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Understanding Social Disparities in Hypertension Prevalence, Awareness, Treatment, and Control: The Role of Neighborhood Context

Jeffrey David Morenoff,
University of Michigan Ann Arbor, MI UNITED STATES, morenoff@umich.edu

James S House, PhD,
University of Michigan, jimhouse@umich.edu

Ben B Hansen, PhD,
University of Michigan, bbh@umich.edu

David R Williams, PhD,
Harvard University, dwilliam@hsph.harvard.edu

George A Kaplan, PhD, and
University of Michigan, gkaplan@umich.edu

Haslyn E Hunte
University of Wisconsin, hunte@wisc.edu

Abstract

The spatial segregation of the U.S. population by socioeconomic position and especially race-ethnicity suggests that the social contexts or "neighborhoods" in which people live may substantially contribute to social disparities in hypertension. The Chicago Community Adult Health Study did face-to-face interviews, including direct measurement of blood pressure, with a representative probability sample of adults in Chicago. These data were used to estimate socioeconomic and racial-ethnic disparities in the prevalence, awareness, treatment, and control of hypertension, and to analyze how these disparities are related to the areas in which people live. Hypertension was significantly negatively associated with neighborhood affluence/gentrification, and adjustments for context eliminated the highly significant disparity between blacks/African-Americans and whites, and reduced the significant educational disparity by 10–15% to borderline statistical significance. Awareness of hypertension was significantly higher in more disadvantaged neighborhoods and in places with higher concentrations of blacks (and lower concentrations of Hispanics and immigrants). Adjustment for context completely eliminated blacks' greater awareness, but slightly accentuated the lesser awareness of Hispanics and the greater levels of awareness among the less educated. There was no consistent evidence of either social disparities in or contextual associations with treatment of hypertension, given awareness. Among those on medication, blacks were only 40–50% as likely as whites to have their hypertension controlled, but context played little or no role in either the level of or disparities in control of hypertension. In sum, residential contexts potentially play a large role in accounting for racial-ethnic, and to a lesser degree, socioeconomic disparities in hypertension

Correspondence to: Jeffrey David Morenoff.

prevalence and, in a different way, awareness, but not in treatment or control of diagnosed hypertension.

Keywords

Neighborhoods; social disparities; multi-level modeling; health inequalities; hypertension; blood pressure

Introduction

Understanding and reducing socioeconomic and racial-ethnic disparities in health is arguably the most significant challenge facing U.S. public health research and policy. Despite abundant research on these social disparities in health, important questions remain regarding the reasons for the observed differences, which do not appear to be fully "explained" by the traditional individual-level risk factors included in most analyses. Reasons for social disparities in the individual-level risk factors for health are also not well understood. Given the spatial segregation of the population of the U.S. and other nations by socioeconomic position and race-ethnicity, the social contexts in which people live are increasingly recognized as additional potential determinants of health and factors contributing to health disparities, over and above the effects of individual and household risk factors. Research is beginning to document such effects of social context, though their nature and magnitude is variable and disputed and their role in understanding and explaining racial-ethnic and socioeconomic disparities in health is even less clear (Diez-Roux, 2000; Morenoff & Lynch, 2004).

In this paper we consider the extent to which individual-level racial/ethnic and to a lesser degree socioeconomic disparities in hypertension may be linked to the spatial locations of these groups. We focus on hypertension because it is a significant health problem in the United States that is unevenly distributed across socioeconomic and especially racial/ethnic groups (Hertz, Unger, Cornell, & Saunders, 2005), and there are compelling theoretical reasons for expecting that the spatial locations of racial/ethnic and to a lesser degree socioeconomic groups may be linked to hypertension. The goal of this paper is to assess the extent to which social disparities in four aspects of hypertension – prevalence, awareness, treatment, and control – are associated with differences in the areas where these groups tend to live. We accomplish this by decomposing racial/ethnic and socioeconomic disparities in hypertension prevalence, awareness, treatment, and control into within- and between-area components. This is a necessary first step in assessing the extent to which neighborhood residential context matters for social disparities in all these aspects of hypertension. It will thus target and focus future research that aims to identify whether and through what specific mechanisms residential environments may be causally related to hypertension and aspects of its diagnosis and treatment.

Background

As a major risk factor for heart and kidney disease and the major risk factor for cerebrovascular disease (stroke), hypertension is an important contributor to the burden of disease, disability and death in the population. Hypertension and its consequences are also unevenly distributed. In the United States, African Americans or blacks, have higher incidence, prevalence, and longer duration of hypertension than whites (Gillum, 1996; Saunders, 1995). (There is some evidence suggesting that black-white differences in blood pressure may be more pronounced in the U.S. than elsewhere (Profant & Dimsdale, 1999). Our results probably generalize to blacks in large American cities, but generalizations to other African Americans and blacks in other nations, should be more guarded, contingent on results from replication in other populations in and outside of the U.S.) Moreover, compared to whites, hypertension in blacks has an earlier age of onset, is more aggressive, difficult to treat and severe in terms of target organ damage such as renal failure (Jamerson, 2004; Weir & Hanes, 1996). Hispanics have levels of hypertension that are comparable or lower to those of whites, but the rates have been increasing in recent years, and Hispanics with hypertension are less likely to have their blood pressure treated and controlled compared to whites and blacks (Perez-Stable & Salazar, 2004).

The key factors underlying the elevated rates of hypertension among blacks are not clearly understood. Despite evidence that they are linked more to the psychosocial factors than to genetic factors and access to care (Cooper, Rotimi, & Ward, 1999; Jamerson, 2004; Pincus, Esther, DeWalt, & Callahan, 1998; Williams, 1992) no specific aspects of the social environment that are responsible for the elevated rates of hypertension among blacks have been clearly identified. Although individual measures of socioeconomic position probably play a role, they are unlikely to fully account for racial differences in blood pressure. SEP gradients for hypertension are relatively weak (Pickering, 1999), and hypertension prevalence is high for blacks irrespective of sex and SEP (Mensah, Mokdad, Ford, Greenlund, & Croft, 2005).

Nonetheless, chronic stress linked to the larger social environment is widely regarded as an important contributor to hypertension risk (Pickering, 1999) and there is a long history of interest in the ways in which the residential environment can contribute to cardiovascular risk including hypertension (Diez Roux, 2003). An early study in Detroit found that both blacks and whites who resided in low stress areas (based on area measures of economic deprivation, crime and marital instability) had lower levels of blood pressure than those in high stress areas (Harburg, Erfurt, Hauenstein, Chape, Schull, & Schork, 1973). More recently, analyses of national data for the U.S. and from Europe revealed that area measures of deprivation are positively related to elevated blood pressure independent of individual SES (Aslanyan, Weir, Lees, Reid, & McInnes, 2003; Cubbin, Hadden, & Winkleby, 2001; Galorbardes & Morabia, 2003). However, an experimental study (Kling, Liebman, & Katz, 2007) conducted on families living in high-poverty U.S. housing projects in five major metropolitan areas found that neither of two randomized treatment groups that received housing vouchers to move between 1994 and 1997 experienced lower prevalence of hypertension at follow-up in 2002 compared to the control group that received no vouchers. (Members of one experimental group were given vouchers that could only be used to move to low-poverty neighborhoods while the other group could use their vouchers to move anywhere.) Although this study has the advantage of using a randomized experimental design, it was conducted on a limited sample of low-income families initially living in public housing, and the treatment effects represent not only changes (usually favorable) in residential environments, but also the process of moving, which can be a stressful experience that could modify or negate any beneficial effects of leaving a stressful neighborhood.

The current study is one of few that simultaneously examine individual- and neighborhood-level variation in physical measurements of blood pressure in a large sample that covers a diverse range of urban neighborhood environments. By decomposing disparities into within- and between-area components, it advances our understanding of the possible contribution of residential segregation to social disparities in hypertension. Specifically, we use single- and multi-level models to study: (1) racial/ethnic and socioeconomic disparities in prevalence, awareness, treatment, and control of hypertension, net of several sets of potentially confounding individual-level variables; (2) the degree to which these disparities are reduced after adjustments for neighborhood context and individual-level confounding factors; and (3) associations between a set of neighborhood characteristics and our various hypertension outcomes.

Methods

Data

We analyze data from the Chicago Community Adult Health Study (CCAHS), which was designed to increase understanding of the role of residential context, in conjunction with individual and household factors, in affecting both self-reported and biomedical indicators of adult health. Between May, 2001 and March, 2003, we interviewed and made direct physical health measurements on a probability sample of 3105 adults aged 18 and over, living in the city of Chicago, IL and stratified into 343 neighborhood clusters (NCs) previously defined by the Project on Human Development in Chicago Neighborhoods (PHDCN) (Sampson, Raudenbush, & Earls, 1997). One individual was interviewed per household, with a response rate of 71.8 percent, which is quite high for surveys in large urban areas. Each NC usually included two census tracts (roughly 8,000 people) with meaningful physical and social identities and boundaries (Sampson et al., 1997). Decisions about which tracts to combine were informed by local geographic knowledge (e.g., ecological boundaries such as parks, railroad tracks and freeways) and a cluster analysis of census data (Sampson et al., 1997). Persons in 80 focal areas previously defined by PHDCN were sampled at twice the rate of those in others. The sample contains an average of 9.1 subjects per NC (14.3 per NC in the focal areas and 7.5 per NC in the non-focal areas).

All data and analyses are weighted to take account of the different rates of selection (and also different rates of subsampling for final intensive interview completion efforts) as well as household size and differential coverage and nonresponse across NCs, such that the weighted sample matches the 2000 Census population estimates for the city of Chicago in terms of age, race/ethnicity and sex. The sample weight used in this analysis is a multiplicative combination of (1) a weight to adjust for the oversampling of cases in focal vs. non focal areas at a ratio of 2:1, (2) a weight to adjust for whether a respondent was selected for intensive nonresponse follow-up at the end of the survey vs. those eligible but not so selected at a ratio of 1:2, and (3) a combined nonresponse and post stratification weight, which was the inverse of the ratio of the proportion of respondents in each NC to the proportion of the eligible population in each NC by age, sex, and race/ethnicity. The weight was centered to have a mean of 1.0, with a standard deviation of 0.7, a minimum of 0.2, and a maximum of 5.4. We used robust standard errors throughout our analysis.

Blood Pressure Measures—We collected three measures (approximately one minute apart) of systolic blood pressure (SBP) and diastolic blood pressure (DBP) using highly reliable Omron oscillographic devices certified by the European Society of Hypertension (O'Brien, Waeber, Parati, Staessen, & Myers, 2001). We conducted the blood pressure measures about two-thirds of the way through the survey interview, so most subjects were seated for at least 45–60 minutes prior to having their blood pressure measured. All values of SBP and DBP were extensively cleaned to check for out-of-range values and to take into account interviewer remarks about any problems that arose while measuring respondents' blood pressure. We then calculated the average of the final two measures of SBP and DBP. In cases where only two blood pressure measurements were taken, we used the average of the two to define SBP and DBP, and in cases where blood pressure was measured only once, we used SBP and DBP values from that measurement. All of our results are robust to the inclusion of dummy variables in our models to flag cases (n=50 for systolic and 49 for diastolic blood pressure) in which we did not have three blood pressure observations and thus could not compute the average of the final two. For 155 cases (8 percent of the sample), we were unable to get even one blood pressure reading for a variety of reasons ranging from occasional respondent refusal to interviewer problems in getting the blood pressure monitor to work for some respondents (due to excessively large or small required cuff sizes, irregular heart beats, or other reasons). The sample mean for SBP was 122.5 mmHg, and for DBP it was 77.3 mmHg.

We analyze binary measures of being hypertensive, being aware of a hypertensive condition, receiving treatment for hypertension, and having hypertension under control. We considered subjects to be <u>hypertensive</u> if they (a) had an average SBP of 140 mmHg or higher, <u>or</u> an average DBP of 90 mmHg or higher, or (b) reported that they had taken antihypertensive medications in the last 12 months. Subjects were considered to be <u>aware</u> of their hypertension if they (a) were defined as hypertensive and (b) answered “yes” to the survey question “Has a doctor or health professional ever told you that you have high blood pressure or hypertension?” Subjects were considered to be <u>treated</u> if they reported that they took antihypertensive medications in the last 12 months, and they were considered to have their hypertension <u>controlled</u> if they (a) reported that they had taken antihypertensive medications in the last 12 months and (b) had an average SBP less than 140 mmHg and an average DBP less than 90 mmHg (Hajjar & Kotchen, 2003).

Race/Ethnicity Measures—We use the terms race and ethnicity conjointly because our categorization is based on separate survey questions that ask the respondent to identify both Hispanic ethnicity and race. (Additional information on all of the variables used in our analysis (including the wording of survey questions about racial and ethnic identification), can be found in the web-only supplement [can be found in the web-only supplement available in the online version of this article as Appendix A]). We used the following four category classification of race/ethnicity: *Hispanic* includes all respondents who reported Latino/Hispanic origin, regardless of identification with any other racial group; *non-Hispanic black* includes respondents who identified as African American/Black in any of their responses (respondents could identify with multiple groups), excluding those who reported Latino/Hispanic origins; *non-Hispanic white* includes respondents who listed White/Caucasian as their first response to the race question, excluding those who identified as Latino/Hispanic or Black/African-American; and *non-Hispanic other race* includes respondents who listed American Indian, Asian, or Pacific Islander as their first response to the race question and did not identify as either Latino/Hispanic or Black/African-American (anyone who identified as Filipino was classified in this category, regardless of identification with other groups).

The survey questions on race/ethnicity and analytic categories we use are consistent with those used in the 2000 U.S. Census, which were based on extensive and expert social science deliberation with the understanding that conceptions and definitions of race and ethnicity are personally and socially constructed rather than given or determined by physical characteristics or national origins. These are also the categories used in most prior work on racial/ethnic disparities in hypertension.

Other Individual-Level Covariates—All of the models we present in the tables control for sex, age (18–29, 30–39, 40–49, 50–59, 60–69, 70 and over), and immigrant generation (first, second, third and higher). Some of the models control for a more extensive set of covariates including marital status (married, divorced, separated, widowed, never married), number of children in the household (one, two, three or more), body mass index (less than 22, 22–24.9, 25–29.9, 30–34.9, 35 or higher), health insurance (yes or no), regular source of medical care (yes or no), exercise (never, light-moderate, regular), walking (never walks 20 minutes or more, does so once a week or less, does so 2–5 times a week, does so almost every day), drinking (former drinker, always abstained, has less than four drinks per month, has 5–13 drinks per month, has 14–30 drinks per month, has 31 or more drinks per month), and smoking (former smoker, never smoked more than 100 cigarettes, smokes less than 6 cigarettes per day, smokes 6–10 cigarettes per day, smokes 11 or more cigarettes per day).

Neighborhood-Level Variables—To construct a set of neighborhood-level variables that would characterize the sociodemographic structure of Chicago neighborhoods we conducted a principal factor analysis with an orthogonal varimax rotation of 20 variables from the 2000 Census that include NC-level measures of racial/ethnic composition, socioeconomic status, age composition, family structure, owner-occupied housing, and residential stability. Our aim was to derive a parsimonious set of factors that capture the shared variance of a broad spectrum of neighborhood structural characteristics in order to use these factors to adjust social disparities in blood pressure for neighborhood context. All of the resulting factor scores were standardized to have a mean of zero and a standard deviation of one. The first factor, which we interpret as socioeconomic disadvantage, is characterized by low family incomes, high levels of poverty, public assistance, unemployment, female-headed families, never-married adults, and few owner-occupied homes. The second factor represents a mix of characteristics associated with neighborhood affluence (concentrations of people with high education and in professional/managerial occupations) and gentrification (a residentially mobile population consisting of young adults and few children under the age of 18). The third factor represents racial/ethnic/immigrant composition, (higher values indicate more Hispanic and foreign born and fewer non-Hispanic blacks), and the final factor captures older age composition (especially people over 70 but also those between ages 50–69, and few young adults or people who have never married).

Analytic Plan

We focus on the extent to which estimates of racial/ethnic and socioeconomic disparities in hypertension prevalence, awareness, treatment, and control change when variation in neighborhood context is taken into account. Our analysis proceeds in three stages. In the first stage, we use logistic regression models to estimate racial/ethnic and socioeconomic disparities in hypertension prevalence, awareness, treatment, and control, ignoring neighborhood context. We estimate one model with a limited set of individual-level covariates, including sex, age, race/ethnicity, immigrant generation, education, and income. This model provides baseline estimates of individual-level social disparities in each outcome. A second model includes a more expansive set of individual-level covariates, some suggested in the literature as possible explanations for socioeconomic and racial/ethnic disparities in hypertension (e.g., body mass index, regularity of medical care, physical activity, smoking, and drinking) and others included not only because they may predict hypertension but also because of their potential role in sorting people into neighborhoods (e.g., marital status and the presence of children in the household). These models were estimated with the Stata software package, version 9.

In the second stage of our analysis we examine how adjusting for neighborhood context changes estimates of individual-level disparities in hypertension outcomes. One way to accomplish this would be to add a fixed effect for each neighborhood (with one omitted as the reference category) to the logit models, but nonlinear fixed-effect models can be severely biased with many strata (Breslow & Day, 1980:249), so we used an analogous random-effects formulation (Raudenbush & Bryk, 2002:137), centering each individual-level covariate around its neighborhood mean. This procedure produces results nearly identical to fixed effects models when the dependent variable is continuous (e.g., systolic or diastolic blood pressure). We estimated these models using the HLM software package, version 6, first with the limited set of individual-level covariates and then with the more expansive set.

The final stage of our analysis adjusts for neighborhood context by introducing neighborhood-level variables into our hierarchical models. We use all continuous neighborhood-level variables in this analysis, but we also ran supplemental models with non-parametric specifications of neighborhood characteristics, and we report any differences we found with those results. These models begin to suggest what aspects of neighborhoods are most consequential for hypertension prevalence, awareness, treatment, and control. Again we estimate these models first with a more limited and then with a more expansive set of individual-level covariates.

One concern with the strategy of using neighborhood-level variables to adjust racial/ethnic and socioeconomic disparities in blood pressure outcomes is that high levels of residential segregation may preclude us from making comparisons between members of different social groups who live in similar types of neighborhoods, in which case regression estimates of the adjusted disparities would be based largely on extrapolations (Oakes, 2004). For example, if the distribution of neighborhood affluence among blacks does not overlap with the affluence distribution for whites, then the estimate of the black-white gap that we get after controlling for neighborhood affluence using regression may depend sensitively on linearity or other assumptions about affluence's contribution to the regression.

In our analyses incorporating neighborhood effects but not neighborhood-level variables (stage 2), disparity estimates are built from within-neighborhood comparisons, so that conclusions from these are less likely to be driven by extrapolation. The models that incorporate neighborhood-level covariates (stage 3) necessarily sacrifice this protection to enhance power. To explore the potential for extrapolation to affect them, we examined cross-tabulated frequencies of individual-level race/ethnicity, education, and income by quartiles of all four neighborhood-level factors (can be found in the web-only supplement available in the online version of this article as Appendix A). Despite substantial variance in the distribution of neighborhood characteristics across social groups, we found fairly sizable representations of all groups across the distribution of most neighborhood characteristics. Not surprisingly, there is less overlap in the distribution of the Hispanic/Immigrant/Non-Black factor across racial/ethnic groups than there is with other factors. However, substantial numbers of blacks and whites can be found at all quartiles of neighborhood affluence/gentrification, older age composition, and, to a lesser extent, disadvantage.

Results

Table 1 presents individual-level summary statistics on the outcomes and race/ethnicity, education, and income. 33.8 percent of our sample were hypertensive at the time of our measurements (25.6 percent had measured blood pressure in the hypertensive range and 8.1 percent did not but were on antihypertensive medication). Of these, 68.3 percent were aware of their condition; 85.6 percent of those who were aware were also receiving treatment for their hypertension; and among those being treated, 45.1 percent had their hypertension under control as defined by our measurements.

In Table 2 we examine social disparities in the prevalence of hypertension. Model 1 shows that the odds of being hypertensive are 80 percent higher for blacks compared to whites, 70 percent higher for those with less than 12 years of education compared to those with 16 or more years and 60 percent higher for those with 12–15 years of education compared to 16 or more years. All of these disparities remain significant, if slightly reduced, after controlling for the expanded set of individual-level covariates in model 2. The odds of hypertension are also greater among those with incomes under $10,000, but this association is only marginally significant statistically. Estimates of social disparities in hypertension change rather dramatically when we control for neighborhood context in random effect models, either without (models 3 and 4) or with the use of neighborhood-level variables (models 5 and 6). There are no longer significant differences in the odds of hypertension between blacks and whites or across levels of education after adjusting for neighborhood differences in models 3–6. We also find in models 5 and 6 that higher levels of neighborhood affluence are related to lower odds of being hypertensive. A one-standard deviation change in neighborhood affluence is associated with a 30 percent reduction in the odds of being hypertensive.

In Table 3 we analyze the log odds of ever being diagnosed with hypertension by a doctor or health professional, conditional on being hypertensive (which reduces the analytic sample to 1,029). Model 1 shows that the odds of being aware of hypertension are 80 percent higher for blacks compared to whites, but this association is reduced slightly and becomes only marginally significant when the full set of individual-level controls are added in model 2. Controlling for neighborhood context in models 3–6 further reduces the gap between blacks and whites in awareness, which suggests that odds of awareness are higher in neighborhoods where blacks live. Hispanics are less likely than whites to be aware of their hypertension, and this gap becomes more statistically significant after adjusting for neighborhoods. The odds of awareness are also higher among people with lower levels of education, but this association only becomes significant after controlling for neighborhood context in models 3–6 (and it is marginally significant in model 5). In models 5 and 6 we find that the odds of awareness are higher in more disadvantaged neighborhoods and in neighborhoods where more blacks live, but lower in places where more Hispanics and first-generation immigrants live. Thus, there is an association between neighborhood context and being aware of hypertension, and controlling for neighborhoods accounts for a large part of the differential between blacks and whites in awareness, but it does not explain why Hispanics are less aware of their hypertension than whites or why people with lower levels of education are more aware than those with 16 or more years, In fact, educational differences only become statistically significant after controlling for neighborhood context, perhaps because blood pressure screening is more common in areas where less educated people live (e.g., in churches or work places).

In Table 4 we model the log odds of being treated for hypertension, conditional on being aware. The sample size for this analysis is relatively small compared to previous analyses (*n*=719), and there is not as much variation in this outcome (86 percent of those who are aware of hypertension are also being treated with antihypertensive medications). As a result, there are few significant predictors of being treated. Model 1 shows that there are no discernible racial/ethnic or educational disparities in being treated for hypertension among those already aware. Due to the small sample size and lack of variation, the “non-Hispanic other” race category perfectly predicted treatment for hypertension, and so we had to remove it from the model. Thus, the reference group for racial/ethnic comparisons in this model includes both whites and those in the non-Hispanics other category. There is one, possibly chance, significant difference across income groups: people who make between $10,000–$29,999 are more likely to receive treatment for hypertension than those who make $50,000 or more. Estimates of racial/ethnic and socioeconomic differences in treatment change little when neighborhood fixed effects are added in models 3 and 4, and there are no significant associations with neighborhood-level covariates in models 5 and 6. However, chi-square tests indicated that there was significant residual variance at the neighborhood level that was not fully explained by the model suggesting that there is still unobserved heterogeneity in the way that rates of treatment for hypertension varies across neighborhoods. In short, the available evidence suggests that treatment for hypertension is not strongly patterned by race/ethnicity, education, or income, nor does neighborhood context appear to play a role in the likelihood of being treated.

Finally, Table 5 examines control of hypertension among those who are taking antihypertensive medication. Here again, the sample size is relatively small (*n*=569), but there is more variation to explain (only 45% of those who had been treated for hypertension had their blood pressure measured within the normal range) than was the case with treatment. Model 1 shows that the odds of having one’s hypertension under control are 50 percent lower for blacks compared to whites, and this gap persists after adjusting for the expanded set of individual-level covariates and for neighborhood context in subsequent models (although it is not quite significant when covariates are centered around their neighborhood means). (The reduction of the statistical significance of the black-white gap in hypertension control in models 3 and 4 is due to the increased standard errors in these models; the coefficients themselves actually increase.) Control of hypertension is also less likely among those with less education, but the only statistically significant result is that the odds of controlling hypertension are 50 percent lower for those with 12–15 years of education compared to those with 16 or more years in model 6. In contrast, low income people were slightly more likely to have their hypertension controlled, though again, only one contrast is significant (between those with incomes of less than $10,000 and those with $50,000 or more, in model 6). The association between low income and control of hypertension may reflect better access to care and medication among lower income persons, who are more likely to have health insurance, primarily via Medicaid.

The odds of having hypertension under control are higher in neighborhoods with older age compositions, although this association becomes marginally significant after adding the expanded set of individual-level covariates. A supplemental analysis suggested a possible association between neighborhood affluence and hypertension control. Replacing continuous factor scores with dummy variables for their quartiles, we found that living in a neighborhood at the highest quartile of affluence (compared to the lowest quartile) was associated with higher odds of having one's hypertension under control (OR=2.3, [1.1, 4.9]). These findings may reflect greater access to or quality of health care in affluent neighborhoods and in places with more elderly people.

Conclusion

The central aim of this study is to understand the potential contribution of residential neighborhoods to social disparities in hypertension prevalence, awareness, treatment, and control. We found that blacks and people with lower levels of education have significantly higher odds of hypertension than their respective comparison groups (i.e., whites and people with 16 or more years of education), but that after adjusting for neighborhood context these disparities diminished and became statistically insignificant. The risk of hypertension is also lower in more affluent and gentrified neighborhoods (i.e., places with a high level of residential turnover and greater shares of young adults, highly educated people, and people in professional or managerial occupations), even after adjusting for BMI, health care access, family structure, physical activity, smoking, drinking, and other neighborhood-level controls. One hypothesis is that affluent areas may have cultures that promote behavioral patterns (e.g., exercise, lower body mass, non-smoking) that reduce levels of blood pressure. What other specific factors may account for the association between neighborhood affluence and hypertension prevalence is a topic for future research.

Among those with hypertension, the odds of being diagnosed by a doctor or health professional were higher for blacks compared to whites and people with lower levels of education compared to those with 16 or more years, which is consistent with previous research (Hajjar & Kotchen, 2003). We also found that awareness was higher among people who live in more disadvantaged neighborhoods and neighborhoods with higher proportions of blacks (and fewer Hispanics and foreign-born). Among those who are aware of their hypertension, there were no significant social disparities in the odds of receiving medical treatment. All of this suggests that the public health and health care system is effective at screening, diagnosing, and initiating treatment of high-risk groups. Also, the finding that more disadvantaged and black neighborhoods are associated with higher odds of awareness, and that these neighborhood factors account for the remaining differences in awareness between blacks whites, suggests that some of these public health initiatives to increase awareness of hypertension have been effectively targeted at places rather than just people at risk for hypertension (Benjamins, Kirby, & Bond Huie, 2004).

Despite the encouraging findings regarding awareness and treatment, we found that blacks were significantly less likely to have their hypertension controlled, and the same was true for the less educated, although not all differences were statistically significant. Neighborhood old age composition and, in some models, affluence were positively related to control, but adjustments for context failed to explain racial or educational disparities in control. Pharmacologic treatment of hypertension appears not to be as effective for blacks, but we do not yet adequately understand why. One possibility is that treatment of hypertension may not work as well for persons under high stress, in part because such people are less able to comply with treatment regimens (Williams, 1992). To the extent that stress is related to neighborhood exposures, we would expect racial disparities to diminish after taking neighborhoods into account, but they do not. Alternatively, considerable evidence suggests that the quality and intensity of treatment of a broad range of medical conditions vary by race, with blacks and other minorities receiving poorer quality of care than whites (Smedley, Stith, & Nelson, 2003). Inadequate levels of control of hypertension among blacks seeking treatment remains a significant scientific and public health problem, but neighborhood context (at least as it varies within a city like Chicago as opposed to between cities and other areas) does not appear to be a major factor to be pursued in further efforts to understand and alleviate this disparity. However, we also note that our analysis of hypertension control among those being treated for hypertension is based on much smaller sample sizes, both at the individual- and neighborhood-levels, which reduces our power to detect significant neighborhood effects.

In sum, we found that neighborhoods appear to play a role in explaining social disparities in hypertension prevalence and awareness, though in different directions, but not in the treatment and control of hypertension. Our analysis also highlights the potentially protective effects of neighborhood affluence for reducing the risk of hypertension, and increasing the likelihood that people on anti-hypertensive medication will be able to control their condition. This study is part of a growing literature that has found neighborhood SEP to be associated with a variety of health outcomes, but it also makes some distinctive contributions. First, this is the only study of which we are aware that attempts to decompose social disparities in health into their within- and between-neighborhood components, thus focusing on the role of neighborhoods in explaining racial/ethnic and socioeconomic disparities. Second, most previous studies of neighborhood SEP and health have focused on markers of neighborhood disadvantage, whereas we assess both disadvantage and affluence and find the latter to be a stronger predictor of hypertension. Third, unlike many previous studies, we sampled adults from all neighborhoods in a major urban area, Chicago, and collected physical measurements on health rather than relying on self-reports. Fourth, few prior studies have explored social disparities in awareness, treatment, and control of hypertension, and ours is the first (of which we are aware) to examine associations between these outcomes and neighborhood context.

Our study has several limitations. First, it is a study of a single U.S. city with a unique social geography and a high degree of residential segregation (Frey & Meyers, 2005). It is conceivable that in other populations, hypertension, neighborhoods, and social groups associate in different patterns than in Chicago. However, by concentrating on a single city, we have been able to sample clusters of individuals in small geographic areas, which is important for multilevel comparisons within and between neighborhoods. Chicago is also particularly well-suited to studying social disparities in health because it is one of the few major cities to contain substantial representations of whites, blacks, and Mexicans, as well as other ethnic groups.

Second, the study does not identify specific mechanisms linking individual-level race/ethnicity and SEP, or neighborhood sociodemographic characteristics to blood pressure. Nor can a cross-sectional study of this type draw any clear conclusions about causal relationships. Our findings indicate that features of neighborhoods may be stronger or more consistent markers of hypertension risk than race or SEP, but not that either of these in itself clearly causes hypertension (Kraemer, Kazdin, Offord, Kessler, Jensen, & Kupfer, 1997). In the real world people are not randomly assigned to neighborhoods, and although hypertension itself may not be a strong determinant of how people selectively sort themselves into neighborhoods (in part because it is largely asymptomatic), there may be other health conditions that are either predictors (e.g., BMI) or outgrowths (e.g., cardiovascular disease) of hypertension that could in part determine how people select themselves/are selected into neighborhoods.

A possible third limitation is that segregated cities or metropolitan areas may provide too few comparisons between individually similar people living in different neighborhood environments to identify neighborhood effects, or to disentangle the individual-level effects of race/ethnicity and SEP from the contextual effects of neighborhood characteristics (Merlo & Chaix, 2006; Oakes, 2004, 2006). We addressed this issue empirically by examining the overlap in the distributions of neighborhood characteristics across different social groups and by estimating within-neighborhood disparities of hypertension. Although segregation limited our ability to distinguish neighborhood and individual contributions to hypertension risk, this limitation was far from total.

This study takes measured but important steps towards understanding the potentially substantial role that place of residence, and factors that vary with it, play (or do not play) in the etiology of hypertension and its diagnosis, treatment, and control. Future research should be more specific as to the attributes of areas that increase the risk of such hypertension. Candidates for such neighborhood mechanisms include indicators of stress (e.g., crime and disorder), features of the built environment that encourage exercise and walking (e.g., mixed land use), the availability and type of grocery stores and restaurants in and around the neighborhood, the proximity of health care providers, and the availability of social support. Future analysis must also utilize designs (e.g., experimental or longitudinal) that support stronger causal inferences. A better understanding of the causal mechanisms through which neighborhood environments shape the risk of hypertension risk could also help inform decisions as to where future community-level interventions should be targeted.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1
Individual-Level Summary Statistics

Variable	Frequency (unweighted)	Percent (weighted)
Hypertension Outcomes		
Prevalence (*n* =2933)	1029	*33.8*
Awareness (*n* =1029)	719	*68.3*
Treatment (*n* =719)	615	*85.6*
Control (*n* =569)	251	*45.1*
Race/Ethnicity		
Non-Hisp White	983	*38.4*
Non-Hisp Black	1240	*32.1*
Hispanic	802	*25.8*
Non-Hisp Other	80	*3.8*
Education		
<12 years	792	*23.4*
12–15 years	1576	*48.7*
16+ years	737	*27.9*
Income		
< $10,000	365	*10.1*
$10,000–$29,999	876	*26.2*
$30,000–$49,999	581	*18.4*
$50,000+	698	*26.5*

Table 2

Odds Ratios (OR) and 95% Confidence Intervals (CI) for Weighted Logistic Regression and Hierarchical Generalized Linear Models of Hypertension Prevalence: CCAHS 2002 (n=2,933)

	No adjustment for neighborhood				Neighborhood adjustment[a] + random effects				Neighborhood covariates + random effects			
	Model 1[b]		**Model 2[c]**		**Model 3[b]**		**Model 4[c]**		**Model 5[b]**		**Model 6[c]**	
Variable	**OR**	***CI***	**OR**	***CI***	**OR**	***CI***	**OR**	***CI***	**OR**	***CI***	**OR**	***CI***
Race/Ethnicity (ref=non-Hisp white)												
Non-Hisp Black	**1.8**	*[1.4,2.5]*	**1.5**	*[1.1,2.1]*	1.1	*[0.7,1.9]*	1.0	*[0.6,1.6]*	1.2	*[0.7,2.0]*	1.0	*[0.6,1.7]*
Hispanic	1.4	*[0.9,2.1]*	1.1	*[0.7,1.6]*	1.1	*[0.7,1.6]*	0.8	*[0.6,1.3]*	1.2	*[0.8,1.7]*	0.9	*[0.6,1.4]*
Non-Hisp Other	1.6	*[0.8,3.3]*	2.0	*[0.9,4.6]*	1.7	*[0.9,3.3]*	**1.9**	*[1.0,3.7]*	1.7	*[0.8,3.4]*	2.0	*[0.9,4.5]*
Education (ref=16+ years)												
<12 years	**1.7**	*[1.2,2.5]*	**1.7**	*[1.1,2.5]*	1.4	*[0.9,2]*	**1.4**	*[1.0, 2.0]*	**1.5**	*[1.0,2.1]*	**1.5**	*[1.0,2.2]*
12–15 years	**1.6**	*[1.2,2.1]*	**1.5**	*[1.1,2.1]*	1.2	*[0.9,1.6]*	1.2	*[0.9,1.6]*	**1.4**	*[1.0,1.8]*	**1.3**	*[1.0,1.8]*
Income (ref=$50,000+)												
< $10,000	1.3	*[0.9,2.1]*	1.5	*[0.9,2.4]*	1.2	*[0.8,1.8]*	1.3	*[0.8,2.0]*	1.3	*[0.8,2.0]*	1.4	*[0.9,2.2]*
$10,000–$29,999	0.9	*[0.6,1.3]*	0.9	*[0.6,1.3]*	0.9	*[0.6,1.2]*	0.9	*[0.6,1.2]*	0.9	*[0.6,1.3]*	0.8	*[0.6,1.2]*
$30,000–$49,999	0.9	*[0.6,1.3]*	0.9	*[0.6,1.4]*	0.8	*[0.6,1.2]*	0.9	*[0.6,1.3]*	0.9	*[0.6,1.2]*	0.9	*[0.6,1.3]*
Neighborhood Factors												
Disadvantage									1.0	*[0.9,1.2]*	1.0	*[0.9,1.2]*
Affluence/Gentrification									**0.7**	*[0.6,0.9]*	**0.7**	*[0.6,0.9]*
Hispanic/Immigrant/Non-Black									0.8	*[0.7,1.0]*	0.8	*[0.7,1.0]*
Older Age Composition									0.9	*[0.8,1.1]*	**0.9**	*[0.8,1.1]*

Note: Boldface indicates p<.05

[a]Neighborhood adjustment refers to centering all covariates around their neighborhood means.

[b]Includes controls for age, sex, and immigrant generation.

[c]Includes controls for age, sex, immigrant generation, marital status, number of children in the household, health insurance, regular source of medical care, exercise, walking, drinking, and smoking

Table 3

Odds Ratios (OR) and 95% Confidence Intervals (CI) for Weighted Logistic Regression and Hierarchical Generalized Linear Models of Hypertension Awareness: CCAHS 2002 (*n* =1,029)

	No adjustment for neighborhood				Neighborhood adjustment[a] + random effects				Neighborhood covariates + random effects			
	Model 1[b]		Model 2[c]		Model 3[b]		Model 4[c]		Model 5[b]		Model 6[c]	
Variable	**OR**	***CI***	**OR**	***CI***	**OR**	***CI***	**OR**	***CI***	**OR**	***CI***	**OR**	***CI***
Race/Ethnicity (ref=non-Hisp white)												
Non-Hisp Black	**1.8**	*[1.1,2.9]*	1.6	*[1.0,2.7]*	0.9	*[0.4,1.8]*	0.6	*[0.3,1.4]*	0.9	*[0.5,1.6]*	0.7	*[0.4,1.3]*
Hispanic	0.6	*[0.3,1.2]*	0.5	*[0.3,1.1]*	0.5	*[0.2,1.0]*	**0.4**	*[0.2,0.8]*	**0.5**	*[0.3,0.9]*	**0.4**	*[0.2,0.8]*
Non-Hisp Other	0.6	*[0.1,2.2]*	0.8	*[0.2,2.6]*	0.7	*[0.1,3.4]*	0.8	*[0.1,4.5]*	0.5	*[0.1,2.1]*	0.7	*[0.2,2.7]*
Education (ref=16+ years)												
<12 years	1.6	*[0.9,3.1]*	1.7	*[0.8,3.4]*	**2.3**	*[1.2,4.3]*	**2.5**	*[1.3,4.7]*	1.8	*[1.0,3.4]*	**2.1**	*[1.1,3.8]*
12–15 years	1.3	*[0.8,2.2]*	1.4	*[0.8,2.4]*	**1.8**	*[1.0,3.2]*	**1.8**	*[1,3.3]*	1.5	*[0.9,2.6]*	**1.7**	*[1.0,2.8]*
Income (ref=$50,000+)												
< $10,000	1.2	*[0.6,2.3]*	1.2	*[0.6,2.6]*	1.2	*[0.6,2.4]*	1.6	*[0.8,3.5]*	1.2	*[0.6,2.4]*	1.5	*[0.7,3.2]*
$10,000–$29,999	1.4	*[0.8,2.4]*	1.4	*[0.8,2.7]*	0.8	*[0.5,1.5]*	1.0	*[0.5,2.0]*	1.2	*[0.7,2.0]*	1.3	*[0.8,2.4]*
$30,000–$49,999	1.1	*[0.7,2.0]*	1.3	*[0.7,2.3]*	1.0	*[0.6,1.8]*	1.3	*[0.7,2.4]*	1.1	*[0.7,1.9]*	1.4	*[0.8,2.4]*
Neighborhood Factors												
Disadvantage									**1.3**	*[1.0,1.6]*	**1.4**	*[1.0,1.8]*
Affluence/Gentrification									1.1	*[0.9,1.4]*	1.2	*[0.9,1.4]*
Hispanic/Immigrant/Non-Black									**0.6**	*[0.5,0.8]*	**0.6**	*[0.4,0.8]*
Older Age Composition									0.8	*[0.7,1.0]*	0.8	*[0.6,1.0]*

Note: Boldface indicates p<.05

[a]Neighborhood adjustment refers to centering all covariates around their neighborhood means.

[b]Includes controls for age, sex, and immigrant generation.

[c]Includes controls for age, sex, immigrant generation, marital status, number of children in the household, health insurance, regular source of medical care, exercise, walking, drinking, and smoking

Table 4

Odds Ratios (OR) and 95% Confidence Intervals (CI) for Weighted Logistic Regression and Hierarchical Generalized Linear Models of Treatment for Hypertension: CCAHS 2002 (*n* =719)

	No adjustment for neighborhood				Neighborhood adjustment[a] + random effects				Neighborhood covariates + random effects			
	Model 1[b]		Model 2[c]		Model 3[b]		Model 4[c]		Model 5[b]		Model 6[c]	
Variable	**OR**	***CI***	**OR**	***CI***	**OR**	***CI***	**OR**	***CI***	**OR**	***CI***	**OR**	***CI***
Race/Ethnicity (ref=non-Hisp white and other)												
Non-Hisp Black	1.1	*[0.5,2.6]*	1.1	*[0.5,2.5]*	1.7	*[0.4,6.5]*	1.7	*[0.5,5.8]*	1.9	*[0.6,5.7]*	1.8	*[0.6,5.4]*
Hispanic	1.3	*[0.6,3.1]*	1.0	*[0.4,2.6]*	1.4	*[0.6,3.4]*	1.0	*[0.4,2.4]*	1.3	*[0.6,2.7]*	0.9	*[0.4,2.0]*
Education (ref=16+ years)												
<12 years	1.0	*[0.4,2.6]*	0.9	*[0.4,2.4]*	1.1	*[0.4,2.6]*	1.0	*[0.4,2.4]*	1.0	*[0.4,2.1]*	0.9	*[0.4,2.1]*
12–15 years	0.8	*[0.3,1.9]*	0.7	*[0.3,1.5]*	1.1	*[0.4,2.9]*	1.0	*[0.5,2.1]*	0.9	*[0.4,2.0]*	0.8	*[0.4,1.5]*
Income (ref=$50,000+)												
< $10,000	1.4	*[0.5,3.7]*	1.8	*[0.6,5.1]*	1.2	*[0.5,2.9]*	1.6	*[0.6,4.3]*	1.2	*[0.5,2.7]*	1.6	*[0.6,3.8]*
$10,000–$29,999	**2.7**	*[1.1,6.3]*	**3.5**	*[1.4,8.7]*	1.9	*[0.8,4.4]*	**2.9**	*[1.3, 6.6]*	**2.4**	*[1.2,4.9]*	**3.5**	*[1.8,7.1]*
$30,000–$49,999	1.2	*[0.5,2.6]*	1.3	*[0.6, 2.8]*	1.3	*[0.5,3.5]*	2.3	*[1.0,5.2]*	1.3	*[0.6,2.9]*	1.9	*[0.9,3.8]*
Neighborhood Factors												
Disadvantage									1.0	*[0.8,1.5]*	1.1	*[0.8,1.6]*
Affluence/Gentrification									1.0	*[0.7,1.5]*	1.2	*[0.8,1.8]*
Hispanic/Immigrant/Non-Black									1.3	*[0.9,1.9]*	1.3	*[0.9,1.9]*
Older Age Composition									1.0	*[0.7,1.3]*	1.0	*[0.8,1.3]*

Note: Boldface indicates p<.05

[a] Neighborhood adjustment refers to centering all covariates around their neighborhood means.

[b] Includes controls for age, sex, and immigrant generation.

[c] Includes controls for age, sex, immigrant generation, marital status, number of children in the household, health insurance, regular source of medical care, exercise, walking, drinking, and smoking

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Table 5

Odds Ratios (OR) and 95% Confidence Intervals (CI) for Weighted Logistic Regression and Hierarchical Generalized Linear Models of Hypertension Control: CCAHS 2002 (n=569)

	No adjustment for neighborhood				Neighborhood adjustment[a] + random effects				Neighborhood covariates + random effects			
	Model 1[b]		Model 2[c]		Model 3[b]		Model 4[c]		Model 5[b]		Model 6[c]	
Variable	**OR**	***CI***	**OR**	***CI***	**OR**	***CI***	**OR**	***CI***	**OR**	***CI***	**OR**	***CI***
Race/Ethnicity (ref=non-Hisp white)												
Non-Hisp Black	**0.5**	*[0.3,0.9]*	**0.4**	*[0.2,0.7]*	0.3	*[0.1,1.0]*	0.3	*[0.1,1.1]*	**0.5**	*[0.2,1.0]*	**0.4**	*[0.2,0.8]*
Hispanic	0.6	*[0.3,1.3]*	0.5	*[0.2,1.1]*	0.8	*[0.2,2.7]*	0.8	*[0.2,2.9]*	0.8	*[0.3,1.8]*	0.7	*[0.3,1.7]*
Non-Hisp Other	1.9	*[0.4,9.5]*	1.7	*[0.3,10.1]*	0.4	*[0.1,2.3]*	0.3	*[0.0,2.0]*	1.7	*[0.4,8.1]*	1.3	*[0.2,7.0]*
Education (ref=16+ years)												
<12 years	0.7	*[0.3,1.4]*	0.5	*[0.2,1.0]*	0.8	*[0.3,2.0]*	0.7	*[0.3,1.9]*	0.7	*[0.4,1.5]*	0.5	*[0.2,1.1]*
12–15 years	0.7	*[0.3,1.3]*	0.5	*[0.3,1.0]*	0.6	*[0.3,1.3]*	0.6	*[0.2,1.4]*	0.6	*[0.3,1.1]*	**0.5**	*[0.2,0.8]*
Income (ref=$50,000+)												
< $10,000	1.6	*[0.7,3.5]*	2.4	*[1.0,6.0]*	1.5	*[0.5,4.8]*	1.9	*[0.6,6.2]*	2.0	*[0.9,4.8]*	**3.1**	*[1.2,8.0]*
$10,000–$29,999	1.2	*[0.6,2.3]*	1.5	*[0.7,3.1]*	1.2	*[0.5,3.1]*	1.9	*[0.7,4.8]*	1.5	*[0.7,2.9]*	2.0	*[1.0,4.1]*
$30,000–$49,999	1.4	*[0.7,2.7]*	1.4	*[0.7,2.9]*	1.2	*[0.5,3.1]*	1.2	*[0.5,3.0]*	1.5	*[0.8,3.1]*	1.6	*[0.8,3.4]*
Neighborhood Factors												
Disadvantage									1.1	*[0.8,1.4]*	1.1	*[0.8,1.4]*
Affluence/Gentrification									1.2	*[0.9,1.6]*	1.2	*[0.9,1.6]*
Hispanic/Immigrant/Non-Black									0.9	*[0.6,1.3]*	0.8	*[0.6,1.2]*
Older Age Composition									**1.3**	*[1.0,1.6]*	1.3	*[1.0,1.6]*

Note: Boldface indicates p<.05

[a] Neighborhood adjustment refers to centering all covariates around their neighborhood means.

[b] Includes controls for age, sex, and immigrant generation.

[c] Includes controls for age, sex, immigrant generation, marital status, number of children in the household, health insurance, regular source of medical care, exercise, walking, drinking, and smoking