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Place matters: Neighborhood deprivation and cardiometabolic risk factors in the Diabetes Study of Northern California (DISTANCE)

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ABSTRACT

While neighborhood deprivation is associated with prevalence of chronic diseases, it is not well understood whether neighborhood deprivation is also associated with cardiometabolic risk factors among adults with chronic disease. Subjects ($n = 19{,}804$) from the Diabetes Study of Northern California (DISTANCE) cohort study, an ethnically-stratified, random sample of members of Kaiser Permanente Northern California (KPNC), an integrated managed care consortium, with type 2 diabetes who completed a survey between 2005 and 2007 and who lived in a 19 county study area were included in the analyses. We estimated the association between a validated neighborhood deprivation index (NDI) and four cardiometabolic risk factors: body mass index (BMI = kg/m^2), glycosylated hemoglobin (A1c), low density lipoproteins (LDL) and systolic blood pressure (SBP) using multi-level models. Outcomes were modeled in their continuous form and as binary indicators of poor control (severe obesity: BMI $\geq$35, poor glycemic control: A1c $\geq$9%, hypercholesterolemia: LDL $\geq$130 mg/dL, and hypertension: SBP $\geq$140 mmHg). BMI, A1c and SBP increased monotonically across quartiles of NDI ($p < 0.001$ in each case); however, LDL was significantly associated with NDI only when comparing the most to the least deprived quartile. NDI remained significantly associated with BMI and A1c after adjusting for individual level factors including income and education. A linear trend ($p < 0.001$) was observed in the relative risk ratios for dichotomous indicators of severe obesity, poor glycemic control, and 2 or more poorly controlled cardiometabolic risk factors across NDI quartile. In adjusted models, higher levels of neighborhood deprivation were positively associated with indicators of cardiometabolic risk among adults with diabetes, suggesting that neighborhood level deprivation may influence individual outcomes. However, longitudinal data are needed to test the causal direction of these relationships.

Introduction

Cardiovascular disease is a major contributor to disease progression among adults with diabetes (Kannel & McGee, 1979; Koskinen et al., 1992; Stevens, Kothari, Adler, Stratton, & United Kingdom Propsective Diabetes Study (UKPDS) Group, 2001), and one in which there are pronounced health disparities (Duru et al., 2006; Shah, Dolam, Gao, Kimball, & Urbina, 2011). In cross-sectional studies among adults in a number of countries, neighborhood deprivation has been consistently and positively associated with prevalence of cardiovascular disease (e.g., Cubbin et al., 2006; Diez-Roux et al., 2001; Mobley et al., 2006; Sundquist, Malmstrom, & Johansson, 2004; Sundquist, Winkleby, Ahlen, & Johansson, 2004) and obesity (e.g., Black, Macinko, Dixon, & Fryer, 2010; Dragano et al., 2007; Grafova, Freedman, Kumar, & Rogowski, 2008; Inagami, Cohen, Finch, & Asch, 2006; Matheson, Moineddin, & Glazier, 2008; Mujahid, Diez Roux, Borrell, & Nieto, 2005); it has also been associated with increased incidence of diabetes (Cox, Boyle, Davey, Feng, & Morris, 2007; Cox, Boyle,

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Davey, & Morris, 2007), and with insulin resistance among healthy, young adults in the US (Auchincloss, Diez Roux, Brown, O'Meara, & Raghunathan, 2007; Diez Roux, Jacobs, & Kiefe, 2002). A causal relationship between neighborhood deprivation and cardiovascular disease has not been well established, particularly among patients with diabetes (Leal & Chaix, 2011). In this study, we sought to better understand the extent to which neighborhood deprivation is independently associated with specific modifiable risk factors for cardiovascular disease progression among adults with diabetes in the US.

Neighborhood deprivation may produce negative health effects such as increased cardiovascular disease, obesity, and diabetes through several pathways (Cox, Boyle, Davey, Feng et al., 2007; Diez Roux & Mair, 2010). Briefly reviewed here, a paucity of resources in more deprived neighborhoods impede engagement in healthy behaviors (Macintyre, 2007), such as acquiring nutritious food and engaging in physical activity (Rundle et al., 2009). Furthermore, limited access to nutritious foods because of household food insecurity, the inability to access nutritious foods in socially acceptable ways because of a lack of money to purchase foods, is significantly associated with diabetes prevalence (Seligman, Bindman, Vittinghoff, Kanaya, & Kushel, 2007) as well as poor diabetes management evidence by higher risk of elevated glycosylated hemoglobin (Seligman, Laraia, & Kushel, 2010). Second, more deprived neighborhoods have higher crime rates and physical incivilities – physical manifestations of neighborhood degradation such as litter, unkempt property, disheveled public space – which may increase threat and induce a stress response (Sundquist et al., 2006). Stressful events, perceived as threat, are associated with non-homeostatic eating (eating for reasons other than caloric need), visceral fat accumulation and weight gain in animal and human research (Adam & Epel, 2007). Stress induced eating is associated with ingestion of highly palatable food – foods high in fat and refined sugars (Epel et al., 2004; Epel, Lapidus, McEwen, & Brownell, 2001). Third, one's residential neighborhood setting may provide cues that support social norms governing smoking, inactivity, and poor diet (Stimpson, Ju, Raji, & Eschbach, 2007) that in turn influence individuals' health behaviors. In more deprived neighborhoods, billboards and other cues may undermine healthy behaviors. Since human interactions with neighborhood environments are complex, it is likely that more than one of these pathways is involved in promoting or impeding health. Neighborhoods may affect both the risk of developing a chronic disease and affect the course of management. This is especially true for diseases whose management is strongly impacted by health behavior. Intervention programs and policies may be more effective if they target not only the individual but also the neighborhood environments that shape individual risk.

The prevalence of diabetes continues to increase in the US with current estimates of 7.8%–9.0% of the population affected (Centers for Disease Control and Prevention, 2008; Cowie et al., 2006). Although family history, race/ethnicity, and socioeconomic status (SES) are predictors of diabetes, behavioral factors including weight gain, poor dietary intake, and sedentary life style are important modifiable risk factors that also contribute to the development of diabetes. Each of these modifiable factors has been associated with neighborhood deprivation (e.g., Cubbin & Winkleby, 2007; Giskes, van Lenthe, Turrell, Brug, & Mackenbach, 2006; Stimpson, Ju et al., 2007; Stimpson, Nash, Ju, & Eschbach, 2007). Engaging in healthy behaviors is a key defense against disease progression for those diagnosed with diabetes. Diagnosed patients who live in a deprived neighborhood encounter the same resource constraints, stressors, and social norms that may have contributed to their risk for developing diabetes in the first place (Cox, Boyle, Davey, & Morris, 2007). Neighborhood deprivation may underlie disparities in diabetes prevalence and severity associated with social status and race/ethnicity. Lower SES individuals and ethnic minorities are more likely to live in deprived neighborhoods and are more exposed to environments that affect risk factors as described above. Identifying and modifying exposures that perpetuate diabetes-related disparities is a critical research and public health priority and understanding the role of neighborhood disparities should help in these efforts.

To understand the association between neighborhood deprivation and cardiometabolic risk factors, we studied a large, ethnically-diverse cohort of adults from all socioeconomic levels with diabetes included in The Diabetes Study of Northern California (DISTANCE). In these analyses, confounding of the association between neighborhood deprivation and cardiometabolic risk factors with being uninsured was minimized since all respondents were insured members of a non-profit, health delivery organization (Karter et al., 2002; Martin, Selby, & Zhang, 1995). We hypothesized that cardiometabolic risk factors were more likely to be poorly controlled in deprived neighborhoods. The aim of the present study was to estimate the associations between neighborhood deprivation and body mass index (BMI), glycosylated hemoglobin (A1c), low density lipoproteins (LDL) and systolic blood pressure (SBP), independent of individual level demographic and socioeconomic characteristics, among a sample of insured adults with diabetes.

Methods

Study setting

Kaiser Permanente Northern California (KPNC) is a non-profit, group practice, health plan that is one of the largest and oldest managed care organizations in the United States. KPNC currently provides comprehensive medical services to over 3.3 million health plan members through 17 hospitals and 32 outpatient clinics located in a 15-county region of Northern California. Approximately 30% of the general population in the region are members of KPNC. The sociodemographic characteristics of KPNC members are generally representative of the overall population, other than for income, where the very poor and very wealthy are enrolled but somewhat under-represented (Gordon, 2006; Karter et al., 2002).

Source population

KPNC maintains the Kaiser Permanente Northern California Diabetes Registry (Registry) that included 227,421 active members with diabetes (as of 1/1/2008). The Registry has been updated on an annual basis continuously since 1993 and has been the basis for extensive epidemiologic and health services research (Karter et al., 2002; Karter et al., 2005; Selby, Karter, Ackerson, Ferrara, & Liu, 2001). At the time of the study, registry eligibility was based on multiple data sources of case ascertainment, including pharmacy prescription records (diabetes medications dispensed), laboratory test results (A1c $\geq$ 7% and/or $\geq$2 elevated fasting glucoses), and outpatient, emergency room and hospitalization records listing a primary diagnosis of diabetes. Sensitivity is about 99% based on a survey-based gold standard of self-reported diabetes. Turnover is very low with an average registry membership period of about 9 years.

Study cohort

The DISTANCE survey was conducted between 2005 and 2007 in an ethnically-stratified random sample of KPNC members who were Diabetes Registry members ($n = 40{,}735$) with approximately