HHS Public Access
Author manuscript
Soc Sci Med. Author manuscript; available in PMC 2023 January 01.

Published in final edited form as:
Soc Sci Med. 2022 January ; 292: 114496. doi:10.1016/j.socscimed.2021.114496.

Social and Built Neighborhood Environments and Blood Pressure 6 Years Later: Results from the Hispanic Community Health Study/Study of Latinos and the SOL CASAS Ancillary Study

Kimberly L. Savin[a], **Scott C. Roesch**[b], **Eyal Oren**[c], **Jordan A. Carlson**[d,e], **Matthew A. Allison**[f], **Daniela Sotres-Alvarez**[g], **James F. Sallis**[h,i], **Marta M. Jankowska**[j], **Gregory A. Talavera**[b], **Tasi M. Rodriguez**[k], **Earle C. Chambers**[l], **Martha Daviglus**[m], **Krista M. Perreira**[n], **Maria M. Llabre**[o], **Linda C. Gallo**[b]

[a]San Diego State University/University of California San Diego, Joint Doctoral Program in Clinical Psychology, Postal Address: 6363 Alvarado Court, San Diego, CA, USA, 92120

[b]Department of Psychology, San Diego State University, Postal Address: 6363 Alvarado Court, San Diego, CA, USA, 92120

[c]School of Public Health, San Diego State University, Postal Address: 5500 Campanile Dr, San Diego, CA, USA, 92182

[d]Center for Children's Healthy Lifestyles & Nutrition, Children's Mercy Kansas City, Postal Address: 2401 Gillham Rd, Kansas City, MO, USA, 64108

[e]Department of Pediatrics, Children's Mercy Kansas City and University of Missouri Kansas City, Postal Address: 2401 Gillham Rd, Kansas City, MO, USA, 64108

[f]Department of Family Medicine, University of California San Diego, Postal Address: 9500 Gilman Drive, La Jolla, CA, USA, 92093

[g]Collaborative Studies Coordinating Center, Department of Biostatistics, University of North Carolina at Chapel Hill, Postal Address: 123 W. Franklin Street, Suite 450, CB #8030, Chapel Hill, NC, USA, 27516

[h]Herbert Wertheim School of Public Health and Human Longevity Science, University of California San Diego, Postal Address: 9500 Gilman Drive, La Jolla, CA, USA, 92093

[i]Mary MacKillop Institute for Health Research, Australian Catholic University, Postal Address: 5/215 Spring St, Melbourne VIC 3000, Australia

[j]Population Sciences, Beckman Research Institute, City of Hope, Postal Address: 1500 E Duarte Rd, Duarte, CA, USA, 91010

Corresponding Author. ksavin@sdsu.edu, Telephone number: 248-520-0122.

[k.]South Bay Latino Research Center, San Diego State University, Postal Address: 780 Bay Boulevard, Suite 200, Chula Vista, CA, USA, 91910

[l.]Department of Family and Social Medicine, Albert Einstein College of Medicine, Postal Address: 1300 Morris Park Avenue, Bronx, NY, USA, 10461

[m.]Institute for Minority Health Research, University of Illinois at Chicago, Postal Address: 835 S Wolcott Ave (Bldg 935), Mailbox #23 (M/C 769), Chicago, IL, USA, 60612

[n.]Department of Social Medicine, University of North Carolina, Postal Address: 333 South Columbia Street, MacNider Hall, Room #348 / CB #7240, Chapel Hill, NC, USA 27599-7240

[o.]Department of Psychology, University of Miami, Postal Address: P.O. Box 248185, Coral Gables, FL, USA, 33124

Abstract

Neighborhood-level socioeconomic deprivation can increase risk for higher blood pressure or hypertension, while greater neighborhood safety and walkability may protect against hypertension. Large-scale prospective research, particularly among Hispanics/Latinos, is lacking. We examined cross-sectional and prospective associations between neighborhood environments and blood pressure and hypertension among 3,851 Hispanic/Latinos enrolled in the Hispanic Community Health Study/Study of Latinos San Diego, CA cohort. Addresses from Visit 1 (2008–2011) were geocoded and neighborhood characteristics were determined as part of the SOL CASAS ancillary study. Home addresses were geocoded and home areas created using 800m circular radial buffers. Neighborhood indices socioeconomic deprivation, residential stability, and social disorder were created using Census and other publicly available data. Walkability was computed as density of intersections, retail spaces, and residences. Greenness was measured via satellite imagery using the Normalized Difference Vegetation Index. Visit 1 and Visit 2 (2014–2017) clinical outcomes included systolic (SBP) and diastolic (DBP) blood pressure, as well as prevalent and 6-year incident hypertension, defined as SBP/DBP ≥ 140/90mmHg or antihypertensive medication use. Complex survey regression models adjusted for covariates revealed cross-sectional associations between greater walkability and lower SBP (B=−0.05; 95% CI: −0.09, −0.003). In prospective analyses, greater neighborhood social disorder was related to increasing SBP (B=0.05; 95% CI: 0.01, 0.09) and DBP (B=0.07; 95% CI: 0.02, 0.12) over time. Greater socioeconomic deprivation (OR=1.47; 95% CI: 1.06, 2.04) and greater social disorder (OR=1.25; 95% CI: 1.02, 1.54) were associated with higher odds of incident hypertension. All other associations were not significant. Beyond individual-level characteristics, greater neighborhood social disorder and socioeconomic deprivation were related to adverse changes in blood pressure over 6 years among Hispanics/Latinos. Neighborhood social environment may help identify, or be an area for future intervention for, cardiovascular risk among Hispanics/Latinos.

Keywords

neighborhood; environment; blood pressure; hypertension; Hispanic/Latino; cohort; United States

Introduction

Social and built features of neighborhood environments can be significant determinants of health with the potential to influence blood pressure and other aspects of cardiovascular risk[1]. Social features include socioeconomic deprivation, social disorder, safety, residential stability, and others, while built features include physical aspects such as walkability and greenness. Previous cross-sectional studies have linked socioeconomic deprivation and neighborhood poverty with higher systolic and diastolic blood pressure (SBP, DBP[2,3]). A cross-sectional analysis in the Multi-Ethnic Study of Atherosclerosis (MESA) showed living in neighborhoods that residents perceived to be more walkable (i.e., having walkable destinations and higher land use mix), safe, and socially cohesive was associated with a lower hypertension prevalence[4]. However, these associations were attenuated after adjustment for race/ethnicity. In analyses of the MESA cohort stratified by racial/ethnic group, resident-reported neighborhood social problems (e.g., excessive noise, heavy traffic, violence) were linked with greater hypertension prevalence in Hispanics/Latinos[5]. Findings from prospective studies are limited and have produced mixed results. Neighborhood socioeconomic deprivation was prospectively associated with increased SBP, DBP, and incident hypertension across seven years in diverse (50% non-Hispanic black) adults from the Dallas Heart Study.[6] Social cohesion and safety were not related to incident hypertension in MESA[7]. High neighborhood walkability, derived from geographic information system (GIS) at the census tract level, was associated with decreases in SBP and DBP one year later in middle aged and older adults in Portland, OR[8]. In contrast, there was no association of resident-reported walkability with 10-year incident hypertension in MESA[7]. More large-scale prospective research is needed particularly in Hispanics/Latinos to help clarify associations between neighborhood environmental features and blood pressure in this population.

The association between neighborhood factors and blood pressure may be mediated by behavior or stress physiology. When neighborhoods have favorable social characteristics, (e.g., are considered safe with low crime and social disorder), individuals engage in more physical activity[9], which is protective for blood pressure. Similarly, neighborhoods with certain built characteristics, including high walkability[9] and green spaces[10], can promote physical activity. On the other hand, some neighborhood social environmental characteristics such as neighborhood crime or socioeconomic deprivation might serve as chronic stressors[11,12], which in turn could influence blood pressure over time. Chronic stressful living situations can lead to increased “allostatic load,”[12] or the cumulative wear and tear on the body as a result of stress over time, which has been linked to poorer health and mortality[13].

The prevalence of hypertension varies by race/ethnic group. In the National Health and Nutrition Examination Survey (NHANES) 2015–2016, non-Hispanic black adults had the highest rates of hypertension (40.3%) compared to other groups, while non-Hispanic white and Hispanic adults both had a prevalence of 27.8%[14]. Sorlie and colleagues[15] examined hypertension prevalence in the Hispanic Community Health Study/Study of Latinos (HCHS/SOL), a large, representative cohort of Hispanics/Latinos of various heritage groups from four U.S. cities. They found the overall age-adjusted prevalence of hypertension was 25.5%, but rates differed by heritage group, sex, and location of residence. For example, individuals of Mexican heritage living in the Bronx, NY had a lower hypertension prevalence (13.3%) than those of Mexican heritage living in San Diego, CA (21.2%). Elfassy and colleagues[16] found the age-adjusted probability of 6-year incident hypertension in HCHS/SOL was 21.7%, though incidence rates also varied by heritage group. Neighborhood built and social environmental characteristics and resources from one's neighborhood community may be protective factors especially for Hispanics/Latinos[17] and could contribute to regional differences in hypertension prevalence. Disparities in neighborhood quality have also been identified in Hispanics/Latinos and other racial/ethnic minorities compared to non-Hispanic whites. Likely due to discriminatory housing practices such as redlining, racial/ethnic minorities tend to live in neighborhoods characterized by disadvantaged physical[18] and social environments[19,20] with less access to resources[18,21].

There is little previous longitudinal research in large exclusively Hispanic/Latino populations examining associations of thoroughly defined measures of built and social neighborhood characteristics with change in blood pressure and hypertension incidence. The current study aimed to address these gaps in the literature and examine associations between multiple social and built neighborhood environmental factors at baseline and changes in blood pressure and incident hypertension across six years among Hispanics/Latinos of primarily Mexican heritage living in San Diego from the HCHS/SOL Community and Surrounding Areas (SOL CASAS) study. We hypothesized socioeconomic deprivation and social disorder would be associated with higher blood pressure and hypertension prevalence at baseline, and with adverse changes in blood pressure and higher incident hypertension over six years, whereas walkability, residential stability, and greenness would be protective for these outcomes. Improved understanding of links between built and social environments with blood pressure among Hispanics/Latinos could lay the foundation for improvements in neighborhood environments to help prevent and control hypertension.

Methods

Sample

The HCHS/SOL is a population-based cohort that enrolled 16,415 Hispanic/Latino adults from 4 U.S. cities (Bronx, Chicago, Miami, and San Diego) and collected data at Visit 1 between 2008–2011[22,23]. The sampling design allowed for a broadly diverse sample, and sampling weights were adopted in analyses to ensure effect estimates are representative of the target population[22]. There were 4,086 Hispanics/Latinos in the San Diego cohort. The analytic sample for cross-sectional analyses included HCHS/SOL San Diego participants whose Visit 1 addresses were geocoded (n=3,851) as part of the SOL CASAS ancillary study[24]. The analytic sample for longitudinal analyses included the San Diego cohort with geocoded addresses and who were re-assessed at Visit 2 of the HCHS/SOL between 2014 and 2017 (n=2,860). The analytic sample for primary hypertension incidence analyses was limited to those without hypertension at Visit 1 and who were re-assessed at Visit 2 (n=2,090). The study was conducted with approval from the institutional review boards of each of the institutions involved in the study. Written informed consent was obtained from all participants.

Neighborhood Environment Characteristics

An 800-meter circular radial buffer around each participant's home address was constructed using GIS software, to reflect reasonable walking distance (about 10 minutes) around the home[25–28]. Built and social environment characteristics within that buffer were computed and geocoded. *Walkability* was computed as density of intersections, retail spaces, and residences, using an index that has been validated in international studies and linked to walking trip choices[29,30]. These components signify greater street connectivity (intersection density) which facilitates easier walking between destinations and having more destinations for an individual to walk towards (retail and residential density). Land use was determined according to San Diego Association of Governments (SANDAG) land parcel classification. Residential land included categories such as single/multi-family homes and group quarters. *Greenness* was computed using the Normalized Difference Vegetation Index (NDVI). This index was calculated from 2010 annual composite average satellite imagery via Landsat and Google Earth Engine (Google 2017, Mountain View, CA).

Three neighborhood indices were created – socioeconomic deprivation, residential stability, and social disorder – using principal components analysis (PCA). The variables that make up the components were obtained from publicly available sources. The *socioeconomic deprivation index* comprised the following: percent of adults 25 years or older with no high school diploma; percent of adults unemployed; percent of households that rented; percent of households that are defined as crowded (using standard Census ACS and U.S. Department of Housing and Urban Development definition of more than one person per room[31]); percent of households living below the poverty line; percent of female headed households with dependent children; percent of households on public assistance; and percent of population on public health insurance. The *residential stability index* consisted of the following: percent of the population under the age of 18; percent of the population who lived in the same residence 1 year ago. The *social disorder index* consisted of the following: percent of households that are vacant; percent of the census block group that is vacant land (vacant land and households determined by SANDAG land parcel classifications); part 1 crime (e.g., aggravated assault, robbery, forcible rape) per 10,000; part 2 crime (e.g., fraud, other sex crimes, vandalism) per 10,000; liquor stores selling to-go alcohol per 10,000 residents. Additional information about these variables is available in the ancillary study's protocol paper[24].

Blood Pressure and Hypertension

At both visits, blood pressure was measured 3 times, 1 minute apart after a 5-minute rest period, and the average of the 3 measures was used to represent SBP and DBP in analyses. Anti-hypertensive medication use was collected by self-report. Hypertension was defined according to the Seventh Report of the Joint National Committee (JNC VII) on Prevention, Detection, Evaluation and Treatment of High Blood Pressure[32] as average measured SBP $\geq$ 140 mmHg, DBP $\geq$ 90 mmHg, or use of anti-hypertensive medication. Incident hypertension was defined as not having hypertension at Visit 1 and having hypertension at Visit 2. Another hypertension cutoff defined by the American College of Cardiology/American Heart Association (ACC/AHA) 2017 guideline[33], as average measured SBP $\geq$ 130 mmHg, DBP $\geq$ 80 mmHg, or antihypertensive medication, was used in sensitivity analyses.

Covariates

Demographic characteristics including age, gender, education, income, place of birth (U.S. 50 states or other), and duration of U.S. residence were self-reported at Visit 1. BMI and waist to hip ratio were obtained using a standardized protocol at both visits. Participants were asked to wear Actical accelerometers (version B-1; model 198-0200-03) for one week at Visit 1 to measure moderate to vigorous physical activity (MVPA; mins/day with activity counts ≥1535). Participants' addresses were collected again at Visit 2 to determine whether they had moved between visits.

Statistical Analysis

Statistical analyses accounted for HCHS/SOL complex design including stratification, clustering and baseline sampling weights for cross-sectional analyses and Visit 2 sampling weights, which accounted for loss to follow-up, for prospective analyses. Weighted descriptive statistics were performed using SPSS version 27 (IBM, Inc., Armonk, NY) complex survey procedures. To address missing data, the maximum likelihood robust (MLR) full-information maximum likelihood estimation procedure in MPlus version 8[34] was used to fit models. This approach uses both complete and partial cases to estimate model parameters and standard errors[35]. Multivariable linear regression models were fit to examine cross-sectional associations between the neighborhood variables and SBP and DBP at Visit 1. Models were also fit to examine the association between the Visit 1 neighborhood variables in relation to longitudinal changes in SBP and DBP at Visit 2. The first set of models ("Model 1") entered each of the 5 neighborhood variables individually (5 separate models) and controlled for age, gender, education, income, place of birth, years living in the U.S., and anti-hypertensive medication use. The second set of models ("Model 2") adjusted for the same covariates as the first set, and additionally entered all 5 neighborhood variables into models together to determine associations of neighborhood variables over and above each of the others. A third set of models ("Model 3") additionally adjusted for Visit 1 MVPA, BMI, and waist to hip ratio, to determine associations of neighborhood variables with blood pressure independent of these potential mediators. Longitudinal models additionally controlled for time between visits, moving status (whether a participant moved residences between visits), and baseline values. Prior to analysis, neighborhood independent variables and blood pressure (SBP, DBP) dependent variables were z-score standardized for ease of interpretation of parameter estimates. Multivariable logistic regression models with the same covariate adjustment described above, excluding antihypertensive medication use, were fit to examine the association between neighborhood variables with Visit 1 prevalent hypertension and 6-year incident hypertension among those without hypertension at Visit 1.

Sensitivity Analyses.—First, sensitivity analyses were conducted to examine 6-year incident hypertension using the hypertension definition as outlined in 2017 ACC/AHA guidelines (SBP/DBP ≥ 130/80 mmHg) or anti-hypertensive medication use. This was conducted to reflect the more updated hypertension guidelines which were not yet in place during data collection. Second, all prospective models above were repeated stratified by anti-hypertensive medication use (i.e., in those who were and were not taking anti-hypertensive medications separately), to separate any changes in participant blood pressure that may be systematically influenced by antihypertensive medication use. Third, all prospective models were repeated excluding those that moved between visits.

Results

Descriptive Statistics and Missing Data

The San Diego sample (N=3,851 participants) represents the target population which was 39.4 years old on average, 53.3% female, 92.9% of Mexican origin, 28.2% obtained a less than high school education, and 31.7% were born in the U.S. 50 states. The mean baseline SBP was 117.3 (SE=0.4) mmHg and DBP was 70.4 (SE=0.3) mmHg. At visit 1, there were 981 participants with prevalent hypertension. At Visit 2, mean SBP was 117.7 (SE=0.4) mmHg, DBP was 69.5 (SE=0.3) mmHg, and 1,008 individuals had prevalent hypertension. About one-fourth (27.9%) of the cohort moved between baseline and Visit 2. Other characteristics can be found in Table 1. The cohort that was missing Visit 2 outcome data (n=991) was significantly younger (mean age = 35.3 vs. 41.3 years, $p < 0.001$) and were significantly more likely to be male (54.2% vs. 43.2%, $p < 0.001$), born in the U.S. 50 states (38.4% vs. 28.7%, $p = 0.04$), and without hypertension (85.1% vs. 79.9%, $p = 0.02$) than those with Visit 2 outcome data. They were similar on other demographic and clinical characteristics.

Cross-Sectional Analyses

In cross-sectional analyses (N=3,851), lower walkability (B = −0.05; 95% CI: −0.09, 0.003) and greater socioeconomic deprivation (B = 0.06; 95% CI: 0.002, 0.11) were associated with higher SBP (see Supplementary Table 1). The walkability association persisted even after adjustment for potential mediators MVPA, BMI, and waist to hip ratio (B = −0.06; 95% CI: 0.11, −0.01), while the association of socioeconomic deprivation with higher SBP was no longer significant (B = 0.05; 95% CI: −0.02, 0.11). No other statistically significant cross-sectional associations were found after adjustment for other neighborhood variables.

Prospective Analyses

Social disorder was associated with prospective increases in SBP and DBP over time when it was entered into the model separately or together with the other neighborhood variables (n=2,860, see Table 2). Specifically, a 1 standard deviation (SD) increase in social disorder was associated with a 0.05 SD increase in SBP (B = 0.05; 95% CI: 0.01, 0.09) and a 0.07 SD increase in DBP (B = 0.07; 95% CI: 0.02, 0.12), controlling for sociodemographic covariates and other neighborhood variables. The estimates differed only slightly when adjusted for MVPA, BMI, and waist to hip ratio, though the association of social disorder with DBP was no longer statistically significant (B = 0.04; 95% CI: −0.01, 0.09). No other neighborhood variable was statistically significantly associated with SBP or DBP.

Complex survey frequencies (unadjusted for covariates) estimated there were 292 incident cases of hypertension in the 2,090 participants free of hypertension at Visit 1 who attended Visit 2 (14 cases per 100 persons). When neighborhood variables were entered individually into the model, greater social disorder, but no other neighborhood variable, was related to increased odds of incident hypertension (OR = 1.25; 95% CI: 1.04, 1.50; See Table 3). When all neighborhood variables were entered together in the model, socioeconomic deprivation (OR = 1.47; 95% CI: 1.06, 2.04) and social disorder (OR = 1.25; 95% CI: 1.02, 1.54) were associated with a greater odds of incident hypertension. When the model additionally adjusted for MVPA, BMI, and waist to hip ratio, only socioeconomic deprivation (OR: 1.49; 95% CI: 1.02, 2.17) was significantly associated with a greater odds of incident hypertension.

Sensitivity Analyses

AHA/ACC 2017 Hypertension Cutoff.—When examining the lower hypertension threshold (SBP/DBP ≥ 130/80 mmHg or anti-hypertensive medication), no neighborhood variable was significantly associated with incident hypertension (see Table 3).

Stratification by Anti-Hypertensive Medication Use Status.—In those not taking antihypertensive medications at Visit 2, greater social disorder was associated with similar increases in SBP and DBP as in the full sample, with no other statistically significant associations in fully-adjusted models. When the sample was limited to only participants who were taking antihypertensive medications at Visit 2, there were no significant associations of any neighborhood variable with SBP or DBP.

Exclusion of movers.—When analyses were limited to the cohort that did not move residences between visits, walkability was significantly and positively associated with changes in SBP across all levels of adjustment (see Supplementary Table 2). Similar to the primary analyses, social disorder was significantly and positively associated with changes in SBP and DBP and with higher odds of incident hypertension.

Discussion

This study examined cross-sectional and prospective associations of neighborhood factors with blood pressure and hypertension in a large cohort of Hispanics/Latinos. A consistent pattern was found with social disorder representing a risk factor for adverse blood pressure changes over time. Greater social disorder significantly predicted increases in SBP and DBP across 6 years, as well as 6-year incident hypertension, in the overall cohort, in only those not taking anti-hypertensive medications, and in those who did not move between visits. Socioeconomic deprivation was also associated with greater SBP at Visit 1 and predicted incident hypertension 6 years later. Notably, this association was robust to adjustment for other neighborhood variables and MVPA. Greater walkability was associated with lower SBP in cross-sectional analyses. Prospectively, no significant associations with walkability were found in the full cohort and unexpectedly, in the cohort who did not move residences between visits 1 and 2 only, greater walkability at baseline related to increases in SBP. Our findings add to a small body of literature that has examined neighborhood environmental factors in relation to blood pressure changes and is the first study to examine these associations over 6 years in an exclusively Hispanic/Latino population. Furthermore, our findings begin to address recent policy efforts aimed at social determinants of health such as the Healthy People 2030 Initiative[36], which includes specific goals related to creating neighborhoods and environments that promote health and safety and increase social and community support.

Prior research in U.S. non-Hispanics has linked components of the social disorder index (i.e., vacant houses/land, crime, liquor store density) with indicators of cardiovascular risk and disease[37,38]. Social disorder has been linked with racial stigma and “broken window” policing (i.e., emphasis on policing low-level offenses)[39], which can disproportionately affect and harm racial/ethnic minorities,[40] causing an additional burden of stress. Fortunately, these components of social disorder are areas of potential intervention at the neighborhood-level. Specifically, restoring or greening vacant land has been linked to reduced perceived crime and safety concerns,[41] improved mental health,[42] and reduced ambulatory heart rate[43]. Violence prevention interventions, such as upgrading urban infrastructure and improved access to social programs, have been effective for reducing exposure to violence in South Africa[44]. Liquor store density reductions could also be intervened upon for better health outcomes. Interventions targeting neighborhood socioeconomic factors could include education, housing, and employment initiatives in areas with higher socioeconomic deprivation. Interventions on the physical/built environment could also be implemented, though these features were not related to blood pressure in the current study.

Using the JNC VII hypertension cutoff, greater socioeconomic deprivation and social disorder were associated with higher odds of incident hypertension in the adjusted model, but they were not associated with incident hypertension according to the newer ACC/AHA guidelines[33]. The lowering of the hypertension cutoff results in a greater proportion of the population with a diagnosis, which may aid prevention efforts but also may be less predictive of future CVD events than the higher cutoff[45].

Sensitivity analyses stratified by anti-hypertensive medication use status were conducted to distinguish the effect of medications on blood pressure, but the results were similar to those in the full cohort. Social disorder had a consistent association with increases in blood pressure in those not taking anti-hypertensive medications at Visit 2. In those taking anti-hypertensive medications, there were no significant prospective associations of neighborhood variables with blood pressure, suggesting that current medication use has the greater influence on blood pressure.

The significant, positive association of walkability with SBP in sensitivity analyses excluding movers was contrary to hypotheses, and in the opposite direction of the baseline cross-sectional analyses. In our study, walkability is correlated with socioeconomic deprivation, which may be driving physiological stress and blood pressure downstream, though the association of walkability with SBP was the same when adjusted for the other neighborhood variables and was also robust to adjustment for adiposity and MVPA. It is also possible that those living in a neighborhood for longer periods of time might stop appreciating and benefitting from physical amenities such as walkability over time. While this sensitivity analysis excluded movers in attempt to capture only those with consistent exposure to the baseline neighborhood over time, it does not account for the time living in the neighborhood prior to the baseline assessment. More nuanced tracking of residences and environmental changes over time may be needed to clarify the associations of walkability with blood pressure and hypertension in this population.

In analyses examining variables potentially in the path from neighborhood environments to blood pressure, the association of social disorder with change in SBP persisted after adjustment for physical activity, BMI, and waist to hip ratio, but the associations of social disorder with change in DBP and incident hypertension were no longer statistically significant after this adjustment. In these models, the associations of BMI with DBP (B=0.11; p <0.001) and with incident hypertension (OR=1.07; p<0.001) were statistically significant, but the associations of MVPA and waist to hip ratio with DBP and incident hypertension were not. These analyses suggest that BMI may mediate the associations between social disorder and DBP/hypertension through behaviors other than physical activity (e.g., diet, alcohol consumption). However, the analytic approach used does not directly test for mediation and this pathway should be tested with techniques such as path analysis for confirmation in future research. On the other hand, the association of socioeconomic deprivation with incident hypertension was robust to adjustment for MVPA, BMI, and waist to hip ratio, suggesting it may influence hypertension through other pathways, such as by influencing physiologic stress responses.

Standardized effect sizes on blood pressure were small but may be meaningful at a population level. Randomized controlled trials of anti-hypertensive medications and dietary changes in individuals with elevated blood pressure have shown decreases in SBP and DBP of around 10 mmHg and 5 mmHg respectively, or less[46–48]. The SDs of Visit 2 SBP and DBP are 18 and 10 mmHg, respectively. Therefore, the prospective change in SBP and DBP in response to a 1-SD change in social disorder of around 0.06 SD units of SBP and DBP correspond to around 1.08 and 0.6 mmHg unit changes in SBP and DBP, after controlling for anti-hypertensive medication use. While this is a smaller effect on blood pressure compared to that of medication intervention trials, this effect was observed in a non-interventional observational study, indicating the potential for neighborhood environments to make an impact on the health of residents. Additionally, the current results can be applied more broadly, beyond only individuals with elevated blood pressure. Because blood pressure is continuously related to cardiovascular outcomes[49], lowering blood pressure even within the “normal” range in the population is expected to have public health benefit.

While the study contributes novel information about environmental correlates of Hispanic/Latino health, the results should be interpreted in the context of several limitations. First, about one-fourth of participants moved residences between Visit 1 and Visit 2 and we did not collect data about when they moved. It is reasonable to expect that some built environment characteristics such as walkability would change more after a move than socioeconomic or social disorder characteristics unless substantial changes in income also occurred. The inability to model changes in built environments could have contributed to the lack of significant prospective findings regarding walkability in the overall cohort. Our study was representative of Hispanics/Latinos of mostly Mexican heritage living in the San Diego area and findings cannot be assumed to generalize to other Hispanic/Latino populations. Our operational definitions of these neighborhood variables were informed by prior research, but there is no gold standard, and definitions for some indices (e.g., residential stability, social disorder) have varied widely in the literature. The use of other operational definitions for these constructs could produce different results. Lastly, we considered the role of physical activity and adiposity in the pathway from neighborhood environments to blood pressure but did not consider other potential mediating factors such as physiological stress responses. It is possible that neighborhood environments contribute to increased chronic stress, which may influence blood pressure and cardiovascular health.

The present study aligns with policy goals outlined in the Healthy People 2030 Initiative[36] and contributes novel information about social and built environmental factors in relation to blood pressure and hypertension in Hispanics/Latinos, a previously understudied group. Over and above individual-level factors, neighborhood environmental factors such as social disorder and socioeconomic deprivation were associated with increases in blood pressure and hypertension incidence over time. Community and neighborhood-level interventions, especially targeting social factors (e.g., restoring/greening vacant land, violence prevention programs, and liquor store density reduction), are warranted to improve the health of communities on a broader scale.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments and Funding Disclosure:

The Hispanic Community Health Study/Study of Latinos is a collaborative study supported by contracts from the National Heart, Lung, and Blood Institute (NHLBI) to the University of North Carolina (HHSN268201300001I / N01-HC-65233), University of Miami (HHSN268201300004I / N01-HC-65234), Albert Einstein College of Medicine (HHSN268201300002I / N01-HC-65235), University of Illinois at Chicago (HHSN268201300003I / N01-HC-65236 Northwestern Univ), and San Diego State University (HHSN268201300005I / N01-HC-65237). The following Institutes/Centers/Offices have contributed to the HCHS/SOL through a transfer of funds to the NHLBI: National Institute on Minority Health and Health Disparities, National Institute on Deafness and Other Communication Disorders, National Institute of Dental and Craniofacial Research, National Institute of Diabetes and Digestive and Kidney Diseases, National Institute of Neurological Disorders and Stroke, NIH Institution-Office of Dietary Supplements. SOL CASAS is supported by the National Institutes of Health/ National Institute of Diabetes and Digestive and Kidney Diseases (5 R01 DK106209; Allison/Gallo mPIs). KS was also supported by grant HL079891. LG, GT, and EC were supported by 5 P30 DK111022. LG was supported by 5 U54 TR002550.

The funding source(s) had no role in the study design; in the collection, analysis and interpretation of data; in the writing of the articles; and in the decision to submit it for publication.

The authors thank the staff and participants of HCHS/SOL and SOL CASAS for their important contributions.

References

1. Leal C, Chaix B. The influence of geographic life environments on cardiometabolic risk factors: a systematic review, a methodological assessment and a research agenda. Obes Rev. 2011;12(3):217–230. [PubMed: 20202135]
2. Coulon SM, Wilson DK, Alia KA, Van Horn ML. Multilevel Associations of Neighborhood Poverty, Crime, and Satisfaction With Blood Pressure in AfricanAmerican Adults. Am J Hypertens. 2016;29(1):90–95. [PubMed: 25917562]
3. Dubowitz T, Ghosh-Dastidar M, Eibner C, et al. The Women’s Health Initiative: The food environment, neighborhood socioeconomic status, BMI, and blood pressure. Obesity. 2012;20(4):862–871. [PubMed: 21660076]
4. Mujahid MS, Diez Roux AV, Morenoff JD, et al. Neighborhood characteristics and hypertension. Epidemiology. 2008;19(4):590–598. [PubMed: 18480733]

5. Mujahid MS, Diez Roux AV, Cooper RC, Shea S, Williams DR. Neighborhood stressors and race/ethnic differences in hypertension prevalence (the Multi-Ethnic Study of Atherosclerosis). Am J Hypertens. 2011;24(2):187–193. [PubMed: 20847728]
6. Claudel SE, Adu-Brimpong J, Banks A, et al. Association between neighborhood-level socioeconomic deprivation and incident hypertension: A longitudinal analysis of data from the Dallas heart study. Am Heart J. 2018;204:109–118. [PubMed: 30092412]
7. Kaiser P, Diez Roux AV, Mujahid M, et al. Neighborhood Environments and Incident Hypertension in the Multi-Ethnic Study of Atherosclerosis. Am J Epidemiol. 2016;183(11):988–997. [PubMed: 27188946]
8. Li F, Harmer P, Cardinal BJ, Vongjaturapat N. Built environment and changes in blood pressure in middle aged and older adults. Prev Med. 2009;48(3):237–241. [PubMed: 19297686]
9. Suminski RR, Poston WS, Petosa RL, Stevens E, Katzenmoyer LM. Features of the neighborhood environment and walking by U.S. adults. Am J Prev Med. 2005;28(2):149–155. [PubMed: 15710269]
10. Coombes E, Jones AP, Hillsdon M. The relationship of physical activity and overweight to objectively measured green space accessibility and use. Soc Sci Med. 2010;70(6):816–822. [PubMed: 20060635]
11. Shannon MM, Clougherty JE, McCarthy C, et al. Neighborhood Violent Crime and Perceived Stress in Pregnancy. International journal of environmental research and public health. 2020;17(15).
12. Ribeiro AI, Amaro J, Lisi C, Fraga S. Neighborhood Socioeconomic Deprivation and Allostatic Load: A Scoping Review. Int J Environ Res Public Health. 2018;15(6).
13. Beckie TM. A systematic review of allostatic load, health, and health disparities. Biol Res Nurs. 2012;14(4):311–346. [PubMed: 23007870]
14. Fryar CD, Ostchega Y, Hales CM, Zhang G, Kruszon-Moran D. Hypertension Prevalence and Control Among Adults: United States, 2015–2016. NCHS Data Brief. 2017(289):1–8.
15. Sorlie PD, Allison MA, Avilés-Santa ML, et al. Prevalence of hypertension, awareness, treatment, and control in the Hispanic Community Health Study/Study of Latinos. Am J Hypertens. 2014;27(6):793–800. [PubMed: 24627442]
16. Elfassy T, Zeki Al Hazzouri A, Cai J, et al. Incidence of Hypertension Among US Hispanics/Latinos: The Hispanic Community Health Study/Study of Latinos, 2008 to 2017. J Am Heart Assoc. 2020;9(12):e015031. [PubMed: 32476602]
17. Gallo LC, Penedo FJ, Espinosa de los Monteros K, Arguelles W. Resiliency in the Face of Disadvantage: Do Hispanic Cultural Characteristics Protect Health Outcomes? J Pers 2009;77(6):1707–1746. [PubMed: 19796063]
18. Landrine H, Corral I. Separate and unequal: residential segregation and black health disparities. Ethn Dis 2009;19(2):179–184. [PubMed: 19537230]
19. Adams MA, Hurley JC, Phillips CB, et al. Rationale, design, and baseline characteristics of WalkIT Arizona: A factorial randomized trial testing adaptive goals and financial reinforcement to increase walking across higher and lower walkable neighborhoods. Contemp Clin Trials. 2019;81:87–101. [PubMed: 31063868]
20. Kershaw KN, Diez Roux AV, Burgard SA, Lisabeth LD, Mujahid MS, Schulz AJ. Metropolitan-level racial residential segregation and black-white disparities in hypertension. Am J Epidemiol. 2011;174(5):537–545. [PubMed: 21697256]
21. Bailey ZD, Krieger N, Agénor M, Graves J, Linos N, Bassett MT. Structural racism and health inequities in the USA: evidence and interventions. Lancet. 2017;389(10077):14531463.
22. Lavange LM, Kalsbeek WD, Sorlie PD, Avilés-Santa LM, Kaplan RC, Barnhart J, Liu K, Giachello A, Lee DJ, Ryan J, Criqui MH, Elder JP Sample design and cohort selection in the Hispanic Community Health Study/Study of Latinos. Ann Epidemiol. 2010;20:642–649. [PubMed: 20609344]
23. Sorlie PD, Avilés-Santa LM, Wassertheil-Smoller S, Kaplan RC, Daviglus ML, Giachello AL, Schneiderman N, Raij L, Talavera G, Allison M, Lavange L, Chambless LE, & Heiss G Design and implementation of the Hispanic Community Health Study/Study of Latinos. Ann Epidemiol 2010;20:629–641. [PubMed: 20609343]

24. Gallo LC, Carlson JA, Sotres-Alvarez D, et al. The Hispanic Community Health Study/Study of Latinos Community and Surrounding Areas Study: sample, design, and procedures. Ann Epidemiol. 2019;30:57–65. [PubMed: 30551973]
25. Weinstein Agrawal A, Schlossberg M, Irvin K. How Far, by Which Route and Why? A Spatial Analysis of Pedestrian Preference. J Urban Des 2008;13(1):81–98.
26. Mavoa S, Bagheri N, Koohsari MJ, et al. How Do Neighbourhood Definitions Influence the Associations between Built Environment and Physical Activity? Int J Environ Res Public Health. 2019;16(9):1501.
27. Watson KB, Carlson SA, Humbert-Rico T, Carroll DD, Fulton JE. Walking for Transportation: What do U.S. Adults Think is a Reasonable Distance and Time? J Phys Act Health. 2015;12 Suppl 1(0 1):S53–61. [PubMed: 25158016]
28. Barnett DW, Barnett A, Nathan A, et al. Built environmental correlates of older adults' total physical activity and walking: a systematic review and meta-analysis. Int J Behav Nutr Phys Act. 2017;14(1):103. [PubMed: 28784183]
29. Frank LD, Sallis JF, Saelens BE, et al. The development of a walkability index: application to the Neighborhood Quality of Life Study. Br J Sports Med. 2010;44(13):924–933. [PubMed: 19406732]
30. Adams MA, Frank LD, Schipperijn J, et al. International variation in neighborhood walkability, transit, and recreation environments using geographic information systems: the IPEN adult study. Int J Health Geogr. 2014;13(1):43. [PubMed: 25343966]
31. U.S. Department of Housing and Urban Development. Measuring Overcrowding in Housing. 2007.
32. Chobanian AV, Bakris GL, Black HR, et al. Seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. Hypertension. 2003;42(6):1206–1252. [PubMed: 14656957]
33. Whelton PK, Carey RM, Aronow WS, et al. 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA Guideline for the Prevention, Detection, Evaluation, and Management of High Blood Pressure in Adults: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. J Am Coll Cardiol. 2018;71(19):e127–e248. [PubMed: 29146535]
34. Muthén LK, Muthén BO. MPlus Los Angeles: Muthén & Muthén; 2006.
35. Enders CK. Applied Missing Data Analysis. New York: Guilford press; 2010.
36. Healthy People 2030, U.S. Department of Health and Human Services, Office of Disease Prevention and Health Promotion. Retrieved September 10, 2021, from https://health.gov/healthypeople/objectives-and-data/social-determinants-health
37. Mayne SL, Moore KA, Powell-Wiley TM, Evenson KR, Block R, Kershaw KN. Longitudinal Associations of Neighborhood Crime and Perceived Safety With Blood Pressure: The Multi-Ethnic Study of Atherosclerosis (MESA). Am J Hypertens. 2018;31(9):1024–1032. [PubMed: 29897398]
38. Ahern J, Margerison-Zilko C, Hubbard A, Galea S. Alcohol outlets and binge drinking in urban neighborhoods: the implications of nonlinearity for intervention and policy. Am J Public Health. 2013;103(4):e81–87.
39. Sampson RJ Raudenbush SW. Seeing Disorder: Neighborhood Stigma and the Social Construction of "Broken Windows". Soc Psychol Q. 2004;67(4):319–342.
40. Sampson RJ. Disparity and diversity in the contemporary city: social (dis)order revisited. Br J Sociol. 2009;60(1):1–31; discussion 33–38. [PubMed: 19317670]
41. Branas CC, South E, Kondo MC, et al. Citywide cluster randomized trial to restore blighted vacant land and its effects on violence, crime, and fear. Proc Natl Acad Sci U S A. 2018;115(12):2946–2951. [PubMed: 29483246]
42. South EC, Hohl BC, Kondo MC, MacDonald JM, Branas CC. Effect of Greening Vacant Land on Mental Health of Community-Dwelling Adults: A Cluster Randomized Trial. JAMA Netw Open. 2018;1(3):e180298. [PubMed: 30646029]
43. South EC, Kondo MC, Cheney RA, Branas CC. Neighborhood blight, stress, and health: a walking trial of urban greening and ambulatory heart rate. Am J Public Health. 2015;105(5):909–913. [PubMed: 25790382]

44. Matzopoulos R, Bloch K, Lloyd S, et al. Urban upgrading and levels of interpersonal violence in Cape Town, South Africa: The violence prevention through urban upgrading programme. Soc Sci Med. 2020;255:112978. [PubMed: 32330747]
45. Brunström M, Carlberg B. Association of Blood Pressure Lowering With Mortality and Cardiovascular Disease Across Blood Pressure Levels: A Systematic Review and Meta-analysis. JAMA Intern Med. 2018;178(1):28–36. [PubMed: 29131895]
46. Manisty CH, Hughes AD. Meta-analysis of the comparative effects of different classes of antihypertensive agents on brachial and central systolic blood pressure, and augmentation index. Br J Clin Pharmacol. 2013;75(1):79–92. [PubMed: 22625662]
47. Appel LJ, Moore TJ, Obarzanek E, et al. A clinical trial of the effects of dietary patterns on blood pressure. DASH Collaborative Research Group. N Engl J Med. 1997;336(16):1117–1124. [PubMed: 9099655]
48. Bramlage P, Hasford J. Blood pressure reduction, persistence and costs in the evaluation of antihypertensive drug treatment--a review. Cardiovasc Diabetol. 2009;8:18. [PubMed: 19327149]
49. Lewington S, Clarke R, Qizilbash N, Peto R, Collins R. Age-specific relevance of usual blood pressure to vascular mortality: a meta-analysis of individual data for one million adults in 61 prospective studies. Lancet. 2002;360(9349):1903–1913. [PubMed: 12493255]

- Greater social disorder related to adverse changes in blood pressure 6 years later
- Greater socioeconomic deprivation related to incident hypertension
- Associations were independent of traditional individual cardiovascular risk factors

Author Manuscript

Author Manuscript

Author Manuscript

Table 1.

Descriptive statistics for sociodemographic factors and blood pressure measures in HCHS/SOL and SOL CASAS (N=3851)

	Unweighted n (Weighted %) Or Weighted M (SE)
Sociodemographic factors	
Age (years)	39.4 (0.5)
Female gender	2496 (53.3%)
Mexican origin	3596 (92.9%)
Less than High School Education	1348 (28.2%)
Income	
< $10,000	422 (9.5%)
$10,001–$20,000	971 (23.1%)
$20,001–$40,000	1352 (33.8%)
$40,001–$75,000	676 (20.3%)
> $75,000	232 (9.3%)
Did not respond/Missing	198 (4.1%)
Place of birth/duration of US residence	
Born in US 50 states	892 (31.7%)
Born outside US 50 states and duration of US residence ≥ 10 years	2273 (46.8%)
Born outside US 50 states and duration of US residence < 10 years	666 (21.2%)
BMI (kg/m^2)	29.1 (0.2)
Waist to Hip Ratio	0.9 (0.0)
Movers between Visit 1 and Visit 2	1123 (27.9%)
Blood pressure and hypertension	
Visit 1 SBP (mmHg)	117.3 (0.4)
Visit 1 DBP (mmHg)	70.4 (0.3)
Visit 1 Hypertension Prevalence	981 (18.5%)
Visit 2 SBP (mmHg)	117.7 (0.4)
Visit 2 DBP (mmHg)	69.5 (0.3)
Visit 2 Hypertension Prevalence	1008 (24.0%)

Note: HCHS/SOL = Hispanic Community Health Study/Study of Latinos. SOL CASAS = Study of Latinos Community and Surrounding Areas Study. BMI = Body Mass Index. SBP = Systolic Blood Pressure; DBP = Diastolic Blood Pressure.

Table 2.

Prospective associations between neighborhood environment characteristics and blood pressure at Visit 2, HCHS/SOL and SOL CASAS San Diego (N=2860)

Neighborhood Variable	Visit 2 SBP			Visit 2 DBP		
	Model 1[a]	Model 2[b]	Model 3	Model 1[a]	Model 2[b]	Model 3
	B (95% CI)	B (95% CI)	B (95% CI)	B (95% CI)	B (95% CI)	B (95% CI)
Socioeconomic Deprivation	0.01 (−0.03, 0.06)	−0.01 (−0.07, 0.05)	0.04 (−0.03, 0.11)	0.02 (−0.05, 0.09)	0.03 (−0.06, 0.11)	0.03 (−0.05, 0.11)
Walkability	0.04 (−0.01, 0.09)	0.03 (−0.03, 0.09)	0.02 (−0.06, 0.09)	0.02 (−0.04, 0.07)	−0.004 (−0.07, 0.06)	−0.05 (−0.11, 0.02)
Residential Stability	−0.03 (−0.07, 0.01)	−0.001 (−0.04, 0.04)	−0.02 (−0.07, 0.03)	−0.03 (−0.07, 0.02)	−0.01 (−0.05, 0.04)	−0.03 (−0.08, 0.02)
Social Disorder	0.06** (0.02, 0.09)	0.05* (0.01, 0.09)	0.05** (0.01, 0.10)	0.07** (0.02, 0.11)	0.07* (0.02, 0.12)	0.04 (−0.01, 0.09)
Greenness	−0.03 (−0.07, 0.01)	−0.004 (−0.07, 0.06)	0.02 (−0.06, 0.09)	−0.02 (−0.09, 0.05)	0.01 (−0.07, 0.09)	0.01 (−0.07, 0.08)

Note: SBP = Systolic Blood Pressure; DBP = Diastolic Blood Pressure. Model 1 adjusts for age, gender, education, income, place of birth/duration of US residence, anti-hypertensive medication use at visit 2, years between visit 1 and visit 2, moving status between visit 1 and visit 2, and visit 1 values of each visit 2 outcome. Model 2 adjusts for all covariates in Model 1, and additionally adjusts for each of the other neighborhood variables. Model 3 adjusts for all covariates in Model 2, and additionally adjusts for Visit 1 BMI, waist to hip ratio, and moderate to vigorous physical activity.

[a] In Model 1, the effect of each neighborhood variable is tested individually (in 5 separate models) with covariates.

[b] In Model 2, the effects of all 5 neighborhood variables are tested jointly in a single model.

* $p<0.05$,

** $p<0.01$

Table 3.

Prospective associations between neighborhood environment characteristics and 6-year hypertension incidence, using 2 hypertension cutoffs at Visit 2, HCHS/SOL and SOL CASAS San Diego

	Incident Hypertension (SBP/DBP ≥ 140/90 or anti-hypertensive medication use; n=2090)			Incident Hypertension (SBP/DBP ≥ 130/80 or anti-hypertensive medication use; n=1730)		
	Model 1[a]	Model 2[b]	Model 3	Model 1[a]	Model 2[b]	Model 3
Neighborhood Variable	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Socioeconomic Deprivation	1.21 (0.96, 1.53)	1.47* (1.06, 2.04)	1.49* (1.02, 2.17)	1.13 (0.92, 1.38)	1.16 (0.87, 1.55)	1.04 (0.76, 1.41)
Walkability	0.98 (0.80, 1.20)	0.76 (0.57, 1.01)	0.71 (0.50, 1.03)	0.96 (0.80, 1.16)	0.86 (0.59, 1.14)	0.88 (0.66, 1.19)
Residential Stability	0.87 (0.74, 1.02)	0.88 (0.74, 1.06)	0.91 (0.75, 1.09)	1.08 (0.93, 1.26)	1.08 (0.84, 1.30)	1.16 (0.96, 1.42)
Social Disorder	1.25* (1.04, 1.50)	1.25* (1.02, 1.54)	1.14 (0.96, 1.35)	0.99 (0.87, 1.12)	1.03 (0.84, 1.20)	1.05 (0.90, 1.23)
Greenness	0.86 (0.72, 1.03)	1.03 (0.77, 1.39)	0.95 (0.65, 1.40)	0.94 (0.77, 1.14)	0.92 (0.59, 1.30)	0.94 (0.69, 1.29)

Note: SBP = Systolic Blood Pressure; DBP = Diastolic Blood Pressure. Model 1 adjusts for age, gender, education, income, place of birth/duration of US residence, years between visit 1 and visit 2, moving status between visit 1 and visit 2. Model 2 adjusts for all covariates in Model 1, and additionally adjusts for each of the other neighborhood variables. Model 3 adjusts for all covariates in Model 2, and additionally adjusts for Visit 1 BMI, waist to hip ratio, and moderate to vigorous physical activity.

[a] In Model 1, the effect of each neighborhood variable is tested individually (in 5 separate models) with covariates.

[b] In Model 2, the effects of all 5 neighborhood variables are tested jointly in a single model.

* $p<0.05$,

** $p<0.01$