Neighborhood Disadvantage and Variations in Blood Pressure

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Abstract:

Purpose: To examine the extent to which neighborhood disadvantage accounts for variation in blood pressure. **Methods:** Demographic, biometric, and self-reported data from 19 261 health screenings were used. Addresses of participants were geocoded and located within census block groups (n = 14 510, 75.3%). Three hierarchical linear models were formulated to identify individual and census block group risk factors for hypertension. Neighborhood-level deprivation was determined using the Townsend Deprivation Index. **Results:** Of the 14 510 participants, 24% had a systolic blood pressure (SBP) of ≥ 140 mmHg, and 15% had a diastolic blood pressure (DBP) of ≥ 90 mmHg, indicating hypertension. At the neighborhood level, significant variation in average SBP and DBP across census block groups ($P < .001$) was found. Model 2 suggested that deprivation accounts for some of the variability in average SBP and DBP between block groups ($P < .001$). After controlling for individual-level risk factors in model 3, deprivation remained a significant predictor of average SBP ($P = .009$). **Discussion:** The findings highlight the role of individual and neighborhood characteristics on blood pressure, specifically SBP. Modifying neighborhood contexts may help reduce environmental risks of hypertension. **Translation to Health Education Practice:** Educating officials about health risks for residents associated with neighborhood resources is essential in changing policies and reallocating resources.

Keywords: blood pressure | neighborhood conditions | socioeconomic status | coronary heart disease | stroke

Article:

BACKGROUND

There is a strong connection between where people live and their health. People do not live in isolation; they are embedded in contexts that shape their lives and health, making where people live an important area of study and action for health educators. The conditions where people live impact their health directly and indirectly.[1] Exposure to toxins or environmental stressors such as crime or overcrowding can have a direct impact on health outcomes. Neighborhood conditions, such as lighting and green space, can impact health-related choices that individuals make, impacting health indirectly. Neighborhood socioeconomic status (SES) has an independent effect on morbidity (and mortality); populations living in lower SES neighborhoods have higher incidences of diseases.[4,5] These findings suggest that there is geographic variation in disease and that the broader neighborhood context is an important factor in health outcomes beyond personal factors.

The prevalence of coronary heart disease is higher in more disadvantaged neighborhoods.[3,6-9] Beyond individual-level factors for stroke, neighborhood SES contributes to geographic stroke patterns in the United States.[10,11] Several studies have examined the effect of neighborhood SES on blood pressure with mixed results. Three studies found an association between neighborhood SES and blood pressure, and one did not find an association.[15]

Neighborhood-Level Stress and Health

A potential influence of neighborhood contexts on health is the stress caused by environmental or neighborhood-level stressors. Although neighborhood-level stress has not been well studied, it has been suggested that neighborhood characteristics can be a source of acute and/or chronic stress.[16] Neighborhood-level stress is caused by physical and social factors that exist in the neighborhood context that are beyond the individual's control, such as overcrowding, noise, crime, poor lighting, poor-quality public spaces, and lack of social interactions, to name a few. Baum et al.[17] examined the effect of SES on stress and health and proposed that SES is correlated with environments that contribute to chronic stress, thus impacting health outcomes; neighborhoods with low SES tend to be neighborhoods with more stressors. There are 2 plausible explanations for how neighborhood disadvantage may influence hypertension, either through limiting behavior or a biological pathway where neighborhood factors moderate a stress response.[16,18-20] For example, neighborhoods maybe segregated by socioeconomic position. Socioeconomic segregation occurs when the socioeconomic status of the neighborhood creates a barrier to social and physical resources such as green spaces and social interactions, resulting in health inequalities for the residents.[21] Physical attributes include green spaces, noise, and the built environment. Social features of neighborhoods that may influence health include crime and social connections or cohesion. Diez-Roux and Mair[21] suggested that socioeconomic segregation influences the physical and social neighborhood environments that impact individual behavior and stress. They further suggest that individual behavior and stress are dynamically related and influence health. This means that stress can cause an individual to create an unhealthy behavior as a coping mechanism, such as staying indoors in high-crime neighborhoods, resulting in greater stress and poorer social health. Alternatively, individuals who adopt healthy behaviors as coping mechanisms, such as walking in the local mall instead of outside in high-crime neighborhoods, can act to buffer the effects of stress, resulting in improved health.

More disadvantaged neighborhoods tend to have more potentially stress-causing physical attributes such as crime, noise, and overcrowding.[17,22,23] The number of stressors and the level of each stressor a neighborhood or community has and supports, such as crime, violence, noise, and overcrowding, can be more or less protective or harmful to health.[16,17] A potential reason that disadvantaged neighborhoods may have more ambient stressors is that they have less access to resources that could diminish them. This lack of resources leaves residents more susceptible to chronic stress.[24]

During the stress response, the body releases hormones to prepare for fight or flight.[2,20] However, when the stress is chronic, the hormones can cause adaptive changes in body functioning. The effects of stress are cumulative; thus, when exposed to persistent stress, these physiological changes can have harmful effects on health outcomes. One such change is chronically increased sympathetic nervous system activity, which increases blood pressure due to allostatic load.[20,25] Residents in neighborhoods with more neighborhood-level stressors are continuously exposed creating chronic stress. A study examining the association between neighborhood-level stressors and neighborhood instability on health outcomes found that stress had a significant impact on the physical health of residents in more unstable neighborhoods.[2]

PURPOSE

This article examines disadvantage as a neighborhood-level stressor and its impact on hypertension. Our research question was whether neighborhoods with more neighborhood-level stressors, and thus higher scores on the Townsend Deprivation Index (TDI), would have a higher prevalence of hypertension that neighborhoods with fewer environmental stressors and lower scores on the TDI. We propose that the more disadvantaged neighborhoods will have a higher prevalence of hypertension than the less disadvantaged neighborhoods due to environmental stressors, after controlling for individual-level factors. Multilevel analyses make it possible to examine environmental-level effects, while controlling for individual-level effects.[26,27] The aim of this article is to examine the extent to which neighborhood-level disadvantage accounts for variation in blood pressure after controlling for individual risk factors. The hypothesis is that after controlling for individual-level factors, there will be greater variation in blood pressure among individuals living in more deprived neighborhoods.

METHODS

This study is a secondary analysis of data from community screenings conducted as part of the Community Initiatives to Eliminate Stroke (CITIES) Program in North Carolina. CITIES was funded and administrated by the Office of Minority Health. The overall goal of the program was to "complement and enhance existing local, regional, and national activities designed to contribute to reducing and ultimately eliminating the excessive rates of stroke in the southeastern region of the U.S."[28] This initiative had a 4-year grant operation period from August 1, 2004, to July 31, 2008. The Forsyth Medical Center Foundation in North Carolina was the lead organization of this project to reduce the risk factors of stroke among the minority communities in Forsyth and Guilford counties in North Carolina. Researchers at the University of North Carolina at Greensboro and the Moses H. Cone and Novant Health systems partnered for the project. The Institutional Review Boards at Novant Health Incorporated and the University of North Carolina at Greensboro approved the project. More than 80 locations accessed by minority and rural communities within Forsyth and Guilford counties were recruited as project partner sites. Mobile screening units regularly visited the partner sites to serve the target population of the CITIES project population, which was composed of more than 70% minorities and rural residents having an annual individual income of less than $35 000. Details of the CITIES project and the original study procedures are published elsewhere.[29]

Sample

A total of 19 261 people voluntarily visited the mobile screening units, participated in the screening interview, and completed a personal cardiovascular risk factor assessment consisting of demographic characteristics, self-reported cardiovascular risk factors, including self-reported smoking status and stress, and measured clinical cardiovascular risk factors, such as a blood sample to test cholesterol and glucose levels. Only those participants who were 18 years old or older and signed the consent form were included.

Geocoding

Respondent addresses were geocoded within the 2000 census block group boundaries using ArcGIS 9.3.[30] In this analysis, we were interested in neighborhood determinants of systolic blood pressure (SBP) and diastolic blood pressure (DBP); therefore, we excluded participants for whom we did not have a complete address (house number, street name, city, state, ZIP code; $n = 1301$), 3 homeless, and 159 who lived outside of North Carolina. Using the geocoding function within ArcGIS, 15 171 of the 17 798 eligible respondents were successfully geocoded (85% match). The census block group map was combined with the geocoded street addresses to assign the corresponding block group to each participant. To provide the most stable estimates, census block groups with less than 5 cases per block group, all participants ($n = 661$) excluded from the analysis were omitted from the final analysis.[31] Thus, 75% of all screenings were included in the final analysis. The final data set consisted of 574 census block groups with 14 510 participants, a mean of 25 individuals per block group. Among the 574 block groups used in the analysis, the mean number of participants within each block group was 25.28 (SD = 21.77). Block groups included between 5 and 143 participants.

Outcome Variable

A physical assessment of systolic and diastolic blood pressure was carried out during the screening interview. Blood pressure was examined in a mobile clinic by a senior registered cardiovascular nurse. An automated sphygmomanometer was used to measure the participants' blood pressure levels. If a participant's blood pressure was outside the normal range, the blood pressure was taken 2 additional times and the average blood pressures were recorded. Blood pressure was operationalized as a continuous variable; SBP and DBP were treated as separate measurements measured in millimeters of mercury. Analyses were conducted independently for SBP and DBP.

Individual-Level Variables

Eight individual sociodemographic and health-related variables were controlled for in the multivariate models: (1) age, as a continuous variable measured in years; (2) gender, as a dichotomous variable; (3) race, measured by self-report and coded as Caucasian, African American, or other; (4) self-reported stress: "Do you suffer from high-level stress on a daily basis that leads you to function poorly and/or sleep abnormally every day?" measured as a dichotomous variable; (5) a clinical blood test measured total cholesterol levels, low density lipoprotein (LDL), high-density lipoprotein (HDL), and triglycerides, as continuous variables; (6) calculated body mass index, using the Centers for Disease Control and Prevention's formula: weight (lb)/[height (in)]^2 × 703, measured as a continuous variable (this measure was used due to its high specificity)[31] ; (7) self-reported blood pressure lowering medication use, as "Do you use blood pressure lowering medication?"; and (8) self-reported smoking, as "Do you currently or have you ever smoked?" both measured as a dichotomous variables.

Neighborhood-Level Variables

Neighborhoods were operationalized as census block groups. Census block groups are subdivisions of U.S. Census tracts with an average of 1500 residents.[32] he block group level was used as a proxy for neighborhood and hypothesized to be most appropriate for this study because the block group level is small enough to be able to identify patterns that may be useful to practitioners.[21] Neighborhood-level variables were linked to individuals by geocoding.

Neighborhood Disadvantage

Neighborhood disadvantage was examined as a primary source of stress. For each block group a summary score of socioeconomic disadvantage was created using the TDI.[33] The TDI is a measure of material deprivation in a geographic area. The TDI uses 4 neighborhood-level variables to calculate a composite score for the overall socioeconomic status of an area. Data for the 4 indicators, unemployment, car ownership, homeownership, and overcrowding, were gathered for each of the census block groups from the 2000 U.S. Census data.[34] To create the summary score, the technique detailed by Diez Roux was used.[3,33] Equal weights were given to each of the 4 measures: unemployment, car ownership, housing tenure, and overcrowding. The unemployment measure provides an indication of overall lack of material resources and financial insecurity. Car ownership is a proxy measure for current income because of the continued costs associated with car ownership, and housing tenure represents long-term wealth. Overcrowding serves an indicator of poor housing quality. A deprivation score for each of the 4 measures was calculated using census block group data. Az-score was computed for each measure. The deprivation index is the sum of the 4 *z*-scores. The scores are then categorized into quartiles, with the deprivation index scores in the top 2 quartiles indicating greater neighborhood disadvantage. As described by Agyemang and colleagues,[18] neighborhood characteristics may act as a pathway to the development of high blood pressure due to stress. The summary neighborhood disadvantage score was used as an indicator of neighborhood level stressors.[18] Although all 4 indicators in the TDI may not be relevant for all neighborhoods, the TDI has the advantage of using the sum of the 4 indicators to provide an overall description of deprivation.

Data Analysis

The central hypothesis, that after controlling for individual-level factors there will be greater variation in blood pressure among individuals living in more deprived neighborhoods, was tested using multilevel modeling.[26] Using the mixed procedure in SPSS 16.0,[27] we formulated separate multilevel models for the 2 dependent variables, systolic and diastolic blood pressure, to represent the variation in blood pressure across neighborhoods after controlling for individual-level variables. Due to the independent roles that systolic and diastolic blood pressure have in predicting health outcomes, separate analyses were conducted to examine the effects of neighborhood-level variables on each dependent variable.[35] Thus, individuals with both high systolic and diastolic blood pressure were included in each analysis. We employed multilevel modeling to account for the hierarchical structure of the data, 14 510 individual cases (level 1) nested within 574 census block groups or neighborhoods (level 2) to differentiate between person level and true contextual effects.[26] Models were estimated using restricted maximum likelihood.[26] he means for the level 1 predictor variables were centered allowing us to control for individual-level variables to examine the effect of level 2 variables on blood pressure.[26] Centering the means for the level 1 variables that were measured as continuous, where there is no true zero, facilitated data analysis and interpretation.[26] Missing data at level 1 were handled using the imputation method of taking the median of the 10 points nearest to the missing item.[33,36,37] This method of imputation was used to maintain the distribution of the item values and measurement errors that would have likely been found if the value had been completed by the respondent.[37]

Our analysis began with an unconditional one-way analysis of variance model to examine the variation in SBP and DBP across neighborhoods, as specified by model 1. The means as outcome regression models (model 2) examined how blood pressure varies across the block groups due to neighborhood disadvantage. This model was used to determine whether neighborhood disadvantage is significantly associated with average blood pressure levels.

Separate multilevel models (Tables 1 and 2) for SBP and DBP were created using an intercepts and slopes as outcomes model. These models include both the individual-level variables and neighborhood disadvantage to determine whether neighborhood disadvantage is significantly associated with blood pressure levels after controlling for individual-level characteristics. The individual-level variables included in models 3 and 4 were blood pressure medication, age, gender, self-reported smoking status, self-reported stress, race, body mass index (BMI), LDL, HDL, and triglycerides. The deprivation index was the sole variable included at the census block (neighborhood) level. A significance level of $\alpha < .05$ was selected for both fixed and random effects.

TABLE 1
Results of Multilevel Regression for Systolic Blood Pressure[a]

	Model 1		Model 2		Model 3	
Variable	*Coefficient (SE)*	P	*Coefficient (SE)*	P	*Coefficient (SE)*	P
			Fixed Effects			
Intercept	128.84 (.21)	< .001	128.78 (0.21)	< .001	131.47 (0.58)	< .001
Medication[b]					− 5.34 (0.42)	< .001
Age					0.39 (0.01)	< .001
Gender[c]					4.90 (0.31)	< .001
Smoking[b]					− 0.80 (0.37)	.032
Stress[b]					− 1.28 (0.33)	< .001
Race[d]					4.19 (0.33)	< .001
					1.03 (0.53)	.051
BMI					0.48 (0.02)	< .001
LDL					0.04 (0.004)	< .001
HDL					0.06 (0.01)	< .001
Triglycerides					0.02 (0.002)	< .001
Disadvantage			0.36 (0.06)	< .001	0.12 (0.05)	.011
			Random Effects			
Variance components						
Intercept	9.36 (1.31)	< .001	7.83 (1.22)	< .001	0.27 (0.51)	.594

[a] BMI indicates body mass index; LDL, low-density lipoprotein; HDL, high-density lipoprotein.
[b] The reference group for these variables is yes.
[c] The reference group for this variable is female.
[d] The reference group for this variable is white/Caucasian. Race is presented in the following order: white/Caucasian, African American/black, other.

TABLE 2
Results of Multilevel Regression for Diastolic Blood Pressure[a]

	Model 1		Model 2		Model 3	
Variable	*Coefficient (SE)*	P	*Coefficient (SE)*	P	*Coefficient (SE)*	P
			Fixed Effects			
Intercept	79.39 (0.11)	< .001	79.36 (0.11)	< .001	80.01 (0.36)	< .001
Medication[b]					− 1.62 (0.26)	< .001
Age					0.02 (0.01)	.002
Gender[c]					2.70 (0.19)	< .001
Smoking[b]					− 0.48 (0.22)	.034
Stress[b]					− 0.92 (0.20)	< .001
Race[d]					2.23 (0.21)	< .001
					0.07 (0.33)	.828
BMI					0.31 (0.01)	< .001
LDL					0.03 (0.003)	< .001
HDL					0.04 (0.006)	< .001
Triglycerides					0.003 (0.001)	< .001
Disadvantage			0.14 (0.03)	< .001	− 0.03 (0.03)	.359
Random Effects						
Variance components						
Intercept	1.54 (0.36)	< .001	1.41 (0.34)	< .001	1.20 (0.31)	< .001

[a] BMI indicates body mass index; LDL, low-density lipoprotein; HDL, high-density lipoprotein.
[b] The reference group for these variables is yes.
[c] The reference group for this variable is female.
[d] The reference group for this variable is white/Caucasian. Race is presented in the following order: white/Caucasian, African American/black, other.

RESULTS

In this sample of 14 510 people, 24% of participants had a systolic blood pressure of ≥ 140 mmHg and 15% had a diastolic blood pressure of ≥ 90 mmHg at the screening, indicating high blood pressure. Overall, 28% of the sample had high blood pressure as classified by one or both values and 11% of the sample had both high SBP and DBP. Fourteen percent of participants reported taking blood pressure lowering medication (Table 3). The sample was predominately female (65%), 45% Caucasian and 46% African American, with a mean age of 47 years old (SD = 14.14; range = 18–96). Thirty percent of the sample had completed high school and 60% had more than a high school education. The mean neighborhood summary deprivation score was 0.303 (− 3.82 minimum score, 15.13 maximum score; Table 4). The average median household income was $42 593 from sampled census block groups; the interquartile range was $19 012.

TABLE 3
Descriptive Statistics of Individual Characteristics[a]

	Descriptive Statistics	
Variables	*Mean (SD) or %*	*Range*
Dependent variables		
Diastolic blood pressure	79.43 (10.60)	36–186
Systolic blood pressure	128.94 (18.47)	67–241
	Mean (SD) or %	Range
Medication[b]	14.4%	
Age	47.38 (14.46)	18–96
Gender[c]	65.3%	
Smoking[b]	18.0%	
Stress[b]	23.5%	
Race[d]	9.4%	
	46.0%	
	44.6%	
BMI	28.98 (6.52)	13–76
LDL cholesterol	108.16 (34.73)	1–289
HDL cholesterol	49.97 (15.33)	0–122
Triglycerides	157.1 (100.86)	0–651

[a] BMI indicates body mass index; LDL, low-density lipoprotein; HDL, high-density lipoprotein.
[b] The reference group for these variables is yes.
[c] The reference group for this variable is female.
[d] The reference group for this variable is white/Caucasian. Race is presented in the following order: white/Caucasian, African American/black, other.

TABLE 4
Descriptive Statistics of Neighborhood Characteristics

	Descriptive Statistics	
Variables	*Mean*	*Range*
Explanatory Variables: Neighborhood Level		
Townsend Deprivation Index[a]	0.3025	− 3.83 to 15.13
	Mean (%)	
Unemployment[b]	4.85	
Renter occupied homes	32.72	
Overcrowding (> 1 person per room)[b]	3.27	
Households without car ownership[b]	8.32	

[a] Townsend Deprivation Index was calculated by summing the *z*-score for each of the 4 neighborhood-level indicators (subtracting the mean of each variable and dividing by its standard deviation). Higher scores, those in the top 2 quartiles, indicate greater disadvantage.
[b] Mean before *z*-score transformation.

Tables 1 and 2 present the results of the multilevel regression analysis for SBP and DBP, respectively. Model 1 is an unconditional model. Significant variation in both mean SBP and DPB was found between neighborhoods (Υ_{00} = 128.84 $P < .001$; Υ_{00} = 79.39, $P < .001$, respectively). Model 2 is a conditional model with the deprivation index added at level 2, showing the effects of neighborhood disadvantage on blood pressure. The estimates for model 2 (Tables 1 and 2) indicate that neighborhood disadvantage is a significant factor accounting for some of the variability in SBP and DBP between low and high deprivation neighborhoods (Υ_{00} = 128.78, $P < .001$; Υ_{00} = 79.36, $P < .001$, respectively). Model 3 is a full model with all level 1 variables and the level 2 variable included. After controlling for individual-level characteristics, neighborhood disadvantage remained significantly associated with SBP (Υ_{00} = 131.47, $P < .011$; Υ_{10} = 0.12, $P = .011$; Table 1). A greater deprivation index suggests a higher mean SBP. This relationship was not found for DBP (Υ_{00} = 80.01, $P < .011$; $\Upsilon_{10} = -0.03$, $P = .359$; Table 2). In model 1, initially, without adding any additional variables, on average, there was 2.7% of variance in SPB and 1.4% of variance in DBP across neighborhoods. In model 2, 16% of the true between-neighborhood variance in SBP and 8% of the true between-neighborhood variance in DBP is explained by deprivation. In model 3, for SBP, 17.6% of the variance at level 1 is explained by the individual-level variables; for DBP, 8.7% of the variance at level 1 was explained by the individual-level variables.

DISCUSSION

Our findings suggest that neighborhood disadvantage has implications for blood pressure, over and above individual-level characteristics that are known to influence health. We were interested in whether individuals living in neighborhoods with greater disadvantage had higher systolic and diastolic blood pressure. After controlling for individual-level factors, our findings indicate that neighborhood-level disadvantage remained significantly associated with SBP. Residents of neighborhoods with greater disadvantage tended to have higher systolic blood pressure. Our findings are consistent with studies examining the association between environmental factors and increased cardiovascular risk factors, including hypertension. Diez-Roux and colleagues[12] found that living in more deprived neighborhoods was associated with increased cardiovascular risk factors such as smoking and increased blood pressure. A study in The Netherlands found that blood pressure and hypertension were significantly associated with environmental factors among ethnic groups.[18] Their results indicated that crowding was associated with higher SBP but not DBP. The finding that SBP is more sensitive to environmental stressors is important because variability in SBP is more predictive of future cardiovascular outcomes such as stroke.[38,39] Winkleby and colleagues[9] found that after controlling for 7 individual-level factors, age, marital status, family income, education, immigration status, mobility, and urban/rural status, that increased disadvantage was significantly related to increased coronary heart disease and mortality in men and women. These findings and the findings from our study generally conclude that living in less advantaged neighborhoods is associated with poorer health outcomes and increased prevalence of disease, supporting the potential importance of the environment on individual health. In this study, 28% of the participants had a measured blood pressure indicating hypertension, which is below the national average of approximately 33%. One explanation for this is that the sample included people whose blood pressure was being controlled by taking blood pressure–lowering medications. Another possibility is that although the average age of the sample was 47 years old, the sample included people who were as young as 18 years old and not prone to high blood pressure.

The use of multilevel modeling to examine variation in systolic and diastolic blood pressure for individuals with characteristics of neighborhood-level disadvantage in a large sample distinguished between the effects of the individual level characteristics and the effects of neighborhood on SBP and DBP. Study participants were selected from several counties of central North Carolina without preference for their blood pressure level. Strengths of this study include using an index of deprivation that includes environmental factors that have been positively associated with generally poorer health outcomes. Other strengths include the large sample size (*n* = 14 510 individuals and *n* = 574 census block groups) and the large mean number of individuals sampled per census block group (*n* = 25). In one study of neighborhood-level factors and individual-level characteristics on cardiovascular risk, the majority of the neighborhoods had only one resident.[21]

This study is subject to several limitations. First, a cross-sectional design was used, limiting the ability to establish causal relationships. Second, although the study population was large, it was used a convenience sample, limiting generalizability. Third, the definition of neighborhood and operationalization of neighborhood disadvantage for this study could also limit use of the findings. The study used census block groups, which have an average of 1500 residents, as proxies for neighborhoods.[40] This definition of neighborhood is large and may not accurately characterize features of the neighborhoods individuals live in that impact their health.[36] Studies are needed that define a geographic scale for neighborhoods that may be more appropriate for the question being examined. Fourth, there is also the possibility that associations found may be related to unmeasured individual-level socioeconomic variables and not the effect of neighborhood level disadvantage, including education and occupation.[41] Future studies examining neighborhood-level disadvantage as a stressor associated with increased blood pressure should measure and more finely control for individual-level socioeconomic characteristics. In addition, studies are needed that permit the investigation of specific neighborhood-level attributes, not just a combined index of deprivation, to determine areas on which neighborhood-level interventions should focus and be tested. The final limitation is related to the demographic data that were collected. The gender and race categories were limited and may not have been representative of the study population. Additionally, participant ethnicity was not recorded. These are serious limitations to being able to fully describe the population and generalize to other populations. Finally, the use of the TDI as a measure of neighborhood-level deprivation may not accurately capture true deprivation in a neighborhood because not all neighborhoods are impacted by each of the indicators. For example, neighborhoods in rural areas may not be impacted by overcrowding but may have other factors that indicate deprivation that are not experienced in urban areas.

TRANSLATION TO HEALTH EDUCATION PRACTICE

Variations in health outcomes, such as blood pressure, are the result of many factors including where and how people live.[1] Our findings highlight the combined role of individual-level and neighborhood-level variables on systolic and diastolic blood pressure. Work remains to understand the causal processes linking neighborhood-level factors to health outcomes. Further investigations of the effect of neighborhood disadvantage on the variation in blood pressure could benefit from including individual-level socioeconomic characteristics and a variety of neighborhood contexts. As the role of environmental factors in health is refined and the process of how environmental factors impact health is elucidated, local administrators and planners could use results from these studies to identify areas to target for change. Although social and economic policies are not traditionally thought of as health policies, their effects could have health implications for residents in neighborhoods.[21,42] Many of the neighborhood-level factors (e.g., lack of material resources, availability of healthy foods, and lack of green space) related to health could be addressed through policy change.[21] Knowing that neighborhood-level deprivation influences SBP can help city administrators and planners could use the findings from studies like this one to make resource allocation and building decisions. Further, cities and counties could use their own geographic information system data and their local data to pin point areas of disadvantage that would benefit from further investigation or resource allocation. Future research is needed to identify which specific features of neighborhoods have the greatest impact on SBP and thus could be targeted for change.

As advocacy takes on an ever more important role for public health education, these findings are important for informing public health policy decisions. Educating city and county officials, including administrators and planners, about the health risks for residents associated with neighborhood resources is an essential step in changing policies and reallocating resources. Modifying neighborhood contexts may help reduce the environmental impact on health. Resource allocation decisions made on smaller geographic areas that better reflect the neighborhoods that individuals live in may have a significant impact on improving health.

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