Neighborhood social and physical environments and health:

Examining sources of stress and support in neighborhoods and their relationship with self-rated health, cortisol and obesity in Chicago

by

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A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
(Social Work and Sociology)
in The University of Michigan
2010

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Acknowledgements

I have many thanks to give for the institutional, intellectual and emotional support I have received throughout my years in the doctoral program. I would first like to thank The University of Michigan, and the taxpayers who fund this incredible institution, for providing excellent financial support for doctoral students. I am in debt to Todd Huynh and Laura Thomas in the Social Work Doctoral Office for their administrative support and constant encouragment. I would also like to thank the Institute of Social Research, particularly Barb Strane and Cathy Doherty, for their administrative and technical support.

I have received incredible support and mentorship from advisors during my time at Michigan. I will begin by thanking Andy Grogan-Kaylor, my primary advisor in the School of Social Work. I have worked with Andy since almost my first week in the doctoral program, and am honored to consider him a friend as well as a mentor. I am grateful to have witnessed Andy's passion for learning about how the world works and thinking about how to make it better. Andy has been a great listener over the years, and has served as a rare example for balancing work and life in an often hectic and demanding environment. He was always available for help with statistical problems, whether technical or conceptual, or to just talk through an idea.

I must also thank my primary advisor in Sociology, Jeff Morenoff. I have learned so much from Jeff about the practice of research, and he has truly pushed me to become more meticulous and thoughful scholar. I am extremely grateful for the time Jeff has spent helping me think through the details of my projects. I often went into meetings with Jeff feeling a little lost and overwhelmed, but always came out with a clearer vision of where I was going and a concrete plan for how to get there.

I would also like to thank Sandy Danziger, who has been a great mentor throughout the years. Sandy is so easy to talk with and share a laugh with, often at the most necessary of times. I am grateful for the support of Dave Harding and Jim House. Dave has been a great teaching mentor and has provided invaluable feedback on my dissertation projects. I convinced Jim to join my dissertation committee a little late in the game, and he has provided important feedback and advice for future projects.

I certainly would not have made it through the program without the support of my fellow comrades. In particular, I would like to thank Megan, Ellen, Emily, and Kristin for their support, wisdom, and smiles.

And finally, to Clare, who makes me possible.

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Abstract

In recent years, there has been an increasing interest in neighborhood environments as potential contributors to racial and socioeconomic health disparities. This trend reflects a growing recognition that individualistic explanations of health inequalities are both theoretically and empirically insufficient. Although neighborhood structural disadvantage has consistently been linked with increased rates of morbidity and mortality, the mechanisms through which neighborhood environments might get "under the skin" remain largely unknown. This dissertation contributes to the literature on neighborhoods and health by identifying potentially stressful and supportive dimensions of the neighborhood environment and testing their impact on both health outcomes and hypothesized physiological mediators.

This dissertation begins by theorizing and constructing four non-sociodemographic measures of the neighborhood social and phyiscal environment: perceived stressors, observed stressors, social support, and participation. Since neighborhood effects have been documented for range of health outcomes, I use a widely accepted global indicator of health—self-rated health—to examine the relative effects of these different neighborhood dimensions on physical health. I find that perceived stressors have a strong negative effect on self-rated health, and appear to partially mediate the effects of neighborhood socioeconomic disadvantage.

The second analysis examines the relationship between neighborhood stressors and support and cortisol, a commonly theorized physiological linking mechanism between stress and physical health outcomes. Using multilevel spline regression, I examine the effects of neighborhood characteristics on diurnal cortisol pattern. I find that individuals living in more stressful neighborhoods have lower overall levels of cortisol, characterized by blunted diurnal patterns. These results add to increasing evidence that long-term stress exposure can lead to hypocortisolism, which may have an important role in the pathophysiology of disease.

In the final analysis, I examine the moderating role of gender in the relationship between obesity (measured by both BMI and waist size) and neighborhood socioeconomic, social and physical characteristics. Neighborhood disadvantage has a strong positive effect on BMI and waist size for women, but no effect for men. The results suggest that men and women respond differently to similar neighborhood environments in ways that are important for understanding the social causes of obesity.

Chapter 1

Introduction

Socioeconomic and racial disparities in mental and physical health have been well documented (Williams & Collins, 1995; House, 2002; Browning & Cagney, 2003). However, purely individualistic explanations of health inequalities have proven to be both theoretically and empirically insufficient. Health research must examine not only individual characteristics, but characteristics of the social contexts in which individuals are embedded in order to more fully understand health disparities (Diez-Roux, 2007). In recent years, neighborhoods have become a focus of much of the research on the social health disparities because of 1) variations in exposure to health-relevant risk and protective factors across neighborhoods, and 2) racial and socioeconomic neighborhood segregation (Massey, 1996).

Sociologists have long critiqued the biomedical model for its individualistic and reductionist approach. Despite these calls from sociologists, biomedical and public health research has been slow to incorporate the larger social context into the etiology of disease. Although the biomedical paradigm has started to shift toward a broader "biopsychosocial" model that incorporates social and psychological factors (Fremont & Bird, 2000), it is still dominated by the belief that individual knowledge, attitudes, and socioeconomic status determine health behavior and health outcomes (Cohen et al, 2003). For the most part, people have been viewed as "islands" of individual-level risk factors.

Neighborhood environments as emergent and causal phenomena

The geographic clustering of disadvantaged individuals in neighborhoods has complicated the investigation of neighborhood effects on health. Until recently, individual-level explanations of health disparities have been favored over environmental ones because of the dominance of the biopsychosocial paradigm and longstanding methodological concerns. Research on neighborhood effects on health—and more generally—has been plagued by fear of falsely attributing individual differences to environmental variations (known as the "ecological fallacy"). However, Diez Roux (2003) argues that researchers should be equally as weary of the "individualistic fallacy", or the failure to consider important contextual factors in drawing individual-level inference.

There are both theoretical and empirical justifications for recognizing neighborhood environments as ontologically distinct from the individual. The concern about the ecological fallacy has led to a denial of social structure as possessing *sui generis,* as Durkheim called it, or emergent properties that possess irreducible causal powers (Willmott, 1999). In fact, the effort to assign social phenomena an ontological status has been one of the major struggles of sociology, and is particularly salient with the growth of interdisciplinary work with the biomedical sciences. If social phenomena—collective behavior, institutions, social structures, networks and dynamics—are only composed of the people within them, then all of sociology can ultimately be reduced to facts about individuals (Sawyer, 2002). However, it has been shown empirically that neighborhood variations in health outcomes persist even after controlling for a wide range of individual-level characteristics (Ellen et al, 2001). Durkheim was the first to challenge the notion that society is simply the sum of its parts, and to attempt to account for both "the emergence of the social from the individual, and downward causation from the social to the individual" (Sawyer, 2002, p. 12).

Neighborhood socioeconomic status is, by definition, compositional—individual socioeconomic characteristics are aggregated to the area-level—and therefore epiphenomenal. As a result, an individual's or family's SES is often perceived as a confounder of neighborhood SES effects because of the well documented relationship between individual SES and health (Diez Roux, 2007), and because of pervasive residential stratification by SES (Massey and Denton, 1993; Massey, 1996). By contrast, the social and physical environments of neighborhoods can be thought of as emergent properties, creating a context that is not independent of the individuals within it, yet is not reducible to them. While there is a mutually reinforcing and reciprocal relationship between residents and neighborhood environments, those environments are also shaped by larger sociopolitical structures that determine the distribution of resources (infrastructure, policing, services, etc). Moreover, neighborhood social phenomena emerge from individuals within a neighborhood, yet take on properties that cannot be explained using purely individual-level information.

Therefore, a disadvantaged neighborhood is not simply one in which disadvantaged people live, but is characterized by multiple, and potentially interdependent, social and physical phenomena that can shape health and health behavior. This has perhaps been obfuscated by the fact that the vast majority of neighborhood studies, in the absence of better measures, utilize census charactertistics. Diez Roux (2007) emphasizes that the theoretical *causal* effect of interest is the social and physical neighborhood phenomena which researchers assume neighborhood SES is proxying (Diez Roux, 2007).

In addition to challenging the idea of neighborhood phenomena as social facts, critics of neighborhood effects research also argue that, empirically, these effects are quite small compared to many individual-level risk factors. However, it is important to keep in mind that these small individual effects (or relative risk) can translate into large population differences (population attributable risk) in health. Relative risk is the ratio of the incidence of disease or death among those exposed to a particular risk factor compared with those unexposed. By contrast, population attributable risk is a function of relative risk *and* the prevalence of the risk factor, and represents the amount of disease produced by a risk factor among individuals with the risk factor compared with those without (Altman, 1995). Although neighborhood effects are "small" in regression models, targeted health interventions at the neighborhood level have the potential to produce large changes in population health.

Neighborhood social and physical phenomena as sources of chronic stress

Researchers know relatively little about the pathways through which neighborhood socioeconomic differences manifest in health disparities. One explanation for the association between lower socioeconomic status and poor health is the unequal distribution of environmental stressors across different kinds of neighborhoods (Latkin & Curry, 2003). Stress experienced by individuals has been found to increase the risk of a wide range of physical health outcomes, including mortality, low birth weight, heart disease and self-rated health (Lantz et al, 2005). One series of experimental studies demonstrated that individuals with higher levels of psychological distress had a greater incidence and severity of colds, while individuals with a greater variety of stress-buffering social ties also developed fewer and less severe colds (Fremont & Bird, 2000). However, most research on stress and health has focused exclusively on individual-level stressors, such as job-related stress, major life events, and friend and/or relative social support.

Both quantitative and qualitative research indicates that socioeconomically disadvantaged neighborhoods may be highly stressful to their inhabitants (Latkin & Curry, 2003; Israel et al, 2006; Frohlich et al, 2002). Individuals in these neighborhoods are disproportionately exposed to psychosocial hazards such as crime and disorder. These kinds of ambient chronic stressors are largely uncontrollable and therefore pose severe threats that are not easily adapted to or overcome (Baum et al, 1999, p. 132). Moreover, the resources necessary for coping with chronic stress, such as social support, are unevenly distributed across socioeconomic status (Williams & Collins, 1995).

The concept of neighborhood stress as mediator of the relationship between disadvantage and health is theoretically attractive because it integrates both behavioral and physiological pathways. Individuals can potentially respond to stressful environments by modifying health behaviors, such as diet, physical activity, and drug and/or alcohol use. In addition, the effect of stress on health can be mediated physiologically through the sympathetic nervous system and the hypothalamic–pituitary–adrenal (HPA) axis , which releases stress hormones such as cortisol (McEwen, 1998). The concept of “allostatic load” has been used to explain the long-term physiological effects of exposure to chronic stress. The wear and tear on the body that results from chronic activation of the stress-reponse systems is hypothesized to erode the health of residents in ways that make them more vulnerable to mortality from any given disease (Ellen et al, 2005).

Research on chronic stress and health has focused primarily on the physiological pathways, and has only recently taken an interest in the social patterning of stress exposure and the nature of specific environmental stressors (Boardman, 2004). Neighborhoods can influence health outcomes through: (1) neighborhood institutions and resources; (2) stressors in the physical environment; (3) stressors in the social environment; and (4) neighborhood-based social support and norms (Ellen et al, 2005). These neighborhood factors will in turn operate through a variety of behavior and physiological mechanisms to ultimately manifest in physical health outcomes.

The intersection of biomedical research on stress with sociological research on mechanisms linking neighborhoods and physical health represents an important and relatively new area of social scientific inquiry (Boardman, 2004). Currently, few measures of chronic neighborhood stressors have been developed (Ellen et al, 2005). Distinct measures of neighborhood problems would enable researchers to examine whether the adverse effects of living in certain neighborhoods are due in part to repeated exposure to neighborhood stressors as well as to deficits in neighborhood protective phenomena such as social support or participation.

Hill et al (2005) have argued for an advancement of research on the "biodemography of stress". While sociologists have tended to treat physiological mechanisms as a "black box", biomedical research on stress and health has largely ignored the social distribution of stressors, particularly across neighborhood environments. The recent inclusion of biomarkers in population-based studies has allowed researchers to begin closing this gap; however, much work still lies ahead.

Organization of Dissertation

This dissertation contributes to the literature on neighborhoods and health by identifying potentially stressful and supportive dimensions of the neighborhood environment and testing their impact on both health outcomes and hypothesized physiological mediators. I conduct three analyses using data from the Chicago Community Adult Health Study (CCAHS). The CCAHS combines uniquely rich data on the urban social and physical environment with individual-level health outcomes and biological markers of stress.

The first analysis examines the presence of multiple non-sociodemographic dimensions of the neighborhood environment and their relationship to both neighborhood disadvantage and self-rated health. Combining multiple secondary data sources, I construct four measures of the neighborhood environment and assess their independent affects on self-rated health, as well as their mediating role in the relationship between neighborhood socioeconomic disadvantage and health. Due to the richness of the data, I am able to distinguish between objective measures of neighborhood stressors and resident perceptions of neighborhood stressors. Neighborhoods have been associated with a range of health outcomes, and neighborhood disparities in mortality cut across many different health processes (Ellen et al, 2003; Cohen et al, 2003). Therefore, self-rated health (SRH) is used in this study as a widely accepted global indicator of health that allows for assessment across a range of illnesses (Weden et al, 2008; Franksa et al, 2003).

The second analysis models the relationship between neighborhood stressors and support and cortisol, a commonly theorized physiological linking mechanism between stress and physical health outcomes. I use multilevel spline regression to examine diurnal patterns of salivary cortisol, and the effects of neighborhood characteristics on these daily patterns. The experience of stress is hypothesized to increase the risk for disease by dysregulating stress-related biological pathways (Cohen et al, 2006). Cortisol specifically has received increasing attention in the sociological literature, yet empirical evidence linking social contexts with cortisol is practically nonexistent. I examine the potential environmental causes, and physiological consequences, of HPA dysregulation, including both hypercortisolism (chronically high levels of cortisol) and hypocortisolism (chronically low levels of cortisol).

In the final analysis, I examine the role of neighborhood in explaining gender differences in social disparities in obesity. I first outline the commonly theorized dimensions of "obesogenic" neighborhood environments, and then present theoretical perspectives on the potential gendered effects of neighborhood on health behavior and obesity. I then use multilevel analyses to examine neighborhood influences on BMI and waist size, and the extent to which men and women respond differently to various neighborhood characteristics. I examine the moderating role of gender in the relationship between obesity (measured by both BMI and waist size) and neighborhood socioeconomic, social and physical characteristics.

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Chapter 2

Neighborhood socioeconomic disadvantage and self-rated health: The mediating role of the social and physical neighborhood environment

Neighborhood socioeconomic conditions have consistently been associated with both mental and physical health outcomes. It is widely believed that social and physical neighborhood characteristics mediate the effects of neighborhood SES on health; however, empirical evidence on these theorized mechanisms has lagged behind theory. Due primarily to methodological limitations, the majority of studies examine the relationship between neighborhood SES and health despite the fact that the theoretical causal effect of interest is often the social and physical neighborhood attributes which researchers assume neighborhood SES is proxying (Diez Roux, 2007). Identifying the specific non-income neighborhood features that link neighborhood disadvantage to health is essential for strengthening causal inference and furthering our understanding of how neighborhoods influence health (Diez Roux, 2007; O'Dwyer et al, 2007; Cohen et al, 2003).

Bourdieu (1999) has argued that "using material poverty as the sole measure of all suffering keeps us from seeing and understanding a whole side of the suffering characteristic of the social order" (p. 4). While it is important to establish the empirical link between neighborhood SES and health, it is also important that we attempt to understand the dynamic ways in which poor neighborhoods structure the daily lives of residents. The conceptualization and measurement of the multiple aspects of neighborhood life may be key to understanding the pervasive effects of disadvantage on health. In addition, although most research treats neighborhood SES as the "fundamental cause" of neighborhood variations in health, it is possible that there are unhealthy components of neighborhood social and physical environments that are not necessarily preceded by or dependent on socioeconomic composition.

This paper seeks to understand the relationship between neighborhood socioeconomic disadvantage and multiple dimensions of the neighborhood social and physical environment. I will first review theory and empirical evidence on the environmental stressors and social resources that are thought to influence health outcomes. I then review the potential individual-level pathways through which neighborhoods operate. Finally, I examine the effects of neighborhood stress and social resources on self-rated health.

Neighborhood Disadvantage and Stress

Both quantitative and qualitative research indicates that socioeconomically disadvantaged neighborhoods are more likely to contain physical and social stressors that can shape both individual health behaviors and physiological processes (Latkin & Curry, 2003; Israel et al, 2006; Frohlich et al, 2002). Deterioration of the physical infrastructure (i.e. vacant housing, litter, vandalism), fear of crime, and the weakening of social cohesion shapes the daily lives of residents. Even if residents are not directly victimized, these signs of social and physical disorder indicate that their immediate environment is unsafe or unpredictable (Kim & Ross, 2009).

Israel et al (2006) used focus groups to examine how residents in Detroit, MI perceive and cope with neighborhood stressors. Participants were asked to indentify aspects of their neighborhoods that they found stressful, as well as their psychological and behavioral responses to stressors. Commonly reported stressors such as deteriorated buildings, crime, and lack of social networks and trust in neighbors made residents feel depressed, sad, angry, frustrated, and nervous. Although the language of stress has been prominent in the literature, there has been little advancement in empirically identifying health-relevant environmental stressors. The majority of neighborhood studies utilize census measures of material deprivation and simply assume that more disadvantaged neighborhoods are uniformly characterized by these stressors.

Perceived and observed neighborhood stress

The relative importance of perceived versus observed neighborhood characteristics has been of recent interest in the neighborhood effects literature. The effects of neighborhoods on health may be partially dependent on the meaning that people ascribe to their environments. Frohlich et al (2002) argue that researchers should attempt to understand health-related behaviors by focusing on individuals' subjective experiences. The authors state that "we cannot necessarily infer from the objective measures of the social structure how people are using and interacting with them, the point being that context is neither just the reflection of the distribution of individual characteristics nor just the attributes of the area, but is also the significance that these characteristics and attributes hold for people" (p. 1416). Understanding resident perceptions may be key to understanding how social and physical environments can shape health behavior and stress responses.

Objective or observed neighborhood measures are those that can be characterized independent of a resident's own perception (such as census characteristics or outsider ratings of the neighborhood) (Weden et al, 2008). Subjective or perceived measures refer to resident assessments their own neighborhood environments, and most closely reflect local appraisals of neighborhood conditions. As such, they may capture aspects of the neighborhood environment that objective measures cannot. On the other hand, objective measures may reflect important structural characteristics of the environment that the respondent may not or cannot perceive while still shaping opportunity and health behavior. Recent research that has attempted to understand the relative importance of observed versus perceived neighborhood characteristics has suffered from methodological shortcomings.

Most research on neighborhoods and health measures objective characteristics of neighborhoods using single- or multiple-item indexes of census measures of socioeconomic conditions (Weden et al, 2008). Far fewer studies have had the ability to go beyond socioeconomic characteristics and objectively measure the neighborhood physical environment, such as the condition of the infrastructure, local services, and the commercial environment. There are a small handful of exceptions; for example, Stockdale et al (2007) found that violent crime and the density of bars and liquor stores mediated the relationship between neighborhood socioeconomic disadvantage and mental health.

The majority of studies have found that, when available, neighborhood perceptions are a better predictor of mental and physical health compared to census characteristics. For example, Ross and Mirowsky (2001) and Hill et al (2005) found that perceived neighborhood disorder (measured by perceptions of crime, safety, and the condition of the neighborhood infrastructure) accounted for the relationship between neighborhood conditions (measured by census characteristics) and self-rated health. Wen et al (2006) and Weden et al (2008) found that perceived neighborhood quality was predictive of self-rated health controlling for objective neighborhood SES. Wen et al (2006) also report that the effects of perceived neighborhood quality are partially explained by individual psychosocial factors, including loneliness, hostility, and stress.

Latkin & Curry (2003) argue that neighborhood disorganization- measured by respondent assessments of vandalism, litter, vacant housing, burglary, drug selling, and robbery- is a key chronic stressor responsible for neighborhood differences in mental health. After adjusting for baseline levels of depressive symptoms, perceptions of neighborhood physical disorganization predicted depressive symptoms at a 9-month followup interview. Ellaway et al. (2001) similarly reported that self-rated health and mental health were associated with perceived neighborhood problems while controlling for neighborhood SES. Previous research comparing observed and perceived neighborhood characteristics has been insufficient for two primary reasons: 1) observed measures used have primarily been Census-based, rather than actual objective measures of crime or the physical environment, and 2) perceived characteristics have been overwhelmingly measured at the individual-level, thus failing to capture neighborhood-level social constructs.

Neighborhood social resources

Individuals are embedded within complex social structures that not only determine exposure to stressors, but also stress buffers and social resources (Stockdale, 2007). Social support networks are hypothesized to be an important resource that may directly influence mental and physical health or may be drawn upon to buffer the effects of stress (Latkin & Curry, 2003). Most research on social support and social networks has focused on general (non-geographically defined) support, but more recent work has attempted to understand the potential direct or buffering effect of neighborhood-specific social ties. While the physiological mechanisms of how social interactions influence health are not well understood, clinical trials have shown a robust relationship between social support and immune functioning (Cohen et al, 1997). Positive and consistent interactions with neighbors may be healthful in and of themselves, and may also provide access to other important resources that can be called upon in response to environmental stress (Boardman, 2004; Ross & Jang, 2000).

Several studies have found that social support has either a direct effect or a stress buffing effect on mental health. Kohen et al (2008) found that neighborhood structural disadvantage affected maternal depression through a decreased sense of neighborhood cohesion. Young et al (2004) found that, after controlling for neighborhood socioeconomic status, a better sense of neighborhood was associated with better physical and mental health and physical activity. Franzini et al (2005) found that neighborhood trust and reciprocity mediated the effect of neighborhood poverty on self-rated health. Kim & Ross (2009) examined the relative role of general and neighborhood-specific social support, and found that both had a buffering effect on neighborhood disorder. However, general social support had a stronger effect than neighborhood-specific support. Ross and Jang (2000) found that informal social ties with neighbors buffered the effect of neighborhood disorder on fear of crime. The evidence has not been consistent, however. Boardman and colleagues (2001) did not find that social support had a direct effect or a buffering effect of neighborhood disadvantage on drug use.

In addition to social networks, collective efficacy is a concept that has been hypothesized to effect health and well-being. Sampson and colleagues (Sampson 1997; Sampson et al, 1999) define collective efficacy as the mutual trust and shared expectations for collective action among local residents. Sampson (2003) argues that collective efficacy can exist in communities without the presence of strong ties among residents. In other words, the construct of collective efficacy does not have to be tied to an outdated, idealistic view of neighborhoods as the center of social life, but rather a shared confidence in a neighborhood's ability to exercise social control and engage in collective action.

The specific mechanisms through which neighborhood collective efficacy may influence health outcomes include the social control of health-compromising behaviors, access to services and amenities, and the management of neighborhood physical hazards (Kawachi and Berkman 2000). In the last decade, researchers have shown that collective efficacy is a potentially critical mediating process relevant to health outcomes, including obesity (Cohen et al, 2006; Burdette et al, 2006) and cardiovascular disease (Cohen et al, 2003). Browning & Cagney (2002) found that residents of neighborhoods with higher levels of collective efficacy reported better overall health. Xue et al (2005) found that collective efficacy mediated the effects of neighborhood disadvantage on children's mental health.

While collective efficacy represents shared *expectations* for action, neighborhood participation reflects the active engagement of community members in local formal and informal organizations. Participation in local organizations or community events can affect health through a variety of mechanisms. Engagement in the community provides the opportunity for individual residents to simply be part of a group, bringing the benefits of social interaction and integration. In addition, a high degree of actual or perceived community participation may help foster a sense of community empowerment and an understanding that they live in a location where people are looking after the concerns of the neighborhood and its residents (Carpiano, 2006; Kawachi & Berkman, 2001). Neighborhood participation may also reflect connections between the neighborhood and the broader community. In comparison to collective efficacy and social ties, much less research has examined the effects of neighborhood participation levels on health and well-being.

Individual-Level Pathways

Diez Roux (2007) argues that because disease is ultimately expressed in individuals, neighborhood effects *must* be mediated through individual-level processes. Similarly, the effects of individual-level variables ultimately will be mediated through cellular and molecular processes (Diez Roux, 2007).   Rather than acting as "independent" effects on an outcome, individual-level factors can both mediate and moderate neighborhood-level effects through individual health behavior, physiological responses to stress, and even gene expression (Cummins et al, 2007).

Many studies of self-rated health control for individual psychological factors such as depression, anxiety, or pessimism, arguing that these characteristics confound the relationship between neighborhoods and physical health.   This "same source bias" is said to occur when a third, often unobserved factor (such as psychological disposition), influences both a respondent's reporting on his/her neighborhood and his/her health (Weden et al, 2008).

Same source bias is more of a potential threat when using only individual-level assessments of neighborhoods (as most research does) compared to using aggregated data. However, even at the individual-level the direction of causality is not obvious; psychological disposition is not clearly exogenous to the relationship between neighborhoods and physical health. Psychology does not just affect how we perceive our physical health or our environments. Rather, it can be argued (and has been supported empirically) that neighborhood environments play a role in shaping psychological disposition, and that psychological disposition exerts a real (not just perceived) effect on physical health. Therefore, psychological conditions such as anxiety may partially mediate the effects of stressful neighborhood environments on physical health. Diez Roux (2008) argues that psychosocial factors should not be viewed exclusively as individual characteristics to be controlled for, but as the patterned response of social groups to the external environment. Therefore, controlling for anxiety or pessimism may lead to an underestimation of neighborhood effects.

In addition to affecting psychological disposition, neighborhood environment may also influence the quantity and quality of individual social ties. Social ecological conditions of local neighborhoods may influence the extent and nature of individual social ties. For example, in a neighborhood characterized by crime and disorder, it may be difficult for individuals to find friends and build support networks. Fear and mistrust may not be easily compartmentalized, and so mistrust of neighbors may seep into the dynamics of other interpersonal relationships. Therefore, the effect of neighborhood stress and social support on physical health may operate partly through the impact of neighborhood on individual social networks (Weden et al, 2008).

Self-Rated Health

Neighborhoods have been associated with a range of health outcomes, and neighborhood disparities in mortality cut across many different health processes (Ellen et al, 2003; Cohen et al, 2003). Therefore, self-rated health (SRH) is used in this study as a widely accepted global indicator of health that allows for assessment across a range of illnesses (Weden et al, 2008; Franksa et al, 2003). SRH can be understood as ‘‘a summary statement about the way in which numerous aspects of health, both subjective and objective, are combined within the perceptual framework of the individual respondent’’ (Tissue, 1972, p. 93 quoted in Jylha, 2009).

In a review of twenty-seven studies, Idler & Benyamini (1997) found that global self-rated health was a reliable predictor of morbidity and mortality. Moreover, the association between self-rated health and mortality has been found to be consistent across gender and racial groups (Weden et al, 2008). However, critics of SRH argue that the relationship between SRH and disease may not be uniform across age groups. Schnittker (2005) found that the association chronic illness and SRH declines with age, while the association between depression and SRH increases with age.

Interestingly, the association between SRH and mortality is usually attenuated but does not disappear with the inclusion of primarily health indicators (Jylha, 2009). For example, in patients with advanced cancer, self-rated health was found to be a stronger predictor of mortality than performance and clinical indicators, symptoms, and health-related quality of life measures (Shadbolt et al, 2002).Some (eg Schnittker, 2005) have argued that this remaining correlation indicates that SRH is capturing other than the presence or absence of disease, and therefore may not be a valid indicator of health. However, others have argued that the persistence of the association between SRH and mortality actually speaks to its superior predictive power.

Research on SRH has attempted to explain the ability of the measure to predict mortality above and beyond chronic disease and other objective health measures. Jylha et al (2006) posit that SRH has a real biologic basis and can capture subtle bodily information that is not necessarily represented as diagnosed health conditions. As such, recent attention has focused on the relationship between SRH and biomarkers that may reflect nascent subclinical conditions. SRH has shown a graded relationship with white blood cells and creatinin (Jylha et al, 2006), cytokines involved in inflammation (Lekander et al, 2004), s-prolactin and s-testosterone (Halford et al, 2003) and urinary epinephrine and cortisol (Goldman et al, 2004).

Halford et al (2003) argue that the well-documented association between chronic stress and SRH (Lantz et al, 2005; Williams et al, 1997) may be a potential explanation for the persistence predictive power of SRH on mortality. Individuals under chronic stress may feel the physiological wear and tear on their bodies before it manifests in clinical outcomes. Therefore, SRH may be an ideal outcome measure for examining the pervasive effects of neighborhood stressors on physical health.

Current Study

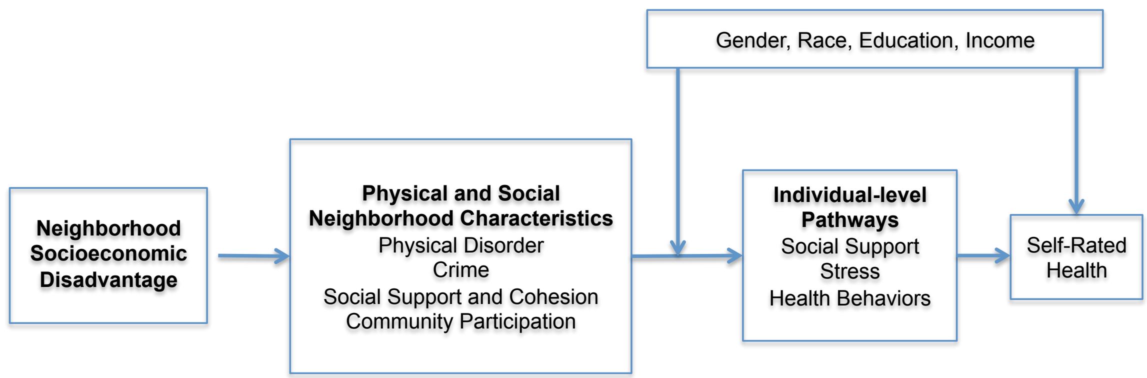
The current study improves on the literature in several important ways. First, I drawn upon non-resident data sources to objectively measure neighborhood-level stress, while previous research has relied almost exclusively on Census data for objective characteristics. Second, perceived neighborhood stress and social resources are measured at the neighborhood-level, while previous research has overwhelmingly utilized individual-level neighborhood assessments. Finally, I will examine these multiple neighborhood dimensions independently and simultaneously to assess their relative importance for self-rated health. Prior research has often focused on only one aspect of the neighborhood environment in addition to socioeconomic disadvantage (Mair et al, in press).

I conceptualize neighborhood stress as capturing physical disorder and deterioration, crime and safety, and general neighborhood upkeep. Neighborhood stress is measured using non-resident data (observed stress) and resident data (perceived stress). I consider two dimensions of neighborhood social resources: social support and participation. Social support captures aspects of both collective efficacy and neighborhood social ties, while participation captures active resident engagement in community activities or organizations.

This study attempts to address the following questions: 1) How are multiple dimensions of the neighborhood social and physical environment related to neighborhood socioeconomic disadvantage? 2) Do resident perceptions of neighborhood stress or objective measures of neighborhood stress account for the relationship between neighborhood disadvantaged and self-rated health? 3) Is there a main effect or a buffering effect of neighborhood resources such as social support and participation on self-rated health? and 4) What are the individual-level pathways through which neighborhood social and physical characteristics operate?

It was hypothesized that neighborhoods with higher levels of socioeconomic disadvantage would have more objective and perceived stress and lower levels of social support and participation. Moreover, it was hypothesized that these characteristics would partially mediate the effect of neighborhood socioeconomic status on self-rated health, and that this effect would in turn operate through individual-level mechanisms such as anxiety and individual social support.

Figure 2.1: Theoretical Model of Neighborhood Pathways to Self-Rated Health



Data and Methods

Data Sources

I will analyze data from the Chicago Community Adult Health Study (CCAHS), a multistage probability sample of 3,105 adults aged 18 or more years, living in the city of Chicago between 2001 and 2003. The city of Chicago is stratified into 343 neighborhood clusters (NCs), previously defined by the Project on Human Development in Chicago Neighborhoods (PHDCN) as one or more geographically contiguous census tracts aggregated based on the demographic characteristics of the population, local knowledge of the city's neighborhoods and major ecological boundaries (Sampson et al. 1997).   One adult aged 18 or over was interviewed from each sampled home, with a final response rate of 72%. Subjects were oversampled from 80 focal neighborhood clusters, defined by the PHDCN and chosen due to their socioeconomically and racially-ethnically heterogeneous composition. The sample had an average of 9.1 subjects per neighborhood cluster (range: 1-21). Respondents in the CCAHS completed a community survey (CS) which was used to create NC-level measures of the social and physical environment.

I will draw upon additional data sources to characterize the neighborhood environment, including systematic social observation (SSO) of participant neighborhoods, Census measures, and Uniform Crime Reports. The SSO component of the CCAHS involved trained raters that observed and rated neighborhood conditions on both sides of the streets enclosing the blocks of sampled residents. There were 6631 observations at the street level, with an average of 19.4 observations per NC. NC-level measures for each scale in the SSO were created using empirical Bayes estimation, which adjusts for missing items and improves neighborhood-level estimates by borrowing information across clusters (Mujahid et al., 2007). CS measures of resident perceptions were aggregated using the same estimation techniques as the SSO.

Sample weights were used in individual-level analyses to handle differential rates of selection and participation by neighborhood cluster. The sample weight was constructed as a multiplicative combination of three weights adjusting for oversampling of individuals in focal neighborhood clusters, whether a participant was selected for intensive non-response follow-up at the end of the survey, and a post-stratification weight. The weight was centered to have a mean of 1.0 (range: 0.2-5.4) (Morenoff et al., 2007).

I will include NC-level crime rates (homicide, robbery, and burglary) obtained from the Uniform Crime Reports. Census data aggregated to the NC-level will be used to measure the neighborhood socioeconomic disadvantage as well as aspects of the physical environment.

Neighborhood Measures

The selection of neighborhood measures for this analysis was guided by previous neighborhood based research and theory linking neighborhood social and physical environments to health (Sampson et al, 1999; Hill et al., 2005; Franzini et al, 2006). A total of 21 measures were used to construct the four neighborhood scales: perceived stress, observed stress, social support, and participation. Appendix A reports individual items for each SSO or CS scale used. *Perceived stress* includes resident perceptions of the physical neighborhood environment and neighborhood safety, and is comprised of five CS scales: perceived disorder (CS), perceived violence(CS), neighborhood safety (CS), services (CS) and hazards (CS). *Observed Stress* includes objective or outsider-rated measures of the physical neighborhood environment and neighborhood safety, and is comprised of the following: physical disorder (SSO), physical deterioration (SSO), vacant lots (SSO), vacant housing (Census), homicide/robbery/burglary rates (Uniform Crime Report), and street condition (SSO). *Social Support* includes resident perceptions of neighborhood social organizational dynamics, and is comprised of four CS scales: social cohesion, social control, intergeneration closure, and reciprocal exchange. *Participation* measures resident engagement in the local community, and is comprised of four CS scales: organizational participation, voting, contact with community officials, and civic activities. Standardized alpha scales were created for each neighborhood dimension (alphas reported in Table 1). The spatial distribution of the four neighborhood dimensions across the city of Chicago is shown in Appendix B.

A principal factor analysis with orthogonal rotation was performed to confirm the number of neighborhood dimensions and the measures included in each scale (Table 1). In general, the results of the analysis validate the theoretical constructs. With an eigenvalue greater than 7, the first factor contains high loadings (>.65) for the measures of perceived neighborhood stress. The second factor captures observed neighborhood stress, including crime rates, vacant housing, and measures from the SSO. Observed physical disorder cross-loaded onto both perceived and observed stress, but was retained in the final observed stress scale for conceptual consistency. The final two factors captured social support and participation.

U.S. Census data provide information on the socioeconomic composition of neighborhood clusters. A composite measure of *neighborhood socioeconomic disadvantage* was created using the following census variables: percent of families with income less than $10,000, percent of families with income greater than $50,000, percent of families below the poverty level, percent of families receiving public assistance, percent unemployed, percent of residents with 16 or more years of education, percent never married, percent female headed households, median home value, and percent in professional or managerial positions. The neighborhood SES measure is a standardized scale with an alpha of 0.95.

Individual-Level Measures

Self-rated health was measured by the question ‘‘All in all, would you say that your health is generally excellent, very good, good, fair, or poor?’’ For the purposes of the analysis, self-rated health was transformed to a dichotomous variable, with respondents reporting “fair” or “poor” health in one category. The collapsing of categories of a categorical variable is generally recognized to potentially involve loss of information and a reduction in efficiency. However, Manor et al (2000) compared logistic models of self-rated health with multiple types of models that accounted for the ordered nature of the outcome, and found that dichotomization did not change the size or significance of the association between SES and self-rated health.

Table 2.1: Rotated Factor Loadings for Neighborhood Variables (n=343)

	Perceived Stress	Observed Stress	Social Support	Participation
Perceived Disorder	**0.86**			
Perceived Violence	**0.78**			
Safety	**0.66**			
Hazards	**0.85**			
Services	**-0.69**			
Homicide Rate		**0.60**		
Robbery Rate		**0.74**		
Burglary Rate		**0.52**		
Physical Disorder	0.59	**0.40**		
Physical Deterioration		**0.68**		
Vacant Lots		**0.64**		
Vacant Housing		**0.67**		
Street Condition		**-0.41**		
Social Cohesion			**0.79**	
Social Control	-0.47		**0.59**	
Intergeneration Closure			**0.87**	
Exchange			**0.60**	
Organizational Participation				**0.70**
Voting				**0.57**
Contact with Community Officials				**0.63**
Civic Engagement				**0.73**
Eigenvalue	7.77	2.69	1.20	0.92
Alpha for Standardized Scale	0.92	0.89	0.85	0.76

* All loadings >.40 are shown
** Bolded items are included in the standardized scales

Respondent *age* is included as a continuous measure. The mean age is 42.5 (sd=16.5), ranging from 18 to 92. *Race/ethnicity* is constructed from the respondents' self-reports and contains four mutually-exclusive categories: 31.7% were non-Latino white (reference), 40% non-Latino black, 25.8% Latino, and 2.6% non-Latino other. For *gender*, males are the reference category, and the sample was 39.8% male and 60.2% female. *Educational attainment* is measured in four categories: less than a high school degree (25.5%), high school degree (24.4%), some college (26.3%), and college degree or higher (23.7%). *Family income* is measured in four categories: less than $5,000 (6%), $5-15,000 (16.1%), $15-40,000 (28.8%), and greater than $40,000 (30.5%). Because there was significant missing data (18.6%) on income an additional missing income category is included to retain those individuals in the analysis. *Marital status* is a five category variable: married (35.1%), separated (5.5%), divorced (13.3%), widowed (8.2%), and never married (37.8%).

Anxiety is measured as a 5-item index (α=.79). Respondents were asked how often (never, hardly ever, some of the time, most of the time) they felt the following: nervous, faint, hands trembling, had fear of the worst happening, had fear of dying. *Friend/relative social support* is measured as a 5-item index (α=.68). Respondents were asked the following questions (responses ranged from "a great deal" to "not at all"): "On the whole, how much do your friends and relatives make you feel loved and cared for?", "On average, how much do you feel your friends and relatives make too many demands on you?", "How much are friends or relatives willing to listen when you need to talk about your worries or problems?", and "How much are your friends and relatives critical of you or what you do?".

Statistical Procedures

The analysis begins with an examination of the correlations among neighborhood-level variables followed by a description of the individual-level sample. I then conduct a multilevel logistic regression of self-rated health, beginning with the null model. This is followed by a series of models first introducing individual-level sociodemographic covariates and then neighborhood sociodemographic disadvantage. The mediating role of the neighborhood social and physical characteristics is tested by introducing them one by one and examining the change in significance of the socioeconomic disadvantage coefficient. Finally, the individual-level non-sociodemographic variables are entered to test their mediation of the neighborhood measures.

Results

Neighborhood Correlations

Table 2.2 shows bivariate correlations among the neighborhood measures. For the most part, the social and physical neighborhood characteristics are correlated with neighborhood socioeconomic disadvantage and residential stability in the expected directions. More disadvantaged neighborhoods have higher levels of perceived and observed stress, and lower levels of social support. Interestingly, observed stress is more highly correlated with neighborhood disadvantage than perceived stress, indicating that resident perceptions of their neighborhoods may be capturing things other than objective neighborhood characteristics. Participation is correlated with residential stability and social support, but not with socioeconomic disadvantage or stress. This lends support to the notion that there are multiple dimensions of the neighborhood environment that cannot be captured with a single measure. Appendix B shows maps of the neighborhood clusters in Chicago and the spatial distribution of the neighborhood measures.

Table 2.2: Correlation Matrix of Neighborhood Measures (n=343)

	(1)	(2)	(3)	(4)
Percieved Stressors (1)				
Observed Stressors (2)	0.71 **			
Social Support (3)	-0.49 *	-0.37 **		
Participation (4)	-0.06	0.09	0.28 **	
Socioeconomic Disadvantage (5)	0.72 *	0.80 *	-0.29 *	-0.02

**** p<.01 *p<.05 +p<.10**

Descriptive Statistics and Self-Rated Health

Table 3 reports descriptive statistics for the sample (n=3105), as well as the bivariate relationships between the covariates and poor/fair self-rated health. The odds of reporting poor or fair self-rated health increase with age, while higher education and income reduce the odds of poor or fair health. Blacks and Hispanics are more likely to report poor or fair health, as are respondents who are separated or widowed. All neighborhood measures, with the exception of residential stability, have a significant effect on health in the expected direction. Finally, the odds of reporting poor or fair health increase with higher levels of anxiety and decrease with higher levels of friend/relative social support.

Table 2.3: Descriptive Statistics and Bivariate Odds of Poor/Fair SRH (n=3105)

	Percent/ Mean	SD	Min	Max	Bivariate Odds of Poor/Fair Self-Rated Health
Individual-Level					
Fair/Poor SRH	17.62		0	1	
Age	42.51		18	92	1.02**
Sex					
Male (reference)	39.77		0	1	
Female	60.23				1.52**
Race					
White (reference)	25.83		0	1	
Black	31.66		0	1	2.43**
Latino	39.94		0	1	3.12**
Other	2.58		0	1	.76
Education					
College (reference)	23.74		0	1	
Some College	26.31		0	1	2.91**
High School	24.44		0	1	4.06**
Less than HS	25.51		0	1	9.62**
Income					
40k+ (reference)	30.53		0	1	
15-40k	28.79		0	1	2.51**
5-15k	16.14		0	1	4.54**
Less than 5k	5.96		0	1	3.91**
Missing	18.58		0	1	2.69**
Marital Status					
Married (reference)	35.14		0	1	
Separated	5.51		0	1	1.91**
Divorced	13.33		0	1	1.08
Widowed	8.24		0	1	1.95**
Never Married	37.78		0	1	.81
Friend/Relative Social Support	3.90	0.72	1	5	.62**
Anxiety	1.96	0.77	1	4	2.63**
Neighborhood-Level					
Perceived Stressors	0.03	0.88	-1.81	2.11	1.69**
Observed Stressors	-0.03	0.70	-1.49	2.32	1.6**
Social Support	-0.01	0.85	-2.35	2.54	.77**
Participation	-0.02	0.75	-1.88	2.89	.81**
Residential Stability	-0.01	-0.87	-1.97	2.06	.98
Socioeconomic Disadvantage	-0.01	0.77	-2.13	2.86	1.82**

**** p<.01 *p<.05 +p<.10**

Multilevel Logistic Regression

I began by estimating an unconditional multilevel logit model (not shown) to examine the variation in self-rated health across neighborhoods. In logistic regression, the aim is to predict the probability, φ, that a respondent reports poor or fair health. The probability is transformed into log odds, taking on values from -∞ to +∞. Multilevel logistic regression takes into account that individual probability is dependent on neighborhood residence. The unconditional model takes on the following form:

$$\text{Prob}(\text{Poor Health} = 1/\beta_0) = \varphi$$

$$\text{Log}[\varphi/(1-\varphi)] = \beta_0$$
$$\beta_0 = \gamma_{00} + u_0$$

where γ_{00} is the overall prevalence expressed on the logistic scale and u_0 is the neighborhood-level residual with a mean of 0 and variance σ_u^2. The intra-class correlation for a logistic regression can be calculated as (Hox, 2000):

$$\text{ICC} = \rho = \sigma_u^2 / \sigma_u^2 + \sigma_e^2 \text{ where } \sigma_e^2 = \pi^2/3$$

More recently, some have argued that the ICC in logistic regression is not as useful as in the linear case because the distinction between individual-level variance and area level variance is not as clear. Merlo et al (2008) argue for use of the median odds ratio (MOR), which is defined as the median value of the odds ratio between the area at highest risk and the area at lowest risk when randomly picking out two areas. Unlike the ICC, the MOR is statistically independent of the prevalence of the outcome (Merlo et al, 2008). A MOR equal to 1 means that there are no neighborhood differences in the outcome, while a value greater than 1 means that neighborhood is a source of variation in the outcome. Another advantage of the MOR is that it can be compared to the odds ratios for other variables in the model. The MOR can be calculated using the following equation:

$$\mathrm{MOR} = \exp\sqrt{(2 * \sigma_u^2)} * .67451 \approx \exp(.95 * \sqrt{\sigma_u^2})$$

For the unconditional model, the ICC = .10, meaning that 10% of the variation in self-rated health is attributable to neighborhoods. Correspondingly, the MOR for the unconditional model is 1.78 (greater than 1), indicating that neighborhood are a risk for poor/fair self-rated health.

Model 1 (Table 4) reports results of the multilevel model including only individual-level sociodemographic variables. As expected, income and education are highly significant. Females are more likely to report poor/fair health than males (OR=1.44), and blacks and Hispanics are more likely to report poor/fair health than whites (OR=1.60 and OR= 2.01 respectively). There is a marginally significant effect of being separated compared to being married (OR=1.48). The inclusion of individual sociodemographics reduces the ICC to .03 and the MOR to 1.37, indicating that much, but not all, of the neighborhood variation in self-rated health is due to compositional effects.

In model 2, neighborhood socioeconomic disadvantage has a significant effect (OR=1.53) on self-rated health. The inclusion of neighborhood disadvantage completely attenuates the black-white disparity, but has only a small effect on income and education. This suggests that income and education exert independent effects on physical health, but black-white racial disparities are largely a result of differences in neighborhood environments. Disparities between whites and Hispanics do not appear to be due to differences in neighborhoods of residence.

In model 3, perceived stress appears to fully mediate the effect of neighborhood socioeconomic disadvantage and explains most of the neighborhood-level variation (ICC=.01). Models 4 and 5 introduce individual-level mediators of the neighborhood effects. Anxiety is highly significant and partially attenuates the effect of perceived neighborhood stress. When friend/relative social support is added (model 5), the neighborhood effects become insignificant.

Models 6 and 7 include neighborhood observed stress and neighborhood social support. Neither of these measures appear to mediate the effects of neighborhood socioeconomic disadvantage. Neighborhood participation (model 8) has a marginally significant effect that is independent of neighborhood disadvantage (not surprisingly, since these measures are not correlated). Model 9 reports a significant interaction between neighborhood participation and gender, indicating that neighborhood participation only has an effect on self-rated health for females. Gender interactions were estimated for the other neighborhood variables (not shown) but were not significant. The effect of participation for women is not mediated by anxiety or friend/relative support (model 10). Model 11 estimates the simultaneous effect of all neighborhood measures, and includes the gender interaction for participation. Neighborhood perceived stress remains significant even with other neighborhood social and physical characteristics in the model, as does the effect of participation for women. The final model (12) includes anxiety and friend/relative social support, which again mediate the effects of perceived stress but not participation.

Table 2.4: Odds Ratios for Multilevel Logistic Regression Predicting Fair/Poor Self-Rated Health (n=3105)

	1	2	3	4	5	6	7	8	9
Individual Level									
Intercept	0.02 **	0.03 **	0.03 **	0.03 **	0.03 **	0.03 **	0.03 **	0.03 **	0.03 **
Income (>40k reference)									
Less than 5k	2.42 **	2.27 **	2.24 **	2.24 **	2.24 **	2.24 **	2.25 **	2.21 **	1.76 **
5-15k	2.17 **	2.03 **	2.00 **	2.01 **	2.01 **	2.01 **	2.02 **	1.97 **	1.70 **
15-39k	1.53 *	1.46 *	1.44 *	1.45 *	1.45 *	1.45 *	1.47 *	1.44	1.27
Income Missing	1.53 *	1.44 +	1.45 *	1.45 +	1.44 +	1.40 +	1.40 +	1.41	1.32
Age	1.02 **	1.03 **	1.03 **	1.03 **	1.03 **	1.03 **	1.03 **	1.03 **	1.03 **
Race (White reference)									
Hispanic	2.01 **	1.73 **	1.64 **	1.72 **	1.71 **	1.72 **	1.72 *	1.64 +	1.72 *
Black	1.60 **	1.06	1.05	1.00	1.05	1.17	1.17	1.13	1.08
Other	0.76	0.76	0.74	0.75	0.75	0.78	0.78	0.76	0.76
Female	1.44 **	1.45 **	1.45 **	1.44 **	1.45 **	1.45 **	1.39 *	1.40 *	1.33 *
Education (College Reference)									
Less than High School	5.43 **	4.52 **	4.59 **	4.61 **	4.60 **	4.36 **	4.34 **	4.44 **	3.74 **
High School	2.87 **	2.52 **	2.63 **	2.59 **	2.56 **	2.45 **	2.41 **	2.55 **	2.09 **
Some College	2.54 **	2.27 **	2.37 **	2.32 **	2.31 **	2.24 **	4.27 **	2.39 **	2.04 **
Marital Status (Married reference)									
Separated	1.48 +	1.39	1.37	1.37	1.37	1.39	1.41	1.38	1.35
Divorced	1.17	1.15	1.12	1.15	1.13	1.14	1.15	1.13	0.98
Widowed	0.99	1.00	1.00	1.00	1.00	1.00	1.01	1.01	0.93
Never Married	0.99	0.99	0.98	0.98	0.98	0.99	1.01	1.00	0.93
Anxiety									2.16 **
Friend/Relative Social Support									0.74 **
Neighborhood Level									
Socioeconomic Disadvantage		1.53 **	1.24	1.38 *	1.47 **	1.51 **	1.44 *	1.21	1.34
Percieved Stressors			1.29 **					1.26 *	1.16
Observed Stressors				1.18				1.05	0.95
Social Support					0.88			0.98	0.95
Participation						0.86 +	1.04	1.06	1.06
Participation x Female							0.73 *	0.73 *	0.71 *
σ_u^2	0.11 **	0.06 **	0.03 *	0.06 **	0.05 **	0.05 **	0.05 **	0.03 +	0.03 +
ICC	0.03	0.02	0.01	0.02	0.01	0.01	0.01	0.01	0.01
MOR	1.37	1.26	1.18	1.26	1.24	1.24	1.24	1.18	1.18

**** p<.01 *p<.05 +p<.10**

Discussion

This study examined four dimensions of the neighborhood social and physical environment—observed stress, perceived stress, social support and participation—and the relative strength of their relationship with self-rated health. In addition, the individual-level pathways through which neighborhood environments might affect health were tested. The results suggest that perceptions of neighborhood stressors such as crime, physical disorder and hazards mediate the effect of neighborhood socioeconomic disadvantage on self-rated health. Perceptions of neighborhood stress influence self-rated health through higher anxiety and lower levels of individual social support.

The correlations among the neighborhood measures indicate that there is not a uniform relationship between disadvantage and distinct dimensions of the social and physical environment. While disadvantage is strongly correlated with both perceived and observed stress, it is less correlated with social support and has no relationship with participation. In order for something to be a mediating mechanism, it must be related to both the distal cause (disadvantage) and the outcome (self-rated health). Neighborhood participation is positively related to self-rated health but not neighborhood disadvantage, and so cannot be thought of simply as a mechanism through which disadvantage influences health. This has important implications for the ways in which we conceptualize the causal pathways of neighborhood effects. The vast majority of research treats socioeconomic disadvantage as the most distal factor in the causal chain, with all other aspects of the neighborhood environment as more proximal mechanisms. However, it is possible that there are dimensions of neighborhood life that are relevant to health and that do not simply "explain" socioeconomic disparities.

A closer examination of the relationship between neighborhood participation and socioeconomic disadvantage reveals that participation is highest at the ends of socioeconomic spectrum. This suggests that participation may be motivated by either demand (perceptions of crime and disorder) or privilege (availability of social and economic resources). Moreover, it suggests that the nature of neighborhood participation may vary across socioeconomic contexts. Morenoff & Swaroop (2006) find that socioeconomic disadvantage is positively related to instrumental neighborhood participation (involvement in groups that are explicitly dedicated to maintaing or improving neighborhood conditions), but that there is no association between disadvantage and expressive neighborhood participation (involvement in formal organizations whose primary function is to build social networks and promote a sense of community). The measure of neighborhood participation used in this analysis captures resident engagement both within the neighborhood and the broader community (i.e. connections with local schools and city government). Therefore, it is difficult to determine from this study what kinds of participation are most relevant for health. More work is needed to examine the sources of neigbhorhood-based participation and how organizational goals might moderate the effects of participation on health.

Neighborhood participation had a significant effect on self-rated rated health for women, but no effect for men. A review of the literature revealed no studies (to my knowledge) that have examined gender interactions and neighborhood participation. Araya et al (2006) found that social participation had a positive effect on mental health for both men and women. Some research suggests that women spend more time in their neighborhoods than men, and know more of their neighbors by name and talk or visit with them more frequently (Matheson et al, 2008). This embeddedness may make women more aware of the ways in which their neighborhoods are connected to the larger social structure. Therefore, the gender difference in the effect of neighborhood participation on health may reflect gender differences in resident awareness of community engagement. Alternatively, there could be a differential impact of this kind of "bridging" social capital on health for men and women.

Although observed stressors were more highly correlated with neighborhood disadvantage, it was perceived stressors that mediated the relationship between disadvantage and health. This suggests that how a community collectively views the neighborhood may be most important for the behavioral, psychological, and physiological responses of residents to the environment. Subjective perceptions of neighborhood stressors may be more salient, and therefore more proximate determinants of health compared to objective measures of stress.

Neighborhood stress must operate through some individual-level mechanisms in order to influence physical health. The perceived presence of ambient stressors in a neighborhood may influence health directly via psychological and physiological mechanisms, as well as indirectly through health behaviors. The results of this study suggest that neighborhood stressors operate partly through increased anxiety and partly through decreased levels of general (non-neighborhood-based) friend/relative social support. Unsafe and disordered environments may elicit anxious feelings among residents, which may have a physiological effect on physical health through the chronic activation of the body's stress response systems. Anxiety may also affect physical health through behavioral mechanisms, such as poor diet or lack of exercise. Residents of stressful neighborhoods have lower levels of friend and relative social support, suggesting that it may be more difficult to build interpersonal connections within the context of unsafe or unpredictable environments.

There are several limitations to the current study. The cross-sectional nature of the data makes it impossible to tease out the causal relationships among measures. There are potentially complex relationships between the social and physical neighborhood dimensions examined in this study. For example, the physical environment (i.e. street connectivity, the condition of sidewalks and parks, and signs of physical disorder) may determine the quantity and quality of resident interactions, thus influencing social cohesion and social support (Diez Roux, 2007). Conversely, physical features of local environments may emerge as a result of social conditions (i.e. physical disorder arising from a lack of social capital and collective efficacy) (MacIntyre & Ellaway, 2003). These reciprocal causal relationships at the neighborhood-level deserve attention and certainly complicate the investigation of causal pathways. Future research should examine how the physical and social characteristics of neighborhoods emerge and how they influence one another over time.

The spatial distribution of neighborhood stress and social resources across a city may also be an important component of the relationship between disadvantage and health. Neighborhoods with similar levels of objective stressors may have different levels of perceived stress depending on the condition of surrounding neighborhoods. More work is needed to understand how collective perceptions of neighborhood environments are related to objective characteristics of the neighborhood and surrounding areas.

Finally, although this study is unique in the richness and diversity of data at the neighborhood level, there is more work to be done in identifying health-relevant dimensions of the neighborhood environment. The commercial environment, land use, and access to health and social service organizations are also potentially important for health. The accurate measurement of neighborhood characteristics and their relationship to health is essential for the advancement of neighborhood-level health interventions. Although neighborhoods have been targeted recently as health intervention sites, the success of these interventions has been mixed (O'Dwyer et al, 2007). Moreover, the successes of neighborhood-based interventions on health and/or health behavior have been relatively small. However, this may not necessarily be reflective of the effects of neighborhoods on health (or the potential of neighborhood interventions to improve health), but rather the current state of the evidence base. Neighborhood-based health interventions must incorporate the theoretical and empirical advancements being made in the research on neighborhoods and health.

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Appendix A

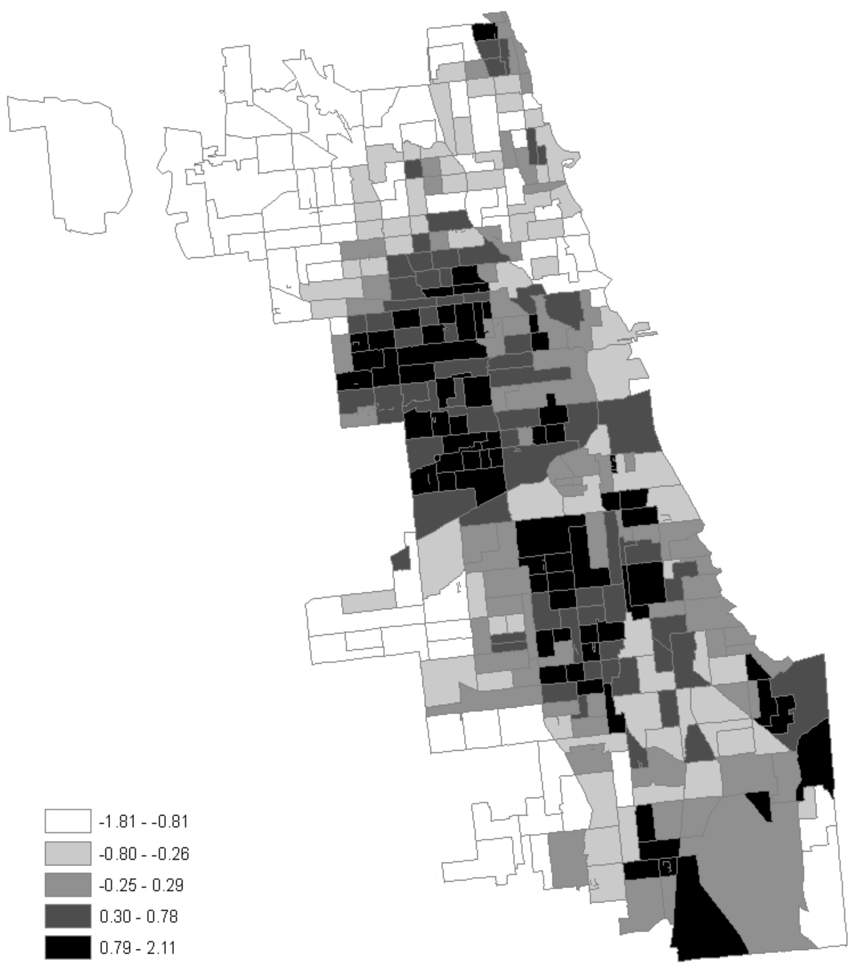
Social Cohesion	1. People around here are willing to help their neighbors 2. People in this neighborhood generally get along with each other 3. People in this neighborhood can be trusted 4. People in this neighborhood share the same values 5. This is a close-knit neighborhood
Social Control	1. If a group of neighborhood children were skipping school and hanging out on a street corner, how likely is it that your neighbors would do something about it? 2. If some children were spray-painting graffiti on a local building, how likely is it that your neighbors would do something about it? 3. If a child was showing disrespect to an adult, how likely is it that people in your neighborhood would scold that child? 4. If there was a fight in front of your house and someone was being beaten or threatened, how likely is it that your neighbors would break it up? 5. Suppose that because of city budget cuts the library or fire station closest to your home was going to be closed down by the city. How likely is it that neighborhood residents would organize to try to do something to keep the fire station or library open?
Intergenerational Closure	1. Adults in this neighborhood know who the local children are 2. There are adults in this neighborhood that children can look up to 3. You can count on the adults in this neighborhood to watch out that children are safe and don't get in trouble 4. Parents in this neighborhood know their children's friends 5. Parents in this neighborhood generally know each other
Reciprocal Exchange	1. About how often do you and people in your neighborhood do favors for each other? By favors we mean such things as watching each other's children, helping with shopping, lending garden or house tools, and other small acts of kindness. 2. When a neighbor is not at home or on vacation, how often do you and other neighbors watch over their property? 3. How often do you and other people in the neighborhood ask each other advice about personal things such as child rearing or job openings? 4. How often do you and people in this neighborhood have parties or other get-togethers where other people in the neighborhood are invited? 5. How often do you and other people in this neighborhood visit in each other's homes or on the street?
Perceived Disorder	1. How much trash or broken glass on sidewalks and streets do you see in your neighborhood? 2. How much graffiti do you see on buildings and walls in your neighborhood? 3. How many vacant or deserted houses or storefronts do you see in your neighborhood? 4. How often do you see people drinking in public places in your neighborhood? 5. How often do you see unsupervised children hanging out in then street in your neighborhood?

Perceived Violence	During the past six months, how often: 1. was there a fight in your neighborhood in which a weapon was used? 2. was there a violent argument between neighbors? 3. were there gang fights in your neighborhood? 4. was there a sexual assault or rape in your neighborhood? 5. was there a robbery or mugging in your neighborhood?
Organizational Participation	1. Are you a member of any service, civic, or social/fraternal organizations, such as the Elks, Masons, Lions, Rotary Club, League of Women Voters, or a local women's club? 2. Are you a member of a group affiliated with your religion, such as the Knights of Columbus or B'Nai B'rith? 3. Do you belong to a church, synagogue, or other religious congregation? 4. Do you belong to a block group, tenant association, or community council? 5. Do you belong to any kind of neighborhood watch program? 6. Have you participated in any group that took local action for reform in the past 12 months? 7. Have you participated in a ethnic, nationality, or civil rights organization in the past 12 months?
Hazards	1. Some neighborhoods have problems with air quality because of things like exhaust from cars, trucks, and buses; smoke from nearby industrial areas; or dust and dirt from trash or construction. How would you rate the quality the air in this neighborhood? 2. How often do you see rats, mice, or roaches in your neighborhood? 3. How dangerous do you think traffic is in your neighborhood either to people driving in cars or walking on the street? 4. Some neighborhoods are noisier places to live than others. Noise can come from people living nearby, people walking or hanging out on the street, traffic, or construction. How noisy would you say your neighborhood is? 5. How often do you encounter potentially toxic substances in your neighborhood like lead from peeling paint, asbestos or other hazardous materials in older buildings, or potentially dangerous fumes from places like factories?
Services	1. How would you rate your neighborhood on its accessibility to parks or other areas where people can jog and exercise or kids can play? 2. What about the quality of street cleaning and garbage collection in this neighborhood?
Voting	1. Did you vote in the last presidential election? 2. Did you vote in the last mayoral election?
Contact with Community Officials	Which of these community officials have you had direct contact with during the last year? - school principal - chair of local school council - religious leader - director of a neighborhood business association or local chamber of commerce - editor of a neighborhood newspaper - alderman - ward committeeperson - officer of the Chicago police department - director of a community development organization

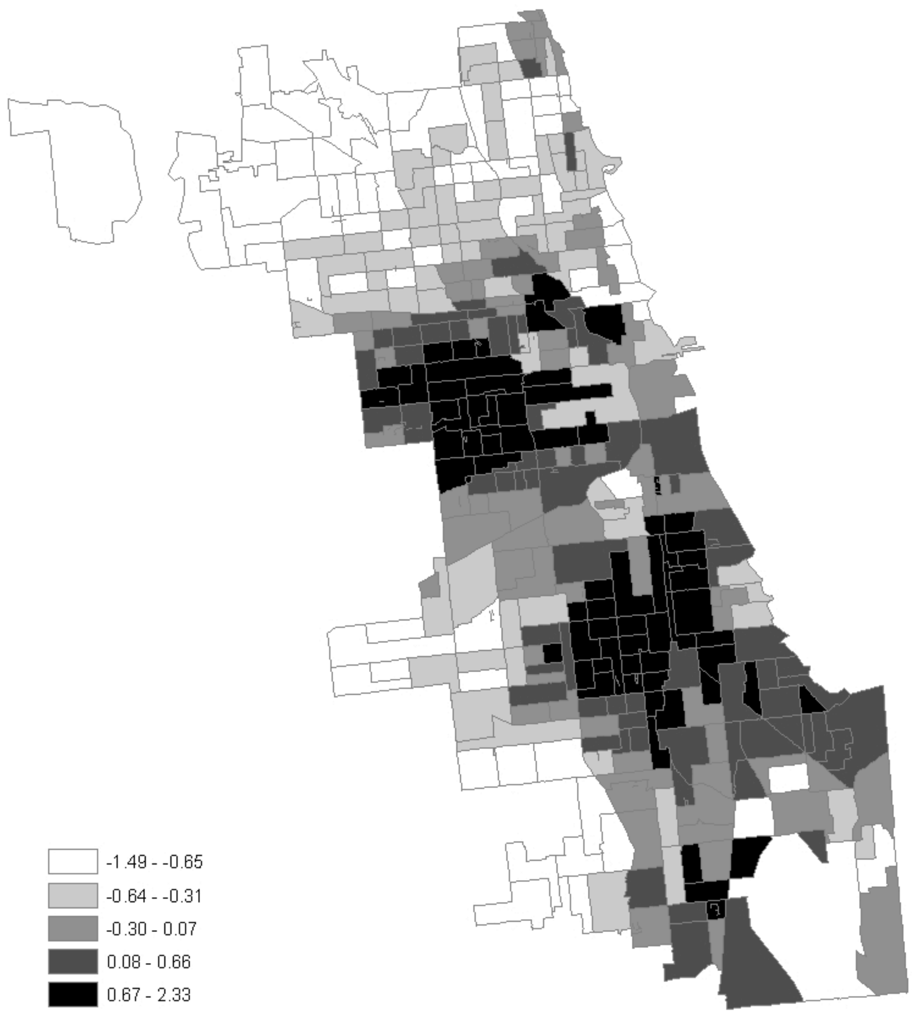
Civic Engagement	Which of these civic activities have you done in the past 12 months? - signed a petition - attended a political meeting or rally - worked on a community project - participated in any demonstration, protests, boycotts or marches - participated in any group that took local action for reform - participated in ethnic, nationality, or civil rights organization - participated in labor union
Neighborhood Safety	1. Is there any place — within 3 blocks of your current home — that you are afraid to walk alone at night? 2. How safe is it to walk around alone in your neighborhood after dark ?
Physical Disorder	1. Garbage, litter or broken glass on sidewalks or in the streets 2. Evidence of graffiti painted over 3. Cigarette or cigar butts or discarded cigarette packages on the sidewalks or in gutters 4. Empty beer or liquor bottles in street, yard or alley 5. Gang graffiti on buildings, signs or walls 6. Other graffiti on buildings, signs or walls 7. Abandoned cars 8. Condoms on the sidewalk, in gutters, or street 9. Needles, syringes or drug-related paraphernalia on the sidewalk, in gutters or street
Physical Deterioration	1. Residential buildings in poor/badly deteriorated condition 2. Commercial buildings in poor/badly deteriorated condition 3. Recreational buildings in poor/badly deteriorated condition 4. Abandoned, burned out, or boarded up house/building 5. Condition of streets is fair or very poor

Appendix B

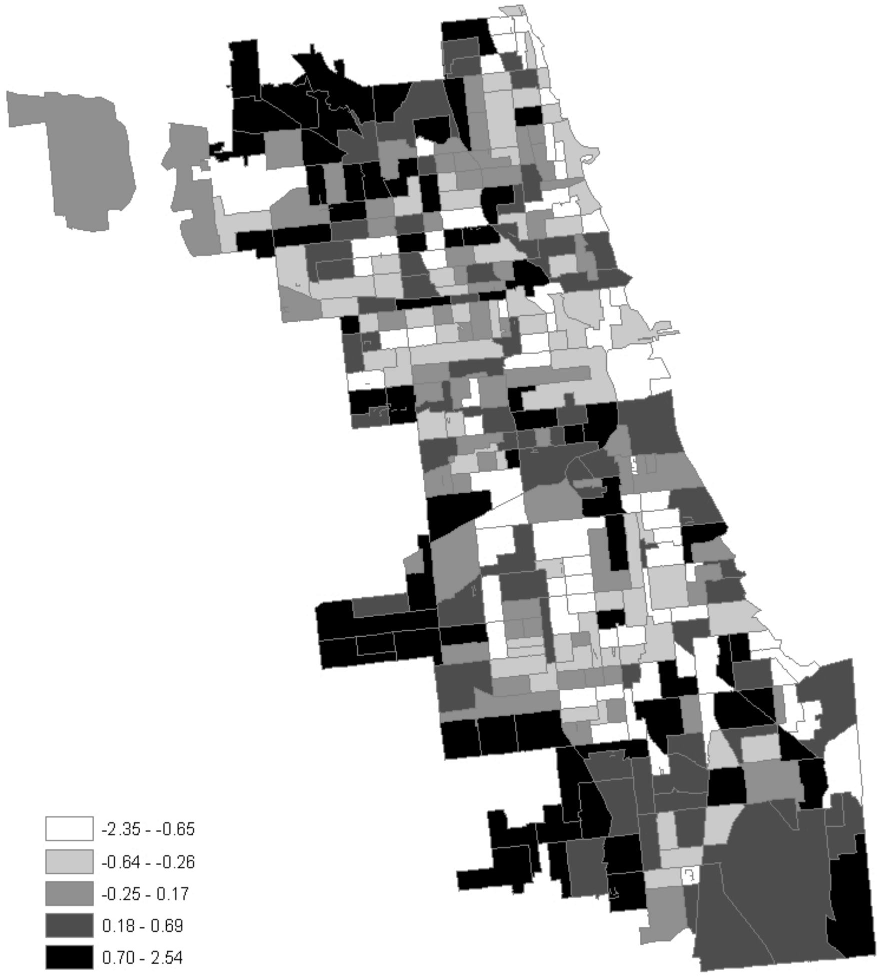
Perceived Neighborhood Stress in Chicago



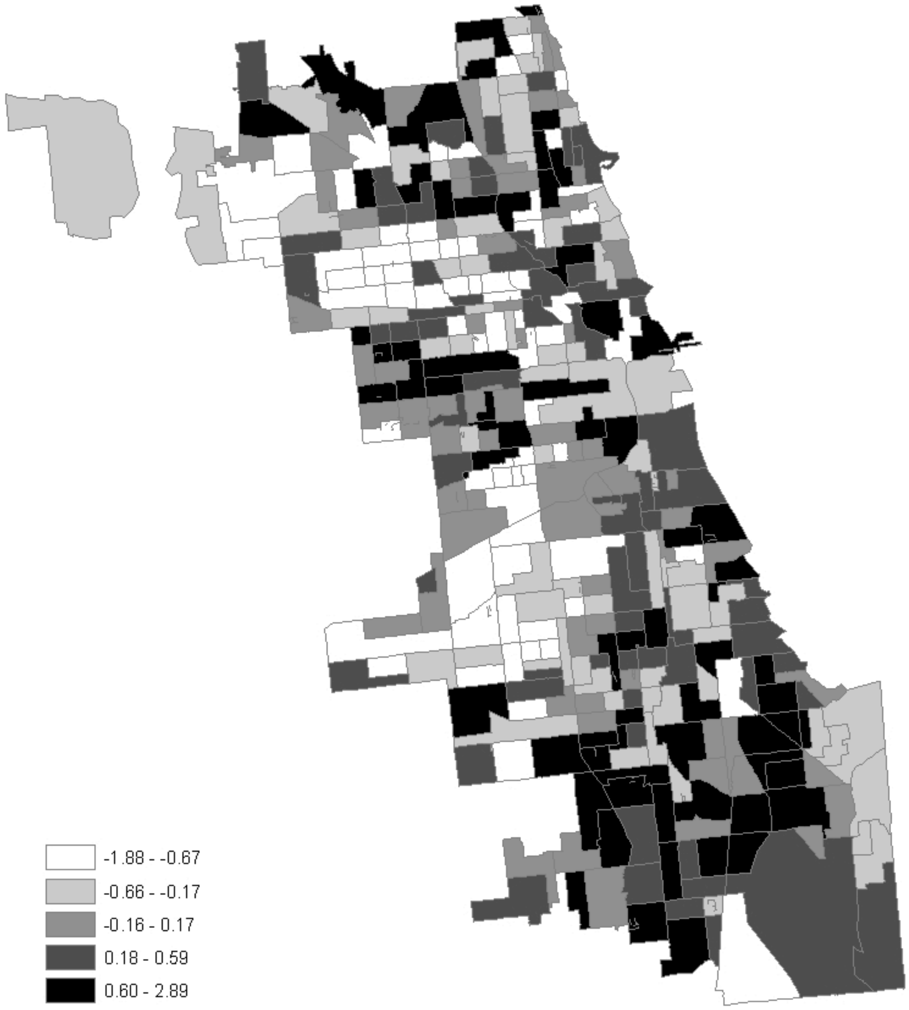
Observed Neighborhood Stress in Chicago



Neighborhood Social Support in Chicago



Neighborhood Participation in Chicago



Chapter 3

Neighborhood Stressors, social support, and cortisol: Neighborhood variations in diurnal cortisol patterns

Neighborhood structural disadvantage has consistently been linked with increased rates of morbidity and mortality, but the mechanisms through which neighborhood environments might get "under the skin" remain largely unknown. Differential exposure to chronic environmental stressors has been identified as a potential pathway linking neighborhood disadvantage and poor health. The experience of stress is hypothesized to increase the risk for disease by dysregulating stress-related biological pathways (Cohen et al, 2006). The hypothalamic-pituitary-adrenal (HPA) axis plays a key role in coordinating the body's physiological response to real or perceived environmental challenges, and the adrenal glucocorticoid cortisol is the principal actor in this system. As such, cortisol has received increasing attention in the neighborhood effects literature as a potential lynchpin mechanism.

The "ecology of stress" has emerged as an important area of research because it is able to integrate both environmental and biological mechanisms to explain health disparities (Matheson et al, 2006). However, there remains a large disconnect between the neighborhood effects literature on stressful environments and biomedical research on stress physiology. Although researchers of neighborhood effects on health have become quite enamored with the mediating role of the endocrine system (and cortisol specifically) in linking socioeconomic disadvantage to poor health, empirical evidence is sorely missing (due in large part to the paucity of physiological measures available). Conversely, the majority of biomedical studies examining the determinants and consequences of endocrine dysregulation utilize animal models and laboratory settings. As a result, individuals are taken out of their social and physical contexts in order to examine physiological responses to contrived stressful experiences. This experimental set-up effectively ignores the ways in which real-life stressful experiences are distributed in the population. Hill et al (2005) argue that psychoendocrinology- the study of the relationship between physiological hormonal stress responses and psychosocial characteristics of the individual- must expand to take into account the social and physical environments in which individuals are embedded: "it is time to move psychoendocrinology from laboratories and clinics into the world in which disadvantaged individuals live, where threat and danger characterize place" (p 171).

Researchers have begun closing this gap by integrating the use of biomarkers in observational studies. However, the vast majority of observational studies on stress and endocrine functioning have thus far focused exclusively on individual-level stressors and psychosocial characteristics, despite the widespread recognition that disadvantaged neighborhoods may be a potential source of chronic stress for residents.

The current study examines neighborhood effects on the diurnal cortisol patterns of 302 individuals from Chicago, IL. The paper is organized as follows. I begin with a summary of the normal function of cortisol and what constitutes different forms of endocrine dysfunction. I then discuss the dominant theoretical paradigm regarding the role of cortisol in explaining health disparities. I review the current literature on the social determinants of cortisol levels, followed by a conceptual framework for the study of neighborhoods and cortisol. Finally, I conduct a multilevel spline analysis modeling the effects of neighborhood characteristics on diurnal cortisol patterns.

Stress, Cortisol and HPA dysfunction

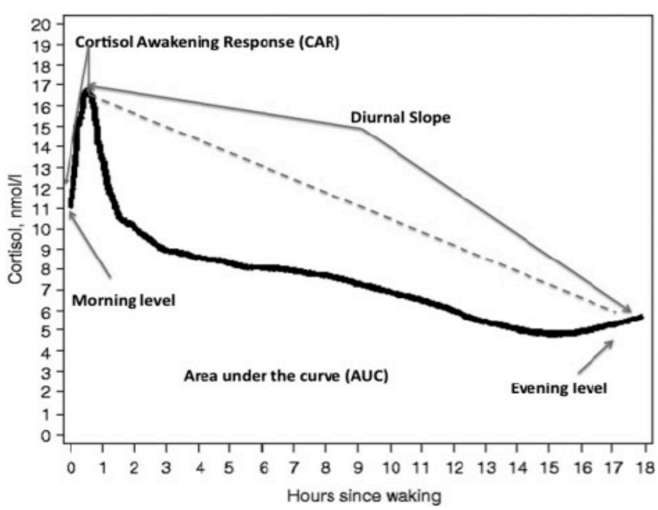
Stress can be generally defined as a state occurring when an individual perceives that the demands (or anticipated demands) of the environment exceeds his or her ability to cope (Lupien et al, 2001). The experience of stress illicits both physiological and psychological responses. The physiological response to stress includes the activation of specific brain circuits and neuroendocrine systems. Two key systems that are hypothesized to mediate the effects of stress exposure on disease outcomes are the sympathetic nervous system (SNS), which stimulates release of epinephrine (commonly referred to as adrenaline) from the adrenal gland, and the Hypothalamic Pituitary Adrenal (HPA) axis, which produces cortisol (Fremont & Bird, 2000).

During periods of stress, activity of the SNS and the HPA axis increase dramatically, resulting in increased levels of both cortisol and epinephrine, as well as numerous physiological changes (such as increased heart rate) that prepare the body for action (Fremont & Bird, 2000). Once released, cortisol has several important functions such as increasing access to energy stores, increasing protein and fat mobilization, as well as regulating the magnitude and duration of inflammatory responses (Sapolsky et al., 2000). While the stress response system is active, the body downplays functions that do not have an immediate role to play in the fight or flight response (such as immune system functioning).

Of the stress hormones, cortisol has received the most attention because of the extensive regulatory role it plays in the central nervous system, the metabolic system and the immune system (Dowd et al, 2009). Cortisol follows a diurnal rhythm, with peak levels found 45-60 minutes after waking. Levels typically drop rapidly for the next couple of hours and then continue to decline slowly throughout the day and night, reaching a low point around midnight (Adam et al, 2006). Figure 1 (taken from Dowd et al, 2009) shows a hypothetical diurnal cortisol pattern.

In addition to the diurnal pattern, considerable variation also exists across individuals, as well as within individuals across different days (Hruschka et al, 2005). As a result, a number of different approaches to modeling cortisol have been examined in the literature: slope from highest to lowest point (diurnal slope), size of the cortisol awakening response (CAR), morning or evening levels, and total concentration over the day measured as area under the curve (AUC) (Dowd et al, 2009).

Figure 3.1: Typical Diurnal Cortisol Pattern



Due to methodological limitations, most population-based studies have used either morning or evening mean levels. Recently, attention has focused more on the shape of the diurnal curve rather than mean levels for two reasons. First, because of the complex diurnal pattern, it is unclear how abnormal diurnal deviations are related to overall mean levels of cortisol. Second, relatively little is known about the cumulative effects of stress exposure over the life course on endocrine functioning.

Stress and Allostatic Load

Recently, the stress paradigm has dominated the literature on socioeconomic health disparities. Although there are posited behavioral mechanisms linking stress to poor physical health, the primary pathway is thought to be physiological. The damaging physiological response to adverse social or environmental conditions over the life cycle has been termed "allostatic load", or the wear and tear on the body that occurs from chronic overactivity of the allostatic systems (McEwen, 1998; Hayward, 2000). While allostasis is critical to adaptation and survival, "allostatic load" is "the price the body pays over long periods of time for adapting to challenges" (McEwen, 2001, p. 44).

The SNS and the HPA axis are examples of allostatic systems. Sterling and Eyer (1988) introduced the concept of allostasis, literally meaning "achieving stability through change", as a heuristic for understanding the "ever-shifting integrated biobehavioral, endocrinological and physiological systems of the body that promote adaptation" (p. ?). Allostatic systems allow our bodies to remain healthy by their capacity for change and adaptation. For example, as part of an allostatic system, blood pressure will vary continuously throughout the day to adapt the individual to changing circumstances. Because it continuously changes, the individual does not have a single "homeostatic" blood pressure state per se, but rather has many stable states, which are directly related to changing internal and external environmental conditions to which the individual must adapt. Similarly, increases in cortisol in response to acute stress are beneficial, preparing the body for action.

As with other endocrine systems, the HPA axis is regulated by a negative feedback system, whereby receptors detect changes in cortisol levels and adjust production accordingly (McEwen, 2000). Cortisol secretion will be inhibited when circulating levels rise or stimulated when levels fall. While cortisol levels typically return to normal quickly after exposure to acute stressors due to negative feedback, long-term exposure to stressors, such as those associated with lower socioeconomic status, is thought to damage feedback loops, resulting in chronically elevated levels (West et al, 2010).

There has been much laboratory work on the biological effects of exposure to elevated glucocorticoid levels. Stress hormones such as cortisol can have effects on gene expression because of the presence of glucocorticoid receptors in the cell nucleus. When stress hormones bind to receptors in the nucleus, they can trigger or inhibit the synthesis of proteins that influence neuronal structure and function (Ciccheti & Walker, 2001). Young rats exposed to stress-like levels of glucocorticoids for 3 months showed significant loss of neurons in the hippocampal regions and decreased dendritic branching, indicating an acceleration of the brain aging process (Cicchetti & Walker, 2001). Elevated cortisol has also been linked to cognitive decline, immunosuppression, obesity and insulin resistance (Dowd et al, 2009).

Although theoretical work suggests that the key biological mechanism linking disadvantage and poor health is elevated cortisol, empirical evidence linking chronic stress to elevated cortisol has been mixed (Dowd et al, 2009). While it is well known that cortisol increases in response to acute stressors and in laboratory settings, there is inconsistent evidence concerning the effects of long-term exposure to chronically stressful environments. More recently, it has been suggested (Fries et al, 2005; Dowd et al, 2009; Gunnar & Vazquez, 2001) that long-term chronic activation of the HPA-axis might ultimately lead to a blunted under-active HPA response (i.e. lower waking levels, smaller CAR, or flatter evening slopes). This blunted pattern- often resulting in lower overall cortisol production- represents a form of HPA-axis dysfunction termed "hypocortisolism". Murison and his colleagues (unpublished data, cited in Fries et al, 2005) exposed rats to a prolonged period of chronic stress, during which time the animals showed elevated glucocorticoid levels. However, two weeks after the stress exposure, the rats showed blunted glucocorticoid patterns and lower overall levels compared to rats who had not been previously exposed to the stress.

Low cortisol levels have received less theoretical attention and research because they challenge the dominant paradigm on the neuroendocrinology of stress. However, Heim et al (1999) argue that there is increasing evidence for hypocortisolism in individuals who have been exposed to severe stress or suffer from stress-related disorders. A chronic lack of cortisol may promote increased vulnerability for disease, and has been linked to post-traumatic stress disorder (Aardahl-Erickson, 2001), aggression (McBurnett et al, 2000), behavior problems (Gavin et al, 2003), disengagement (Mason et al, 2001) and inattention (Spangler, 1995). Fries et al (2005) find that individuals with hypocortisolism report higher levels of fatigue, pain, and stress sensitivity. However, the authors also argue that reduced HPA axis reactivity may not be entirely maladaptive. In fact, hypocortisolism may have protective effects and be advantageous for individuals under long-term stress.

The Social Determinants of Cortisol

Biomedical research on cortisol has, until recently, focused on the endocrine response to acute stressors. For example, studies have found increased cortisol levels among students taking exams, individuals engaging in public speaking, parachute jumpers, and emergency room patients (Lupien et al, 2001). Numberous animal studies have documented increased glucocorticoid production in response to applied stress stimuli (Lupien et al, 2001). While these studies are useful for understanding the physiological role of the endocrine system in general, they shed little light on the ways in which stressors—and stress responses—are distributed in the population. Only recently have population-based studies attempted to understand the relationship between social position, chronic stress, and endocrine function.

In a review of the literature on SES and cortisol, Dowd et al (2009) found highly inconsistent results across studies in terms of the relationship between SES and overall cortisol. Because the dominant paradigm in the sociological literature is that disadvantage should be related to higher overall cortisol, these recent results from population-based studies have caused some confusion. However, among studies that have had the ability to estimate the diurnal pattern, the results have been much more consistent. Dowd et al (2009) found that in the majority of studies lower SES was related to a blunted pattern of diurnal cortisol secretion, despite the fact that this inconsistently corresponded to overall cortisol means.

Cohen et al. (2006) found that lower income and education were associated with flatter slopes and higher levels of cortisol during the evening and at bedtime in a sample of 781 middle-aged adults in the CARDIA study. Ranjit et al (2005) similarly found a flatter slope among those with lower SES; however, in this study the flatter slope resulted from a lower CAR and no difference in evening levels. Buchanan et al. (2004) and Thorn et al. (2006) both documented evidence of a reduced, blunted CAR in participants experiencing high levels of psychological stress.

Vedhara et al (2003) found that the high anxiety women had similar morning levels to low anxiety women, with levels dipping lower during the midday and then rising at night. O'Connor et al (2009) found that the diurnal mean was significantly lower for adult females experiencing psychological distress compared to a low stress group. Adam & Gunnar (2001) found that positive relationship functioning was associated with higher morning cortisol levels and steeper decline across the day. Van de Bergh et al (2008) found that greater emotional distress and anxiety among a group of adolescents was associated with flatter diurnal cortisol profiles due to elevated evening levels.

In a study of adolescents, DeSantis et al (2007) found that African-American and Hispanic youth had flatter cortisol slopes across the waking day than their Caucasian counterparts. The difference is slopes was due both to higher bedtime cortisol levels and to lower wakeup. The authors argue that bedtime levels of cortisol may be more strongly influenced by social factors than waking levels or the CAR. Higher evening levels suggest either continued stress exposure throughout the day or a failure to "turn off" the stress-response system in the evening. Moreover, the higher evening levels may be responsible for low morning levels via negative feedback over the night (DeSantis et al, 2007).

Gunnar & Vazquez (2001) argue that empirical evidence supporting hypocortisolism has often been downplayed because it challenges prevailing concepts on the neuroendocrinology of stress. In a review of the literature on stress and cortisol in children, Gunnar & Vazquez (2001) find that, more often than not, basal cortisol levels are actually lower for individuals experiencing higher levels of adversity and disadvantage. The lower levels are often the result of flatter daily patterns characterized by low morning levels and high evening levels.

Neighborhoods and Stress

In order to more fully understand the etiology of endocrine dysfunction, it is necessary to examine characteristics of the multiple environments in which individuals are embedded. Social structures determine, in part, the exposure of individuals to stressor as well as stress-buffering resources. Wheaton (1999) defines stressors as "conditions of threat, demands, or structural constraint that, by their very occurrence or existence, call into question the operating integrity of the organism". Both quantitative and qualitative research indicates that socioeconomically disadvantaged neighborhoods may be highly stressful to their inhabitants (Latkin & Curry, 2003; Israel et al, 2006; Frohlich et al, 2002). Individuals in these neighborhoods are disproportionately exposed to psychosocial hazards such as crime and disorder. Moreover, the resources necessary for coping with chronic stress, such as social support, are unevenly distributed across socioeconomic status (Williams & Collins, 1995). The neighborhood environment--

although perhaps more distal that other sources of chronic stress, such as individual-level socioeconomic status, family functioning, or work-related stress-- is a potentially important component of the etiology of endocrine dysfunction.

Social disorganization, crime, and signs of physical deterioration (eg vacant housing, litter, graffiti) in a neighborhood can signal to residents that their immediate environment is unsafe. For individuals living in disadvantaged neighborhoods, ambient stressors are difficult to avoid and become integrated into daily living (Matheson et al, 2006). Israel et al (2006) used focus groups to examine perceptions of neighborhoods in Detroit, MI and found that the language of "stress" emerged as meaningful across groups of participants. Common stressors reported by the focus groups included crime, deteriorated buildings, lack of trust in neighbors, gangs, inadequate services, discrimination, and job insecurity.

Gould et al (2001) outline four potential ecological stressors that may operate as causal mechanisms linking neighborhood socioeconomic disadvantage and health: neighborhood institutions and resources (i.e. transportation, social services, accessibility to parks), physical stressors (i.e. housing stock, street maintenance, litter and graffiti), social stressors (i.e. crime, distrust), and neighborhood-based social networks (i.e. social support). Identifying the specific neighborhood features and processes that link neighborhoods to health is key to developing health promoting interventions targeted at neighborhood conditions (Diez Roux, 2007).

To my knowledge, there is only one published study that examines the effects of neighborhood characteristics on cortisol (Chen & Patterson, 2006); however, they use only Census data and analyze overall mean levels of cortisol among adolescents. The authors found that lower neighborhood SES was related to lower overall cortisol exposure. The current study contributes to the literature by modeling the diurnal cortisol pattern and examining the effects of multiple neighborhood dimensions on rates of change throughout the day.

Data and Methods

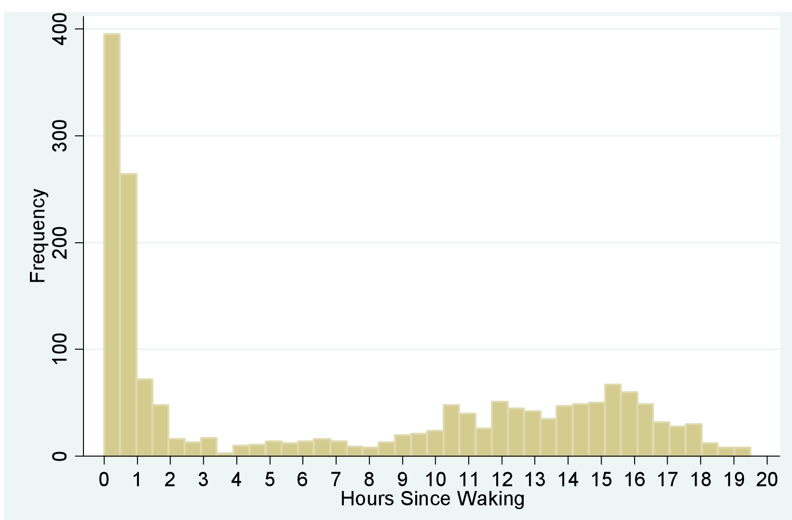
The individual-level data for this analysis come from the Chicago Community Adult Health Study (CCAHS), a multistage probability sample of 3,105 adults aged 18 or more years, living in the city of Chicago between 2001 and 2003. A representative subsample of 311 respondents provided up to four cortisol samples for each of two consecutive days. The city of Chicago is stratified into 343 neighborhood clusters as previously defined by the Project on Human Development in Chicago Neighborhoods (PHDCN) as one or more geographically contiguous census tracts aggregated based on the demographic characteristics of the population, local knowledge of the city's neighborhoods and major ecological boundaries (Sampson et al. 1997). I draw upon multiple additional data sources to obtain measures of the neighborhood environment, including systematic social observation (SSO) of participant neighborhoods, Census measures, and Uniform Crime Reports.

Measures

Cortisol

Participants were asked to collect saliva samples at waking, 30 minutes after waking, 45-60 minutes before dinner, and right before going to bed. Respondents were asked to record information on waking and sleeping times as well as the time each sample was collected. Saliva samples were returned by mail to the University of Michigan and frozen at -20C until assayed. Cortisol is measured in micrograms per deciliter (μg/dL). For the analysis, it was important that both the measure of cortisol and the collection time to be valid. 41% of respondents (n=127) collected all 8 samples. Another 39.7% of respondents (n=123) collected between 4 and 7 samples, and 19% (n=59) collected between 1-3 samples. Three participants were dropped from the analysis because of missing information on collection times and waking time. This resulted in a final sample of 308 participants, with an average number of 5.7 cortisol measures per respondent and a total of 1,747 valid observations. Figure 2 reports a histogram of the number of cortisol measures by hours since waking. The mean cortisol level was .313μg/dL(SD=.269), with a range of .0002-1.95μg/dL.

Figure 3.2: Histogram of Cortisol Collection Times



Individual-level Sociodemographic Measures

Table 1 summarizes descriptive statistics for the sociodemographic variables. Respondent *age* is included as a continuous measure. The mean age is 45.7(sd=16.9), ranging from 18 to 89. *Race/ethnicity* is constructed from the respondent's self-reports of race and Latino ethnicity into four mutually-exclusive categories: 23.2% were non-Latino white (reference), 36.6% non-Latino black, 37.3% Latino, and 2.9% non-Latino other. For *gender*, males are the reference category, and the sample was 42.4% male and 57.6% female. *Educational attainment* is measured in two categories: less than a high school degree (reference) and a high school degree or higher. 28% had less than a high school education, with the remainder (78%) having a high school degree or higher. *Family income* is measured in two categories: less than $40,000 (reference) and greater than $40,000. Because there was significant missing data on income an additional missing income category is included to retain those individuals in the analysis. 52.7% had a family income of less than $40,000 per year, 34.1% had a family income of $40,000 per year or greater, and 13.2% had missing data on family income. For both income and education, preliminary analyses suggested that initial categories (5 for income and 4 for education) could be collapsed into the above categories without loss of information.

Table 3.1. Sample Descriptive Statistics

	Mean/Proportion	SE	Min	Max
Individual-Level Measures				
Age	45.7	0.97	18	89
Sex				
Male	42.40%	0.03	0	1
Female	57.60%	0.03	0	1
Race				
White	23%	0.02	0	1
Black	37.20%	0.03	0	1
Latino	36.90%	0.03	0	1
Other	2.90%	0.01	0	1
Income				
<40K	52.40%	0.03	0	1
>40K	34.30%	0.03	0	1
Income Missing	13.30%	0.02	0	1
Education				
Less than High School	27.80%	0.03	0	1
High School or Higher	72.20%	0.03	0	1
Financial Stress	2.60	0.06	1	5
Marital Stress (n=125)	1.91	0.07	1	4.67
Sleep Difficulty	1.76	0.04	1	4
CESD	1.91	0.03	1	3.82
Anxiety	1.59	0.03	1	4
Hopelessness	1.76	0.04	1	4
Drinks per month	12.90	1.9	0	180
Current Smoker	23.3%	0.02	0	1
Physical Activity	4.08	0.08	1	6
Waist/Hip Ratio	0.87	0.01	0.68	1.18
Neighborhood Measures				
Disadvantage	-0.10	0.04	-2.06	0.99
Perceived Stressors	0.01	0.05	-1.81	2.08
Observed Stressors	-0.05	0.04	-1.05	1.65
Social Support	-0.06	0.05	-1.71	2.54
Participation	0.04	0.04	-1.56	1.27

Other Individual-Level Measures

Several theoretically relevant individual-level characteristics and behaviors were examined in separate analyses to determine their effects on diurnal cortisol patterns. Two measures of stress at the individual-level were analyzed: financial stress and marital stress. *Financial stress* is a two-item scale that includes the following questions: “How satisfied are you with your and your family’s financial situation?” and “How difficult is it for you and your family to meet the monthly payments on your bills?”. *Marital stress* is a four-item scale that includes the following questions: “How Often do you feel Bothered or Upset by your Marriage/ Relationship?”, “There is a Great Deal of Love and Affection expressed in our relationship”, “My Spouse/ Partner Doesn’t Treat Me as Well as I Deserve to be treated”, and “I Sometimes Think of Divorcing or Separating from my Spouse/ Partner”.

Depression is measured using an 11-item version of the Center for Epidemiologic Studies depression scale (CES-D). Each item in the shortened CES-D scale was scored from 1-4, with a higher score representing more depressive symptoms (Everson-Rose et al., 2004). *Anxiety* is measured using a 5-item index. Respondent were asked how often (never, hardly ever, some of the time, most of the time) they felt the following: nervous, faint, hands trembling, had fear of the worst happening, had fear of dying. *Hopelessness* is a 4-item index. Respondents were asked whether they strongly agreed, agreed, disagreed, or strongly disagreed with the following statements: “I feel it is impossible for me to reach the goals that I would like to strive for”, “The future seems hopeless to me and I can’t believe things are changing for the better”, “I don’t expect to get what I really want”, and “There’s no use in really trying to get something I want because I probably won’t get it. *Cynical hostility* is measured using the Cook-Medley Hostility Scale. Respondents were asked whether they strongly agreed, agreed, disagreed, or strongly disagreed with the following statements: “Most people inwardly dislike putting themselves out to help other people”, “Most people will use somewhat unfair means to gain profit or an advantage rather than lose it", "No one cares much what happens to you", "I think most people would lie in order to get ahead". *Sleep difficulty* is a three-item scale that measures how often (rarely or never, sometimes, often, almost every day) in the past 4 weeks the respondent had trouble falling asleep, woke up in the middle of the night and could not get back to sleep, and woke up very early and could not get back to sleep. *Physical activity* is measured as a six category index: in bed or chair, never light/moderate and never vigorous exercise, light exercise, light-moderate exercise, moderate-heavy exercise, and heavy exercise.

Measures of the number of *drinks per day* and whether the respondent is a *current smoker* were also included because of the known physiological effects of alcohol and nicotine on cortisol. *Waist/hip ratio* was used because cortisol has been linked to abdominal adiposity (although the causal connection is not well understood).

Neighborhood Measures

Neighborhood context measures included in the analysis come from several sources: U.S. Census Data, Systematic Social Observation (SSO) of the neighborhood physical environment, neighborhood resident surveys, and Uniform Crime Reports. The SSO component of the CCAHS involved trained raters that observed and rated neighborhood conditions on both sides of the streets enclosing the blocks of sampled residents. Neighborhood-cluster-level measures for each scale in the SSO were created using empirical Bayes estimation, which adjusts for missing items and improves neighborhood-level estimates by borrowing information across clusters (Mujahid et al., 2007). Survey-based measures of resident perceptions were aggregated using the same estimation techniques.

A total of 21 measures were used to construct 4 theoretically distinct neighborhood dimensions: perceived stress, observed stress, social support, and participation. Confirmatory factor analysis was performed to justify the number of measures created and the grouping of variables. All measures are standardized alpha scales with means of 0 and a standard deviation of 1. *Perceived stress* includes 5 scales from neighborhood resident surveys: perceived disorder (5 items), perceived violence (5 items), neighborhood safety (2 items), physical hazards (4 items), and the quality of neighborhood services (2 items). Observed stress includes 8 measures from the SSO, Census, and Uniform Crime Reports: homicide rate, robbery rate, burglary rate, physical disorder (9 items), physical deterioration (5 items), vacant lots, percent vacant housing, and the condition of streets. Social support includes 4 scales from neighborhood resident surveys: social cohesion (5 items), social control (5 items), intergenerational closure (5 items), and reciprocal exchange(5 items). Participation includes 4 scales from resident surveys: organizational participation (7 items), voting (2 items), civic activities (8 items), and contact with community officials (9 items).

U.S. Census data provide information on the socioeconomic composition of neighborhood clusters. A composite measure of *neighborhood socioeconomic status* was created using the following census variables: percent of families with income less than $10,000, percent of families with income greater than $50,000, percent of families below the poverty level, percent of families receiving public assistance, percent unemployed, percent of residents with 16 or more years of education, percent never married, percent female headed households, and percent in professional or managerial positions. The neighborhood SES measure is a standardized scale with a mean of 0 and a standard deviation of 1.

Analysis

As a result of the diurnal pattern of cortisol excretion, a variety of modeling techniques have been employed in the literature. The most common approaches look at overall cortisol levels, the CAR or AUC; however, the most recent research on HPA dysregulation suggest that the diurnal *pattern* is of most consequence, with dysregulated patterns of cortisol activity involving not only differences in overall levels but also in patterns of change (Van Ryzin et al, 2009). The shape of the diurnal pattern is complex and not easily captured using a polynomial function. Therefore, I will use multilevel linear splines with appropriately placed knots. Visual examination of the data suggested that spline knots be placed at 1 and 3 hours after waking.

Linear splines can be used to build a piece-wise linear function. We can imagine splitting the data points up into three groups based on time since waking using the knots k_1 and k_2 and solving three separate regression problems. However, this does not assure continuity. If we want the curve to be continuous, we can reduce the problem to straight linear regression using a simple linear combination of basis functions (Jo et al, 2007). I first start with a linear function:

$$y_{ijk} = \beta_{0ijk} + \beta_1 x_{ijk}$$

where x_{ijk} is the hour since waking for observation i for person j in neighborhood k. This function accounts for points before the first knot k_1, in this case all points between waking and 1 hour after waking. Next, I add second line that is zero up until the first knot k_1, and accounts for all points between k_1 and k_2 (3 hours after waking). Finally, I add third line that is zero up until the second knot k_2, and accounts for all points after k_2.

$$y_{ijk} = \beta_{0ijk} + \beta_1 x_{ijk} + \beta_2 (x_{ijk} - k_1) + \beta_3 (x_{ijk} - k_2)$$

$$\text{where } (z) = \begin{cases} z \text{ if } z \geq 0 \\ 0 \text{ if } z < 0 \end{cases}$$

The three-level model accounts for the clustering of cortisol measures within individuals over time, and of individuals within neighborhoods.

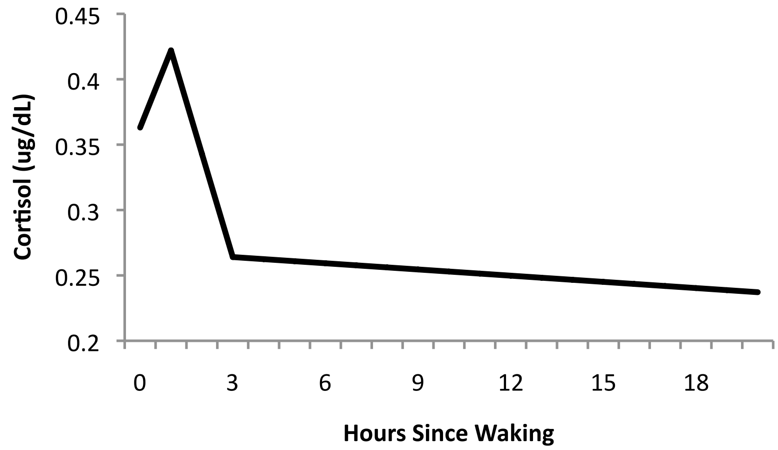
$$\beta_{0ijk} = \beta_0 + v_{0k} + u_{0jk} + e_{0ijk}$$

where,

- v_{0k} is the random effect at the neighborhood level, and $\text{var}(v_{0k}) = \sigma^2_{v0} =$ variance between neighborhoods
- u_{0jk} is the random effect at the individual level, and $\text{var}(u_{0jk}) = \sigma^2_{u0} =$ variance between individuals within neighborhoods
- e_{0ijk} is the random effect at the time level, and $\text{var}(e_{ijk}) = \sigma^2_{e0} =$ variance between time periods within individuals
- $\sigma^2_{v0} + \sigma^2_{u0}$ = the variance between individuals

Figure 3.3 shows the unconditional three-level spline model. The intercept (.36) represents the expected cortisol level at waking. Slope 1 represents the expected change in cortisol between waking and 1 hour after waking, or the CAR. Cortisol increases .059 units by 1 hour after waking, and then begins to decrease sharply at a rate of .079 units per hour between 1 and 3 hours after waking (slope 2). Levels continue to decrease at a much slower rate (.002 units per hour) throughout the day (slope 3).

Figure 3.3. Unconditional Diurnal Cortisol Pattern



Using the unconditional model, the total variance in cortisol can be decomposed into three components: between neighborhood, between individuals within neighborhoods, and within individuals.

The proportion of variance due to differences between neighborhoods is referred to as the intra-class correlation, or the ICC. The ICC represents the expected correlation between two individuals randomly selected within a neighborhood, and is calculated using the following equation (Hox, 2000):

$$\frac{\sigma_{v0}^2}{\sigma_{v0}^2 + \sigma_{u0}^2 + \sigma_{e0}^2} = \frac{.05}{.05 + .16 + .20} = .122$$

Similarly, the proportion of variance due to differences between individuals is calculated as follows:

$$\frac{\sigma_{v0}^2 + \sigma_{u0}^2}{\sigma_{v0}^2 + \sigma_{u0}^2 + \sigma_{e0}^2} = \frac{.05 + .16}{.05 + .16 + .20} = .512$$

An ICC of 12.2% is relatively large in the neighborhood effects literature, which rarely finds ICCs greater than 10 percent for health outcomes (Morenoff, 2003).

Results

I begin by reporting the overall mean cortisol levels, mean morning levels (within the first hour after waking), and mean evening levels (more than 12 hours after waking) for categories of independent variables (Table 3.2). The overall cortisol level averaged throughout the day for the full sample was .31 ug/dL (SD=.19). As expected, levels were higher in the morning (.37 ug/dL, SD=.26) and lower in the evening (.27 ug/dL, SD=.25).

Table 3.2. Cortisol Levels by Independent Measures

	Mean Cortisol		Mean Morning Level <1 hour since waking		Mean Evening Level >12 hours after waking	
Total Sample	0.31 (0.19)		0.38 (0.26)		0.27 (0.25)	
Individual Measures						
Sex						
Male (reference)	0.33 (0.19)		0.40 (0.27)		0.30 (0.27)	
Female	0.29 (0.18)	*	0.36 (0.24)		0.25 (0.24)	
Race						
White (reference)	0.30 (0.18)		0.36 (0.24)		0.27 (0.26)	
Black	0.33 (0.19)		0.42 (0.28)		0.25 (0.22)	
Latino	0.29 (0.19)		0.34 (0.23)		0.29 (0.29)	
Other	0.34 (0.16)		0.42 (0.21)		0.28 (0.2)	
Income						
>40K (reference)	0.30 (0.19)		0.36 (0.23)		0.27 (0.25)	
<40K	0.33 (0.2)	*	0.42 (0.31)		0.25 (0.22)	
Income Missing	0.29 (0.16)		0.30 (0.13)		0.33 (0.38)	
Education						
High School or Higher (reference)	0.33 (0.19)		0.40 (0.26)		0.27 (0.23)	
Less than High School	0.26 (0.18)	**	0.30 (0.22)	**	0.28 (0.31)	
Neighborhood Measures						
Disadvantage						
Tertile 1 (reference)	0.34 (0.19)		0.44 (0.28)		0.26 (0.24)	
Tertile 2	0.30 (0.2)	+	0.35 (0.26)	*	0.26 (0.23)	
Tertile 3	0.29 (0.17)	+	0.34 (0.22)	*	0.30 (0.29)	
Perceived Stressors						
Tertile 1 (reference)	0.33 (0.2)		0.40 (0.29)		0.26 (0.22)	
Tertile 2	0.31 (0.2)		0.40 (0.25)		0.26 (0.25)	
Tertile 3	0.28 (0.16)	+	0.32 (0.21)	*	0.29 (0.28)	+
Observed Stressors						
Tertile 1 (reference)	0.32 (0.2)		0.40 (0.27)		0.26 (0.22)	
Tertile 2	0.31 (0.2)		0.39 (0.28)		0.26 (0.25)	
Tertile 3	0.29 (0.17)		0.34 (0.21)		0.30 (0.29)	
Social Support						
Tertile 1 (reference)	0.31 (0.18)		0.37 (0.26)		0.31 (0.28)	
Tertile 2	0.30 (0.17)		0.37 (0.22)		0.25 (0.2)	
Tertile 3	0.32 (0.21)		0.39 (0.28)		0.26 (0.21)	
Participation						
Tertile 1 (reference)	0.32 (0.2)		0.40 (0.28)		0.27 (0.28)	
Tertile 2	0.31 (0.19)		0.36 (0.25)		0.28 (0.27)	
Tertile 3	0.29 (0.18)		0.37 (0.24)		0.26 (0.22)	

+ p<.10, * p<.05, ** p<.01

An interesting pattern emerges among the socioeconomic and neighborhood measures. The overall mean cortisol levels for objectively more disadvantaged categories are consistently lower than the overall mean levels for less disadvantaged groups. For example, the mean cortisol level for respondents with an income of less than $40,000 is .30 ug/dL (SD=.19) compared to .33 ug/dL (SD=.2) for respondents with an income greater than $40,000. Similarly, for respondent without a high school degree and respondents with a high school degree or higher, the mean cortisol levels are .26 (SD=.18) and .33(SD=.19) respectively.

The five continuous neighborhood measures were split into tertiles for the purposes of descriptive analyses. Again, we can see that overall cortisol levels are slightly higher is less disadvantaged neighborhoods, with the exception of neighborhood participation. This pattern holds true for morning cortisol levels; less disadvantaged groups have lower average cortisol levels in the first hour of waking. However, when we look at evening cortisol levels (more than 12 hours after waking), the pattern is reversed. Respondents in the most disadvantaged neighborhood tertiles have higher evening levels of cortisol. This results in a smaller daily cortisol range among disadvantaged groups that is characterized by low morning levels and high evening levels, suggesting a blunted pattern. These descriptive means underscore the importance of examining the patterns of change throughout the day.

Table 3.3 reports the results of spline models with individual-level characteristics interacted with each spline slope. There were no significant effects of age, race, or income on cortisol waking levels or on rates of change throughout the day. Respondents with a high school degree or higher had significantly higher waking levels of cortisol than respondents with less than a high school education; however, education did not affect the slope coefficients. Individual sociodemographics were kept in the subsequent neighborhood models as main effects, but were not interacted with the spline slopes.

Table 3.3. Individual-Level Sociodemographics and Spline Slopes

	Waking			Slope 0-60 Min		Slope 60-180 Min			Slope 180+ Min	
Constant	0.415	(0.045)	**	0.051	(0.049)	-0.064	(0.031)	*	-0.007	(0.004)
Age	0.000	(0.001)		0.001	(0.001)	-0.001	(0.001)		0.000	(0.000)
Female	-0.035	(0.031)		0.042	(0.046)	-0.041	(0.026)		0.002	(0.004)
Race (White reference)										
Black	-0.018	(0.038)		-0.046	(0.057)	0.018	(0.033)		0.004	(0.004)
Latino	0.004	(0.043)		-0.014	(0.062)	0.020	(0.035)		-0.004	(0.005)
Other	0.005	(0.089)		-0.020	(0.131)	0.031	(0.097)		-0.009	(0.015)
Income (>40k Reference)										
<40K	-0.043	(0.034)		0.015	(0.05)	-0.002	(0.029)		0.004	(0.004)
Income Missing	-0.089	(0.055)		0.070	(0.083)	0.018	(0.047)		0.001	(0.007)
Less than High School Education	-0.066	(0.038)	+	-0.022	(0.054)	-0.006	(0.03)		0.005	(0.004)

+ p<.10, * p<.05, ** p<.01

Table 3.4 introduces the neighborhood measures and their slope interactions. There were no significant effects of any neighborhood measures on waking levels of cortisol. Neighborhood SES had no significant effects on the rate of cortisol change throughout the day. Neighborhood perceived and observed stress had significant effects on the slope from 3 hours onward, such that respondents who live in neighborhoods characterized by high levels of both perceived and observed stress experience a slight increase in cortisol throughout the day and into the evening. By contrast, respondents in low stress neighborhoods experience a decline in cortisol, consistent with the expected rate of change for a normal diurnal pattern. Figure 5 shows the predicted diurnal patterns from waking to 20 hours past waking for respondents with high (one standard deviation above the mean), medium (mean), and low (one standard deviation below the mean) levels of perceived neighborhood stress.

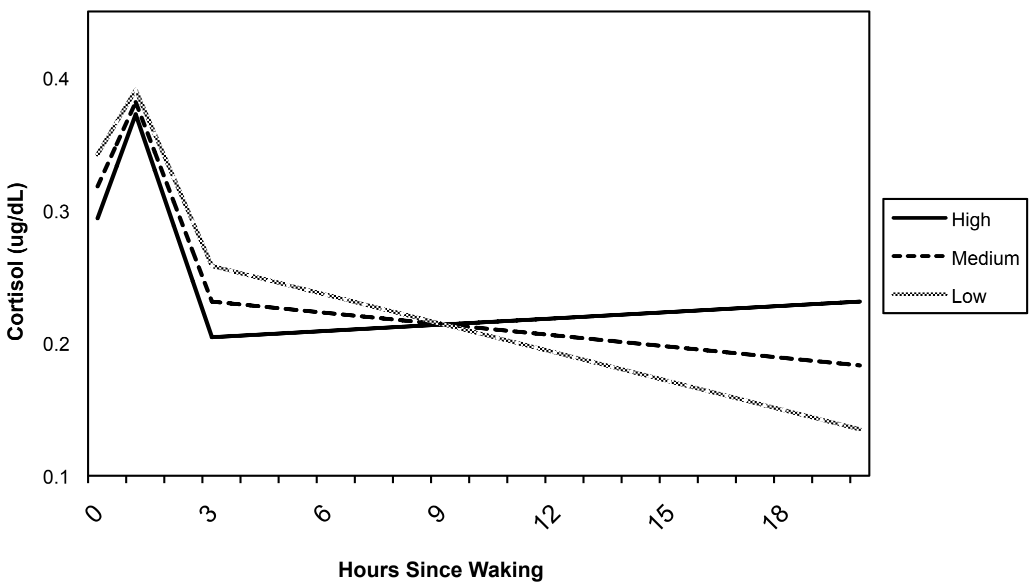
Table 3.4. Multilevel Spline Models Predicting Cortisol

	1			2			3			4			5		
Waking Level	0.398	(.043)	**	0.395	(.041)	**	0.395	(.042)	**	0.402	(.041)	**	0.394	(.041)	**
Slope 1 (0-60 Min)	0.063	(.03)	**	0.061	(.022)	**	0.060	(.022)	**	0.060	(.022)	**	0.062	(.022)	**
Slope 2 (60-180 Min)	-0.077	(.013)	**	-0.074	(.013)	**	-0.076	(.013)	**	-0.077	(.012)	**	-0.078	(.012)	**
Slope 3 (180+ Min)	-0.002	(.002)	+	-0.003	(.002)		-0.002	(.002)		-0.001	(.002)	*	-0.002	(.002)	*
Age	0.001	(.001)		0.001	(.001)		0.001	(.001)		0.001	(.001)		0.001	(.001)	
Female	-0.042	(.023)	+	-0.042	(.022)	+	-0.041	(.023)		-0.040	(.023)		-0.040	(.023)	
Race (White reference)															
Latino	-0.003	(.034)		0.004	(.034)		-0.001	(.033)		-0.004	(.032)		-0.007	(.033)	
Black	-0.013	(.068)		-0.006	(.029)		-0.008	(.031)		-0.009	(.028)		-0.003	(.028)	
Other	-0.025	(.039)		-0.024	(.068)		-0.022	(.068)		-0.022	(.068)		-0.022	(.068)	
Income (>40k Reference)															
<40K	-0.013	(.026)		0.008	(.026)		-0.012	(.026)		-0.011	(.025)		-0.014	(.025)	
Income Missing	-0.012	(.036)		0.001	(.036)		-0.011	(.036)		-0.011	(.038)		-0.012	(.038)	
Less than High School Education	-0.063	(.027)	*	-0.061	(.027)	*	-0.061	(.028)	*	-0.061	(.027)	*	-0.066	(.028)	*
<u>Neighborhood Measures</u>															
SES	-0.021	(.025)													
SES x Slope 1	0.019	(.032)													
SES x Slope 2	-0.007	(.019)													
SES x Slope 3	0.004	(.003)													
Percieved Stress				-0.025	(.019)										
Percieved Stress x Slope 1				0.016	(.026)										
Percieved Stress x Slope 2				-0.020	(.014)										
Percieved Stress x Slope 3				0.005	(.002)	*									
Observed Stress							-0.013	(.028)							
Observed Stress x Slope 1							-0.010	(.035)							
Observed Stress x Slope 2							-0.010	(.02)							
Observed Stress x Slope 3							0.005	(.003)	*						
Social Support										0.011	(.017)				
Social Support x Slope 1										-0.007	(.024)				
Social Support x Slope 2										0.021	(.013)				
Social Support x Slope 3										-0.003	(.002)	*			
Participation													-0.020	(.024)	
Participtation x Slope 1													-0.055	(.032)	+
Participation x Slope 2													0.035	(.018)	+
Participation x Slope 3													-0.004	(.002)	
σ^2_{v0}	0.050	(.019)	**	0.051	(.019)	**	0.051	(.019)	**	0.050	(.019)	**	0.048	(.02)	**
σ^2_{u0}	0.159	(.01)	**	0.159	(.01)	**	0.159	(.01)	**	0.159	(.01)	**	0.159	(.01)	**
σ^2_{e0}	0.197	(.004)	**	0.197	(.004)	**	0.197	(.004)	**	0.197	(.004)	**	0.197	(.004)	**

+ p<.10, * p<.05, ** p<.01

Similarly, neighborhood social support had a significant and negative effect on the slope from 3 hours onward. Respondents in neighborhoods with higher levels of social support experience a steeper decline in cortisol than respondents in neighborhoods with lower social support. As with neighborhood perceived and observed stress, this results in a flatter daytime and evening curve for more disadvantaged neighborhoods. Figure 4 shows predicted diurnal patterns for respondents with high, medium and low levels of neighborhood social support.

Figure 3.4. Diurnal Cortisol and Perceived Neighborhood Stressors



Neighborhood participation appears to have a marginally significant effect on the CAR and the rate of decline from 1 to 3 hours after waking. Respondents in neighborhoods with higher levels of participation experience a lower CAR and, subsequently, a less steep decline from 1 to 3 hours. There is no significant effect of neighborhood participation on the rate of change into the evening, although the slope is flatter for respondents in neighborhoods with low participation.

Figure 3.5. Diurnal Cortisol and Neighborhood Social Support

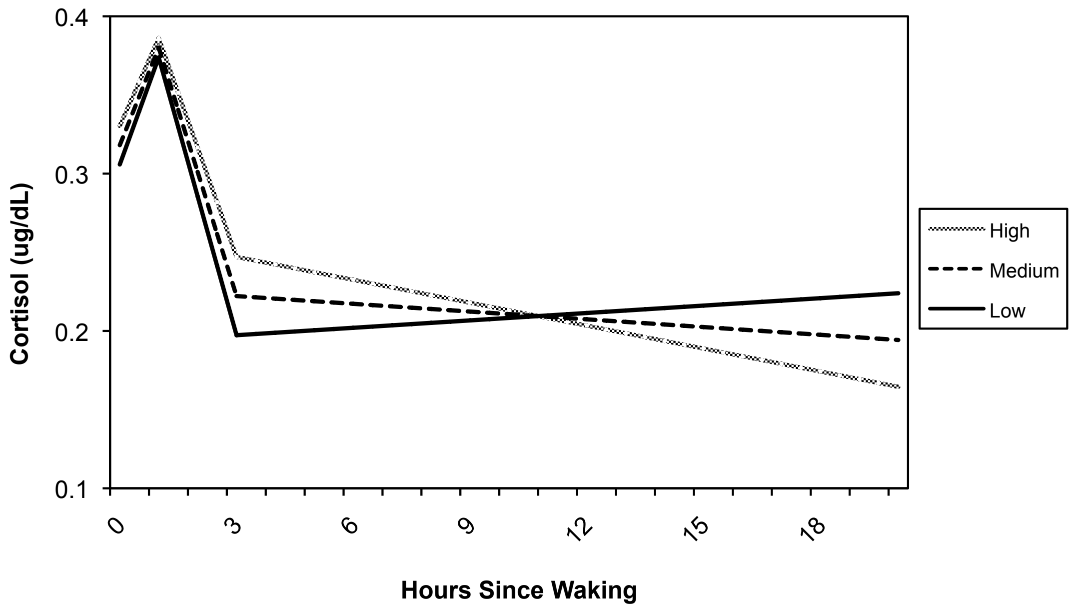


Figure 3.6. Diurnal Cortisol and Neighborhood Participation

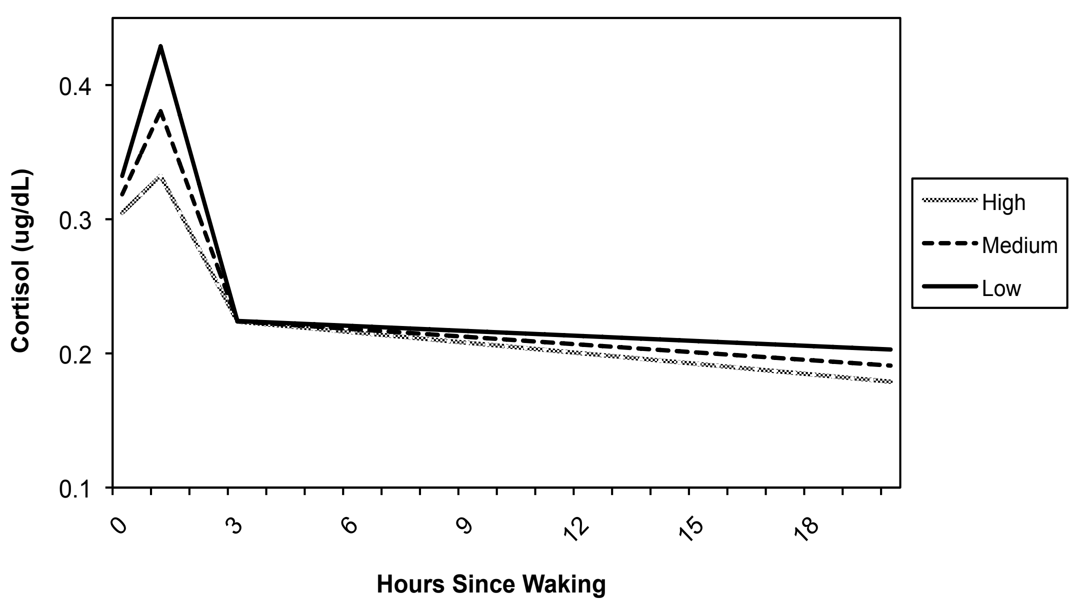


Table 5 shows parameter estimates for the other individual-level measures, adjusted for sociodemographics. Depression and drinks per day had a positive effect on cortisol waking levels. Brandtstadter et al (1991) and Chen & Patterson (2006) similarly found a positive relationship between education and mean levels of cortisol. In a review of the literature on cortisol, Gunnar & Vazquez (2001) state that one of the most robust phenomena in biological psychiatry is the association of major depression with elevated basal levels of cortisol in adults. The authors found that early morning cortisol levels are elevated among depressed individuals, and that levels remain high throughout the day.

The only measure that had a significant effect on the diurnal pattern was physical activity, with higher levels of physical activity resulting in a less steep decline from hours 1 to 3, and then a higher rate of decline from hour 3 onward. The mediating effect of physical activity on the neighborhood measured was tested in separate models (not shown), and physical activity did not attenuate the neighborhood effects.

Table 3.5. Individual Non-Sociodemographic Measures and Spline Slopes

	Waking			Slope 0-60 Min		Slope 60-180 Min		Slope 180+ Min		
Constant	0.311	(0.052)		0.104	(0.047)	-0.116	(0.029)	-0.001	(0.004)	
Financial Stress	-0.025	(0.03)		0.062	(0.045)	-0.045	(0.027)	0.002	(0.004)	
Marital Stress	-0.005	(0.037)		0.032	(0.059)	0.012	(0.036)	-0.002	(0.005)	
Sleep Difficulty	-0.033	(0.041)		-0.034	(0.061)	0.021	(0.037)	-0.001	(0.006)	
CESD	0.21	(0.076)	**	-0.043	(0.123)	-0.088	(0.068)	0.009	(0.009)	
Anxiety	-0.094	(0.065)		-0.142	(0.102)	0.006	(0.056)	-0.002	(0.007)	
Hopelessness	-0.048	(0.04)		0.014	(0.056)	0.015	(0.031)	0.002	(0.004)	
Drinks per day	0.002	(0.001)	*	-0.001	(0.001)	0.001	(0.001)	0.000	(0.001)	
Current Smoker	-0.027	(0.075)		-0.076	(0.113)	0.102	(0.065)	-0.001	(0.001)	
Physical Activity	-0.007	(0.019)		0.003	(0.031)	0.026	(0.018)	-0.005	(0.002)	*
Waist/Hip Ratio	0.359	(0.369)		0.41	(0.546)	-0.036	(0.347)	0.025	(0.046)	

+ p<.10, * p<.05, ** p<.01

Discussion/Conclusion

Although neighborhood socioeconomic status was not significantly related to the diurnal cortisol patterns of respondents, neighborhood social and physical characteristics were found to influence rate of decline in the afternoon/evening. Respondents in neighborhoods with high levels of both perceived and observed stressors, and low levels of social support, experienced a flatter rate of decline throughout the day. In addition, overall mean cortisol levels were found to be lower in high stress, low support neighborhoods.

The results of this study challege the dominant paradigm in the sociological literature is that elevated cortisol levels are a lynchpin mechanism linking disadvantage to poor health. This paradigm posits that disadvantaged individuals are exposed to a greater number and intensity of stressful experiences, chronically activating the HPA axis. Long-term exposure to these elevated cortisol levels is hypothesized to make the body more vulnerable to disease. However, there is very little empirical evidence regarding the effects of long-term exposure to stress on HPA functioning. This study adds to the growing evidence of hypocortisolism among chronically stressed adult populations.

Further research is necessary to determine the etiology of these blunted cortisol profiles. It is possible that blunted patterns are adaptive, serving as a protective factor against chronic exposure to stressful environments. Alternatively, the observed blunted patterns could be a marker of stress exposure in early childhood. DeSantis et al (2007) argue that adverse early childhood experiences (and even prenatal stress exposure) may permanently alter physiological responses to subsequent stressors. The biological programming hypothesis (Barker, 1998) asserts that adverse conditions associated with poverty can influence the development of organ systems during crucial developmental stages in utero and infancy that render individuals more susceptible to illness as children and throughout life. Lupien et al (2005) posit that under conditions of chronic stress individuals can transition from hypercortisolism to hypocortisolism, and that this transition may often occur in infancy or childhood.

Fewer studies have looked at cortisol patterns among infants and young children, but a review of the literature suggests that the relationship between SES and elevated cortisol is much more robust among young children compared to adults. In 366 infants aged 12–20 months from the Generation R Study, both the AUC and the CAR were positively related to indicators of social disadvantage and early adversity. Moreover, infants of mothers experiencing parental stress had higher AUCs (Saridjan et al, 2010). In a group of young children with histories of trauma, Carrion et al (2002) found elevated cortisol levels when compared with a control group. Lupien et al (2005) found significantly higher cortisol levels among low SES compared to high SES children under the age of 10, but no differences among children from age 10-16.

It is possible that early exposure to chronic stress results in frequent elevations in cortisol during infancy and childhood that then cause future down-regulation. Saridjan et al (2010) argue that early life events may modify the maturation of the HPA axis. This is in line with the model posited by Krieger (2001) and Diez Roux (2007) that social factors are not merely "downstream" from biological factors. Rather, social factors are capable of shaping the development of biological systems. Diez Roux (2007) cites an example of experimental research on mice, in which Meaney (2001) shows that early stress exposure is associated with permanent changes in gene expression in regions of the brain that participate in the stress response. Clearly, more research is needed to understand how early exposure can modify endocrine function later in life. In addition, we need a better understanding of the health consequences of different forms of endocrine dysfunction.

The current analysis has several weaknesses. First, the number of cortisol samples collected per person is relatively small given the complexity of the diurnal pattern. Future research should collect more samples across day, allowing for more sophisticated modeling strategies, such as latent growth curve analysis, that can identify different patterns of dysregulation. Second, longitudinal analyses (beginning in infancy) could contribute to our understanding of HPA development. The cross-sectional nature of the current analysis makes it impossible to determine if the observed blunted profile for residents of high stress/ low support neighborhoods is the result of current stress responses or modified endocrine functioning from early stress exposure.

While the endocrine system has been hypothesized as a key mechanism in the relationship between disadvantage and health, there exists a great deal of uncertainty concerning both the antecedents and consequences of endocrine dysfunction. As such, the current emphasis on cortisol per se as a lynchpin mechanism seems premature. However, the evidence is mounting that environmental factors are inextricably linked with biological processes, and future research on endocrine functioning will have to take seriously the effects of the social and physical environment.

The current analysis is the first to examine the effect of neighborhood characteristics on cortisol patterns. The results suggest that future data collection efforts and analyses should focus on identifying and explaining deviations from normal HPA activity.

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Chapter 4

Neighborhoods and Obesity: Gendered Responses to Neighborhood Environments

The prevalence of obesity (BMI>30) in the US has doubled over the past three decades, and recent data shows that almost 34% of the population is obese (Flegal et al, 2010). Overweight and obesity have been linked to numerous adverse health outcomes such as type II diabetes, hypertension, cardiovascular disease, as well as psychosocial outcomes such as depression (Harrington & Elliot, 2009). In 2001, national medical costs attributable to adult overweight and obesity were estimated at $4.3 billion (Katzmarzyk & Janssen, 2004).

Racial and socioeconomic disparities in adult obesity have been well-documented. According to recent estimates, about 44% of blacks and 39% of Hispanics are obese, compared to 32% of whites (Flegal et al, 2010). 36% of individuals living below the poverty line are obese, compared to about 27% of individuals whose income is four times the poverty level or higher (Braveman et al, 2010). Although income disparities persist, educational disparities among the general population have shrunk over the past few decades due to the dramatic increases in the prevalence of obesity among the entire population and, particularly, among higher educated individuals (Zhang & Wang, 2004; Braveman et al, 2010).

Although it has been widely accepted that disadvantaged groups are at increased risk of obesity, a number of more recent studies have uncovered a complex relationship between gender, race, SES, and obesity among US adults (Wang & Beydoun, 2007; Ross et al., 2007; Matheson et al, 2008). Racial and socioeconomic disparities in BMI are greater for women than for men; 78.2% of black women are overweight (BMI>25), compared to 61.2% of white women. 68.5% of black men are overweight compared to 72.6% of white men (Flegal et al, 2010). Socioeconomic disparities are also greater among women (Zhang & Wang, 2004).

Until recently, research on overweight and obesity has focused primarily on identifying individual-level risk factors. However, there is a growing recognition that individual characteristics and health behaviors are influenced by larger social and physical environmental factors (Harrington & Elliot, 2009; Ball et al, 2006), and that these environmental factors have played a pivotal role in fueling the obesity epidemic (Wang & Beydoun, 2007). Neighborhoods have garnered attention because racial and socioeconomic disparities in obesity may be fully or partially explained by inequalities in social and physical neighborhood environments (Browning & Cagney, 2003). However, research on neighborhoods and obesity has failed to adequately explain the gendered nature of racial and socioeconomic disparities.

In this paper I take an ecologically informed approach to explaining gender differences in social disparities. I first outline the commonly theorized dimensions of "obesogenic" neighborhood environments, and then present theoretical perspectives on the potential gendered effects of neighborhood on health behavior and obesity. I then use multilevel analyses to examine neighborhood influences on BMI and waist size. I examine the extent to which men and women respond differently (in terms of weight status) to various neighborhood factors by testing the moderating role of gender in multilevel models.

Neighborhoods and Obesity

Residents of disadvantaged neighborhoods are exposed to a variety of environmental factors that have the potential to influence BMI, making these environments more “obesogenic” (Black and Macinko, 2008; Wang & Beydoun, 2007). Within these neighborhoods, access to healthy foods and modes of physical activity is often restricted. In addition, disadvantaged neighborhoods are often characterized by the presence of stressors such as physical deterioration, crime, and lack of social support (Burdette & Hill, 2008). Figure 1 presents a theoretical model outlining six commonly theorized dimensions of obesogenic neighborhood environments: 1) stressors and hazards, 2) land use, 3) access to parks and recreational facilities, 4) access to healthy foods, 5) social support, and 6) the normative environment.

Disadvantaged neighborhoods are home to a variety of environmental stressors, including vacant housing, crime, litter and graffiti, and deterioration of the local infrastructure. Social and physical disorder in neighborhoods may be sources of daily stress for residents, and may affect BMI via both behavioral and metabolic pathways. Disorder inspires fear not only by signaling a lack of regard for public order but also by indicating that law enforcement is limited in its ability to maintain order (Chang et al, 2009). Several studies have found an association between fear of crime, physical activity and BMI (Stafford et al, 2007; Cecil-Karb & Grogan-Kaylor, 2009; Burdette & Hill, 2008; Chang et al, 2009). The stress caused by neighborhood crime and disorder could also negatively affect eating behaviors (Zick et al, 2009). Although it remains untested, it is widely believed that stressful neighborhoods can influence obesity by chronically activating neuroendocrine systems, which can lead to overexposure to stress hormones such as cortisol that are known to contribute to fat accumulation.

Some researchers (e.g. Browning & Cagney, 2003, Cohen et al, 2006; Giles-Corti, 2006) have posited that neighborhood social support structures may be relevant to obesity outcomes. Individual-level social support has been consistently linked to morbidity and mortality because it can facilitate healthier behaviors such as exercise and eating well (Uchino, 2006). Cohen et al (2006) found that high levels of collective efficacy in a neighborhood predicted lower BMI. The authors argue that social interactions with neighborhoods can be beneficial in and of themselves, and can also serve as a means of discouraging negative health behaviors. Distinct from individual social support, neighborhood-level social support can serve to cultivate and enforce local norms of health behavior and body image.

However, some researchers (eg Portes, 2004) have warned against a ameliorative view of social support because not all types of support networks transmit healthful behaviors. Wilson (1996) has argued that a combination of concentrated poverty and immobility has resulted in increased social and spatial isolation of poor neighborhoods from mainstream influence. In these contexts, "health-related subcultures" may emerge that are characterized by a tolerance for risky lifestyles and detachment from "mainstream" norms and values (Browning & Cagney, 2003). Disadvantaged communities may experience the normative transmission of health compromising behavior, such as poor diet and lack of exercise. Such "health compromising" behavior may be an accepted (and adaptive) method of coping with community disadvantage, poverty, and crime (Browning & Cagney, 2003). In addition, local norms regarding body image and health behaviors may also contribute to neighborhood disparities in obesity. Boardman et al (2005) find that the prevalence of obesity in a neighborhood is predictive of a individual's obesity, suggesting that local norms influence either body image and/or health behaviors related to obesity.

Recent work has examined the effect of the land use on walking and exercise. In a review of neighborhood effects on obesity, Black and Macinko (2007) found that features of the environment that discourage physical activity—such as land use, aesthetics, and transportation systems—were consistently associated with increased body mass index. In a study of elderly adults, Michael et al (2006) found that concerns about traffic and inadequate pedestrian infrastructure limit walking by making older adults feel unsafe. In addition, a neighborhood's overall sense of attractiveness, including gardens, buildings, and streets, encourages walking for exercise and pleasure (Michael et al, 2006).

Mixed land use appears to consistently promote walking among residents; those who can easily walk from home to commercial areas demonstrate lower BMI and increased walking and physical activity (Black & Macinko, 2007). Black et al (2010) found that the percent of commercial land use was negatively associated with obesity, while residential land use predicted higher rates of obesity (Black et al, 2010). However, the relationship between the built environment, health behaviors, and obesity may not be straightforward. For example, Lovasi et al (2009) found that the association between the built environment (measured by mixed land use, population density, and public transportation) was strongest among respondents with higher levels of income and education, and within more advantaged areas. This suggests that the built environment may not be sufficient to promote activity within disadvantaged neighborhoods, possibly because of overriding fear of safety or the impact of the normative environment (Lovasi et al, 2009).

Neighborhood access to healthy foods and places to walk and exercise can influence the daily behaviors of individuals. In a review of the literature on built environments, Sorensen et al (2003) found that middle-class neighborhoods have proportionally more pharmacies, restaurants, and specialty stores compared to low-income neighborhoods, which have more fast-food restaurants, check-cashing stores, and liquor stores. There are four times as many people per food market in poor neighborhoods, and the typical food purchases are more costly (Sorensen et al, 2003). Frumkin (2005) found that in poor neighborhoods with a high percentage of minorities, junk food, soda and cigarettes are more readily available in stores, while fresh produce is both scarce and expensive. In a separate review of behavioral correlates of built environment characteristics, Lovasi et al (2009) find that disadvantaged groups were living in worse environments with respect to food stores, places to exercise, aesthetic problems, traffic, and crime-related safety.

Evidence of gender differences in the relationship between neighborhoods and obesity

Neighborhoods have been tapped as a potential explanation for well-documented racial and socioeconomic disparities in obesity. However, it is unclear if or how neighborhoods may help to explain larger social disparities among women. Recently, a small handful of studies have suggested that neighborhood disadvantage may be responsible for gender differences in BMI and obesity (Matheson et al, 2008). Most studies of neighborhood effects on BMI or waist size have not examined the moderating role of gender. Among the few that have, evidence suggests that neighborhood disadvantage is strongly related to obesity for women, but has no effect (King et al 2006; Robert & Reither, 2004; Harrington & Elliot, 2009; Mujahid et al, 2005) or a negative effect (Matheson et al, 2008) for men. Ross et al (2007) found that urban sprawl was significantly associated with increased BMI among men but not among women. Chang et al (2009) found that high black racial isolation is associated with higher BMI for women but not men, and that this relationship is partly mediated by physical disorder. Even among these studies, there is little theoretical attention paid to reasons for gender differences in neighborhood effects. To my knowledge, there are no other studies that have examined gender-specific effects of non-socioeconomic neighborhood characteristics.

Theoretical Perspectives on Gender and Neighborhoods

Neighborhood factors that have the potential to help explain gender differences in racial and socioeconomic disparities must be both related to obesity and differentially distributed by race and SES. Moreover, there must be gender differences in the relationship between these factors and obesity *or* gender differences in the way these factors are distributed across racial or SES groups. While it is clear that neighborhoods are segregated by race and individual SES, there is little evidence that this segregation is greater for women than for men. Therefore, a more likely explanation is that women and men respond differently to at least some aspects of the neighborhood environment.

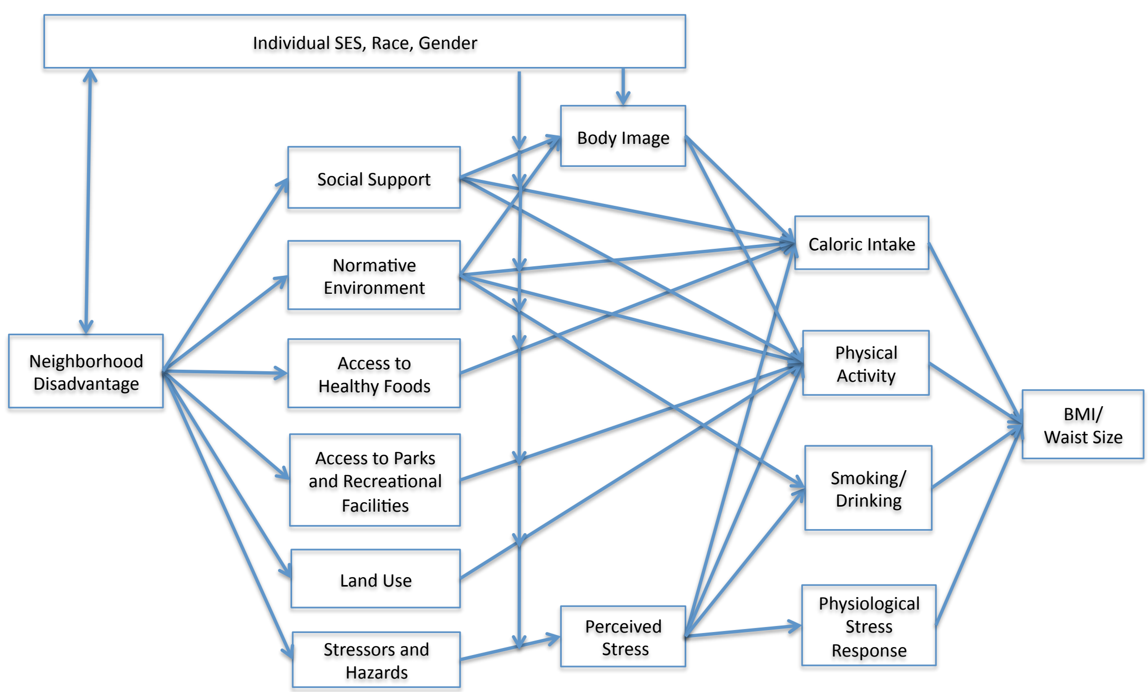
Neighborhood disorder may precipitate a greater quantity, or perhaps different quality, of psychological stress among women. Moreover, coping responses to stress are known to vary by sex. In a randomized study, Grunberg & Straub (1992) found that stress significantly decreased food consumption among men but resulted in increased food consumption by women. Moreover, stressed women ate almost twice as much sweet food compared to non-stressed women. Men, on the other hand, are more likely to engage in substance abuse in response to stress (Matheson et al, 2008), which can be associated with weight loss.

Women may also be more likely to restrict their outdoor activity in response to crime and fear, and this adaptive sedentary behavior may become the norm, resulting in fewer social cues and less social pressure to exercise. By contrast, men may be inclined to engage in "street life" and develop a "hypermasculine" identity in the face of crime or disorder (Bourgois, 1996; Courtenay, 2000). For men, physical dominance and violence are resources that can be called upon to negotiate and sustain masculinity, particularly when access to other forms of power (racial, economic) is restricted (Courtenay, 2000). Barroso et al (2010) suggests that for women obesity may be a protective factor in unsafe neighborhoods. Using focus groups, the authors found that many women claimed that "people leave you alone when you are bigger". Since there is less general societal pressure for men to be thin, in the absence of environmental stressors or a built environment that encourages walking and physical activity, men may be at higher risk of obesity.

Relatedly, the normative environment within a neighborhood may prescribe different norms for body image among men and women. What constitutes a desirable body weight differs significantly for men and women, and also varies by race (McCreary & Sadava, 2001). Several qualitative studies report that blacks tolerate large body sizes and view the meaning of large body size differently from whites. A study of 9-10 year-old white and African American girls reported that African American girls with a "normal" weight were more likely to receive maternal messages that they were underweight than white girls (Mavoa et al, 2010). Barroso et al (2010) found that black men found excess body weight among women attractive because it is related to a perceived skill in self-protection. These racial norms may be more salient in racially segregated neighborhoods. Lovejoy (2001) argues that black women in segregated communities may find more support for resisting the dominant culture's call for thinness.

Figure 4.1 presents a theoretical model of the neighborhood pathways to obesity, including the moderating effects of gender.

Figure 4.1: Theoretical Model of Neighborhood Pathways to BMI/Waist Size



Data and Methods

Data Sources

I analyze data from the Chicago Community Adult Health Study (CCAHS), a multistage probability sample of 3,105 adults aged 18 or more years, living in the city of Chicago between 2001 and 2003. The city of Chicago is stratified into 343 neighborhood clusters (NCs), previously defined by the Project on Human Development in Chicago Neighborhoods (PHDCN) as one or more geographically contiguous census tracts aggregated based on the demographic characteristics of the population, local knowledge of the city's neighborhoods and major ecological boundaries (Sampson et al. 1997). One adult aged 18 or over was interviewed from each sampled home, with a final response rate of 72%. Subjects were oversampled from 80 focal neighborhood clusters, defined by the PHDCN and chosen due to their socioeconomically and racially-ethnically heterogeneous composition. The sample had an average of 9.1 subjects per neighborhood cluster (range: 1-21). Respondents in the CCAHS completed a community survey (CS) which was used to create NC-level measures of the social and physical environment.

I draw upon additional data sources to characterize the neighborhood environment, including systematic social observation (SSO) of participant neighborhoods, Census measures, and Uniform Crime Reports. The SSO component of the CCAHS involved trained raters that observed and rated neighborhood conditions on both sides of the streets enclosing the blocks of sampled residents. There were 6631 observations at the street level, with an average of 19.4 observations per NC. NC-level measures for each scale in the SSO were created using empirical Bayes estimation, which adjusts for missing items and improves neighborhood-level estimates by borrowing information across clusters (Mujahid et al., 2007). CS measures of resident perceptions were aggregated using the same estimation techniques as the SSO.

Sample weights were used in individual-level analyses to handle differential rates of selection and participation by neighborhood cluster. The sample weight was constructed as a multiplicative combination of three weights adjusting for oversampling of individuals in focal neighborhood clusters, whether a participant was selected for intensive non-response follow-up at the end of the survey, and a post-stratification weight. The weight was centered to have a mean of 1.0 (range: 0.2-5.4) (Morenoff et al., 2007).

Individual-Level Measures

BMI and Waist Size

Biometric measurements of each respondent were taken by trained interviewers. Respondent height and weight were used to calculate BMI by dividing weights (in kilometers) by height (in meters) squared. Waist and hip measurements were also collected in both centimeters and inches. Multivariate imputation techniques were used in cases of missing data.

Health Behaviors

Physical activity is measured using a four item index. Respondents are placed in one of six categories: unable to exercise, never exercise, light exercise, light to moderate exercise, moderate to heavy exercise, heavy exercise. I use a condensed categorical version of the index without loss of information: unable to exercise, never exercise, light and light to moderate, moderate to heavy exercise, and heavy exercise.

I measure *walking* behavior with the following question "On average, over the past year, how many days a week do you walk continuously 20 minutes or more, either to get somewhere or just for exercise or pleasure?" Response categories were: unable to walk, never, less than once a week, once a week, 2 to 3 times a week, 4 to 5 times a week, or almost everyday. Again, I use a condensed categorical version of the variable with four categories: never=1, once a week or less=2, 2-5 times a week=3, and almost every day=4.

Diet is measured by fruit and vegetable intake. Respondents were asked the following question: "How many servings of fruit or vegetables do you usually eat in a day?" Responses ranged from 0 to 20 daily servings, and were categorized as follows: 0 to 1 servings = 1, 2 to 3 servings = 2, and 4 or more servings = 3. *Alcohol consumption* is measured in drinks per month and categorized as follows: never drinks=1, 1-12 drinks per month=2, 13-89 drinks per month=3, 90 or more drinks=4. A dummy variable indicating whether the respondent is a current smoker is also included.

<u>Individual-Level Covariates</u>

Age is categorized into 6 groups (18-29, 30-39, 40-49, 50-59, 60-69, 70 and over) with the youngest age group used as the omitted category. *Race/ethnicity* is constructed from the respondents' self-reports and contains four mutually-exclusive categories: non-Hispanic white (reference), Hispanic, non-Hispanic black, Latino, and non-Hispanic other. *Immigrant status* distinguishes between 1^{st}, 2^{nd}, and 3^{rd}+ (reference) generation immigrants. For *gender*, males are the reference category. *Educational attainment* is measured in four categories: less than a high school degree, high school degree, some college, and college degree or higher. *Family income* is measured in four categories: less than $5,000, $5-15,000, $15-40,000, and greater than $40,000. Because there was significant missing data on income an additional missing income category is included to retain those individuals in the analysis. *Marital status* is a five category variable: married, separated, divorced, widowed, and never married.

Neighborhood Measures

Neighborhood context measures included in the analysis come from several sources: U.S. Census Data, Systematic Social Observation (SSO) of the neighborhood physical environment, neighborhood resident surveys, and Uniform Crime Reports. The SSO component of the CCAHS involved trained raters that observed and rated neighborhood conditions on both sides of the streets enclosing the blocks of sampled residents. Neighborhood-cluster-level measures for each scale in the SSO were created from unconditional multilevel models using empirical Bayes estimators, which adjusts for missing items and improves neighborhood-level estimates by borrowing information across clusters (Mujahid et al., 2007). Survey-based measures of resident perceptions were aggregated using the same estimation techniques.

A total of 21 measures were used to construct 4 theoretically distinct neighborhood dimensions: perceived stress, observed stress, social support, and participation. Confirmatory factor analysis was performed to justify the number of measures created and the grouping of variables. All measures are standardized with means of 0 and a standard deviation of 1. *Perceived stress* (α=.92) includes 5 scales from neighborhood resident surveys: perceived disorder (5 items), perceived violence (5 items), neighborhood safety (2 items), physical hazards (4 items), and the quality of neighborhood services (2 items). *Observed stress* (α=.89) includes 8 measures from the SSO, Census, and Uniform Crime Reports: homicide rate, robbery rate, burglary rate, physical disorder (9 items), physical deterioration (5 items), vacant lots, percent vacant housing, and the condition of streets. *Social support* (α= .85) includes 4 scales from neighborhood resident surveys: social cohesion (5 items), social control (5 items), intergenerational closure (5 items), and reciprocal exchange(5 items). *Participation* (α= .76) includes 4 scales from resident surveys: organizational participation (7 items), voting (2 items), civic activities (8 items), and contact with community officials (9 items).

U.S. Census data provide information on the socioeconomic composition of neighborhood clusters. A composite measure of *neighborhood socioeconomic status* was created using the following census variables: percent of families with income less than $10,000, percent of families with income greater than $50,000, percent of families below the poverty level, percent of families receiving public assistance, percent unemployed, percent of residents with 16 or more years of education, percent never married, percent female headed households, and percent in professional or managerial positions. The neighborhood SES measure is a standardized scale with a mean of 0 (SD=1).

Lastly, I include a measure of suburban land use derived from the SSO. The scale (α = 0.86) includes the following seven items: proportion of block faces with low-rise apartments (-), proportion of block faces with detached single-family homes (+), proportion of streets that are residential only (+), proportion of streets that are both residential and commercial (-), proportion of block faces with housing above businesses (-), the mean of street noise level (-), and the mean traffic volume (-). Table 1 presents neighborhood-level correlations for the neighborhood measures.

Table 4.1: Correlation Matrix of Neighborhood Measures (n=343)

	(1)	(2)	(3)	(4)	(5)
Disadvantage (1)					
Suburban Land Use (2)	-0.11 +				
Perceived Stressors (3)	0.71 **	-0.43 **			
Observed Stressors (4)	0.77 **	-0.26 **	0.71 **		
Social Support (5)	-0.28 **	0.36 **	-0.49 **	-0.37 **	
Participation (6)	-0.03	0.21 **	-0.06	0.09	0.28 **

**** p<.01 *p<.05 +p<.10**

Analytic Strategy

I begin with a descriptive analysis of gender differences in the bivariate associations of independent measures with both BMI and waist size. I then conduct multilevel regressions of BMI and waist size. I first introduce the individual-level sociodemographic covariates, followed by the neighborhood measures. I examine gender variation in neighborhood effects by interacting the neighborhood measures with gender. Health behaviors are then entered to test their mediation of neighborhood effects. I then estimate multilevel models of walking and physical activity using the same strategy.

Results

Descriptive Results

Table 4.2 presents descriptive statistics for the sample (n=3105) by gender. The sample is about 40% male, and comprised off 32% non-Hispanic whites, 40% non-Hispanic blacks, and 26% Hispanics. Almost 26% have less than a high school education, 25% have a high school degree, 26% have completed come college, and 24% have a college degree. 42% of the sample engages in moderate to heavy physical activity, and 38% walk for more than 20 minutes a day almost every day. 26% are current smokers, 40% do not drink, and almost 20% have 4 or more servings of fruits and/or vegetables a day.

Table 4.2. Descriptive Statistics (n=3105)

	Percent		
	Total	Women	Men
Individual			
Sex			
Male	47.4%	N/A	N/A
Female	52.6%	N/A	N/A
Age			
18-29	27.5%	25.6%	29.5%
30-39	22.7%	21.9%	23.6%
40-49	18.7%	19.1%	18.3%
50-59	12.9%	13.0%	12.8%
60-69	9.0%	11.0%	6.8%
70+	9.2%	9.4%	9.0%
Race			
White	38.4%	36.7%	40.2%
Black	32.1%	35.0%	28.8%
Hispanic	25.8%	25.2%	26.5%
Other	3.8%	3.1%	4.5%
Immigrant Status			
1st Generation	26.9%	25.7%	28.2%
2nd Generation	13.7%	11.5%	13.2%
3rd + Generation	59.4%	61.1%	57.5%
Education			
Less than HS	23.4%	24.4%	22.4%
High School	23.8%	22.8%	24.8%
Some College	24.9%	26.1%	23.6%
College	27.9%	26.7%	29.3%
Income			
Less than 5k	5.2%	5.6%	4.7%
5-15k	14.9%	15.6%	14.2%
15-40k	26.4%	28.4%	24.2%
40k+	34.9%	29.7%	40.6%
Missing	18.6%	20.7%	16.2%
Marital Status			
Married	41.8%	39.4%	44.5%
Separated	4.0%	4.7%	3.3%
Divorced	10.8%	12.4%	9.0%
Widowed	6.7%	10.3%	2.8%
Never Married	36.7%	33.3%	40.5%
Physical Activity			
In bed/chair	3.8%	3.8%	3.8%
Never	16.6%	19.1%	13.8%
Light-Moderate	35.9%	39.7%	31.7%
Moderate-Heavy	43.7%	37.4%	50.7%
Walking			
Never	9.9%	9.6%	10.4%
Once a week or less	14.8%	14.3%	15.3%
2-5 times a week	34.4%	37.3%	31.2%
almost every day	37.1%	35.1%	39.4%
Drinks per Month			
None	37.7%	46.7%	27.7%
1-12	36.1%	39.1%	32.7%
13-89	22.8%	13.5%	33.1%
90 or more	3.4%	0.7%	6.5%
Current Smoker	25.2%	21.4%	29.6%
Servings of Fruits/ Vegetables per Day			
0-1	33.2%	28.4%	39.6%
2-4	47.5%	50.3%	44.5%
4+	19.3%	22.3%	15.9%

The average BMI for the sample is 28.6 (29 for women and 28 for men), and the average waist size is about 37 inches (36.4 for women and 37.9 for men). According to clinical guidelines (NHLBI 2000), the sample is in the overweight range (BMI of 25.0-29.9). Waist size is a marker of abdominal obesity and circumferences greater than 40 inches for men and 35 inches for women are associated with increased risk of obesity-related problems (NHLBI 2000). Women in the sample have an average waist size that puts them at risk for obesity-related disease.

Table 3 shows gender-specific means for BMI and waist size by levels of each independent variable. Separate bivariate regressions were run for men and women, and starred means indicate significant differences compared to the reference category. Race and education differences in BMI and waist size are greater for women than for men. For both men and women, blacks and Hispanics have a higher BMI than whites. For women, both BMI and waist size decrease with education; however, there is very little association between BMI/waist size and education for men. BMI and waist size are negatively correlated with income for women, but positively correlated with income for men. Socioeconomic disadvantage and stress appear to be strongly related to BMI and waist size for women, but not for men. Conversely, suburban land use and social support are associated with BMI and waist size for men, but not for women.

Table 4.3. BMI and Waist Size for Men and Women by Independent Measures

	BMI				Waist Size			
	Women		Men		Women		Men	
Total	29.0		28.0		36.4		37.9	
Age								
18-29 (reference)	27.2		27.0		34.3		36.1	
30-39	29.1	**	28.4	**	35.9	**	37.6	**
40-49	30.1	**	28.2	*	37.2	**	38.2	**
50-59	30.2	**	28.8	**	37.6	**	39.5	**
60-69	29.9	**	28.8	**	38.5	**	39.5	**
70+	28.7	*	27.7		37.3	**	40.2	**
Race								
White (reference)	26.4		27.0		33.9		37.6	
Black	30.8	**	28.3	**	38.2	**	38.3	
Hispanic	29.4	**	29.0	**	36.4	**	38.2	
Other	24.6		26.1		32.3		34.7	**
Education								
College (reference)	26.8		27.4		33.9		37.6	
Some College	29.3	**	28.0		36.7	**	37.8	
High School	29.3	**	28.1		36.9	**	37.9	
Less than HS	30.4	**	28.4	*	37.8	**	38.4	
Income								
40k+ (reference)	28.4		28.3		35.3		38.2	
15-40k	29.7	**	27.4	*	37.0	**	37.3	*
5-15k	30.3	**	28.3		37.9	**	38.6	
Less than 5k	28.4		26.8	*	35.9		36.1	**
Missing	28.0		28.3		35.7		38	
Marital Status								
Married (reference)	28.8		28.8		35.9		38.9	
Separated	30.0	+	27.4	+	37.3	*	37.7	
Divorced	30.2	**	28.5		37.5	**	39.3	
Widowed	29.1		26.9	*	37.6	**	38.5	
Never Married	28.6		27.2	**	35.8		36.6	**
Immigrant Status								
3rd + Generation (reference)	29.6		27.8		37.0		37.9	
2nd Generation	28.0	**	28.4		35.3	**	38.6	
1st Generation	27.8	**	28.2		35.0	**	37.5	
Neighborhood Measures								
Disadvantage								
Tertile 1 (reference)	26.5		27.6		33.9		37.6	
Tertile 2	29.3	**	28.3	+	36.5	**	38.2	
Tertile 3	30.9	**	28.1		38.5	**	37.9	
Suburban Land Use								
Tertile 1 (reference)	29.0		27.6		36.3		37.5	
Tertile 2	28.7		27.8		36.2		37.7	
Tertile 3	29.3		28.7	**	36.5		38.7	**
Perceived Stressors								
Tertile 1 (reference)	27.1		28.0		34.5		38.1	
Tertile 2	29.3	**	27.8		36.6	**	37.6	
Tertile 3	30.4	**	28.1		37.8	**	37.9	
Observed Stressors								
Tertile 1 (reference)	26.8		27.8		34.3		37.7	
Tertile 2	29.4	**	28.1		36.5	**	38.1	
Tertile 3	30.5	**	28.1		38.1	**	38.1	
Social Support								
Tertile 1 (reference)	29.2		27.3		36.6		37.2	
Tertile 2	28.7		28.3	*	36.1		38.1	*
Tertile 3	29.1		28.3	*	36.4		38.4	**
Participation								
Tertile 1 (reference)	28.6		27.9		36.0		37.6	
Tertile 2	28.9		27.6		36.4		37.7	
Tertile 3	29.5	*	28.5		36.7	+	38.5	*

**** p<.01 *p<.05 +p<.10**

Multivariate Results

Results of multilevel models on BMI are reported in Table 4. The null model (not shown) decomposes the variance in BMI into two components: between neighborhood and between individuals within neighborhoods. The proportion of variance due to differences between neighborhoods is referred to as the intra-class correlation, or the ICC. The overall ICC for BMI is 0.08; however, there are large differences between men and women in neighborhood variation. The ICC for men is 0.03, while for women it is 0.13, indicating that neighborhood disparities are greater for women.

$$\text{ICC} = \frac{\sigma_{u0}^2}{\sigma_{u0}^2 + \sigma_{e0}^2} = \frac{3.50}{3.50 + 38.37} = 0.08$$

Model 1 examines the impact of race and immigration status, along with gender interactions for race. Significant gender interactions show that racial/ethnic disparities in BMI are greater for women than for men. Both Hispanic and black men have higher BMIs than white men, and black females have higher BMIs than white or Hispanic women. In model 2, I examine the effects of education and income, and find that higher levels of education are associated with lower BMI for women but not for men. Model 3 includes all sociodemographic variables. Both race and education effects are reduced, reflecting the correlation between race and education; however, gender differences in these disparities persist. Model 4 includes individual health behaviors and marital status. As expected, social disparities are reduced, but only slightly. These individual-level health behaviors only reduce the black-white disparity among women by about 5%.

Table 4.4. Individual-Level Predictors of Body Mass Index with Neighborhood Random Effects (n=3105)

	1			2			3			4		
	Coef	SE		Coef	SE		Coef	SE		Coef	SE	
Individual												
Intercept	24.32	(.36)	**	25.10	(.44)	**	23.65	(.41)	**	24.40	(.6)	**
Male	1.07	(.37)	**	1.17	(.46)	*	1.99	(.47)	**	2.14	(.47)	**
Age (18-29 reference)												
30-39	1.63	(.35)	**	1.56	(.37)	**	1.64	(.35)	**	1.44	(.37)	**
40-49	2.44	(.42)	**	2.16	(.44)	**	2.40	(.43)	**	1.99	(.43)	**
50-59	2.99	(.48)	**	2.67	(.5)	**	2.90	(.49)	**	2.30	(.51)	**
60-69	3.12	(.49)	**	2.32	(.52)	**	2.79	(.5)	**	2.07	(.54)	**
70+	2.06	(.47)	**	1.17	(.51)	*	1.77	(.49)	**	0.84	(.58)	
Immigrant Generation (3rd+ reference)												
1st Generation	-0.72	(.37)	*				-0.75	(.37)	*	-1.14	(.38)	*
2nd Generation	0.35	(.45)					0.38	(.45)		0.28	(.44)	
Race (White reference)												
Hispanic	4.02	(.48)	**				3.16	(.53)	**	2.76	(.55)	**
Male x Hispanic	-1.35	(.61)	*				-0.39	(.7)		-0.11	(.7)	
Black	4.54	(.48)	**				4.05	(.52)	**	3.81	(.52)	**
Male x Black	-3.49	(.6)	**				-2.85	(.63)	**	-2.82	(.62)	**
Other	-0.53	(.5)					-0.44	(.5)		-0.55	(.52)	
Education (College + reference)												
Less than HS				3.60	(.54)	**	2.35	(.6)	**	2.42	(.6)	**
Male x Less than HS				-3.27	(.65)	**	-2.83	(.73)	**	-2.85	(.73)	**
High School				2.55	(.55)	**	1.73	(.55)	**	1.60	(.54)	**
Male x HS				-1.97	(.73)	**	-1.70	(.72)	*	-1.43	(.72)	*
Some College				2.20	(.51)	**	1.22	(.51)	*	1.27	(.51)	**
Male x Some college				-1.97	(.72)	**	-1.41	(.7)	*	-1.32	(.69)	+
Income (40k/year + reference)												
Less than 5k				-1.22	(.63)	*	-1.29	(.63)	**	-1.02	(.63)	
5-15k				0.72	(.47)		0.34	(.47)		0.56	(.46)	
15-40k				0.07	(.34)		-0.15	(.34)		-0.05	(.33)	
Income Missing				-0.77	(.4)	*	-0.40	(.39)		-0.48	(.39)	
Health Behaviors and Marital Status												
Marital Status (married reference)												
Separated										-0.53	(.64)	
Divorced										0.32	(.52)	
Widowed										-0.90	(.56)	
Never Married										-0.77	(.35)	*
Physical Activity (Moderate/Heavy reference)												
In bed/chair										1.36	(.98)	
Never										0.45	(.45)	
Light-Moderate										0.53	(.28)	*
Walking (Every Day reference)												
Never										0.98	(.48)	*
Once a week or less										1.30	(.41)	**
2-5 times a week										-0.12	(.28)	
Drinks per Month (None reference)												
1-12										-0.53	(.33)	
13-89										-0.79	(.37)	*
90 or more										-0.86	(.69)	
Fruits/Vegerables (0-1 reference)												
2-4										-0.11	(.41)	
4+										0.45	(.38)	
Current Smoker										-1.22	(.29)	**

**** p<.01 *p<.05 +p<.10**

Table 4.5. Individual-Level Predictors of Waist Size with Neighborhood Random Effects (n=3105)

	1			2			3			4		
	Coef	SE		Coef	SE		Coef	SE		Coef	SE	
Individual												
Intercept	31.72	(.37)	**	32.02	(.44)	**	30.72	(.42)	**	31.89	(.62)	**
Height	0.31	(.05)	**	0.29	(.04)	**	0.32	(.04)	**	0.34	(.04)	**
Male	2.01	(.44)	**	2.46	(.5)	**	3.11	(.53)	**	3.06	(.53)	**
Age (18-29 reference)												
30-39	1.57	(.34)	**	1.61	(.35)	**	1.68	(.34)	**	1.44	(.36)	**
40-49	2.83	(.4)	**	2.64	(.43)	**	2.87	(.42)	**	2.37	(.44)	**
50-59	4.15	(.45)	**	3.92	(.47)	**	4.15	(.46)	**	3.46	(.47)	**
60-69	5.05	(.49)	**	4.27	(.5)	**	4.73	(.49)	**	3.96	(.56)	**
70+	4.91	(.48)	**	4.00	(.52)	**	4.59	(.5)	**	3.60	(.57)	**
Immigrant Generation (3rd+ reference)												
1st Generation	-0.57	(.38)					-0.54	(.37)		-0.89	(.37)	*
2nd Generation	0.35	(.47)					0.43	(.47)		0.31	(.46)	
Race (White reference)												
Hispanic	3.94	(.46)	**				2.97	(.48)	**	2.56	(.5)	**
Male x Hispanic	-1.37	(.6)	*				-0.44	(.67)		-0.06	(.66)	
Black	4.25	(.45)	**				3.58	(.46)	**	3.31	(.44)	**
Male x Black	-3.49	(.61)	**				-2.72	(.63)	**	-2.65	(.61)	**
Other	-0.60	(.5)					-0.54	(.48)		-0.57	(.51)	
Education (College + reference)												
Less than HS				3.70	(.51)	**	2.51	(.54)	**	2.47	(.54)	**
Male x Less than HS				-3.23	(.65)	**	-2.78	(.73)	**	-2.77	(.72)	**
High School				2.91	(.49)	**	2.13	(.48)	**	1.94	(.48)	**
Male x HS				-2.57	(.71)	**	-2.27	(.71)	**	-2.01	(.71)	**
Some College				2.59	(.47)	**	1.70	(.47)	**	1.70	(.47)	**
Male x Some college				-2.52	(.68)	**	-2.01	(.69)	**	-1.93	(.69)	**
Income (40k/year + reference)												
Less than 5k				-0.95	(.62)		-0.92	(.61)		-0.66	(.61)	
5-15k				1.21	(.45)	**	0.89	(.46)	*	1.04	(.45)	*
15-40k				0.21	(.3)		0.03	(.3)		0.13	(.29)	
Income Missing				-0.85	(.38)	*	-0.53	(.37)		-0.64	(.38)	
Health Behaviors and Marital Status												
Marital Status (married reference)												
Separated										-0.21	(.65)	
Divorced										0.33	(.48)	
Widowed										-1.01	(.54)	+
Never Married										-0.88	(.32)	*
Physical Activity (Moderate/Heavy reference)												
In bed/chair										1.92	(.95)	*
Never										0.49	(.42)	
Light-Moderate										0.66	(.27)	*
Walking (Every Day reference)												
Never										0.65	(.47)	
Once a week or less										1.03	(.38)	*
2-5 times a week										-0.31	(.28)	
Drinks per Month (None reference)												
1-12										-0.86	(.32)	**
13-89										-0.77	(.37)	*
90 or more										-0.92	(.68)	
Fruits/Vegerables (0-1 reference)												
2-4										-0.04	(.4)	
4+										0.30	(.38)	
Current Smoker										-1.11	(.28)	

**** p<.01 *p<.05 +p<.10**

Results of multilevel models on waist size are reported in Table 4.5. The ICC was calculated from the null model (not shown), and shows similar between neighborhood variation as BMI. Again, the gender specific ICCs reveal much greater neighborhood variation among women; the male ICC is 0.03, compared to 0.15 for women.

$$\text{ICC} = \frac{\sigma_{u0}^2}{\sigma_{u0}^2 + \sigma_{e0}^2} = \frac{3.23}{3.23 + 36.44} = 0.08$$

As with BMI, racial disparities in waist size are greater for women than for men (Model 1), and educational disparities in waist size exist only among women (Model 2). Similarly to BMI, the inclusion of health behaviors reduces the black-white gap in waist size for women by less than 5% (Model 3 compared to Model 4). Educational disparities are also largely unaffected by inclusion of the health behaviors.

Table 4.6 reports neighborhood effects by gender for both BMI and waist size, controlling for all individual sociodemographics. First, I examine the impact of each neighborhood measure separately, as well as the significance of the gender interaction. Patterns for BMI and waist size are very similar. Neighborhood socioeconomic disadvantage has a strong positive effect on both BMI and waist size for women, but no effect for men. Perceived stressor reduce BMI and waist size for men, but increase BMI and waist size for women. Interestingly, neighborhood observed stressors show no effect for men or women, despite its high correlation with disadvantage and perceived stressors. Neighborhood social support and suburban land use have positive effects on BMI and waist size for men, but no effect for women.

I then include all significant neighborhood factors in a final model: socioeconomic disadvantage, perceived stress, social support, and suburban land use.

Disadvantage remains the biggest predictor of BMI and waist size for women. For men, social support and land use appear to dominate. The black-white disparity in BMI for women is reduced by over 20% compared to Model 3 in Table 4.4, while the black-white disparity in BMI among men remains unchanged. For waist size, the reduction in the black-white disparity among women is reduced by over 30% compared to Model 3 in Table 4.5. Similar trends are present for educational disparities among women. The neighborhood factors do not seem to account for any racial disparities among men. The results lend support for the theory that differential responses of men and women to neighborhoods partially help to explain gender differences in racial disparities.

Table 4.6. Multilevel Models of Neighborhood Measures and BMI/Waist Size by Gender

	Entered Separately					Entered Simultaneously				
	Men		Women		p-value for	Men		Women		p-value for
	Coef	SE	Coef	SE	Interaction	Coef	SE	Coef	SE	Interaction
BMI										
Disadvantage	-0.02	(0.28)	0.86	(0.30) **	0.02	-0.11	(0.36)	0.77	(0.37) *	0.20
Perceived Stressors	-0.53	(0.22) *	0.45	(0.23) *	<.01	-0.04	(0.36)	0.17	(0.35)	0.67
Observed Stressors	-0.54	(0.37)	0.17	(0.37)	0.16					
Social Support	0.68	(0.20) **	0.20	(0.20)	0.05	0.37	(0.22) +	0.42	(0.23) +	0.84
Participation	0.11	(0.28)	0.19	(0.27)	0.78					
Suburban Land Use	0.97	(0.25) **	-0.20	(0.26)	<.01	0.76	(0.31) *	-0.2	(0.32)	0.02
Social Disparities										
Black-White Difference						1.22	(0.55) *	3.11	(0.61) **	
Hispanic-White Difference						3.02	(0.55) **	2.73	(0.55) **	
College-Less than High School Difference						-0.66	(0.57)	1.93	(0.57) **	
Waist Size										
Disadvantage	0.14	(0.28)	1.27	(0.27) **	<.01	0.22	(0.37)	1.27	(0.33) **	0.03
Perceived Stressors	-0.33	(0.20) +	0.63	(0.23) **	<.01	0.04	(0.37)	-0	(0.34)	0.91
Observed Stressors	-0.23	(0.35)	0.46	(0.35)	0.15					
Social Support	0.58	(0.18) **	0.07	(0.20)	0.03	0.37	(0.19) *	0.32	(0.22)	0.84
Participation	0.29	(0.28)	-0.07	(0.25)	0.25					
Suburban Land Use	0.77	(0.24) **	-0.36	(0.25)	<.01	0.61	(0.31) +	-0.4	(0.28)	0.02
Social Disparities										
Black-White Difference						0.75	(0.58)	2.43	(0.53) **	
Hispanic-White Difference						2.67	(0.57) **	2.37	(0.49) **	
College-Less than High School Difference						-0.49	(0.61)	1.91	(0.56) **	

**** p<.01 *p<.05 +p<.10**

Table 7 examines neighborhood-level interactions. I first test the interaction between neighborhood disadvantage and social support to examine the possibility that social support operates differently in different kinds of neighborhoods. There is a positive interaction of disadvantage and social support among women but men. For women in more disadvantaged neighborhoods, social support has a positive effect on BMI. However, for women in less disadvantaged neighborhoods, social support is negatively associated with BMI. Figure 1 illustrates the relationship between disadvantage, social support and waist size by gender.

An interaction between neighborhood disadvantage and suburban land use was also tested to determine if the effects of land use are uniform across neighborhoods. There is a significant negative interaction for men, while the effects of land use for women remain insignificant. The positive effect of land use on BMI for men is smaller in more disadvantaged neighborhoods. Figure 2 shows the relationship between disadvantage, suburban land use, and BMI by gender.

Table 4.7. Neighborhood-Level Interactions and BMI/Waist Size by Gende

	BMI			Waist Size		
	Coef	SE		Coef	SE	
Males						
Disadvantage	0.02	(.3)		0.21	(.3)	
Social Support	0.57	(.2)	**	0.55	(.2)	**
Disadvantage x Social Support	-0.27	(.25)		-0.14	(.22)	
Disadvantage	-0.25	(.32)		-0.12	(.33)	+
Suburban Land Use	0.69	(.55)	**	0.48	(.27)	
Disadvantage x Suburban	-0.67	(.34)	*	-0.73	(.33)	*
Females						
Disadvantage	1.02	(.33)	*	1.41	(.29)	**
Social Support	0.46	(.23)	**	0.36	(.22)	+
Disadvantage x Social Support	0.49	(.27)	+	0.49	(.25)	*
Disadvantage	0.79	(.3)	**	1.08	(.26)	**
Suburban Land Use	-0.15	(.29)		-0.40	(.26)	
Disadvantage x Suburban	-0.13	(.34)		-0.48	(.3)	

**** p<.01 *p<.05 +p<.10**

Figure 4.2: Neighborhood Socioeconomic Disadvantage, Social Support, and Waist Size

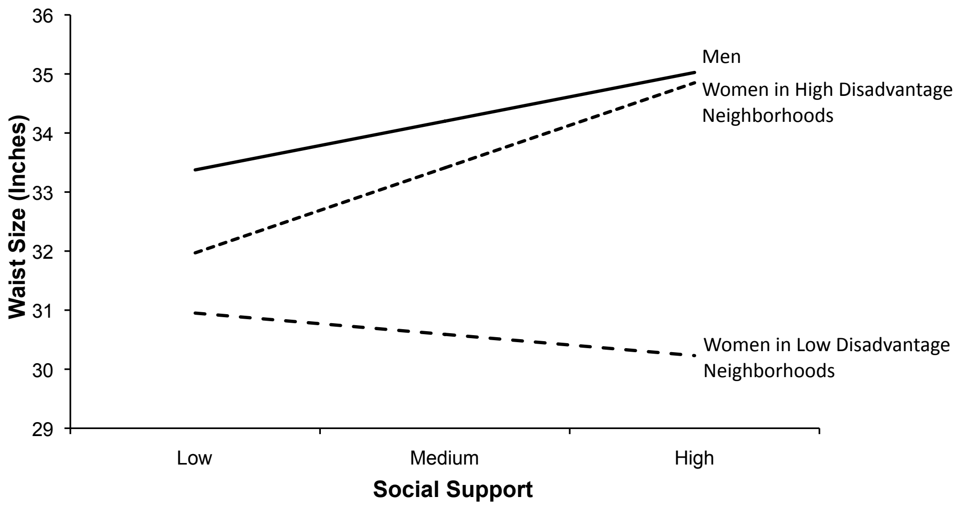
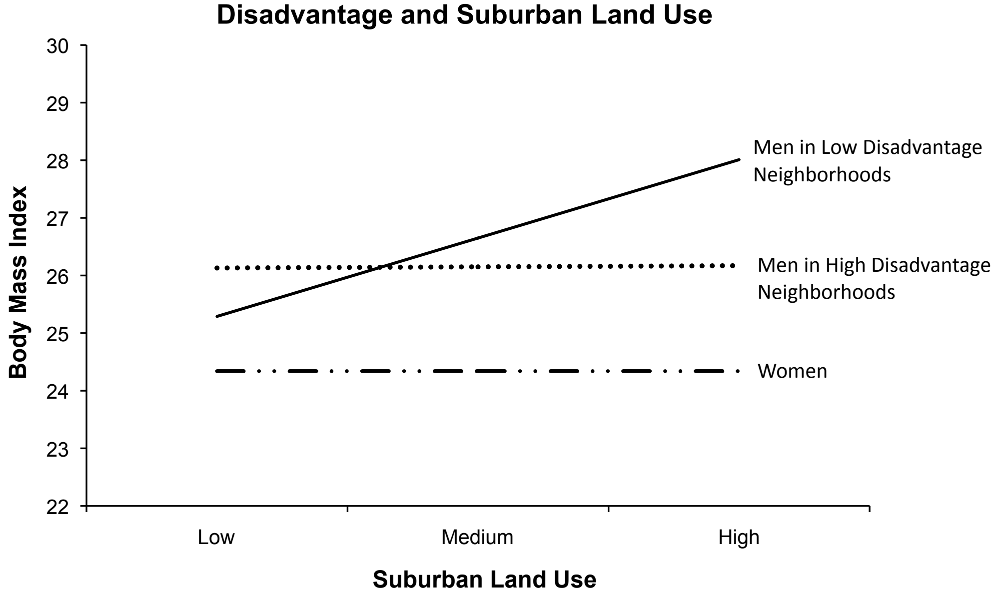


Figure 4.3. BMI by Neighborhood Socioeconomic Disadvantage and Suburban Land Use



Discussion

The results of the study suggest that gender differences in both obesity and its environmental causes deserve greater attention. Past research on obesity has generally found that neighborhood socioeconomic disadvantage increases the risk of obesity; however, more recent research (including this study) suggests that this association exists exclusively for females. These gender differences in the relationship between neighborhood environments and obesity appear to partially explain larger social disparities in obesity among women.

Land use has been consistently linked to measures of obesity and physical activity, with more mixed land use (non-suburban) neighborhoods having lower levels of obesity. However, research has largely ignored the potential moderating effects of gender on the relationship between the built environment, health behaviors, and health outcomes. In this study, suburban land use was associated with higher BMI for men, but not for women. Moreover, the positive effect of suburban land use was only present for men living in low disadvantage neighborhoods. This suggests that changes in the built environment may not be sufficient to influence health behaviors in more disadvantaged neighborhoods where other factors (such as neighborhood stressors) may be more salient.

The results lend cautious support for the possibility that the normative environment plays a larger role that previously thought in neighborhood variations in weight status. A key weakness of the current study is the lack of appropriate measures of neighborhood norms regarding body image, diet, or physical activity. Although this study does not directly measure these aspects of the normative environment, the relative salience and strength of local norms for residents may be reflected in the level of neighborhood social support. Norms are transmitted and enforced through social networks and, therefore, perhaps more powerful in more socially integrated spaces. Therefore, it is the presence of both local norms and the appropriate means through which those norms can effectively shape health behavior that may be relevant for obesity outcomes.

The interaction between neighborhood disadvantage and social support for women may reflect socioeconomic variation in neighborhood normative environments. In disadvantaged neighborhoods, high social support may mean that "unhealthy" local norms regarding diet or physical activity are more influential. Moreover, racial and socioeconomic differences in body image may have a greater impact when concentrated geographically. For example, if higher income women are more likely to diet than lower income women (Matheson et al, 2008), then a greater concentration of high income women in the neighborhood may exacerbate the existing social pressure to diet. Similarly, if there is a greater acceptance among blacks of larger body sizes, then the effect of race-specific norms will be strongest in segregated neighborhoods.

Men may be less likely to manage their weight or depend on physical prowess as a measure of masculinity under more "comfortable" environmental conditions. Conversely, for women the absence of local neighborhood stressors and disadvantage may result in the elevated importance of larger societal pressures for thinness. However, caution should be taken in generalizing about local norms based on neighborhood socioeconomic or racial composition. Future research, including qualitative work, should explore the nature of neighborhood normative environments, their neighborhood-level social and physical correlates, and their effects on health behaviors. While there are a number of qualitative studies that examine body image across racial and, to a lesser extent, socioeconomic groups, there is more work to be done in linking these normative ideals to health behavior and health outcomes. Moreover, future work should explore how these norms are created and reinforced geographically across different neighborhood environments.

In contrast to the built environment, it is less clear how neighborhood-level interventions might target and effectively modify local norms. It is important to keep in mind the ways in which the normative environment may be potentially tied to other neighborhood characteristics, such as neighborhood stressors or socioeconomic disadvantage. There is some qualitative evidence (Barroso et al, 2010) that acceptance of larger body sizes among poor women is partially linked to a perceived ability to defend oneself against crime. Therefore, a singular focus on changing neighborhood norms will be ineffective if the larger structural context of norm formation and maintenance is ignored.

This study examined the ways in which gender moderates the effects of neighborhood characteristics on BMI and waist size, and the extent to which this gendered response to neighborhoods helps to explain larger racial and socioeconomic disparities among women. Very few studies have looked at the gendered nature of the relationship between neighborhood conditions and health outcomes or health behaviors. Furthermore, the majority of studies that have analyzed gender and neighborhood effects have relied primarily on socioeconomic measures. I found that neighborhood characteristics explain some, but not all, of the racial and socioeconomic disparities in obesity among women. The results suggest that women and men respond differently to neighborhood environments, and that future research on neighborhoods and health should pay closer attention to the gender-environment interactions.

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Chapter 5

Conclusions

This dissertation contributes to the literature on neighborhoods and health by identifying potentially stressful and supportive dimensions of the neighborhood environment and testing their impact on both health outcomes (self-rated health and obesity) and hypothesized physiological mediators (cortisol). I sought to advance our understanding of health-relevant neighborhood mechanisms by examining multiple dimensions—both observed and perceived—of the neighborhood environment. In this conclusion, I synthesize findings from the three previous studies, consider the broader implications of my findings, and discuss the limitations of this dissertation work.

The first analysis focused on theorizing and constructing non-sociodemographic measures of the neighborhood environment. Using a uniquely rich set of data, I constructed four neighborhood measures: perceived stressors, observed stressors, social support, and participation. Since neighborhoods have been associated with a range of health outcomes, I use a widely accepted global indicator of health—self-rated health—to examine the relative effects of these different neighborhood dimensions. I find that perceived stressors have a negative effect on self-rated health, and appear to mediate the effects of neighborhood socioeconomic disadvantage. In addition, neighborhood participation has a positive effect on self-rated health for females. Interestingly, participation is uncorrelated with neighborhood disadvantage, challenging the notion that neighborhood socioeconomic status is a “fundamental cause”, and all neighborhood social and physical characteristics are more proximate mediators.

The second analysis models the relationship between neighborhood stressors and support and cortisol, a commonly theorized physiological linking mechanism between stress and physical health outcomes. Using multilevel spline regression, I examined diurnal patterns of salivary cortisol, and the effects of neighborhood characteristics on spline slopes. I found that individuals living in more stressful neighborhoods have lower overall levels of cortisol, characterized by blunted diurnal patterns. These results challenge the dominant paradigm in the literature on stress and health which posits that chronic stress increases the risk of disease by over-exposing individuals to cortisol. It has become commonplace in the sociological literature to claim that cortisol is the lynchpin physiological mechanism responsible for health disparities; however, there is very little empirical evidence for this claim. This study adds to the increasing evidence that long-term stress exposure can actually lead to hypocortisolism.

In the final analysis, I examined the role of neighborhood in explaining gender differences in social disparities in obesity. I examined the moderating role of gender in the relationship between obesity (measured by both BMI and waist size) and neighborhood socioeconomic, social and physical characteristics. The results suggest that men and women respond differently to similar neighborhood environments in ways that important for understanding the social causes of obesity. Neighborhood disadvantage has a strong positive effect on BMI and waist size for women, but no effect for men. Men appear to be more influenced by the built environment, although that relationship is moderated by neighborhood disadvantage. Neighborhood social support is detrimental for women in high disadvantage neighborhoods, but good for women in low disadvantage neighborhoods. This suggests that there may be geographically variable norms regarding body image, physical activity and diet that are enforced through local social networks.

There are several important limitations to the work in this dissertation. First, caution must be taken when using biomarkers as outcomes when so little is currently known regarding their clinical significance. While the stress model, and cortisol in particular, have caught on in the sociological literature, the physiological effects of hyper- and hypo-cortisolism are not clear. It is here that biomedical research on stress and health can help to advance our understanding of the effects of chronic stress (including stress in utero and during infancy) on physiological functioning.

Second, future research should strive to integrate information about neighborhood environments, physiological mechanisms, and clinical health outcomes. Due to limitations in the data, I was unable to explore the full causal chain linking neighborhoods to cortisol and, finally, to obesity. This step must be taken in order to move beyond simply theorizing about the physiological "black box". Neighborhood research on health has been too content in speculating on the physiological mechanisms through which disadvantage manifests in physical health outcomes, rather than testing them empirically.

Finally, although I created novel measures of the neighborhood environment, it is clear that there is still work to be done in understanding and measuring health-relevant neighborhood phenomena. Future research, particularly qualitative work, should explore the role of the neighborhood normative environment in structuring health behaviors.

Individualistic explanations of health disparities have proven to be theoretically and empirically inadequate. The results of these three analyses advance the literature on neighborhoods and health by identifying potentially stressful and supportive dimensions of the neighborhood environment and documenting their empirical relationship with self-rated health, obesity, and cortisol. The confluence of sociological and biomedical research on health disparities represents a new and exciting area of scientific inquiry which highlights the interdependence of the social and the biological.