic regressions of the association between acculturation and perceived community safety. People who spoke English at home were less likely to feel unsafe in the community than those who spoke other languages at home, and this association was strong and significant regardless of the sets of variables included in the model (in model 4, in which we controlled for cross-level interaction, odds ratio [OR] = 0.467; 95% confidence interval [CI] = 0.384, 0.568). In model 4, immigrants who were in the United States for less than 10 years were less likely to feel unsafe than those born in the United States (for immigrants in the United States 0–4 years: OR = 0.683; 95% CI = 0.520, 0.899; for 5–10 years: OR = 0.770; 95% CI = 0.611, 0.971). There were no significant differences between US-born residents and those immigrants who had lived in the United States for 10 years or more (OR = 0.975; 95% CI = 0.841, 1.132).

Other individual-level characteristics were associated with perceptions of safety (model 2). Non-White Hispanic and African American respondents were more likely to report feeling unsafe in their communities than White respondents. However, when we considered community factors (models 3–4), they were less likely to report feeling unsafe. Non-White Hispanic and African American respondents tended to live in lower-income and immigrant communities. Low household income was significantly related to increased odds of feeling unsafe, and this remained significant when we considered community factors (models 2–4).

At the community level, a higher level of community median household income was associated with decreased likelihood of feeling unsafe in the community (in model 3, OR = 0.267; 95% CI = 0.202, 0.353). After we controlled for cross-level interaction terms, the protective relationship of community median household income was significant only among those who spoke English at home (in model 4, OR = 0.385; 95% CI = 0.269, 0.550).

Table 3 presents the results of the multilevel regressions of the relationship between acculturation, perceived community safety, and physical inactivity. Table 4 presents the results of the multilevel regressions of the relationship between acculturation, perceived community safety, and obesity. Feeling unsafe in the community was significantly associated with an increased chance of reporting physical inactivity (OR = 1.127; 95% CI = 1.025, 1.240) and obesity (OR = 1.174; 95% CI = 1.065, 1.295). Primarily speaking English at home was not a significant predictor of physical inactivity, with perceived community safety (OR = 0.903; 95% CI = 0.785, 1.039) or without (OR = 0.881; 95% CI = 0.766, 1.012). Primarily speaking English at home was negatively associated with obesity, with perceived community safety (OR = 0.679; 95% CI = 0.580, 0.795) or without (OR = 0.681; 95% CI = 0.583, 0.795). Recent immigrants (in the United States < 5 years) were more likely than native-born Americans to be physically inactive (without perceived community safety: OR = 1.398; 95% CI = 1.120, 1.745; with perceived community safety: OR = 1.424; 95% CI = 1.137, 1.783) and obese (without perceived community safety: OR = 1.761; 95% CI = 1.392, 2.229; with perceived community safety: OR = 1.843; 95% CI = 1.452, 2.341). By contrast, longer-term immigrants (in the United States ≥ 10 years) were less likely to be obese than native-born Americans (without perceived community safety: OR = 0.816; 95% CI = 0.725, 0.919; with perceived community safety: OR = 0.818; 95% CI = 0.726, 0.921).

None of the community-level factors in these models significantly predicted physical inactivity or obesity as a main effect. However, for the cross-level interaction effects (i.e., the interaction between individual-level linguistic acculturation and community-level factors), the interaction between language preference at home and community median household income was significantly associated with physical inactivity (OR = 0.644; 95% CI = 0.502, 0.825) as well as obesity (OR = 0.674; 95% CI = 0.514, 0.882). In other words, only among those who primarily spoke English at home was one's residence in a high-income community associated with less risk for physical inactivity and obesity.

DISCUSSION

To the best of our knowledge, this is the first multilevel study using cross-level interactions to understand the complex relations between individual-level acculturation and community-level factors. This study of the intervening role of acculturation provides a new perspective: although acculturation is directly associated with health behavior at the individual level, it also mediates the impact of the community environment. The interaction between primarily speaking English at home and community median household income predicts lower risk of feeling unsafe in one's community, lower risk of obesity, and lower risk of physical inactivity. By contrast, at the individual level, community median household income alone, as a main effect, is not significantly associated with physical inactivity or obesity. It is particularly worth noting that the interaction effect between individual-level linguistic acculturation and community-level median household income remained a significant predictor of physical inactivity after we controlled for perceived community safety, which suggests that there are pathways between linguistic acculturation and physical inactivity other than perceived community safety.

TABLE 2—Regressions of the Association Between Acculturation and Perceived Community Safety: Los Angeles County Health Survey, California, 2005 and 2007

Variable	Feel Unsafe in Their Community			
	Model 1 (n = 15 471), OR (95% CI)[a]	Model 2 (n = 15 073), OR (95% CI)[b]	Model 3 (n = 14 802), OR (95% CI)[c]	Model 4 (n = 14 802), OR (95% CI)[d]
Individual-level variables				
Language spoken at home				
Non-English (Ref)	1.000	1.000	1.000	1.000
English	0.370*** (0.320, 0.430)	0.536*** (0.446, 0.644)	0.638*** (0.545, 0.748)	0.467*** (0.384, 0.568)
Time in US, y				
US-born (Ref)	1.000	1.000	1.000	1.000
0–4	0.955 (0.705, 1.293)	0.740 (0.536, 1.021)	0.681** (0.517, 0.896)	0.683** (0.520, 0.899)
5–9	1.080 (0.840, 1.388)	0.819 (0.627, 1.071)	0.764* (0.606, 0.964)	0.770* (0.611, 0.971)
≥ 10	0.950 (0.817, 1.105)	0.915 (0.773, 1.082)	0.969 (0.836, 1.122)	0.975 (0.841, 1.132)
Age		0.985*** (0.981, 0.988)	0.985*** (0.982, 0.988)	0.985*** (0.982, 0.988)
Gender				
Male (Ref)		1.000	1.000	1.000
Female		1.121 (0.999, 1.258)	1.148** (1.044, 1.261)	1.148** (1.045, 1.262)
Race/ethnicity				
White (Ref)		1.000	1.000	1.000
Non-White Hispanic		1.362** (1.128, 1.645)	0.819* (0.694, 0.967)	0.772** (0.651, 0.914)
African American		2.201*** (1.773, 2.732)	0.828 (0.681, 1.006)	0.727** (0.592, 0.893)
Asian		1.139 (0.866, 1.499)	0.836 (0.677, 1.032)	0.735** (0.590, 0.914)
Others		0.914 (0.500, 1.669)	0.758 (0.517, 1.112)	0.739 (0.502, 1.087)
Educational attainment				
< high school (Ref)		1.000	1.000	1.000
High school diploma		0.866 (0.732, 1.025)	0.919 (0.798, 1.058)	0.903 (0.785, 1.040)
Some college		0.930 (0.771, 1.121)	1.066 (0.918, 1.238)	1.048 (0.903, 1.218)
≥ college degree		0.793* (0.638, 0.985)	0.934 (0.789, 1.106)	0.934 (0.789, 1.105)
Household income, % of FPL				
≤ 100		2.039*** (1.680, 2.474)	1.896*** (1.618, 2.222)	1.855*** (1.582, 2.174)
≤ 200		1.932*** (1.603, 2.329)	1.830*** (1.580, 2.120)	1.768*** (1.525, 2.050)
≤ 300		1.448*** (1.184, 1.771)	1.449*** (1.240, 1.694)	1.414*** (1.208, 1.654)
> 300 (Ref)		1.000	1.000	1.000
Community-level variables				
% of immigrants in community			1.186 (0.487, 2.890)	1.425 (0.493, 4.118)
Median household income in community			0.267*** (0.202, 0.353)	0.531** (0.370, 0.761)
Cross-level interactions				
English × % of immigrants in community				0.742 (0.267, 2.062)
English × median household income in community				0.385*** (0.269, 0.550)

Note. CI = confidence interval; FPL = federal poverty level; OR = odds ratio.
[a]Simple logistic regression of the association between acculturation and feel unsafe in the community.
[b]Logistic regression adjusting for individual-level demographic and socioeconomic characteristics.
[c]Multilevel logistic regression adjusting for individual-level demographics, socioeconomic status (SES), and percentage of immigrants.
[d]Multilevel logistic regression adjusting for individual-level demographics, SES, percentage of immigrants, and cross-level interactions.
*$P < .05$; **$P < .01$; ***$P < .001$.

One such pathway may be in terms of different access to higher-quality amenities. For example, richer communities may have better recreational and active transportation facilities that are better integrated into the community design. Pedestrian and bicycle facilities, lower traffic volumes, and aesthetically pleasing design can reduce barriers to walking and biking. Health-related screenings and health promotion can take place at the community-level. Thus, moving to a community with higher median household income can help improve

TABLE 3—Regressions of the Association Between Acculturation, Perceived Community Safety, and Physical Inactivity: Los Angeles County Health Survey, California, 2005 and 2007

Variable	Without Perceived Community Safety, (n = 14 890), OR (95% CI)	With Perceived Community Safety, (n = 14 802), OR (95% CI)
Individual-level variables		
Language spoken at home		
Non-English (Ref)	1.000	1.000
English	0.881 (0.766, 1.012)	0.903 (0.785, 1.039)
Time in US, y		
US-born (Ref)	1.000	1.000
0–4	1.398** (1.120, 1.745)	1.424** (1.137, 1.783)
5–9	0.995 (0.823, 1.204)	1.003 (0.827, 1.217)
≥ 10	0.958 (0.862, 1.065)	0.962 (0.865, 1.070)
Age	1.020*** (1.018, 1.023)	1.021*** (1.018, 1.023)
Gender		
Male (Ref)	1.000	1.000
Female	1.477*** (1.379, 1.583)	1.489*** (1.389, 1.596)
Race/ethnicity		
White (Ref)	1.000	1.000
Non-White Hispanic	0.984 (0.877, 1.104)	0.989 (0.881, 1.110)
African American	1.289*** (1.121, 1.482)	1.295*** (1.126, 1.490)
Asian	1.398*** (1.215, 1.609)	1.422*** (1.235, 1.637)
Others	0.935 (0.734, 1.192)	0.940 (0.737, 1.200)
Educational attainment		
< high school (Ref)	1.000	1.000
High school diploma	0.926 (0.824, 1.042)	0.931 (0.827, 1.048)
Some college	0.815** (0.722, 0.920)	0.822** (0.727, 0.930)
≥ college degree	0.731*** (0.643, 0.831)	0.733*** (0.644, 0.835)
Household income, % of FPL		
≤ 100	1.449*** (1.287, 1.631)	1.430*** (1.269, 1.611)
≤ 200	1.277*** (1.149, 1.419)	1.268*** (1.141, 1.411)
≤ 300	1.189** (1.071, 1.320)	1.174** (1.056, 1.304)
> 300 (Ref)	1.000	1.000
Perceived community safety		
Safe (Ref)		1.000
Unsafe		1.127* (1.025, 1.240)
Community-level variables		
% of immigrants in community	1.083 (0.567, 2.067)	1.160 (0.607, 2.218)
Median household income	1.197 (0.955, 1.500)	1.237 (0.987, 1.551)
Cross-level interactions		
English × % of immigrants in community	0.920 (0.436, 1.940)	0.835 (0.393, 1.776)
English × median household income	0.662** (0.517, 0.848)	0.644** (0.502, 0.825)

Note. CI = confidence interval; FPL = federal poverty level; OR = odds ratio.
*$P < .05$; **$P < .01$; ***$P < .001$.

one's health behavior; however, according to our results, only those who primarily speak English at home are likely to benefit from the community-level resources associated with higher median household income. In other words, immigrants who are less acculturated face a "double jeopardy" in health behavior: they might be less likely to live in a community with more public health resources, and when they do live in a high-income community they are less likely to benefit from the community resources because of barriers such as culture and language. If this is the case, our study reveals a possible pathway for health disparities: there might be language or cultural barriers that keep less-acculturated immigrants from benefiting from their healthy community environment.

In the process of acculturation, immigrants who live in ethnic enclaves may be confined to areas with limited resources and reinforcing norms that present challenges in one's host country. Without an adequate level of acculturation, it may be difficult to take advantage of community-level public health resources outside this enclave. This is supported by a study of English-speaking adults in 49 US states, where higher levels of civic participation and involvement in the local community were associated with decreased obesity and physical inactivity.[33]

One intervening variable that researchers might use in future studies, then, is the construct of loneliness: a less acculturated immigrant could feel socially isolated living in a high-income community, and loneliness has been shown to be an independent risk factor for physical inactivity.[34] The causal direction will be clearer if longitudinal data or instrumental variables become available for future studies.

Some studies have suggested that cultural buffering is associated with lower obesity risk in the United States. Past surveillance reports have noted that, for immigrants, a longer duration of residence in the United States and a higher level of acculturation are associated with more risk for obesity,[35,36] largely because of a car-dependent lifestyle and frequent fast-food consumption. These observed patterns are not supported in this study, as we have shown that those immigrants who had spent less than 5 years in the United States were more likely than native-born Americans to be obese after we controlled for individual-level and community-level confounders. What we observed in this study may differ from previous cohorts of immigrants as the sending countries rapidly industrialize. For example, countries

TABLE 4—Regressions of the Association Between Acculturation, Perceived Community Safety, and Obesity: Los Angeles County Health Survey, 2005 and 2007

Variable	Without Perceived Community Safety, (n = 15 003) OR (95% CI)	With Perceived Community Safety, (n = 14 802) OR (95% CI)
Individual-level variables		
Language spoken at home		
Non-English (Ref)	1.000	1.000
English	0.681*** (0.583, 0.795)	0.679*** (0.580, 0.795)
Time in US, y		
US-born (Ref)	1.000	1.000
0–4	1.761*** (1.392, 2.229)	1.843*** (1.452, 2.341)
5–9	1.189 (0.975, 1.451)	1.195 (0.977, 1.461)
≥ 10	0.816** (0.725, 0.919)	0.818** (0.726, 0.921)
Age	1.001 (0.999, 1.003)	1.001 (0.999, 1.004)
Gender		
Male (Ref)	1.000	1.000
Female	1.312*** (1.218, 1.414)	1.310*** (1.215, 1.413)
Race/ethnicity		
White (Ref)	1.000	1.000
Non-White Hispanic	1.309*** (1.159, 1.479)	1.305*** (1.154, 1.475)
African American	1.254** (1.081, 1.454)	1.251** (1.077, 1.454)
Asian	0.346*** (0.285, 0.418)	0.345*** (0.284, 0.418)
Others	1.160 (0.898, 1.497)	1.160 (0.898, 1.500)
Educational attainment		
< high school (Ref)	1.000	1.000
High school diploma	0.823** (0.730, 0.926)	0.823** (0.740, 0.942)
Some college	0.866* (0.765, 0.980)	0.866* (0.770, 0.990)
≥ college degree	0.640*** (0.559, 0.733)	0.640*** (0.559, 0.735)
Household income, % of FPL		
≤ 100	1.342*** (1.185, 1.521)	1.311*** (1.155, 1.487)
≤ 200	1.141* (1.018, 1.279)	1.121 (0.999, 1.258)
≤ 300	1.058 (0.942, 1.189)	1.045 (0.930, 1.175)
> 300 (Ref)	1.000	1.000
Perceived community safety		
Safe (Ref)		1.000
Unsafe		1.174** (1.065, 1.295)
Neighborhood-level variables		
% of immigrants in community	0.885 (0.471, 1.661)	0.743 (0.391, 1.410)
Median household income	0.853 (0.677, 1.074)	0.857 (0.678, 1.084)
Cross-level interactions		
English × % of immigrants in community	0.508 (0.234, 1.104)	0.615 (0.279, 1.352)
English × median household income	0.655** (0.502, 0.855)	0.674** (0.514, 0.882)

Note. CI = confidence interval; FPL = federal poverty level; OR = odds ratio.
*$P < .05$; **$P < .01$; ***$P < .001$.

such as Mexico[37] have undergone a rapid increase in obesity prevalence over the past decades, and the younger cohorts of immigrants who recently arrived in the United States could be more likely to be obese than older cohorts of immigrants of comparable age. In any case, the fact that speaking English at home predicts less risk for obesity, both through its main effect and its interaction with community-level income (after controlling for the respondent's household income and perceived community safety), suggests that there could be significant health benefits associated with linguistic acculturation, in addition to pathways such as better communication with health care providers and living in a safer community where outdoor activities are less dangerous.

We did not find any significant association between community immigrant composition and individual-level health outcomes, in either main or interaction effects. Even though it has been shown that certain food intake behavior and physical activity are correlated with the percentage of certain ethnicities in a community,[7,33] we did not stratify across race and ethnicity and thus could not isolate potential differences between Asian and Hispanic community food environments and their effects on health. Disparate effects within these 2 immigrant populations may have canceled each other out in the aggregate analysis. We chose not to run the analysis on an Asian-only or Hispanic-only sample because of the insufficient sample size within each community. A population survey that is focused on Hispanics or Asians in 1 defined geographic area might help resolve this issue. In addition, in Los Angeles County, there may be multigenerational families with a mix of US-born and non–US-born family members. US-born family members can be a bridge to resources for non–US-born members, and food intake can also be influenced by family composition, which was not accounted for in this study.

Community-based resources and other place-based efforts are critical for improving health and reducing health disparities. However, simply providing enabling factors is often not enough. The growing immigrant population in the United States is particularly vulnerable, as they may have reduced access to community resources because of language barriers. ■

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This article was accepted December 22, 2014.

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L. Shi conceptualized and designed the study and drafted the initial article. D. Zhang conducted the initial analyses, interpreted the results, and drafted and revised the article. J. van Meijgaard assisted in the study design, supervised data analysis, and revised the article. K. E. MacLeod grouped the small areas for a multilevel analysis and critically revised the article. J. E. Fielding revised the article. All authors approved the final article as submitted.

Acknowledgments

This study was funded by a National Institutes of Health Exploratory/Developmental Research Grant (ES019112). K. E. MacLeod was supported by a training grant for cancer control and epidemiology from the National Cancer Institute (Award No. T32CA009492).

Note. The contents of this article are solely the responsibility of the authors and do not necessarily represent the official views of the National Cancer Institute or the National Institutes of Health.

Human Participant Protection

The Los Angeles County Health Survey was approved by the ethics commission at the Los Angeles County Department of Public Health. No protocol approval was necessary for this study because data were obtained from secondary sources and were de-identified.

References

1. Lara M, Gamboa C, Kahramanian MI, Morales LS, Hayes Bautista DE. Acculturation and Latino health in the United States: a review of the literature and its sociopolitical context. *Annu Rev Public Health.* 2005;26:367–397.

2. Gomez SL, Kelsey JL, Glaser SL, Lee MM, Sidney S. Immigration and acculturation in relation to health and health-related risk factors among specific Asian subgroups in a health maintenance organization. *Am J Public Health.* 2004;94(11):1977–1984.

3. Zimmerman FJ. Habit, custom, and power: a multi-level theory of population health. *Soc Sci Med.* 2013;80:47–56.

4. Kitayama S. Culture and basic psychological processes—toward a system view of culture: comment on Oyserman et al. (2002). *Psychol Bull.* 2002;128(1):89–96.

5. Wapner S. Person-in-environment transitions: developmental analysis. *J Adult Dev.* 2000;7(1):7–22.

6. Schneider M, Stokols D. Multilevel theories of behavior change: a social ecological framework. In: Ockene JK, Riekert KA, eds. *The Handbook of Health Behavior Change.* New York, NY: Springer Publishing; 2009:85–105.

7. Nobari TZ, Wang MC, Chaparro MP, Crespi CM, Koleilat M, Whaley SE. Immigrant enclaves and obesity in preschool-aged children in Los Angeles County. *Soc Sci Med.* 2013;92:1–8.

8. Hunt LM, Schneider S, Comer B. Should "acculturation" be a variable in health research? A critical review of research on US Hispanics. *Soc Sci Med.* 2004;59:973–986.

9. Gee GC. A multilevel analysis of the relationship between institutional and individual racial discrimination and health status. *Am J Public Health.* 2002;92(4):615–623.

10. Kirby JB, Liang L, Chen HJ, Wang Y. Race, place, and obesity: the complex relationships among community racial/ethnic composition, individual race/ethnicity, and obesity in the united states. *Am J Public Health.* 2012;102(8):1572–1578.

11. Gordon-Larsen P, Harris KM, Ward DS, Popkin BM. Acculturation and overweight-related behaviors among Hispanic immigrants to the US: The National Longitudinal Study of Adolescent Health. *Soc Sci Med.* 2003;57(11):2023–2034.

12. Saelens BE, Sallis JF, Black JB, Chen D. Neighborhood-based differences in physical activity: an environment scale evaluation. *Am J Public Health.* 2003;93(9):1552–1558.

13. Lumeng JC, Appugliese D, Cabral HJ, Bradley RH, Zuckerman B. Neighborhood safety and overweight status in children. *Arch Pediatr Adolesc Med.* 2006;160(1):25–31.

14. Aneshensel CS, Sucoff CA. The neighborhood context of adolescent mental health. *J Health Soc Behav.* 1996;37(4):293–310.

15. Burdette HL, Wadden TA, Whitaker RC. Neighborhood safety, collective efficacy, and obesity in women with young children. *Obesity (Silver Spring).* 2006;14(3):518–525.

16. Pichon LC, Arredondo EM, Roesch S, Sallis JF, Ayala GX, Elder JP. The relation of acculturation to Latinas' perceived neighborhood safety and physical activity: a structural equation analysis. *Ann Behav Med.* 2007;34(3):295–303.

17. Burdette HL, Whitaker RC. A national study of neighborhood safety, outdoor play, television viewing, and obesity in preschool children. *Pediatrics.* 2005;116(3):657–662.

18. Rech CR, Reis RS, Hino AA, et al. Neighborhood safety and physical inactivity in adults from Curitiba, Brazil. *Int J Behav Nutr Phys Act.* 2012;9:72.

19. Molnar BE, Gortmaker SL, Bull FC, Buka SL. Unsafe to play? Neighborhood disorder and lack of safety predict reduced physical activity among urban children and adolescents. *Am J Health Promot.* 2004;18(5):378–386.

20. MacLeod KE, Gee GC, Crawford P, Wang MC. Neighbourhood environment as a predictor of television watching among girls. *J Epidemiol Community Health.* 2008;62(4):288–292.

21. Fowler-Brown AG, Bennett GG, Goodman MS, Wee CC, Corbie-Smith GM, James SA. Psychosocial stress and 13-year BMI change among blacks: The Pitt County Study. *Obesity (Silver Spring).* 2009;17(11):2106–2109.

22. Torres SJ, Nowson CA. Relationship between stress, eating behavior, and obesity. *Nutrition.* 2007;23(11–12):887–894.

23. Dallman MF. Stress-induced obesity and the emotional nervous system. *Trends Endocrinol Metab.* 2010;21(3):159–165.

24. Shively CA, Register TC, Clarkson TB. Social stress, visceral obesity, and coronary artery atherosclerosis in female primates. *Obesity (Silver Spring).* 2009;17(8):1513–1520.

25. Dettlaff AJ, Earner I, Phillips SD. Latino children of immigrants in the child welfare system: prevalence, characteristics, and risk. *Child Youth Serv Rev.* 2009;31(7):775–783.

26. Simon PA, Wold CM, Cousineau MR, Fielding JE. Meeting the data needs of a local health department: The Los Angeles County Health Survey. *Am J Public Health.* 2001;91(12):1950–1952.

27. *2005 Los Angeles County Health Survey. Summary of Survey Methodology.* San Francisco, CA: Field Research Corporation; 2007.

28. *2007 Los Angeles County Health Survey. Summary of Survey Methodology.* San Francisco, CA: Field Research Corporation; 2008.

29. Maas CJ, Hox JJ. Sufficient sample sizes for multilevel modeling. *Methodology (Gott).* 2005;1:86–92.

30. Moineddin R, Matheson FI, Glazier RH. A simulation study of sample size for multilevel logistic regression models. *BMC Med Res Methodol.* 2007;7:34.

31. Schoppe-Sullivan SJ, Schermerhorn AC, Cummings EM. Marital conflict and children's adjustment: evaluation of the Parenting Process Model. *J Marriage Fam.* 2007;69(5):1118–1134.

32. McClelland GH, Judd CM. Statistical difficulties of detecting interactions and moderator effects. *Psychol Bull.* 1993;114(2):376–390.

33. Kim D, Subramanian SV, Gortmaker SL, Kawachi I. US state- and county-level social capital in relation to obesity and physical inactivity: a multilevel, multivariable analysis. *Soc Sci Med.* 2006;63(4):1045–1059.

34. Hawkley LC, Thisted RA, Cacioppo JT. Loneliness predicts reduced physical activity: cross-sectional & longitudinal analyses. *Health Psychol.* 2009;28(3):354–363.

35. Barcenas CH, Wilkinson AV, Strom SS, et al. Birthplace, years of residence in the United States, and obesity among Mexican-American adults. *Obesity (Silver Spring).* 2007;15(4):1043–1052.

36. Goel MS, McCarthy EP, Phillips RS, Wee CC. Obesity among US immigrant subgroups by duration of residence. *JAMA.* 2004;292(23):2860–2867.

37. Filozof C, Gonzalez C, Sereday M, Mazza C, Braguinsky J. Obesity prevalence and trends in Latin-American countries. *Obes Rev.* 2001;2(2):99–106.