HHS Public Access

Author manuscript

Ann Epidemiol. Author manuscript; available in PMC 2016 October 01.

Published in final edited form as:

Ann Epidemiol. 2015 October ; 25(10): 767–772.e2. doi:10.1016/j.annepidem.2015.07.003.

Change in waist circumference with longer time in the US among Hispanic and Chinese immigrants: the modifying role of the neighborhood built environment

Sandra S. Albrecht, PhD, MPH[a], **Theresa L. Osypuk, SD, SM**[b], **Namratha R. Kandula, MD, MPH**[c], **Linda C. Gallo, PhD**[d], **Félice Lê- Scherban, PhD, MPH**[e], **Sandi Shrager, MS**[f], and **Ana V. Diez Roux, MD, PhD**[g]

[a] Department of Nutrition, Carolina Population Center, University of North Carolina at Chapel Hill, 137 E Franklin St, CB #8120, Chapel Hill, NC 27599-8120, USA

[b]Department of Epidemiology and Community Health, University of Minnesota, West Bank Office Building, Suite 435 1300 S. Second Street Minneapolis MN 55454, USA

[c]Division of General Internal Medicine, Northwestern University Feinberg School of Medicine, 750 N Lake Shore, Chicago IL 60611, USA

[d]Department of Psychology, San Diego State University, 6363 Alvarado Ct., Ste. 103/3 San Diego, CA 92120, USA

[e]Department of Epidemiology and Biostatistics, Drexel University, 3215 Market St., Philadelphia, PA 19104, USA

[f]Collaborative Health Studies Coordinating Center, University of Washington, Bldg. 29, Suite 210, 6200 NE 74th Street, Seattle, WA 98115, USA

[g]Drexel University, School of Public Health, 3215 Market Street, Nesbitt Hall, 2nd Floor, Room 255, Philadelphia, PA 19104, USA

Abstract

Purpose—We examined whether living in neighborhoods supportive of healthier diets and more active lifestyles may buffer immigrants against the unhealthy weight gain that is purported to occur with longer length of US residence.

Methods—Neighborhood data referring to a 1-mile buffer around participants' baseline home addresses were linked to longitudinal data from 877 Hispanic and 684 Chinese immigrants aged 45-84 years in the Multi-Ethnic Study of Atherosclerosis. We used ethnicity-stratified linear mixed models to examine whether food and activity-based neighborhood measures (healthy food

Corresponding author: Sandra S. Albrecht, PhD, MPH, Carolina Population Center, University of North Carolina at Chapel Hill, 137 East Franklin Street, CB #8120, Chapel Hill, NC 27599-8120, Phone: (919) 962-6150; Fax: (919) 962-6139; ssalb@unc.edu.

Conflict of interest: None declared.

stores, walkability, and recreational facilities) were associated with change in waist circumference (WC) over a 9-year follow-up.

Results—Among Hispanics, living in neighborhoods with more resources for healthy food and recreational activity was related to lower baseline WC. However, there was no association with change in WC over time. Among Chinese, living in more walkable neighborhoods was associated with lower baseline WC and with slower increases in WC over time, especially among the most recent immigrant arrivals.

Conclusions—Where immigrants reside may have implications for health patterns that emerge with longer time in the US.

Keywords

immigrants; longitudinal; waist circumference; acculturation; neighborhood

Introduction

Understanding the health of immigrants is an important population health objective given their size, growth, and demographics [1]. Studies have documented an immigrant health advantage relative to the US-born that appears to erode with longer time in the US [2-7]. The adoption of health-harming behaviors may be one mechanism through which increased acculturation, often proxied by nativity or length of residence, may be associated with outcomes, like increased weight [4, 8]. However, existing research is dominated by cross-sectional designs – meaning these studies do not document the experience of the same immigrant over time. Results from the few available prospective studies suggest most immigrants, young and old, experience similar or less weight gain over time compared to US-born groups, thus maintaining their health advantage [9-13].

An immigrant's risk of obesity is likely shaped not only by influences related to their country of origin, but also by the residential context to which they migrate. Since the receiving context is an important determinant of successful adaptation of immigrants to the host country, it seems logical that health trajectories of immigrants could be related to environmental factors. A body of evidence has linked residential environments to a range of diet and activity-related behaviors and associated health outcomes [14, 15]. Area-level attributes theoretically relevant for weight, such as food and recreational environments (walkability and access to recreational resources), have also been linked to obesity in some, but not all studies [16, 17]. However, little research has explored the role of the neighborhood environment in shaping anthropometric trajectories among immigrants the longer they live in the US. Residence in neighborhoods which support the maintenance of healthier diets and more active lifestyles may buffer immigrants against the unhealthy weight gain that is purported to occur after migration. The few studies available have reported cross-sectional associations between census tract-level foreign-born, linguistic, or Hispanic ethnic composition with healthier diets [18-20], less physical activity [20], and lower BMI [21] or higher BMI [22-24]. Only two longitudinal studies have investigated the role of contextual factors (census-derived measures of race/ethnic composition, population density, socioeconomic disadvantage; survey-based social environment measures) and change in body mass index (BMI) or waist circumference (WC) in samples including Hispanic immigrants [12, 25]. No studies to our knowledge have used food and activity-based measures of the neighborhood environment which may be more directly relevant to weight.

Using prospective data from Hispanic and Chinese immigrants in the Multi-Ethnic Study of Atherosclerosis (MESA), we investigated whether food and activity-based measures of the neighborhood environment were associated with change in WC over a median follow-up of 9 years. Given research that suggests immigrants experience a more accelerated risk of obesity and associated outcomes within the first 10-15 years of arrival [4, 11, 26], we also investigated whether more recent immigrants were more susceptible to neighborhood influences than long-term immigrants.

Methods

Individual-level data

MESA is a prospective study designed to investigate risk factors for subclinical cardiovascular diseases (CVD). Design details are provided elsewhere [27]. Briefly, participants aged 45-84 years without clinical CVD at baseline were recruited from six sites using population-based approaches (Baltimore, MD; Chicago, IL; Forsyth County, NC; Los Angeles,, CA; Manhattan, NY; and St. Paul, MN). MESA includes 6814 individuals who self-identified as white, African-American, Hispanic or Chinese-American. This analysis included only Hispanic and Chinese participants because of the limited number of immigrants in other race/ethnic groups. We used data from baseline (2000-2002), and four follow-up examinations (2002-2003, 2004-2005, 2006-2007, and 2010-2012). All participants provided written informed consent and the study was approved by the Institutional Review Boards at participating institutions.

Waist circumference (WC) (cm) was measured at all study visits using standardized procedures. We chose to model WC instead of BMI because it is associated with an increased risk for CVD, and is stronger marker of adiposity in older individuals [28]. Age (continuous), sex (male, female), race/ethnicity (Hispanic, Chinese), nativity (US, other), education (less than high school, high school , some college/technical school, college graduate), and income (see below) were obtained during the baseline interview. When missing, income data from follow-up exams were used to impute baseline income (2.5% of foreign-born Hispanics; 0.58% foreign-born Chinese). Participants selected their annual family income from 13 categories; a continuous measure of household-equivalized income was created by taking the midpoint for each category divided by the number of household members. Income was then categorized into quartiles. Length of US residence was also obtained at baseline and categorized using previously used classifications [20]: <15 years, 15-30 years, >30 years, and missing. Time since baseline, in years, was used to examine change in WC over time.

Neighborhood Data

MESA subjects who participated in the MESA Neighborhood Ancillary Study were included in these analyses. Food (healthy food availability) and activity-based (recreational facilities and walkability) measures of the neighborhood built environment were obtained from Geographic Information System (GIS) and survey-based data, and linked to participants' baseline home addresses.

GIS-based measures

Densities of healthy food stores and recreational facilities were derived from the National Establishment Time Series (NETS) database from Walls and Associates (Oakland, CA) for years that overlapped with the MESA baseline exam. Participants' home addresses were geocoded using TeleAtlas EZ-Locate (TomTom North America, Inc., Lebanon, New Hampshire). Healthy food stores were defined as fruit and vegetable markets (Standard Industrial Classification (SIC) #5431) and supermarkets (food stores with at least $2 million in annual sales or at least 25 employees; these data were augmented using supermarket store name lists, as described elsewhere [29]). For recreational facilities, 114 SIC codes were selected based on existing lists [30, 31] to represent a summary measure of total physical activity resources. Kernel estimation [32] was used to calculate the densities (units/mile^2), such that healthy food stores and recreational facilities closer to participants' addresses were given more weight than facilities farther away. Densities were created for 1-mile (1.6 km) buffers around each participant's baseline home address.

Survey-based measures

MESA participants were asked to rate various neighborhood characteristics within 1-mile of their home. Two scales were used in this analysis: healthy food availability (2 items) and walkability (6 items) (Supplemental Table 1). Scale items were derived from published work [33, 34]. Each item within a scale had a 5-point response option and within-scale items were averaged. Scales were created by calculating the mean of the responses for all MESA participants living within a one mile radius of the referent MESA participant's home address. These averaged scales calculated for each MESA participant's neighborhood environment did not include the MESA respondent's own report of their neighborhood to avoid spurious associations that can result when neighborhood information and behaviors are self-reported by the same subjects [35]. Higher scale scores indicated more favorable environments.

Analytic Sample

Of the 1802 foreign-born Hispanic (n=1030) and Chinese (n=772) MESA baseline participants, 1588 participated in the Neighborhood Study (Hispanics: n=895; Chinese: n=693). We further excluded 27 respondents with incomplete covariate information, yielding a sample of 877 Hispanics and 684 Chinese. Of these 1561 baseline respondents, 68% of Hispanics and 70% of Chinese completed all follow-up examinations and 100% of the analytic sample had information for at least 2 visits. Longitudinal analyses included all 1561 baseline participants.

Statistical analyses

Analyses were ethnicity-stratified based on prior work documenting race/ethnic differences in immigrant experiences [20], and in assocations between the built environment and obesity [36]. We first classified each of the four neighborhood indicators (density of healthy food stores, healthy food availability scale, walkability scale, and density of recreational facilities) into ethnicity-specific tertiles to compare means and frequencies of covariates across tertiles. Ethnicity-specific tertiles were used because distributions of the neighborhood variables differed between ethnic groups. After confirming linearity, we opted to include all neighborhood indicators as continuous variables in longitudinal models. We estimated cross-sectional and longitudinal associations between each of the neighborhood indicators and WC using linear mixed models with a random intercept and time slope for each individual (PROC MIXED SAS 9.2; SAS Institute Inc., Cary, NC). Inclusion of a random intercept for each census tract did not alter estimates. The first set of models included length of US residence, age, sex, education, income, time since baseline, and time-by-age and time-by-length of US residence interactions. The coefficient on the time-by-length of US residence term estimated differences in annual mean change in WC depending on how long immigrants had lived in the US at baseline. In subsequent models, we added each of the neighborhood variables, separately, and their interaction with time. To compare associations for neighborhood variables with different units, estimates were standardized to correspond to differences between the 90th and 10th percentiles of each indicator. In sensitivity analyses, we also examined if results differed based on whether participants moved from their baseline address. To investigate whether associations between each of the neighborhood indicators and WC at baseline and over time differed between recent and long term immigrants, we used likelihood ratio tests to determine the joint significance of a 2-way interaction for length of US residence-by-neighborhood variable, and a 3-way interaction for length of US residence-by-neighborhood variable-by-time.

Results

Compared to Chinese immigrants, Hispanic immigrants were of lower socioeconomic status (SES), lived in the US longer, and had higher mean baseline WC (Table 1). Hispanic immigrants also lived in neighborhoods with higher densities and more variability of healthy food stores and recreational facilities than Chinese immigrants, but there was little ethnic difference when comparing healthy food availability and walkability scales.

Among Hispanics, participants living in neighborhoods with more resources to support healthy eating and physical activity (i.e. highest tertile for each neighborhood indicator) had a lower mean baseline WC , higher SES, and lived in the US longer than participants in worse neighborhoods (lowest tertiles) (Supplemental Table 2A). Generally, higher tertiles for a particular neighborhood indicator corresponded to higher median values for the other neighborhood indicators measured. Among Chinese, there was a less consistent pattern between each of the neighborhood indicators with baseline WC and covariates (Supplemental Table 2B). Moreover, unlike among Hispanic immigrants, the highest tertile for a particular neighborhood indicator did not necessarily correspond to more favorable values for the other neighborhood indicators.

Adjusting for individual-level covariates, Hispanic immigrants in the US <15 years had greater annual increases in WC than immigrants in the US >30 years (Table 2A, Model 1). Living in neighborhoods with more resources to support healthy eating and physical activity was associated with a lower mean baseline WC among Hispanic immigrants. The magnitudes were largest for indicators associated with healthy food resources; no associations were observed with walkability. Specifically, comparing the 90th to the 10th centile for each neighborhood indicator, mean differences in baseline WC were −2.5 cm (standard error (SE)=1.3) for density of healthy food stores; −2.7 cm (SE=1.1) for healthy food availability, and −1.5 cm (SE=0.53) for density of recreational resources. However, there was no evidence these neighborhood resources were associated with differences in change in WC over time.

Among Chinese, more recent immigrants (<15 years and 15-30 years in the US) experienced greater annual increases in WC relative to immigrants in the US >30 years (Table 2B). Only measures related to the support of physical activity were statistically significantly associated with WC. Comparing the 90th to 10th centile for walkability, mean WC at baseline was −1.9 cm (SE=0.79). There was also some evidence that living in neighborhoods with better walkability and more recreational resources was associated with smaller increases in WC over time.

Among Hispanics and Chinese, associations between neighborhood indicators and change in WC over time did not differ for participants who relocated during follow-up (not shown; P-interactions with move status: > 0.2). Among Hispanics, estimates were suggestive of a stronger association of density of healthy food resources with mean WC at baseline and in change over time among immigrants in the US <15 years compared to immigrants in the US >30 years. However, formal interaction tests were not statistically significant (not shown; P-interactions:>0.2).

Among Chinese, the association of walkability with change in WC over time significantly differed by length of US residence (P-interaction = 0.04) (Figure 1). Although Chinese immigrants in the US <15 years and 15-30 years had faster increases in WC over time relative to immigrants in the US >30 years even in the most walkable neighborhoods (90th percentile, solid black lines), the magnitude of increase for these recent immigrants was even larger in the least walkable neighborhoods (10th percentile, dashed gray lines).

Discussion

In a sample of older Hispanic and Chinese immigrants to the US, we investigated whether immigrants experienced differential increases in WC depending on the features of the neighborhood environment in which they lived. Our results suggest that where immigrants live may have implications for anthropometric patterns. Among Hispanic immigrants, living in neighborhoods with greater availability of healthy food and recreational activity resources was related to lower baseline WC. However, there was no association with change in WC. Among Chinese immigrants, living in a neighborhood with better walkability was associated with lower baseline WC and with slower increases over time. For both groups, the most recent arrivals experienced the greatest increases in WC, but there was evidence that living in neighborhoods more supportive of healthier behaviors tempered these gains, particularly in Chinese immigrants.

Migration to the US is thought to be detrimental for immigrant health because it is hypothesized to accompany unhealthy changes in behavior. However, residential environment characteristics likely contribute to variation in health patterning. Past research has linked census-derived measures of the environment to diet and anthropometric outcomes among immigrants though the evidence is mixed and the majority of studies, except for two [12, 25], are cross-sectional [18-21, 23, 24, 37]. In one longitudinal study that used built environment measures, neighborhood walkability was inversely associated with diabetes development in immigrants to Canada [26], consistent with our findings related to change in WC in Chinese immigrants. However, no studies to our knowledge have longitudinally examined associations between features of the neighborhood environment more directly relevant to weight, and change in anthropometric measures over time in immigrants to the US.

Residence in neighborhoods which support the maintenance of healthier behaviors may buffer immigrants against the unhealthy weight gain that is purported to occur with longer time in the US. Our findings suggest that living in more walkable areas was associated with slower gains in WC among Chinese immigrants. Although longitudinal patterns did not extend to Hispanics, living in neighborhoods with greater availability of healthier food and recreational resources was associated lower baseline WC in Hispanics. While we do not know why some features of the neighborhood environment were more relevant for one ethnic group over another, differences between Hispanics and Chinese in terms of SES, length of US residence, and the types of neighborhoods in which they lived (Table 1), may have played a role. Moreover, since the Hispanic immigrants in our sample had lived in the US longer than the Chinese sample, changes in anthropometric measures in Hispanics may have already occurred prior to baseline, which may explain why we did not observe associations with change in WC over time.

Indeed past research has shown that the greatest changes to immigrant health occur within the first few years after migration [4, 11, 26, 38, 39]. Our findings of faster increases in WC among the most recent immigrants are consistent with this notion of a faster decline in health soon after arriving in the US. Although explicit mechanisms have not been tested, factors associated with the migration process itself, and the experiences following migration, such as disruption of support networks and poor living and work conditions may play a role in accelerating health declines [39, 40]. In our study, newer immigrants had greater increases in WC than more long-term immigrants regardless of the neighborhood environment. However, our results also suggest that living in environments more supportive of healthier behaviors may temper gains in WC.

The incorporation of contextual factors and the longitudinal design of our study are important contributions for advancing the study of immigrant health. Another strength relates to the use of multiple dimensions of the physical environment rather than relying only on census-derived measures to characterize immigrants' neighborhoods. However, there were also limitations that may impact the validity of our findings. As with any observational study, we cannot rule out the role of selection or other unmeasured confounding. For example, immigrants with lower WC, or with a tendency for less weight gain, may have selected to move into neighborhoods more supportive of healthier behaviors. We also do not know if the baseline neighborhood reflected the environment into which immigrants initially migrated. Much of the change in WC among longer term immigrants may have occurred prior to study onset, and this change may be related to living in neighborhoods that were different from their neighborhoods at baseline. Future research should consider examining new immigrants over time in the neighborhoods into which they migrated. We tested associations of healthy food availability and presence of recreational resources, but presence may not necessarily reflect greater access and availability if costs were high or if immigrants were unaware of these resources. We supplemented these more 'objective' measures with survey-based measures; however, if the immigrants' neighbors' perceptions of the environment differed from that of the immigrants in our study, then these more subjective measures may not adequately reflect access and use. We also recognize the importance of sub-analyses by gender, Hispanic subgroups, and study site, but sample size limited our power to model this important heterogeneity. Finally, MESA is an older, healthy cohort sampled from selected sites and includes immigrants living in the US for a long time; it is not clear how well findings would generalize to younger, more recent immigrants in the US.

Conclusions

The association between longer time in the US and declines in health may arise from environmental factors that discourage the practice of healthy behaviors. Our findings suggest that where immigrants reside may influence the health patterns that emerge with longer US residence. Future research will be necessary to validate these findings, and to better elucidate the mechanisms underlying these patterns. As immigrants continue to grow as a proportion of the US population, a more nuanced understanding of the migration process and its impacts on health will be important for the success of interventions aimed at stalling any health deterioration that may accompany longer time in the US.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgements

This work was supported by the National Heart, Lung, and Blood Institute Research Supplement to Promote Diversity in Health-Related Research, supplement to grant R01 HL071759 05A1 (Diez Roux); and by the Michigan Center for Integrative Approaches to Health Disparities (P60 MD002249) funded by the National Institute on Minority Health and Health Disparities. The Multi-Ethnic Study of Atherosclerosis is supported by contracts N01-HC-95159 through N01-HC-95169 from the National Heart, Lung, and Blood Institute. Albrecht also received support from the Population Research Training grant (T32 HD007168) and the Population Research Infrastructure Program (R24 HD050924) awarded to the Carolina Population Center at The University of North Carolina at Chapel Hill by the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development.

The authors thank the other investigators, staff, and participants of the MESA study for their valuable contributions. A full list of participating MESA investigators and institutions can be found at: http://www.mesa-nhlbi.org.

List of Abbreviations

BMI	body mass index
CVD	cardiovascular disease
MESA	Multi-Ethnic Study of Atherosclerosis
SES	socioeconomic status
WC	waist circumference

References

1. Martin P, Midgley E. Immigration in America 2010. Population Bulletin Update. Jun.2010
2. Lauderdale DS, Rathouz PJ. Body mass index in a US national sample of Asian Americans: effects of nativity, years since immigration and socioeconomic status. Int J Obes Relat Metab Disord. 2000; 24(9):1188–94. [PubMed: 11033989]
3. Goel MS, McCarthy EP, Phillips RS, Wee CC. Obesity among US immigrant subgroups by duration of residence. JAMA. 2004; 292(23):2860–7. [PubMed: 15598917]
4. Antecol H, Bedard K. Unhealthy assimilation: why do immigrants converge to American health status levels? Demography. 2006; 43(2):337–60. [PubMed: 16889132]
5. Kaushal N. Adversities of acculturation? Prevalence of obesity among immigrants. Health Econ. 2009; 18(3):291–303. [PubMed: 18464286]
6. Oza-Frank R, Cunningham SA. The weight of US residence among immigrants: a systematic review. Obes Rev. 2010; 11(4):271–80. [PubMed: 19538440]
7. Albrecht SS, Diez Roux AV, Aiello AE, Schulz AJ, Abraido-Lanza AF. Secular trends in the association between nativity/length of US residence with body mass index and waist circumference among Mexican-Americans, 1988-2008. Int J Public Health. 2013; 58(4):573–81. [PubMed: 23052250]
8. Abraido-Lanza AF, Chao MT, Florez KR. Do healthy behaviors decline with greater acculturation? Implications for the Latino mortality paradox. Soc Sci Med. 2005; 61(6):1243–55. [PubMed: 15970234]
9. Harris KM, Perreira KM, Lee D. Obesity in the transition to adulthood: predictions across race/ethnicity, immigrant generation, and sex. Arch Pediatr Adolesc Med. 2009; 163(11):1022–8. [PubMed: 19884593]
10. Jackson MI. Foreign-born health integration during the transition to adulthood: The case of weight. Soc Sci Res. 2011; 40(5):1419–33. [PubMed: 25125712]
11. Albrecht SS, Diez Roux AV, Kandula NR, Osypuk TL, Ni H, Shrager S. Immigrant assimilation and BMI and waist size: a longitudinal examination among Hispanic and Chinese participants in the multi-ethnic study of atherosclerosis. Obesity (Silver Spring). 2013; 21(8):1695–703. [PubMed: 23716458]
12. Ullmann SH, Goldman N, Pebley AR. Contextual factors and weight change over time: a comparison between U.S. Hispanics and other population sub-groups. Soc Sci Med. 2013; 90:40–8. [PubMed: 23746607]
13. Albrecht SS, Gordon-Larsen P. Socioeconomic gradients in body mass index (BMI) in US immigrants during the transition to adulthood: examining the roles of parental education and intergenerational educational mobility. J Epidemiol Community Health. 2014; 68(9):842–8. [PubMed: 24847088]
14. Diez Roux AV, Mair C. Neighborhoods and health. Ann NY Acad Sci. 2010; 1186:125–45. [PubMed: 20201871]
15. Kaczynski AT, Henderson KA. Parks and recreation settings and active living: a review of associations with physical activity function and intensity. J Phys Act Health. 2008; 5(4):619–32. [PubMed: 18648125]

16. Holsten JE. Obesity and the community food environment: a systematic review. Public Health Nutr. 2009; 12(3):397–405. [PubMed: 18477414]
17. Feng J, Glass TA, Curriero FC, Stewart WF, Schwartz BS. The built environment and obesity: a systematic review of the epidemiologic evidence. Health Place. 2010; 16(2):175–90. [PubMed: 19880341]
18. Park Y, Neckerman K, Quinn J, Weiss C, Jacobson J, Rundle A. Neighbourhood immigrant acculturation and diet among Hispanic female residents of New York City. Public Health Nutr. 2011; 14(9):1593–600. [PubMed: 21414245]
19. Dubowitz T, Subramanian SV, Acevedo-Garcia D, Osypuk TL, Peterson KE. Individual and neighborhood differences in diet among low-income foreign and U.S.-born women. Womens Health Issues. 2008; 18(3):181–90. [PubMed: 18222706]
20. Osypuk TL, Roux AV, Hadley C, Kandula NR. Are immigrant enclaves healthy places to live? The Multi-ethnic Study of Atherosclerosis. Soc Sci Med. 2009; 69(1):110–20. [PubMed: 19427731]
21. Park Y, Neckerman KM, Quinn J, Weiss C, Rundle A. Place of birth, duration of residence, neighborhood immigrant composition and body mass index in New York City. Int J Behav Nutr Phys Act. 2008; 5:19. [PubMed: 18394171]
22. 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. 102(8):1572–8. [PubMed: 22698012]
23. Do DP, Dubowitz T, Bird CE, Lurie N, Escarce JJ, Finch BK. Neighborhood context and ethnicity differences in body mass index: a multilevel analysis using the NHANES III survey (1988-1994). Econ Hum Biol. 2007; 5(2):179–203. [PubMed: 17507298]
24. Wen M, Maloney TN. Latino residential isolation and the risk of obesity in Utah: the role of neighborhood socioeconomic, built-environmental, and subcultural context. J Immigr Minor Health. 2011; 13(6):1134–41. [PubMed: 21274631]
25. Le-Scherban F, Albrecht SS, Osypuk TL, Sanchez BN, Diez Roux AV. Neighborhood Ethnic Composition, Spatial Assimilation, and Change in Body Mass Index Over Time Among Hispanic and Chinese Immigrants: Multi-Ethnic Study of Atherosclerosis. Am J Public Health. 2014:e1–e9.
26. Booth GL, Creatore MI, Moineddin R, Gozdyra P, Weyman JT, Matheson FI, et al. Unwalkable neighborhoods, poverty, and the risk of diabetes among recent immigrants to Canada compared with long-term residents. Diabetes Care. 2013; 36(2):302–8. [PubMed: 22988302]
27. Bild DE, Bluemke DA, Burke GL, Detrano R, Diez Roux AV, Folsom AR, et al. Multi-ethnic study of atherosclerosis: objectives and design. Am J Epidemiol. 2002; 156(9):871–81. [PubMed: 12397006]
28. Hu, FB. Obesity Epidemiology. Oxford University Press; New York: 2008.
29. Auchincloss AH, Moore KA, Moore LV, Diez Roux AV. Improving retrospective characterization of the food environment for a large region in the United States during a historic time period. Health Place. 18(6):1341–7. [PubMed: 22883050]
30. Powell LM, Chaloupka FJ, Slater SJ, Johnston LD, O'Malley PM. The availability of local-area commercial physical activity-related facilities and physical activity among adolescents. Am J Prev Med. 2007; 33(4 Suppl):S292–300. [PubMed: 17884577]
31. Gordon-Larsen P, Nelson MC, Page P, Popkin BM. Inequality in the built environment underlies key health disparities in physical activity and obesity. Pediatrics. 2006; 117(2):417–24. [PubMed: 16452361]
32. Silverman, BW. Density Estimation for Statistics and Data Analysis. Chapman & Hall/CRC; London, United Kingdom: 1986.
33. Mujahid MS, Diez Roux AV, Morenoff JD, Raghunathan T. Assessing the measurement properties of neighborhood scales: from psychometrics to ecometrics. Am J Epidemiol. 2007; 165(8):858–67. [PubMed: 17329713]
34. Echeverria SE, Diez-Roux AV, Link BG. Reliability of self-reported neighborhood characteristics. J Urban Health. 2004; 81(4):682–701. [PubMed: 15466849]

35. Raudenbush SW, Sampson RJ. 'Ecometrics': Toward A Science of Assessing Ecological Settings, with Application to the Systematic Social Observation of Neighborhoods. Sociological Methodology. 1999; 29:1–41.

36. Lovasi GS, Hutson MA, Guerra M, Neckerman KM. Built environments and obesity in disadvantaged populations. Epidemiol Rev. 2009; 31:7–20. [PubMed: 19589839]

37. 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):1572–8. [PubMed: 22698012]

38. Steffen PR, Smith TB, Larson M, Butler L. Acculturation to Western society as a risk factor for high blood pressure: a meta-analytic review. Psychosom Med. 2006; 68(3):386–97. [PubMed: 16738069]

39. Goldman N, Pebley AR, Creighton MJ, Teruel GM, Rubalcava LN, Chung C. The Consequences of Migration to the United States for Short-Term Changes in the Health of Mexican Immigrants. Demography. 2014; 51(4):1159–73. [PubMed: 24788391]

40. Rogler LH, Cortes DE, Malgady RG. Acculturation and mental health status among Hispanics. Convergence and new directions for research. Am Psychol. 1991; 46(6):585–97. [PubMed: 1952420]

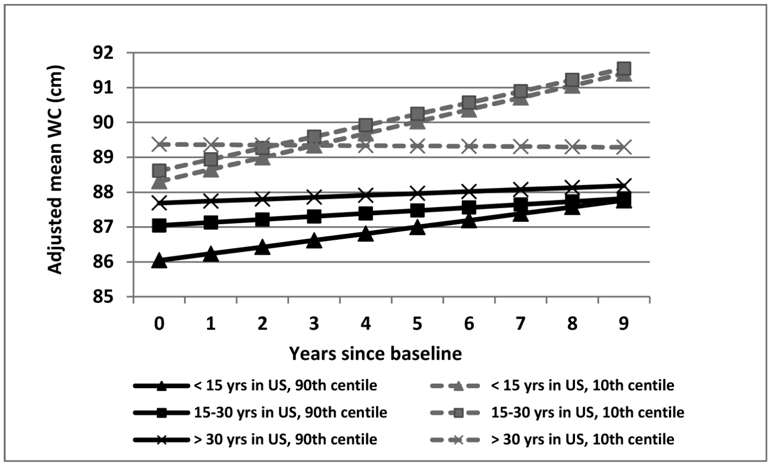

Figure 1. Adjusted mean waist circumference (WC) over time by baseline length of US residence (<15 years in US, 15-30 years in US, > 30 years in US) among Chinese immigrants, at the 90th vs. 10th percentile of neighborhood walkability

Higher centiles indicate better walkability. All models further adjusted for age, sex, education, income, and age*time using linear mixed models. Estimates correspond to the mean age of the entire sample (age=61). P-interaction (length of US residence*walkability*time) = 0.04

Table 1

Sample characteristics, Hispanic and Chinese immigrants, Multi-Ethnic Study of Atherosclerosis (baseline exam: 2000-2002)

	Hispanics	Chinese
N	877	684
Mean age, baseline (SD)	61.0 (10.2)	61.9 (10.3)
Female (%)	54.5	51.2
Education (%)		
Less than high school	54.5	22.8
Completed high school	17.7	16.2
Some college/technical school	19.2	21.2
Bachelor's/graduate degree	8.7	39.8
Income quartiles[†], baseline (SD)		
0	34.2	26.9
1	18.2	20.5
2	28.9	23.0
3	18.7	29.7
Site (%)		
Forsyth County, NC	0.11	0
New York, NY	47.2	0.3
Minneapolis, MN	19	0
Chicago, IL	0	37.3
Los Angeles, CA	33.6	62.4
Length of US residence, baseline (%)		
< 15 years	14.1	35.1
15-30 years	24.5	38.6
>30 years	49.9	19.6
Missing	11.4	6.7
Mean waist circumference, baseline (cm) (SD)	99.6 (12.2)	87.0 (9.6)
Mean 9-year change WC (cm) (SD)	1.2 (7.6)	1.6 (6.6)
Neighborhood information, baseline [a]		
Density of healthy food stores[b,c]	3.8 (0.9-9.0)	1.2 (0.6-1.9)
Healthy food availability scale[b,d]	3.8 (3.5-3.9)	3.8 (3.6-3.9)
Density of recreational facilities[b,c]	2.1 (0.8-4.0)	1.2 (0.6-1.8)
Walkability scale[b,d]	3.9 (3.7-4.0)	3.8 (3.7-4.0)

Abbreviations: SD, standard deviation; WC, waist circumference

[†]Continuous measure of income adjusted for household size, expressed as quartiles

[a]Neighborhood indicators refer to a 1-mile (1.6 km) radius around each participant’s home address at the baseline exam.

[b]Expressed as median (interquartile range)

[c] Kernel density; number per square mile

[d] Item responses had a possible range of 1 to 5; higher value indicates a more favorable environment

Table 2A

Adjusted mean difference at baseline and mean difference in annual change in WC by neighborhood indicator [a], Hispanic immigrants

	Model 1		Model 2		Model 3		Model 4		Model 5	
	Mean difference at baseline	**Mean difference in annual change**	**Mean difference at baseline**	**Mean difference in annual change**	**Mean difference at baseline**	**Mean difference in annual change**	**Mean difference at baseline**	**Mean difference in annual change**	**Mean difference at baseline**	**Mean difference in annual change**
	Coefficient [b] (standard error)									
Length of US residence, baseline										
< 15 years	−0.23 (1.33)	0.20** (0.10)	−2.38 (1.94)	0.18 (0.15)	−0.74 (1.33)	0.20**(0.10)	−0.19 (1.32)	0.19**(0.09)	−0.45 (1.31)	0.19**(0.09)
15-30 years	−0.42 (1.07)	0.02 (0.07)	−0.48 (1.27)	−0.04 (0.09)	−0.45 (1.06)	0.02 (0.07)	−0.44 (1.06)	0.01 (0.07)	−0.46 (1.05)	0.02 (0.07)
>30 years	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref
Missing	0.62 (1.37)	0.01 (0.10)	0.29 (1.65)	0.04 (0.12)	0.34 (1.36)	0.01 (0.10)	0.72 (1.35)	0.01 (0.09)	0.73 (1.35)	0.007 (0.09)
Density of healthy food stores [c]			−2.52**(1.27)	0.02 (0.09)						
Healthy food availability scale [d]					−2.67**(1.06)	0.03 (0.08)				
Walkability scale [d]							−1.54 (1.19)	−0.11 (0.08)		
Density of recreational facilities [c]									−1.53***(0.53)	−0.002 (0.04)

* P<0.1

All models adjusted for age, sex, education, income, time since baseline, age*time

*** P<0.01,

** p<0.05,

[a] Neighborhood indicators refer to a 1-mile (1.6 km) radius around each participant's home address at the baseline exam.

[b] Estimates correspond to a mean difference between the 90th and 10th centiles for each neighborhood indicator

[c] Kernel density; number per square mile

[d] Item responses had a possible range of 1 to 5; higher value indicates a more favorable environment

Table 2B

Adjusted mean difference at baseline and mean difference in annual change in WC by neighborhood indicator [a], Chinese immigrants

	Model 1		Model 2		Model 3		Model 4		Model 5	
	Mean difference at baseline	**Mean difference in annual change**	**Mean difference at baseline**	**Mean difference in annual change**	**Mean difference at baseline**	**Mean difference in annual change**	**Mean difference at baseline**	**Mean difference in annual change**	**Mean difference at baseline**	**Mean difference in annual change**
	Coefficient [b] (standard error)									
Length of US residence, baseline										
< 15 years	−1.04 (1.09)	0.26^{***}(0.08)	−0.97 (1.09)	0.24^{***}(0.08)	−1.00 (1.08)	0.26^{***}(0.08)	−1.38 (1.09)	0.23^{***}(0.08)	−1.01 (1.08)	0.27^{***}(0.08)
15-30 years	−0.47 (1.03)	0.20^{**}(0.08)	−0.42 (1.02)	0.19^{**}(0.08)	−0.44 (1.02)	$.20^{***}$(0.08)	−0.79 (1.03)	0.18^{**}(0.08)	−0.44 (1.02)	0.20^{***}(0.08)
>30 years	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref
Missing	−0.45 (1.64)	0.32^{**}(0.13)	−0.38 (1.63)	0.32^{**}(0.13)	−0.37 (1.63)	0.32^{**}(0.13)	−0.33 (1.62)	0.32^{**}(0.12)	−0.38 (1.63)	0.31^{**}(0.13)
Density of healthy food stores [c]			−0.05 (0.81)	0.11 (0.07)						
Healthy food availability scale [d]					0.35 (0.79)	0.004 (0.06)				
Walkability scale [d]							-1.86^{**}(0.79)	-0.11^{*} (0.06)		
Density of recreational facilities [c]									0.29 (0.60)	-0.08^{*} (0.05)

All models adjusted for age, sex, education, income, time since baseline, age*time

*** P<0.01,

** p<0.05,

* P<0.1

[a] Neighborhood indicators refer to a 1-mile (1.6 km) radius around each participant's home address at the baseline exam.

[b] Estimates correspond to a mean difference between the 90th and 10th centiles for each neighborhood indicator

[c] Kernel density; number per square mile

[d] Item responses had a possible range of 1 to 5; higher value indicates a more favorable environment