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Neighborhood Effects on Birthweight: An Exploration of Psychosocial and Behavioral Pathways in Baltimore, 1995–1996

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Abstract

Neighborhood characteristics have been proposed to influence birth outcomes through psychosocial and behavioral pathways, yet empirical evidence is lacking. Using data from an urban, low-income sample, this study examined the impact of the neighborhood environment on birthweight and evaluated mediation by psychosocial and behavioral factors. The sample included 726 women who delivered a live birth at Johns Hopkins Hospital in Baltimore, Maryland USA between 1995 and 1996. Census tract data were used to create a principal component index of neighborhood risk based on racial and economic stratification (% Black, % poverty), social disorder (violent crime rate), and physical deterioration (% boarded-up housing) (α=0.82). Information on sociodemographic, psychosocial, and behavioral factors was gathered from a postpartum interview and medical records. Random intercept multilevel models were used to estimate neighborhood effects and assess potential mediation. Controlling for sociodemographic characteristics, a standard deviation increase in neighborhood risk conferred a 76 gram birthweight decrement. This represents an approximate 300 gram difference between the best and worst neighborhoods. Although stress (daily hassles), perceived locus-of-control, and social support were related to birthweight, their adjustment reduced the neighborhood coefficient by only 12%. In contrast, the neighborhood effect was reduced by an additional 30% and was no longer statistically significant after adjustment for the behavioral factors of smoking, drug use, and delayed prenatal care. These findings suggest that neighborhood factors may influence birthweight by shaping maternal behavioral risks. Thus, neighborhood level interventions should be considered to address multiple maternal and infant health risks. Future studies should examine more direct measures of neighborhood stress, such as perceived neighborhood disorder, and evaluate alternative mechanisms by which neighborhood factors influence behavior (e.g., social norms and access to goods and services).

Keywords

birthweight; neighborhood; disadvantage; USA; behavioural pathways

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Introduction

Fueled by the appealing efficiency of population-based prevention, there is a growing body of literature linking the residential environment in which women live to birth outcomes, particularly contextual indicators of socioeconomic disadvantage and residential segregation (Culhane & Elo, 2005). Neighborhood effects on birthweight, low and very low birthweight, and their subcomponents of preterm birth and growth restriction, have been observed independent of various individual level characteristics. The notion of “independent” effects, however, may be fallacious as neighborhood influences on individual health must ultimately operate through some mechanism on the individual. A frequent exhortation of contextual critiques is to move beyond “black box” epidemiology toward the examination of theory-based exposures and pathways through which neighborhoods influence health (Diez Roux, 2001; Galea & Ahern, 2006; Kawachi & Subramanian, 2007; O’Campo, 2003; Sampson, Morenoff, & Gannon-Rowley, 2002).

While many researchers have proposed psychosocial and behavioral pathways for neighborhood effects on birth outcomes (Buka, Brennan, Rich-Edwards, Raudenbush, & Earls, 2003; Culhane & Elo, 2005; Dibben, Sigala, & Macfarlane, 2006; Farley, Mason, Rice, Habel, Scribner, & Cohen, 2006; Grady, 2006; Messer, Kaufman, Dole, Savitz, & Laraia, 2006b; Morenoff, 2003; Pearl, Braveman, & Abrams, 2001; Pickett, Ahern, Selvin, & Abrams, 2002; Rauh, Andrews, & Garfinkel, 2001; Roberts, 1997), empirical exploration with individual-level psychosocial or behavioral measures is lacking (Ahern, Pickett, Selvin, & Abrams, 2003; Reagan & Salsberry, 2005). Observed independent effects may be due to confounding by omitted sociodemographic variables that influence the selection of neighborhoods or true effects whose mediators have not been identified or properly evaluated. Largely due to the data constraints of vital records, few multilevel studies of birth outcomes have controlled for the individual level characteristics that parallel aggregated census variables (Rajaratnam, Burke, & O’Campo, 2006), making it difficult to distinguish contextual versus compositional effects. Moreover, no studies have evaluated psychosocial pathways via stress or self-efficacy, and most have controlled for the behavioral factors that may mediate rather than confound the effects of neighborhood context. Likewise, the bulk of perinatal research conducted at the individual level identifies psychosocial, behavioral, and biological risk factors divorced from the contextual/environmental factors that may shape and sustain them.

Using a biopsychosocial framework, the present study integrates individual and contextual approaches by exploring potential individual level pathways through which neighborhood disadvantage may influence birthweight. Specifically, psychosocial, behavioral, and biological mediation is evaluated, while controlling for individual level sociodemographic characteristics that may confound neighborhood effects. The elucidation of neighborhood pathways may promote causal theory and holds promise to inform strategies for intervention at multiple levels.

Background

The neighborhood variables most frequently linked to birth outcomes are census-based indicators of socioeconomic deprivation and racial composition or segregation that proxy structural attributes (Rajaratnam et al., 2006). Socioeconomic indicators, including income, education, employment, occupation, and housing, measured at the level of census block group, tract, or tract clusters have been associated with birthweight (Buka et al., 2003; Morenoff, 2003; Pearl et al., 2001; Subramanian, Chen, Rehkopf, Waterman, & Krieger, 2006), low birthweight (Johnson, Drisko, Gallagher, & Barela, 1999; O’Campo, Xue, Wang, & Caughy, 1997; Rauh et al., 2001; Rich-Edwards, Buka, Brennan, & Earls, 2003; Roberts, 1997), PTB (Ahern et al., 2003; Kaufman, Dole, Savitz, & Herring, 2003; O'Campo, Burke, Culhane, Elo, Eyster, Holzman et al., 2008; Reagan & Salsberry, 2005), gestational age, and fetal growth (Farley et al., 2006). Studies in Europe and Canada have shown similar associations among equivalent administrative units (Dibben et al., 2006; Jarvelin, Elliott, Kleinschmidt, Martuzzi, Grundy, Hartikainen et al., 1997; Luo, Wilkins, & Kramer, 2006; Sloggett & Joshi, 1998). These studies frequently control for a single individual level socioeconomic indicator, generally education, although a few studies have demonstrated effects independent of individual level income (Kaufman et al., 2003; Pearl et al., 2001; Reagan & Salsberry, 2005). Racial density or segregation is also commonly associated with various birth outcomes. Black-white segregation indices and the % Black are often related to adverse outcomes including LBW and infant mortality at the census tract (Grady, 2006; Morenoff, 2003) and MSA levels (Bell, Zimmerman, Almgren, Mayer, & Huebner, 2006; Polednak, 1996), although some positive effects have been noted (Pickett, Collins, Masi, & Wilkinson, 2005; Roberts, 1997).

The actual features and processes that characterize racially and socioeconomically stratified neighborhoods and that may influence an array of health endpoints, including birth outcomes, have been largely conceptualized along dimensions of the physical, social, and service environments that impact social norms, processes, and access to resources (Culhane & Elo, 2005; Robert, 1999). Relatively few studies of birth outcomes have examined these neighborhood attributes that are not purely aggregated individual-level census variables (Rajaratnam et al., 2006).

Aspects of the physical and social environment that have been related to various birth outcomes include the stressors of vacant or boarded up housing (Farley et al., 2006; Reagan & Salsberry, 2005) and violent crime (Collins & David, 1997; Masi, Hawkley, Piotrowski, & Pickett, 2007; Messer, Kaufman, Dole, Herring, & Laraia, 2006a; Messer et al., 2006b; Morenoff, 2003), air pollution (Ponce, Hoggatt, Wilhelm, & Ritz, 2005), and the positive dimension of neighborhood social cohesion (Buka et al., 2003; Morenoff, 2003).

The service environment encompasses the quantity and quality of available goods and services that influence health and behavior, including medical care and dietary intake for example. Several studies have reported no association between area availability of prenatal or primary care and birth outcomes (Gorman, 1999; Heck, Schoendorf, & Chavez, 2002), although others have found positive influences of primary care at larger levels of aggregation (Shi, Macinko, Starfield, Xu, Regan, Politzer et al., 2004; Thompson, Goodman, Chang, & Stukel, 2005). A more recent study also found no association between various census-tract outlet densities (tobacco and alcohol outlets, supermarkets, or fast food restaurants) and fetal growth or gestational age (Farley et al., 2006). It is possible that health behaviors may be influenced irrespective of the availability of services via social norms or psychosocial factors, and/or that the meaningful area unit for services was not measured.

Proposed Pathways—The proposed individual level pathways through which neighborhood context may influence birth outcomes include psychosocial, behavioral, and biological factors. A conceptual model, found in figure 1, depicts the potential direct and indirect neighborhood pathways that may influence the proximate biological production of adverse birth outcomes. There is both theoretical and empirical evidence linking neighborhood context to a variety of psychosocial, behavioral, and biological predictors of perinatal health (Culhane & Elo, 2005; Laraia, Messer, Kaufman, Dole, Caughy, O'Campo et al., 2006; Mullings & Wali, 2001).

Psychosocial Factors—Residents of disadvantaged neighborhoods are exposed to more stressful life events, daily hassles, and chronic stressors (Boardman, 2004; Steptoe &

Feldman, 2001), including ambient hazards or social/physical disorder (e.g. graffiti, noise, crime, abandoned houses) (Aneshensel & Sucoff, 1996; Geis & Ross, 1998), and have greater risk of depressive symptoms (Aneshensel & Sucoff, 1996; Cutrona, Russell, Brown, Clark, Hessling, & Gardner, 2005; Latkin, Williams, Wang, & Curry, 2005; Ross, 2000). In addition to promoting stress, living in a disadvantaged neighborhood may also diminish social and psychological assets, such as social support, self-efficacy, and internal locus-of-control. Perceptions of crime and disorder have been related to social isolation and feelings of powerlessness (Geis & Ross, 1998).

At the individual level, psychosocial factors may have direct biological effects on birth outcomes via neuroendocrine, immune, and vascular mechanisms that influence the timing of delivery directly and secondarily through susceptibility to infection and hypertensive disorders (Wadhwa, Culhane, Rauh, & Barve, 2001). Both stress and social support have been connected to neuroendocrine parameters that regulate parturition and uteroplacental transfer (Wadhwa, Dunkel-Schetter, Chicz-DeMet, Porto, & Sandman, 1996). Stress, in particular, is most consistently related to LBW and preterm delivery, with between 1.5 to 2-fold increased risks observed in both prospective and retrospective studies (Dole, Savitz, Hertz-Picciotto, Siega-Riz, McMahon, & Buekens, 2003; Paarlberg, Vingerhoets, Passchier, Dekker, & Van Geijn, 1995). Chronic stress, as opposed to acute stress, is considered to be most detrimental given its cumulative toll on multiple physiologic systems, known as allostatic load (McEwen, 2001). In a study of pregnant women, an indicator of neighborhood stress (homeless rate) was found to predict rates of bacterial vaginosis—a marker for infection that has been related to preterm birth, independent of sociodemographic characteristics, sexual behavior, and perceived stress (Culhane, Rauh, McCollum, Elo, & Hogan, 2002).

Health Behaviors—Indicators of neighborhood disadvantage have also been related to several health behaviors linked to adverse birth outcomes, including substance use (Finch, Vega, & Kolody, 2001), delayed entry to prenatal care (Perloff & Jaffee, 1999), and poor dietary intake and/or physical activity (Diez Roux, 2003). The stress, hopelessness, and fatalism that can result from stratification and residence in disadvantaged neighborhoods may foster the adoption and/or maintenance of adverse health behaviors as self-medicating coping mechanisms (Lin & Ensel, 1989). Psychological distress has been found to partially mediate the influence of neighborhood disorder and disadvantage on both drug use and frequency of drug use (Boardman, Finch, Ellison, Williams, & Jackson, 2001; Latkin et al., 2005). Residence in disadvantaged neighborhoods may also constrain choices and opportunities. For example, prenatal care may be a less prominent priority in daily conditions of neighborhood stress and disadvantage. There is also some evidence that fear of crime and lack of perceived neighborhood safety may reduce physical activity (CDC, 2005; Harrison, Gemmell, & Heller, 2007).

In addition to psychosocial pathways, neighborhood effects on health behaviors may be explained by shared norms or access to resources. The proportion of area residents who smoke, for example, is strongly associated with the average quantity smoked, independently of their individual socioeconomic status, which tends to support the role of normative transmission (Duncan, Jones, & Moon, 1996). Varying availability of goods and services may also influence behavior (i.e. parks and recreation facilities, prenatal clinics, drugs fast-food outlets). For example, there are fewer supermarkets in disadvantaged areas and the presence of more neighborhood supermarkets is associated with greater consumption of fruits and vegetables, independent of individual income and education (Morland, Wing, & Diez Roux, 2002; Morland, Wing, Diez Roux, & Poole, 2002).

Study Purpose and Objectives

The purpose of this study was to evaluate the effect of neighborhood environment on birth outcomes and to explore proposed pathways suggested in the literature. Accordingly the objectives were 1) to determine the impact of neighborhood context independent of individual sociodemographic confounders and 2) to assess mediation via psychosocial, behavioral, and biological factors. In addition to the examination of pathways, this study is unusual in analyzing a low-income sample with added control for individual material hardship. This socioeconomic restriction introduces an alternative control for individual SES that may help to distinguish individual versus contextual effects.

Methods

Study Design and Sample

The sample for this analysis comes from a hospital-based study designed to examine the patterns of and barriers to prenatal care in a low-income, urban setting. Recruitment occurred in the postpartum unit and eligibility was restricted to women who had received prenatal care at the Johns Hopkins Hospital or a satellite clinic and those who had not received care at all. All women with evidence of drug use (medical record, self-report, or toxicological screen) or no prenatal care, and two out of three remaining women were selected to participate. Informed consent was obtained prior to participation and women were compensated with $15 for their time in completing the 1 hour postpartum interview. Highly trained survey staff helped to achieve a 93% participation rate among eligible women.

The study sample included 824 women, aged 19 or older, who delivered a live or still birth weighing at least 500 grams between February 1995 and June 1996. The 808 women who delivered singleton, live births were selected for analysis. An additional 10% of the sample who lived outside the city (n=34) and those whose addresses were unable to be geocoded (n=48) were excluded from analysis, resulting in a final analytic sample of 726 women (88% of the total sample). Women who were excluded from the analysis were more likely to be white, married, and to have had at least a high school education.

Data were primarily collected from the postpartum interview, which gathered information on social and psychosocial characteristics using standardized instruments, as well as behavioral factors, including a detailed drug use history. Medical records also were abstracted to determine infant birth characteristics, prenatal care utilization, drug use (from toxicology screens or report by a healthcare provider), and the presence of medical risk factors.

Birth Outcomes

Birthweight was selected as the primary dependent variable, modeled as a continuous rather than binary outcome (LBW, <2500 grams), to preserve statistical power and precision. Continuous birthweight may also be more sensitive in capturing potentially subtle effects of the neighborhood environment on fetal growth or the timing of delivery. Reductions in birthweight and its proximate determinants, fetal growth restriction and preterm birth, are linked to morbidity and mortality in childhood (Arias, MacDorman, Strobino, & Guyer, 2003; McCormick, 1985), cognitive delays (Breslau, Paneth, & Lucia, 2004; Kirkegaard, Obel, Hedegaard, & Henriksen, 2006), and adult-onset diseases (Barker, Eriksson, Forsen, & Osmond, 2002). Fetal growth restriction and preterm birth were not examined directly out of concern for the validity of gestational age estimation in a sample overrepresented for drug use and lack of prenatal care (16.5% had no prenatal visits).

Neighborhood Variables

Consistent with other work (Farley et al., 2006; Grady, 2006; Kaufman et al., 2003; O'Campo et al., 1997; Pickett et al., 2002; Reagan & Salsberry, 2005), census tracts were used to define neighborhoods and capture the immediate local environment. Census tracts contain an average of 4,000 residents and were created as relatively small geographic statistical units with homogeneous sociodemographic composition (U.S. Census Bureau, 2000). Contextual sociodemographic and housing data were obtained from the 1990 U.S. Census. We used data from the 1990 rather than 2000 U.S. Census to preserve temporality between predictors and outcomes. Contemporaneous tract level crime statistics from 1995 were available from the Baltimore City Police Department. Because of the collinearity of neighborhood variables, a single index was created through principal component analysis that captured theoretically meaningful and distinct constructs of neighborhood structural indicators and processes. The structural-process risk (SPR) index includes two structural indicators of racial and economic stratification (% Black, % poverty) and two process indicators of social disorder (violent crime rate per 1,000) and physical deterioration (% boarded-up housing). The Cronbach α coefficient for the index was 0.82, indicating appropriate reliability. Table 1 shows the descriptive statistics and principal component score loadings for the four neighborhood variables. There were 126 census tracts represented among the sample with an average of 5.8 subjects per tract and a range of 1 to 40. One extreme outlier for violent crime with significant leverage was recoded to the average crime rate given the poverty level of the tract. The index was standardized with a mean of zero and a standard deviation of 1 with values ranging from −1.95 to 1.97. Table 2 describes the distribution of the four neighborhood variables according to tertile of neighborhood risk.

Individual Level Variables

Sociodemographic Factors—A range of sociodemographic factors were examined to control for compositional influences that may govern the selection of neighborhoods. These included maternal age, race, relationship with the father of the baby, employment during pregnancy, education, money for necessities, public assistance (welfare, Supplemental Security Income, or Medicaid), and home ownership. Money for necessities (e.g. food, housing, heating) was measured by a 7-item subscale of the Family Resources Scale (sample Cronbach α = 0.87) (Dunst & Leet, 1987).

Psychosocial Factors—Three psychosocial variables related to birth outcomes and plausibly influenced by the neighborhood environment were examined: stress, locus-of-control, and social support. *Stress* was measured with a validated 12-item Hassles Scale (Curry, Campbell, & Christian, 1994), that assesses chronic stress during pregnancy due to daily difficulties and circumstances (e.g. money worries, general overload, stress due to crime in the neighborhood) (sample Cronbach α = 0.80). *Locus-of-control* specific to pregnancy was measured by 5 related items in the Pregnancy Belief Scale (Tinsley & Holtgrave, 1989) and refers to self-efficacy and the extent to which a woman believes that her pregnancy outcome is under internal control versus chance or fate (sample Cronbach α = 0.72). A measure of *social support* was defined as having two or more social network members to discuss problems with either sometimes or often. This measure captures emotional support, the dimension most often related to birth outcomes (Hoffman & Hatch, 1996).

Behavioral Factors—Health behaviors included substance use and prenatal care utilization. Self-reported *smoking* and *alcohol consumption* during pregnancy were ordinally categorized by the average number of cigarettes smoked per day (0, 1–9, or 10+) and the frequency of drinking (never, monthly, or weekly). *Hard drug use* of cocaine or opiates was determined by self-report, documentation in the medical record, or a urine screen at delivery. To capture both the initiation and basic continuation of prenatal care in this high risk sample, *late or no prenatal care* was defined as a first visit after the first trimester or three or fewer total visits throughout pregnancy.

Biomedical Factors—Several biomedical factors were examined that may be responsive to neighborhood stressors and resources. An indicator variable of *hypertensive disorders*, including chronic hypertension, pregnancy-induced hypertension, preeclampsia, or eclampsia, captured cardiovascular risk. Another indicator of *infection* included gonorrhea, syphilis, Hepatitis, HIV/AIDS, chorioamnionitis, and pyelonephritis. The medical record was used to determine the presence of these biological risk factors. Nutritional status was measured by *prepregnancy weight* and *net weight gain* during pregnancy (subtracting infant birthweight). These variables were constructed from a combination of information obtained in the medical record and postpartum interview.

Statistical Analyses

The objectives of the analysis were to 1) determine the influence of neighborhood risk on birthweight independent of individual sociodemographic confounders, and 2) to evaluate the psychosocial, behavioral, and biomedical pathways through which neighborhood risk may impact birthweight. First, individual level characteristics were examined according to neighborhood risk tertiles to determine preliminary associations requisite for confounding and mediation. Statistical significance was evaluated with chi-square tests for categorical variables and ANOVA for continuous variables. Scalar variables (money for necessities, stress, locus-of-control) were summed and categorized according to the average item response to preserve the meaning of the original categories.

To evaluate mediation, we followed the steps recommended by Baron and Kenney (Baron & Kenny, 1986). We conducted a series of multilevel regression models to determine the significance of relations between neighborhood risk and the proposed mediators as well as the outcome of birthweight, adjusted for sociodemographic covariates. We then constructed multilevel birthweight models with hypothesized psychosocial, behavioral, and biomedical mediators sequentially added to examine pathways by the diminution of the neighborhood effect. To account for the clustering of observations according to neighborhood, random intercept multilevel regression models were performed using SAS Proc GLIMMIX with a logit link for binomial/categorical mediators and an identity link for continuous birthweight. Variance components are not presented because of estimation difficulties with 38% of all tracts having only 1 observation (Snijders & Bosker, 1999). Based on empirical fit (exploratory observation of a linear association in non-parametric lowess graphs), the risk index was modeled continuously to maximize power and avoid arbitrary percentile cutoffs. Sociodemographic factors and residential mobility during pregnancy were controlled for in all models.

Results

Consistent with the population of low-income, inner city Baltimore, sample women were predominantly Black, receiving public assistance, and had less than a high school education. The rate of low birthweight was 17% and the estimate of preterm birth was approximately 20%, combining information from the date of last menstrual period as well as obstetric and pediatric examinations (not shown). While oversampling for drug use and lack of prenatal care likely exaggerated the disadvantaged nature of the sample, there was sufficient variability in residential context to examine neighborhood influences (Tables 1 and 2).

Table 3 details the sample distribution of sociodemographic, psychosocial, behavioral, and biomedical factors and shows their bivariate associations with neighborhood risk tertiles.

The sociodemographic characteristics of race, cohabitation, education, money for necessities, public assistance, and home ownership were associated with neighborhood risk. Women who were less educated and with fewer economic resources were more likely to live in disadvantaged neighborhoods. Importantly, however, there was considerable variability between individual sociodemographic characteristics and neighborhood risk to permit the examination of independent effects.

Among the proposed mediators, neighborhood risk was associated with stress, perceived locus-of-control, emotional support, substance use, prenatal care, infection, and net pregnancy weight gain. Women who lived in more disadvantaged (riskier) neighborhoods had greater stress levels, reported less internal locus-of-control and emotional support, and were more likely to smoke, drink alcohol, use hard drugs, and to have late or no prenatal care, an infection or inadequate weight gain during pregnancy. The strongest associations with neighborhood risk were observed for smoking, hard drug use, and net weight gain.

Neighborhood Effects on Proposed Psychosocial and Behavioral Mediators (Table 4)

After controlling for sociodemographic characteristics in multilevel models, neighborhood risk was significantly associated with behavioral factors only. In particular, neighborhood risk was significantly related to smoking (1SD, OR: 1.27, p=0.02) and hard drug use (1SD, OR: 1.41, p<0.01), and marginally related to heavy alcohol consumption (1SD, OR: 1.59, p=0.05) and late or no prenatal care (1SD, OR: 1.19, p=0.07).

Neighborhood Effects on Birthweight (Table 5)

In multilevel models controlling for individual level sociodemographic confounders, neighborhood risk was associated with birthweight. A 1 SD increase in neighborhood risk was associated with a 76g decrement in birthweight (95% CI: −137, −16; p=0.01). This corresponds to an approximate 300g difference between the best and worst neighborhoods (4SD*76g=304g), the magnitude of which was similar to material hardship at the individual level.

Mediation

Adjustment for the proposed psychosocial mediators of stress, perceived locus-of-control, and emotional support, modestly reduced the effect of neighborhood risk (12% reduction). Stress and perceived locus-of-control were strongly related to birthweight and appeared to explain more of the individual level effects of sociodemographic characteristics, including maternal age, education, and money for necessities.

After controlling for potential behavioral mediators of substance use and prenatal care, the neighborhood risk coefficient was reduced by an additional 30% and was no longer statistically significant. Smoking in particular was strongly related to birthweight and alone accounted for two-thirds of the reduction. These behavioral factors appeared to mediate between 20–40% of the effects of psychosocial factors and further reduced effects related to maternal age, education, and money for necessities.

Additional model entry of biomedical factors reduced the neighborhood risk coefficient by another 10%. Controlling for biomedical factors further attenuated the individual level effects of sociodemographic variables and behavioral factors, but not the psychosocial factors of stress and perceived locus-of-control, which remained significant.

Discussion

The results of this study provide further evidence that neighborhood structures and processes may influence birth outcomes independent of sociodemographic composition. In this low-income sample with added control for education, adequacy of resources for necessities, public assistance, and home-ownership, women residing in the most disadvantaged neighborhoods delivered infants approximately 300 grams lighter on average than women who lived in the least disadvantaged neighborhoods. The magnitude of this contextual effect was similar to that of individual level risk factors, and may have a large population impact given the sheer number of people living in risky neighborhoods in inner-city Baltimore and other similar urban areas. The linear nature of the observed association is consistent with other studies, suggesting a gradient rather than threshold effect of neighborhood risk. And while it is appropriate to control for the sociodemographic characteristics that influence the selection of neighborhoods, the contextual effect noted may be conservatively estimated since individual/adult socioeconomic status can also be determined by neighborhood resources and opportunity structures.

Our multilevel neighborhood study of birth outcomes is distinct in incorporating individual level psychosocial factors and quantifying the extent of mediation by these and other behavioral and biomedical factors. Results revealed that stress, perceived locus-of-control, and emotional network support were not independently associated with neighborhood risk. Instead, direct effects on health behaviors, particularly smoking and hard drug use, accounted for the largest fraction (~1/3) of the neighborhood risk effect. Further control for biomedical factors explained an additional 10% of the neighborhood effect.

The relative lack of psychosocial mediation may be explained by inadequate or imprecisely measured constructs or a true lack of association between neighborhoods and psychosocial attributes. The measure of stress used in the study was a validated instrument assessing daily hassles that should theoretically be related to neighborhood context. However, the scale more clearly mediated individual level socioeconomic status and only one item specifically captured a neighborhood level feature (stress because of crime in the neighborhood). More specific examination of the violent crime – stress theory revealed a significant correlation between violent crime and the single item reflecting stress because of crime in the neighborhood. However, stress due to neighborhood crime did not mediate the relation between violent crime and birthweight as this single item was unrelated to birthweight after controlling for sociodemographic factors. A study examining psychosocial stressors in North Carolina similarly found no association between perceived neighborhood safety and PTB (Dole et al., 2003). Another multilevel study in California also did not find that perceived neighborhood safety explained the effect of neighborhood economic indicators on birthweight (Pearl et al., 2001).

Future studies should assess more specific measures of perceived neighborhood problems and stressors that may lend credibility to objective measures of social and physical disorder and mediate indicators of disadvantage (for examples see Steptoe & Feldman, 2001). A growing body of literature has linked perceptions of neighborhood disorder (e.g. litter, loitering, graffiti, vacant properties, civil incivilities) to mental health (Aneshensel & Sucoff, 1996; Latkin & Curry, 2003; Ross, 2000), substance use (Hill & Angel, 2005; Wilson, Syme, Boyce, Battistich, & Selvin, 2005), and general health status (Hill, Ross, & Angel, 2005; Ross & Mirowsky, 2001; Wen, Hawkley, & Cacioppo, 2006). Systematic social observation may be preferred over individual subjective ratings to prevent the same-source bias that can induce a correlation irrespective of the actual quality of the neighborhood (Laraia et al., 2006). A recent study, however, did not find that systematically observed signs of physical disorder (graffiti, beer cans, cigarette butts, broken glass, abandoned cars) were related to LBW (Wei, Hipwell, Pardini, Beyers, & Loeber, 2005).

It is also possible that instead of having direct psychosocial effects, neighborhood risk may exacerbate personal vulnerabilites. For example, in a sample of African-American women, Cutrona et al found that neighborhood disadvantage/disorder magnified the effect of negative life events on incident depression (Cutrona et al., 2005). Another study also found that the positive dimension of neighborhood stability buffered the impact of stress on self-reported physical health (Boardman, 2004). In the present study, however, interactions between the neighborhood risk index and individual level variables were tested and while none were found to be significant, the sample may not have been adequately powered to examine cross-level interactions.

Health behaviors, primarily smoking and illicit drug use, by far accounted for the largest portion of the neighborhood effect on birthweight. This is consistent with many studies linking both objective and perceived indicators of neighborhood disadvantage and disorder to smoking (Duncan et al., 1996; Duncan, Jones, & Moon, 1999; Miles, 2006) and drug use (Boardman et al., 2001; Latkin et al., 2005), including use during pregnancy (Finch et al., 2001). Aside from psychosocial pathways, which were not observed in this study, neighborhoods may influence substance use through substance availability (Chuang, Cubbin, Ahn, & Winkleby, 2005; Crum, Lillie-Blanton, & Anthony, 1996), social contagion and norms and/or the absence of social control against adverse health behaviors (Duncan et al., 1996; Miles, 2006), and potentially through access to treatment. Further research is needed to determine the relative role of these factors and in what phase of use (i.e. initiation, progression, cessation) to determine strategies for intervention (Galea, Nandi, & Vlahov, 2004).

Direct mediation through biomedical risk factors was not hypothesized given the control for psychosocial and behavioral determinants. The modest reduction in the neighborhood effect observed when controlling for biomedical factors may be explained by residual mediation via imprecisely measured or omitted variables. For example, diet and exercise—the behavioral determinants of weight and weight gain—were not measured and could not be controlled.

A distinct limitation of this study was the inability to disentangle the effects of specific neighborhood structures and processes given their considerable collinearity. Selecting one of the theoretically and statistically related indicators versus creating a composite index has been described as the choice between dishonest specificity and honest ambiguity (Bingenheimer & Raudenbush, 2004). The latter “honest” approach of creating an index was preferred to account for a greater share of the total variation. Moreover, it is likely that multiple neighborhood features act in synergy rather than independently to influence health outcomes. When the neighborhood variables were alternatively entered singly in separate models, the % Black and violent crime rate were stronger predictors than the % poverty and vacant housing rate, and consistent with the overall index, behavioral factors accounted for the largest coefficient reduction for all four variables.

An additional limitation was the inability to distinguish effects on fetal growth restriction versus gestational age. Nonetheless, both outcomes are adverse and they carry some common risk factors and pathways (i.e. neuroendocrine and vascular mechanisms influence both uteroplacental transfer and the timing of parturition). Neighborhood effects have been noted for both outcomes but few studies have examined them simultaneously (Farley et al., 2006; Masi et al., 2007), representing an opportunity for future research.

Because sample women were predominantly Black and low-income, these results may not extend to more advantaged, non-Black populations. In particular, neighborhood effects may be smaller for White, non low-income women as some studies of birth outcomes have noted stronger effects of neighborhood disadvantage for Black than White women (Buka et al., 2003; Pearl et al., 2001; Reagan & Salsberry, 2005). Studies of other health outcomes have also shown that the effect of neighborhood disadvantage is more consequential for low-income individuals (Boardman et al., 2001; Wight, Aneshensel, Miller-Martinez, Botticello, Cummings, Karlamangla et al., 2006), who may have fewer buffering resources and mobility options. And while we observed that the % Black was associated with birthweight decrements in this largely Black sample, there may be certain groups and conditions in which ethnic concentration is protective (Bell et al., 2006; Masi et al., 2007; Pickett et al., 2005). It is also worth noting that the data are over a decade old; however, neither neighborhood poverty (author calculations from Census data) nor LBW (March of Dimes, 2008) changed appreciably in Baltimore and the relationship between the two is not likely to have changed either.

The cross sectional nature of the study represents the chief limitation constraining causal inference. Observed neighborhood effects may be the result of endogeneity and unidentified factors that influence the sorting of people into neighborhoods (Oakes, 2004). However, sociodemographic characteristics and residential mobility during pregnancy were controlled for in all models. It was assumed that women likely move into and out of similar neighborhoods and neighborhood effects were not appreciably different according to mobility, lending support to this hypothesis. Nevertheless, the presence of drug use in neighborhoods may have led to or hastened deterioration of the physical and social environment as a result of out-migration. Longitudinal, experimental, or intervention studies are necessary to rule out possible selection biases. Planned community-based interventions would not only improve inference but also hold potential to positively impact the lives and health of residents.

Conclusions

Overall findings in this urban, low-income sample suggest that neighborhood structures and processes may have an impact on infant birthweight, an outcome with potential consequence throughout the lifecourse, by shaping maternal behavioral risks. As interventions to alter neighborhood quality could impact multiple health endpoints for thousands of individuals at a time, continued research to quantify and qualify neighborhood influences may yield substantial health gains. Although daily hassles, internality, and network support were not prominent pathways through which neighborhoods affected birthweight, future research might evaluate the role of perceived neighborhood disorder and better delineate the mechanisms by which neighborhoods produce adverse health behaviors. Longitudinal designs assessing changes over time in both neighborhood features and birth outcomes, and natural or planned experiments of community change, would go farthest in promoting causal inference.

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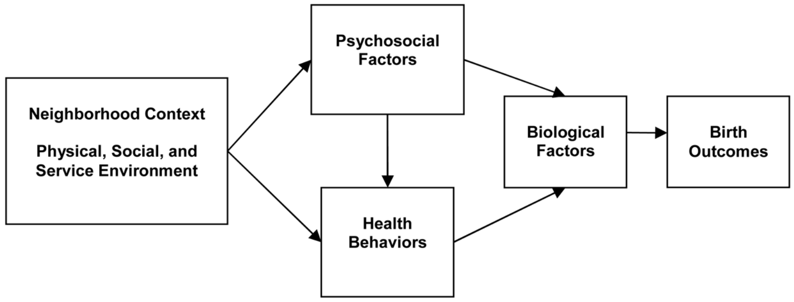
Neighborhood Context
Physical, Social, and Service Environment
Psychosocial Factors
Health Behaviors
Biological Factors
Birth Outcomes

Figure 1.

Table 1

Neighborhood Characteristics (N=126)

Variable	Mean (SD)	Min	Max	PC Score Loadings
% Black	69.2 (35.0)	0.9	99.7	0.26
% Poverty	26.1 (17.3)	2.5	79.2	0.32
Violent Crime Rate (per 1,000)	35.3 (21.4)	4.3	113.5	0.33
% Boarded-Up Housing	1.9 (2.7)	0	13.8	0.32 *

* Score loading for the natural log of boarded-up housing

Table 2

Distribution of Neighborhood Variables According to Neighborhood Risk Tertile

Neighborhood Risk Index	% Black Mean (SD)	% Poverty Mean (SD)	Violent Crime Rate (per 1,000) Mean (SD)	% Boarded Up Housing Mean (SD)
Lower Tertile	36.5 (32.2)	10.6 (5.4)	16.6 (7.9)	0.2 (0.3)
Middle Tertile	76.6 (28.8)	23.1 (11.2)	31.8 (11.6)	1.0 (1.1)
Upper Tertile	92.8 (13.1)	44.3 (12.6)	56.9 (18.4)	4.7 (3.1)

Table 3

Individual Characteristics According to Neighborhood Risk Tertile

		Neighborhood Risk Tertile		
	Total N (%)	**First 109 (15)**	**Second 220 (30)**	**Third 397 (54)**
Sociodemograpic				
Control Variables				
Maternal Age				
19–24	377(52)	51.4	55.0	50.4
25–34	288(40)	38.5	36.8	41.6
35+	61(8)	10.1	8.2	8.1
Race‡				
Black	693(95)	87.2	94.1	98.5
Married or Living with Father of Baby†	192(26)	40.4	24.1	23.9
Education‡				
< High School	340(47)	33.9	43.2	52.4
High School or GED	308(42)	38.5	45.9	41.6
> High School	78(11)	27.5	10.9	6.1
*Enough Money for Necessities**				
Half the time or less	122(17)	17.4	14.1	18.1
More than half	193(27)	15.6	24.6	30.7
Almost always	411(56)	67.0	61.4	51.1
Public Assistance^				
Yes	666(92)	88.1	90.9	93.2
Home Ownership‡				
Yes	129(18)	31.2	22.7	11.3
Psychosocial Factors				
*Stress**				
Little to none	271(37)	45.9	38.2	34.5
Some	252(35)	34.9	35.9	34.0
Mild	109(15)	9.2	13.6	17.4
Moderate to Severe	94(13)	10.1	12.3	14.1
Pregnancy Locus of Control^				
Some or no control	223(31)	25.7	30.5	32.2
Moderate control	300(41)	40.4	40.9	41.8
Strong control	203(28)	33.9	28.6	25.9
*Emotional Support**				
Yes	254(35)	45.0	34.6	32.5
Behavioral Factors				
Cigarettes/day†				
0	462(64)	72.5	69.1	58.2

		Neighborhood Risk Tertile		
	Total N (%)	**First 109 (15)**	**Second 220 (30)**	**Third 397 (54)**
1–9	123(17)	12.8	15.9	18.6
10+	141(19)	14.7	15.0	23.2
*Alcohol**				
Never	593(82)	84.4	83.6	79.9
1–4 days/month	82(11)	13.8	10.5	11.1
1–2 days/week+	51(7)	1.8	5.9	9.1
Hard Drug Use‡	212(29)	20.2	23.6	34.8
Late or No Prenatal Care^	267(63)	56.9	61.4	76.0
Biomedical Factors				
Hypertensive Disorders	73(10)	11.9	7.7	10.8
*Infection**	101(14)	6.4	16.4	14.6
Pre-pregnancy weight				
<120	175(24)	18.4	28.2	23.4
120–159	332(46)	52.3	40.5	46.9
160–199	140(19)	19.3	22.3	17.6
200+	79(11)	10.1	9.1	12.1
Net Weight Gain†				
<10	233(32)	24.8	29.1	35.8
10–29	365(50)	55.1	50.5	48.9
30–39	74(10)	10.1	11.4	9.6
40+	54(7)	10.1	9.1	5.8

^p<0.1,

*p<0.05,

†p<0.01,

‡p<0.001

Table 4

Multilevel Models of Behavioral and Psychosocial Mediators as Outcomes[a,b]

Outcome	Coefficients for 1SD of Neighborhood Risk Index (SE)	Odds Ratios
Stress	0.126 (0.088)	1.14
Internal Locus-of-Control	0.008 (0.087)	1.01
Emotional Support	−0.122 (0.101)	0.89
Smoking	0.239 (0.105)*	1.27
Alcohol[c]	0.465 (0.239)^	1.59
Hard Drug Use	0.335 (0.123)†	1.41
Late or No Prenatal Care	0.177 (0.098)^	1.19

[a]All models adjusted for sociodemographic factors: maternal age, race, living with the father of the baby, education, money for necessities, public assistance, home ownership.

[b]Cumulative logit link for ordinal variables, proportional odds assumption not rejected

[c]Proportional odds assumption rejected; effect noted only for daily/weekly consumption

^p<0.1,

*p<0.05,

†p<0.01

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Table 5

Sequential Multilevel Model Coefficients for Birthweight (SE)

	Model 1	Model 2	Model 3	Model 4
Neighborhood Risk				
Index (1 SD)	−76.4 (31.0)*	−66.9 (30.5)*	−43.0 (30.8)	−34.3 (28.9)
Sociodemograpic				
Control Variables				
Maternal Age				
19–24	--	--	--	--
25–34	−114.9 (53.6)*	−50.8 (53.4)	98.8 (56.6)^	71.7 (54.8)
35+	−261.0 (92.5)†	−165.6 (91.7)^	54.8 (95.0)	65.4 (92.1)
Race				
Black v. other	−48.7 (121.5)	−18.3 (119.0)	15.8 (116.7)	82.4 (113.0)
Married or Living with Father of Baby	78.0 (58.9)	80.3 (57.6)	82.5 (56.2)	60.6 (54.4)
Education				
< High School	--	--	--	--
High School or GED	134.5 (53.2)*	98.7 (52.3)^	39.3 (51.7)	25.8 (49.9)
> High School	149.3 (149.3)^	94.6 (87.0)	9.5 (86.1)	−0.9 (83.9)
Enough Money for Necessities				
Half the time or less	−267.6 (71.1)‡	−70.6 (76.3)	−45.7 (74.3)	−14.4 (71.8)
More than half	−103.4 (59.4)^	8.1 (61.6)	−5.6 (60.1)	29.4 (58.1)
Almost always	--	--	--	--
Public Assistance				
Yes v. no	195.6 (91.7)*	205.9 (90.2)*	202.4 (88.3)*	158.1 (85.6)^
Home Ownership				
Yes v. no	64.5 (67.7)	70.5 (66.3)	76.3 (64.8)	84.7 (62.5)
Psychosocial Factors				
Stress				
Little to none		--	--	--
Some		−112.8 (59.2)^	−61.1 (58.0)	−85.8 (56.2)
Mild		−237.8 (78.8)†	−158.7 (78.2)*	−160.4 (75.6)*
Moderate to Severe		−394.4 (89.1)‡	−234.3 (90.1)†	−267.2 (86.9)†
Pregnancy Locus-of-Control				
Some or no control		--	--	--
Moderate control		136.9 (59.8)*	112.1 (58.5)^	113.6 (56.2)*
Strong control		208.9 (67.2)†	159.6 (66.3)*	154.7 (63.9)*
Emotional Support				
Yes v. no		90.2 (52.2)^	69.9 (50.8)	37.7 (49.1)
Behavioral Factors				

	Model 1	Model 2	Model 3	Model 4
Cigarettes/day				
0			--	--
1–9			−151.1 (72.6) *	−140.7 (70.5) *
10+			−290.7 (78.2)‡	−215.3 (76.2)†
Alcohol				
Never			--	--
Monthly			−19.2 (79.4)	−50.1 (76.8)
Daily/Weekly			−120.7 (103.8)	−71.2 (100.4)
Hard Drug Use			−169.2 (69.6) *	−119.7 (67.7)^
Late or No Prenatal Care			−103.4 (52.1) *	−66.5 (50.7)
Biomedical Factors				
Hypertensive Disorders				−237.5 (76.3)†
Infection				−107.3 (66.7)
Pre-pregnancy weight				
<120				−207.9 (58.7)‡
120–159				--
160–199				172.0 (62.5)†
200+				265.6 (78.3)‡
Net Weight Gain				
<10				−150.2 (53.0)†
10–29				--
30–39				73.4 (78.4)
40+				208.5 (89.6) *
−2 log likelihood	11351.9	11251.2	11141.0	10993.6
Change in model fit		100.7	110.2	147.4

^ p<0.1,

* p<0.05,

† p<0.01,

‡ p<0.001