Exploring Pathways between Neighborhood Built Environment and Inflammation

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Abstract

The social and built environments have been associated with a variety of health outcomes. This study examines the role of the neighborhood built environment in racial disparities in blood levels of C-reactive protein (CRP), a biomarker associated with inflammation. CRP is associated with cardiovascular disease, atherosclerosis, insulin resistance, and has been suggested as a target for disease treatment. Data come from the Chicago Community Adult Health Study (CCAHS), conducted between 2001 and 2003, a probability sample of adults age 18 and over living in Chicago neighborhoods. Blood samples were collected from 629 respondents; CRP levels were valid for 610 persons . Little previous work has explored neighborhood variation in CRP, and no studies have explored the potential role of the built environment. However, CRP is known to be associated both with physical activity and with ambient air pollution, and thus may be related to the built environment through either or both mechanisms. Initial results show that non-Hispanic blacks have significantly higher CRP than non-Hispanic whites, but that BMI explains these differences. Neighborhood services provision appears to explain the relationship between neighborhood socioeconomic characteristics and CRP. Future work on this project will examine the potential contributions of walkability and pollution in the role of neighborhood services in explaining CRP.

Introduction

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In this paper we investigate how differences in the built environment of neighborhoods where individuals live may explain some of the observed differences in inflammatory response. Not only can the built environment been shown to relate to health behaviors such as diet (Morland et al. 2002) and physical activity (King et al. 2005; Frank et al. 2005), but recent research has also investigated access to health-related resources including food outlets, recreational facilities, alcohol outlets, and pharmacies, in terms of their contributions to health disparities. Research on the built environment has been slow due to difficulties in data collection and processing, but

Recent research has demonstrated race/ethnic, gender, and socioeconomic disparities in CRP. Peterson and colleagues (2008) also found an inverse relationship between community SES and CRP. Physical activity, BMI, mental health, and ambient air pollution have all been shown to predict CRP. However, the author is unaware of any work which attempts to elaborate a potentially causal mechanism between an individual's surroundings and inflammation. I propose three possible testable pathways for the built and social environments to influence CRP: (1) through neighborhood walkability's influence on BMI, (2) through the built environment's influence on depression and mental health (Mair et al. forthcoming), (3) through the built environment's relationship with ambient air pollution.

This study adds to the literature about racial/ethnic and socioeconomic disparities and spatial effects on health outcomes in several ways. I provide one of the only population-based analyses including individual- and neighborhood-level measures of CRP, and the sample covers a variety of different neighborhood types. Analysis of socioeconomic, race/ethnic, gender, and health behavioral predictors of CRP contribute to the growing body of knowledge on health disparities. Third, the data sampling design allows use of fixed effects and hierarchical models, which allow assessment of the relative magnitudes of individual vs. neighborhood social characteristics, while the hierarchical models help to identify within- and between-area components of disparities. Finally, the innovative nature of the multiple data sources (systematic social observation, GIS-based census, GIS-based physical data, survey-based community scales, and InfoUSA data) make it possible to model the characteristics of the respondents' neighborhoods in a variety of ways in order to support potential mechanisms for the built environment's contribution to CRP.

METHODS

Data

The Chicago Community Adult Health Study (CCAHS), a prospective multi-level study of the impact of individual and social environmental factors on health, their role in understanding socioeconomic and racial-ethnic disparities in health, and the biological and behavioral pathways that are involved. The CCAHS is a probability sample of 3105 adults age 18 and older in the city of Chicago, with a response rate of 71.8% and including physical measurements of height, weight, waist, hip length, and blood pressure. In addition, saliva and a blood sample have been collected for 681 people (about 60% of respondents - a subsample of 80 of the 342 neighborhood clusters (NCs) covering the entire city of Chicago, developed and characterized by the Project on Human Development in Chicago Neighborhoods (PHDCN) (http://phdcn.harvard.edu/), from which the CCAHS sample is drawn. CRP is valid for 610 individuals. Depression is measured by the CESD scale in accordance with other studies. In addition to utilizing existing and collecting new archival data on these areas, the CCAHS carried out Systematic Social Observations of all 1672 blocks containing sampled households for the study. Further, the locations of all businesses in the area are available from InfoUSA (Ailshire and Bader forthcoming). GIS maps containing roads, public transportation, libraries, waterways, etc. are available. The author has access to the respondents' geo-coded addresses. These, coupled with other GIS-based and areal data allow the creation of multiple distance , buffer, and areal measures which can describe the respondents' physical surroundings in great detail.

CRP is produced during the nonspecific acute-phase response to inflammation, infection, and tissue damage. C-reactive protein levels are strongly predictive of future coronary events. While there is no definitive clinical cutpoint, values over 3 mg/L are commonly considered risky in research on allostatic load. In the CCAHS, 42% of respondents had CRP levels over 3 mg/L. Other summary statistics are reported in Table 1. There is no significant seasonal variation in CRP, so there is no need to control for the season of blood draw.

For socioeconomic controls, I use the set of neighborhood-level variables developed by Morenoff et al. (2008) using factor analysis and 2000 Census NC-level measures. The first factor, which we interpret as socioeconomic deprivation, 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). The population density measure is also derived from the 2000 Census.

Further neighborhood variables come from a variety of sources. While conducting the individual level survey, the CCAHS also recorded the ecological conditions on the block surrounding each respondent's house. The systematic social observation (SSO) method uses trained raters to indicate and measure specific items in a sampled area such as a street or a block (Ailshire and Bader, forthcoming). The resulting "ecometric" measures of respondents' physical and social surroundings are independent of the respondents, thus allowing for statistical analysis of respondents' surroundings (Raudenbush and Sampson 1999; Sampson and Raudenbush 1999). CCAHS collected SSO data on the block immediately surrounding each respondent's home and then aggregated these data to the face, street, block, block group, tract, and neighborhood cluster levels. Variables include land use, commercial and non-commercial destinations, cleanliness, security, etc. are all measured with multiple questions.

A set of community scales are composed of respondents' answers to questions about their neighborhood's social and physical environment, aggregated to the community level using HLM to compose a scale considering a set of individual basic predictors. I use an empirical Bayesian estimate of neighborhood services constructed from two questions about neighborhood availability of parks and recreation opportunities and neighborhood litter and garbage collection.

Other measures are being created by combining the respondents' geocoded residences and other GIS measures from the 2000 Census and the Chicago City Government. Preliminary results suggest that open spaces may be related to CRP levels, so I will create a measure of distance to the nearest park and another of area of park land within a set of buffers from the respondent's home. Similar measures can be constructed relative to waterways and road density.

Analytic Plan

This analysis explores socioeconomic variation in CRP, coupled with features of the built environment which may influence CRP levels. I first apply conventional regression models (ordinary least squares for logged CRP) to estimate racial/ethnic and socioeconomic disparities in blood pressure/hypertension outcomes. As a baseline, I estimate one model with a limited set of individual covariates, including sex, age, race/ethnicity, immigrant generation, education, and income. A second model includes additional individual measures which the literature suggests may be related to socioeconomic disparities in CRP (BMI, physical activity, smoking, and drinking). These models are estimated with Stata software, version 10. Summary statistics on the individual-level covariates used in the models are presented in Table 1.

In the second stage of my analysis, I examine how adjusting for neighborhood context changes estimates of individual-level disparities in CRP by restricting comparisons of social groups to people who share the same residential neighborhoods. To model CRP, I center each dummy variable around its group mean in the HLM model, which is analogous to adding a fixed effect for each neighborhood (with one omitted as a reference category) in OLS models (Raudenbush and Bryk (2002:137). The hierarchical model is necessary because fixed-effect models become unstable with many strata (Breslow and Day, 1980: 249). I estimated this model using the HLM software package, version 6. I estimate these models with and without consideration of health behaviors.

Third, I introduce basic neighborhood-level socioeconomic variables into the hierarchical models. This allows me to compare individuals who live in similar types of neighborhoods (according to the structure of the neighborhood models) and also provides more power to investigate within-neighborhood disparities. Again I repeat the analyses for the restricted and expanded sets of individual-level covariates.

Finally, I expand my investigation of neighborhood effects to include further characteristics of the respondent's neighborhood, focusing on walkability, mental health, and pollution as possible competing theoretical mechanisms for neighborhood effects. Future models may take advantage of the multilevel structural equation modeling methods available in MPlus software to help elucidate the various pathways.

PRELIMINARY RESULTS AND FURTHER WORK

Preliminary results show that non-Hispanic blacks and Hispanics have significantly higher CRP than do non-Hispanic whites. Females have higher CRP than males, while first generation immigrants have lower levels. Controls for individual BMI largely explain the racial/ethnic and immigrant disparities. The first and fourth quartile of BMI are highly significantly different from the second quartile, the quartile closest to the medically recommended range. Vigorous physical exercise is protective, though non-drinkers have elevated levels compared to occasional drinkers. Car owners also experience higher CRP levels.

In models which consider the orthogonal neighborhood socioeconomic characteristics and population density, older age structure and population density predict CRP when BMI is not controlled. When BMI is considered, affluence significantly protects against inflammation.

The Neighborhood Services scale – which measures perception of recreational space availability and quality of street cleaning - is significantly related to inflammation and provides an important clue to what effects the neighborhood built environment may have. Likewise, neighborhood non-commercial destinations, street condition, parking lots, vacant lots, and vacant buildings also show associations with CRP (not shown). These preliminary results suggest walkability is quite likely to be predictive of CRP, while mental health and pollution have not been ruled out.

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