ORIGINAL ARTICLE

Multilevel Associations of Neighborhood Poverty, Crime, and Satisfaction With Blood Pressure in African-American Adults

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BACKGROUND
African-American adults experience the highest rates of elevated blood pressure (BP), and this disparity may be linked to socioeconomic and neighborhood-related disadvantage. Based on a bioecological stress-buffering framework, relations of poverty and neighborhood environmental perceptions with BP were assessed using multilevel regression in at-risk African-American adults.

METHODS
This cross-sectional study used baseline data that were collected in 2008 as part of the Positive Action for Today's Health (PATH) trial ($N = 409$), a community-based intervention to increase walking in low-income, high-crime neighborhoods. BP and perceived neighborhood crime and satisfaction were investigated as individual-level indicators of health and neighborhood environment. Census block groups ($N = 22$) served as geographic proxies for neighborhoods, and poverty was obtained using 2010 U.S. Census data, to characterize the neighborhood-level socioeconomic environment.

RESULTS
There were no individual-level direct associations. Significant cross–product interactions demonstrated that with higher perceived crime, high satisfaction was associated with lower systolic ($\gamma = 3.34$) and diastolic ($\gamma = -1.37$) BP, but low satisfaction was associated with higher systolic ($\gamma = 15.12$) and diastolic ($\gamma = 7.57$) BP. Neighborhood-level poverty was associated with diastolic ($\gamma = 11.48$, SE = 4.08, $P = 0.008$) and systolic BP ($\gamma = 12.79$, SE = 6.33, $P = 0.052$). Variance in BP across block groups was low (intraclass correlation coefficients = 0.002–0.014) and there were no significant random effects.

CONCLUSIONS
Results supported hypotheses, with greater neighborhood satisfaction linked to lower systolic and diastolic BP when perceived crime was high. Neighborhood poverty was also linked to higher systolic and diastolic BP. Prevention efforts should further investigate whether attending to issues of poverty and related neighborhood perceptions reduces high BP in at-risk African-American communities.

Keywords: African-American; blood pressure; hypertension; neighborhood; poverty.

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Socioeconomically disadvantaged groups experience the highest rates of cardiovascular disease and high blood pressure (BP) in the United States,[1] and in particular, 44% of African-American adults have high BP, in contrast to 28% of European-American adults.[2] Prevention efforts have not substantially reduced rates of high BP in at-risk populations, possibly because it is a complex, multifactorial disease influenced not just by individual-level behavioral, genetic, and interpersonal factors, but also by more distal socioeconomic and neighborhood-level risk and protective factors.[3] These more distal environmental factors have received less empirical attention however, which limits a comprehensive understanding of high BP.[4,5] Achieving national health equity and creating physical and social environments that promote well-being are top priorities for the *Healthy People 2020* initiative, under the direction of the U.S. Department of Health and Human Services.[6]

Residing within a stressful neighborhood environment, such as a high-crime or under-resourced community, can contribute to systemic physiologic, neurologic, and psychological dysfunction that adversely impacts BP.[7] However, neighborhood-related risk and protective frameworks have infrequently been used to better understand stress-related health outcomes in at-risk African-American adults.[8] For example, while the link between an individual's socioeconomic status (SES) and poorer cardiovascular outcomes has been studied extensively,[9,10] the potential impact of a neighborhood's socioeconomic context has not.[11,12] SES measured at the neighborhood level may capture unique and influential socioeconomic environmental factors and may also relate to perceptions of neighborhood crime and satisfaction.[3,8] Indeed, it is increasingly suggested that relations among neighborhood risk and protective factors are best understood within interactional frameworks.[4,5,13–17] Consistent with these priorities and also with a bioecological approach to

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human health,[18] the present cross-sectional study aimed to examine the direct and interacting relations of neighborhood SES, perceptions of neighborhood crime and satisfaction, and BP in at-risk African-American communities.

Stress-buffering theory provides a guiding framework for potential interactions among neighborhood environmental factors that influence health. The theory posits that the negative impact of neighborhood risk factors, such as perceived crime, on BP may be attenuated by positive protective factors, such as the perception that one's neighborhood has positive qualities in excess of those that are negative, or rather overall neighborhood satisfaction.[19] At a biological level, the experience of overall satisfaction could buffer the physiologic dysfunction that might occur as a result of chronic exposure to a more stressful environment, such as perceived exposure to crime, and prevent cardiovascular "wear and tear" and high BP.[3]

While no studies have investigated potential neighborhood buffering interactions, a handful have indeed assessed the direct associations of neighborhood factors and neighborhood SES on BP and cardiovascular health in African-Americans.[13–17,20] Findings from most,[13–16,20] but not all,[17] supported hypotheses that neighborhood-level variables and neighborhood SES significantly influence BP and cardiovascular health outcomes, sometimes to a greater degree than individual-level variables. For example, one study found that racial disparities in high BP were no longer statistically significant after adjusting for census-derived neighborhood SES,[13] and others have linked neighborhood SES to preclinical atherosclerosis,[14] increased systolic BP,[21] a diagnosis of high BP,[22] and cardiovascular disease mortality over 6 years,[23] all in African-American adult samples. Similar effects have also been found within international populations,[20] however one study found no link between neighborhood SES and high BP.[17] It is worth nothing however that studies have not assessed objective, census-derived neighborhood SES concurrently with residents' subjective neighborhood perceptions, even though objective and subjective neighborhood characterizations likely account for independent variation in BP.[24,25] An integrated, multilevel approach can therefore provide a more complete understanding of how neighborhoods impact BP.[18]

The present study aimed broadly to examine the impact of neighborhood factors on BP using a bioecological and multilevel stress-buffering framework. Specifically this observational study investigated whether neighborhoods do in fact account for meaningful variation in BP, whether there was a direct association of poverty on BP across neighborhoods, whether there were direct and interacting associations of perceived crime and neighborhood satisfaction on BP across individuals, and whether these individual associations differed across neighborhoods. It was hypothesized that greater neighborhood poverty would be related to higher BP, and that neighborhood satisfaction would buffer the negative association of high perceived crime on BP in these at-risk communities.

METHODS

Participants and design

This study used a subset of baseline data from the PATH trial, which is described in detail elsewhere.[26,27] African-American adults were recruited from 3 communities in the state of South Carolina to participate in the Positive Action for Today's Health (PATH) trial. Based on census and Behavioral Risk Factor Surveillance System data, the communities targeted were largely physically inactive (30–38%) and annually experienced high rates of documented crime for breaking and entering (141–160 incidents) and aggravated assault (65–87 incidents).[27] Assessments in each community were conducted over 2 years, though only cross-sectional baseline data are included in this study ($N = 409$).

Participants

Adults were enrolled in the PATH trial if they met the following criteria: (i) African-American (3 of 4 grandparents of African heritage), (ii) ≥18 years of age, (iii) no plans to move within 2 years, (iv) no medical condition limiting participation in moderate-intensity exercise (e.g., immobile, severely disabled, or bed ridden), (v) residence in specified census tracts within 3 targeted communities, and (vi) BP <180/<110 and blood sugar levels <300 nonfasting, ≤250 fasting. Participants were also excluded if they answered affirmatively to any item on the Physical Activity and Readiness Questionnaire,[28] indicating that they could not safely participate in moderate physical activity. Participants completed the informed consent process and were compensated monetarily for their time. The Institutional Review Board of the University of South Carolina approved the study.

Measures

Demographic and anthropometric measures. Age, sex, marital status, and body mass index (BMI) were assessed as control variables. BMI was calculated based on height and weight measurements obtained by research staff using standard procedures.

Blood pressure measures. BP was measured by a registered nurse using a Dinamap BP apparatus (model 8100; Critikon, Tampa, FL). During assessments, participants were seated with legs uncrossed, and the appropriate cuff size was selected based on upper-arm diameter. The cuff was placed on the left arm and 3 readings were taken after a 5-minute resting period. The average of the second and third readings were used for the analyses, with the first excluded since initial BP readings are typically elevated due to reactivity.[29]

Neighborhood Poverty. Neighborhood poverty was calculated as a marker of neighborhood SES using 2010 census data. Participants' addresses were geocoded using latitude and longitude coordinates that were then linked to census block group data. Block groups represent statistical areas delineated by visible or nonvisible geographic boundaries, such as roads, streams, railroad tracks, city blocks, property lines, or county limits. This study assessed percentage of poverty at the block-group level as an indicator

of neighborhood SES, with 6, 10, and 7 block groups from each the 3 respective PATH communities included in this study, amounting to 23 block groups total.[30] Supplementary Figure S1 provides images to illustrate the contrast across census divisions targeted in the PATH trial, and the degree to which neighborhood characteristics can differ across these discrete geographic boundaries (e.g., railroad tracks; Google Maps, 2014).

Neighborhood Perceptions. Items from the neighborhood satisfaction subscale of the Neighborhood Environment Walkability Survey (NEWS) included 5-point Likert response options to 17 items such as "How satisfied are you with your neighborhood as a good place to live?" Internal consistency generally ranges (α = 0.65–0.86) across items and was high is this sample (α = 0.79). Factorial and criterion validity of the survey for a number of neighborhood constructs has been established within a sample that included African-American adults.[31]

Items from the Safety from Crime subscale of the NEWS included 4-point Likert response options to 6 items such as "the crime rates in my neighborhood make it unsafe to go on walks during the day." The scale was reverse-scored so that higher values would indicate perceptions that the neighborhood environment was unsafe, to aid ease of measurement and interpretation within a buffering hypothesis. In this sample alpha reliability was 0.69 and factorial and criterion validity has been established for the overall scale.[31]

Data analytic plan

A multilevel modeling approach was used to allow estimation of effects occurring at individual- and neighborhood levels of analysis, and to account for the nesting of data within neighborhoods/block groups. A 2-level model was developed with Level-1 variables centered at the sample mean and cross–product interaction terms computed using the centered variables, to protect against multicollinearity. Level-1 control variables of age, being female (sex), marital status, and BMI were included based on previous literature, and previous findings in this sample that these variables are predictive of BP; medication status was included and ultimately dropped from the models as it was not predictive of BP and did not account for meaningful proportions of variance.[32] Predictors of perceived neighborhood satisfaction and crime, and the interaction of the two were also included at Level-1, in accordance with the bioecological stress-buffering framework; percentage of neighborhood poverty was included at Level-2.

Separate, stepped models for systolic and diastolic BP were developed with the R statistical software package, version 2.15.0 (R Development Core Team, 2012). First, an unconditional model was estimated to determine whether BP varied by neighborhood block group. Second, with control variables then added, Level-1 neighborhood perception variables were added to the model. Third, the Level-2 poverty variable was added to the model. Finally, random slopes were added to the model to estimate whether mean BP and relations among Level-1 variables and BP varied by neighborhood/block group. The final combined Level-1 and Level-2 model was therefore estimated follows:

$$\begin{aligned} BP_{ij} = {} & \gamma_{00} + \gamma_{01}\text{Poverty}_{j} + \gamma_{10}\text{Age}_{ij} + \gamma_{20}\text{Female}_{ij} \\ & + \gamma_{30}\text{BMI}_{ij} + \gamma_{40}\text{Marital}_{ij} + \gamma_{50}\text{NSatisfaction}_{ij} \\ & + \gamma_{60}\text{NCrime}_{ij} + \Gamma_{70}\text{NSatisfaction} \times \text{NCrime}_{ij} \\ & + u_{1j}\text{NSatisfaction}_{ij} + u_{2j}\text{NCrime}_{ij} + u_{3j}\text{NSatisfaction} \\ & \times \text{NCrime}_{ij} + u_{0j} + r_{ij} \end{aligned}$$

Variables preceded by a γ coefficient represent fixed effects, and variables preceded by a u coefficient represent random effects. Because effect sizes for interactions of perceived neighborhood crime and satisfaction were not available in the literature, *a priori* estimates of power were conducted assuming a small effect (r^2 = 0.02) for the Level-1 interaction. This power analysis showed that a sample size of 392 participants would result in power of 0.80 (α = 0.05). Listwise deletion due to data missing at Level-2 removed 25 cases or 5% of the total sample. The statistical assumptions of regression were tested prior to the parameter estimation. Analyses were performed in 2015.

RESULTS

The Level-1 sample included 409 adults, with 25 individuals excluded due to missing data. Descriptive data are presented in Table 1. The sample was predominantly female (62%), overweight (M_{BMI} = 30.88, SD = 8.43), and had a mean age of 53 years (SD = 16 years). In terms of marital status, 26% of individuals had never married, 25% were separated or divorced, 23% were married, 19% were widowed, and 7% were part of an unmarried couple. Data for predictor variables were normally distributed with mild skew for neighborhood satisfaction (G_1 = −0.52), indicating that participants were slightly more likely to be satisfied with their neighborhoods. BP values were normally distributed. Neighborhood satisfaction and perceived crime were inversely correlated (r = −0.46), though not at the magnitude of multicolinearity. The Level-2 sample included 22 block groups; 1 block group was excluded due to missing data for the single participant that resided within it. Average neighborhood poverty was 40% (SD = 13%) and ranged from 0.60% to 61.6% across the 22 neighborhood block groups.

Intraclass correlation coefficients by block group indicated that Level-2 effects accounted for 1.4% and .2% of the variation in diastolic and systolic BP, respectively. Greater age, being male, and having a higher BMI were all associated with increased systolic BP (Table 2). Being male was predictive of higher diastolic BP. There were no direct effects of perceived crime and neighborhood satisfaction on BP across individuals. The interaction of perceived crime and neighborhood satisfaction was significantly associated with both systolic (γ_{60} = −4.24, P = 0.052) and diastolic (γ_{60} = −2.78, P = 0.008) BP. Patterns demonstrated that with low neighborhood satisfaction, higher perceived crime was related to higher systolic (γ = 15.12) and diastolic (γ = 7.57) BP, but that high neighborhood satisfaction was relatively protective

of systolic (γ = 3.34) and diastolic (γ = −1.37) BP (Figures 1 and 2). There were no participants with high endorsements (≥1 SD) of both perceived crime and satisfaction, and only 2 with low endorsements (≤1 SD) of both perceived crime and satisfaction, and thus patterns are graphed and interpreted for the valid range of observable data.[33]

Parameters estimating the direct fixed effect of percent neighborhood poverty on BP at Level-2 indicated that a change in neighborhood poverty from 0% to 100% was associated with an increase in diastolic BP of 12 mm Hg (γ_{01} = 12.02, P = 0.01), and in systolic BP of 13 mm Hg (γ_{01} = 13.10, P = 0.05). Thus, individuals residing in neighborhoods that experience 40% poverty, the average rate of neighborhood poverty in this sample, are likely to have diastolic or systolic BPs that are 4.77 or 5.20 mm Hg higher, respectively, than neighborhoods with the lowest level of poverty (0.6%) found in this sample (γ_{01}).

Random effects (u_{0j}, u_{0j}, u_{0j}, and u_{0j}) were not significant and indicated no variation between intercepts and slopes for BP across neighborhoods. A random slope for the interaction was not estimable.

Table 1. Descriptive data for continuous variables (N = 409)

Variable	Mean	SD	Range
BMI	30.94	8.49	13.75–69.77
Age	50.79	15.64	18–85
N Sat	3.71	0.67	1.33–5.00
N Crime	2.27	0.63	1.00–4.00
SBP	132.06	17.88	90.5–178.0
DBP	81.20	11.01	56.0–108.5
Poverty	40.3%	13.3%	.6%–61.6%

Abbreviations: BMI, body mass index; DBP, diastolic blood pressure; N Crime, perceived neighborhood crime; N Sat, perceived neighborhood satisfaction; SBP, systolic blood pressure.

DISCUSSION

This study assessed associations of neighborhood poverty, perceived crime, and satisfaction environmental factors with BP in at-risk African-American communities, using a bioecological stress-buffering framework and a corresponding multilevel model. The pattern of associations showed that greater neighborhood satisfaction related to an attenuation of the adverse link between higher perceived neighborhood crime and higher systolic and diastolic BP. When neighborhood satisfaction was low, perceived crime related to increases in BP of 1.5–3.0 mm Hg. There were no independent effects of the neighborhood individual-level constructs on BP.

At the neighborhood level, poverty across census block groups was positively related to both diastolic BP and systolic BP, with the statistical effect size showing an increase of about 12 mm Hg as poverty increases from 0% to 100%. This association may be more meaningfully interpreted when comparing the average national poverty rate to the average poverty rate in the African-American neighborhoods that

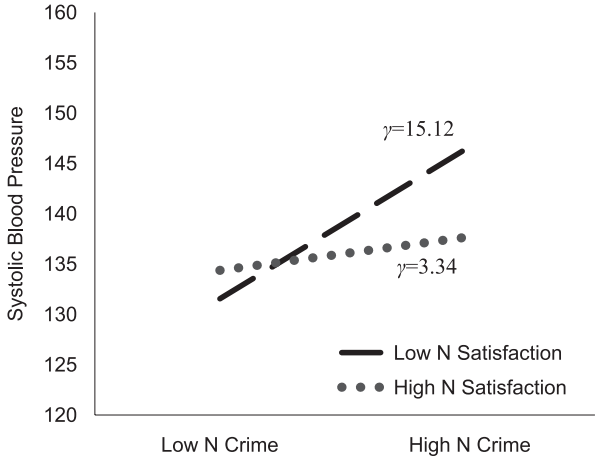

Figure 1. Interaction of perceived neighborhood satisfaction and crime in predicting systolic blood pressure.

Table 2. Model results model for neighborhood influences on blood pressure (N = 409)

	Systolic blood pressure				Diastolic blood pressure			
Fixed effects	Estimate	SE	*t*-value	*P*	Estimate	SE	*t*-value	*P*
Intercept (γ_{00})	126.13	2.69	46.88	0.000*	75.85	1.73	43.85	0.000*
Age (γ_{10})	0.36	0.06	6.24	0.000*	0.03	0.04	0.70	0.486
Female (γ_{20})	−4.42	1.85	−2.39	0.017*	−2.80	1.19	−2.36	0.019*
BMI (γ_{30})	0.38	0.10	3.61	0.000*	0.07	0.07	1.05	0.295
Marital status	0.31	0.52	0.59	0.555	−0.65	0.34	−1.92	0.056
N Sat (γ_{40})	1.60	1.49	1.08	0.282	0.07	0.96	0.07	0.94
N Crime (γ_{50})	2.40	1.56	1.54	0.125	0.24	1.00	0.24	0.813
N Sat × *N* Crime (γ_{60})	−4.24	1.90	−2.23	0.026*	−0.278	1.22	−2.28	0.024*
% Poverty (γ_{01})	13.10	6.34	2.06	0.052*	11.48	4.08	2.82	0.008*

Abbreviations: BMI, body mass index; N Crime, perceived neighborhood crime; N Sat, perceived neighborhood satisfaction.
*$P \leq 0.05$.

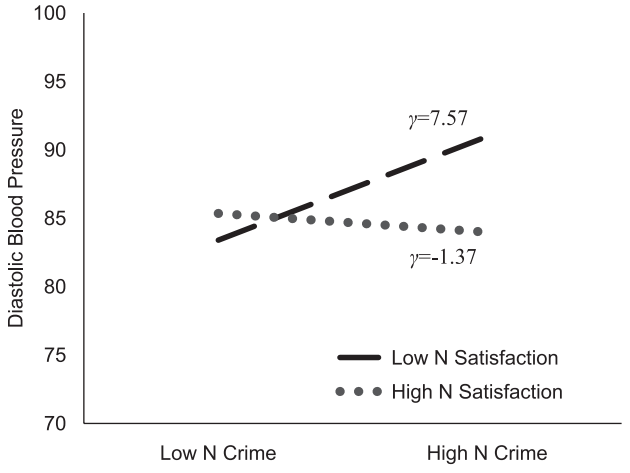

Figure 2. Interaction of perceived neighborhood satisfaction and crime in predicting diastolic blood pressure.

were included in this study. At approximately 15%,[30] the national poverty rate is 25% lower than the average poverty rate of this sample (40%). As a systematic socioeconomic disparity, poverty may therefore account for elevations in BP at a population level of about 3 mm Hg (0.25 × 12 mm Hg). This is substantial given epidemiologic data indicating that a 2 mm Hg population-level decrease in diastolic BP could reduce the prevalence of hypertension by 17% and the incidence of stroke by 15%.[34]

To our knowledge, no previous studies have assessed interactions among the specific measures and constructs presented here, though a handful have shown socioeconomic and neighborhood-level buffering interactions relevant to cardiovascular health. In a large Australian community sample, living in a highly walkable neighborhood buffered the unhealthy impact of fast food availability on BP.[35] A study of Japanese adults showed that higher neighborhood social capital at both individual- and neighborhood levels was related to lower systolic BP, within a multilevel framework similar to the one implemented in this study.[36] Other studies have found that the impact of low SES on elevated nighttime BP in African-Americans was greater with increased perceptions of unfair treatment and that perceived neighborhood safety was related to physical activity and BMI,[37] and that BP reactivity in African-American adolescents was reduced when neighborhood poverty was less than 5% and individual education was higher.[15] A final study investigated a neighborhood-related stress-buffering model and found that social supports buffered the negative effects of neighborhood disorder and poverty on self-rated health, but only for individuals with the greatest exposures to stressors.[38] Thus, this study builds on previous findings linking neighborhood protective factors (e.g., neighborhood satisfaction, walkability) to more positive outcomes in at-risk neighborhoods. The likely complexities of these interacting, multilevel relations warrant continued investigation of potential mechanisms of change, and prevention strategies and priorities to address health disparities related to socioeconomic disadvantage (e.g. *Healthy People 2020*).[6]

Limits of this study include restricted sampling at both neighborhood and individual levels, and limited measures of the neighborhood context. The neighborhood-level sample was relatively small (22 block groups), which likely did not afford the variability needed to detect random effects across block groups. Indeed, intraclass correlation coefficients indicated that only .2%–1.4% of variation in BP could be accounted for by random effects across block groups. African-American adults residing in underserved neighborhoods were recruited from a single state in the United States, and were excluded from participation if they had medical conditions limiting moderate-intensity exercise. It is therefore not clear if these associations would hold across more diverse populations and socioeconomic groups. However, this is the first study to investigate these multilevel neighborhood relations in a sample of African-American males and females who are at-risk for high BP and cardiovascular disease, and who historically have been underserved due to economic and social justice barriers in medical research.[39]

Conceptually, the study is limited by its measurement of only the neighborhood environment; this study did not include specific measures of buffering supports and stressors, and inclusion of these constructs would have provided insights into relations among distal neighborhood factors and BP, consistent with a true stress-buffering model. However, the study did use a powerful statistical approach that was congruent with the multilevel measurement of variables related to socioeconomic disadvantage. This study also did not include objective crime or neighborhood environmental data, but focused solely on neighborhood perceptions; objective neighborhood effects are likely distinct from individual-level perceptions, which could confound each other. More robust assessment of the neighborhood, including objective measures of crime and supports, would strengthen future studies, and further measurement work may also better inform relations across neighborhood-related constructs. Nonetheless, this study provides a novel assessment of multilevel relations linking neighborhood poverty and perceptions of crime and satisfaction to BP in African-American adults.

These findings contribute to a more comprehensive understanding of relations between neighborhoods and cardiovascular health in African-American adults. Both poverty and perceived neighborhood environmental factors are associated with systolic and diastolic BP, and these relations are interdependent and complex. Future research that combines this bioecological, neighborhood-focused approach with direct tests of stress-buffering constructs is warranted. Future prevention efforts may further investigate the potential mechanisms that underlie links between neighborhood poverty and perceptions, and health disparities in high BP.

SUPLEMENTARY MATERIAL

Supplementary materials are available at *American Journal of Hypertension* http://ajh.oxfordjournals.org)..

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DISCLOSURE

The authors declared no conflict of interest.

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