

**The Associations of Neighborhood Social and Physical Conditions and Racial/Ethnic
Composition with Depressive Symptoms**

by

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Abstract

In recent years, there has been a growing interest in understanding the effects of neighborhood conditions on psychological wellbeing. This dissertation used the Multi-Ethnic Study of Atherosclerosis (MESA) and the Chicago Community Adult Health Study (CCHAS) to examine (1) cross sectional and prospective associations of neighborhood social cohesion, violence, and aesthetic quality with depressive symptoms in MESA, (2) cross-sectional associations of neighborhood social support (residential stability, family structure, social cohesion, reciprocal exchange, social ties) and stressors (perceived violence, perceived disorder, physical decay, physical disorder, safety, population density) with depressive symptoms in the CCAHS, and (3) cross-sectional associations of the percent of people of the same racial/ethnic background in subjects' neighborhoods and depressive symptoms in MESA. The first study found that lower levels of social cohesion and aesthetic quality and higher levels of violence were cross-sectionally associated with higher mean CES-D scores in both men and women in MESA, while associations of neighborhood characteristics with incident depression were in the expected direction for women only (although not statistically significant). The second study found that greater neighborhood social support was associated with lower levels of depressive symptoms amongst women, while greater neighborhood stressors was associated with higher levels of depressive symptoms in men in the CCAHS. Adjusting simultaneously for stressors, social support, and neighborhood socioeconomic

status did not alter associations. Study 3 concluded that living in a neighborhood with a higher percentage of residents of the same racial/ethnic background was associated with increased levels of depressive symptoms amongst African American men and decreased CES-D scores amongst Hispanic men and women and Chinese women. Adjusting for other neighborhood characteristics strengthened associations between depressive symptoms and neighborhood racial/ethnic concentration amongst Hispanics, but did not explain the association in African American men. These three studies all illustrate the role that neighborhood environments play in both increasing and decreasing depressive symptoms in residents. Policies and programs that work towards enhancing neighborhood social support and lessening neighborhood stressors, in addition to typical individual-based treatments and therapies, may help address the important public health problem of depression and depressive symptoms.

Chapter 1: Introduction

Specific Aims and Hypotheses

Most research on the predictors of depression and depressive symptoms has focused on individual-level characteristics. Recent years have seen an increasing interest in the extent to which attributes of neighborhood environments may be relevant to depression and other mental health outcomes. Neighborhood characteristics may affect mental health above and beyond the compositional net effects of the individual characteristics of residents. A small number of studies have examined whether specific structural and social characteristics of neighborhoods, such as residential stability, social cohesion, socioeconomic level, and perceived disorder, influence the prevalence of depression after controlling for individual risk factors. While a few neighborhood characteristics have been linked to depression and depressive symptoms, hypotheses about the underlying mechanisms creating patterns of differential depression rates between geographic areas are still in early stages of development.(1) The majority of studies of neighborhood characteristics and depressive symptoms have focused on the effects of area socioeconomic position, after controlling for individual-level characteristics. Very few studies have incorporated direct measures of specific neighborhood characteristics of interest based on a conceptual model.(2, 3) When specific neighborhood attributes are assessed, most studies use the same study population to measure depressive symptoms and neighborhood conditions.(1, 2, 3, 4, 5, 6, 7) Thus, measurement of neighborhood-

level constructs relevant to depression remains an important challenge. This dissertation used two data sets with diverse populations, both of which utilize unique techniques that more objectively measure specific aspects of neighborhood environments. This allowed for specific pathways through which neighborhood context might influence depressive symptoms to be tested, as well as for a comparison of the relative strength of the associations with depressive symptoms for different types of neighborhood characteristics. Furthermore, this dissertation explored whether the racial/ethnic composition of a neighborhood influenced depressive symptoms, and if this relationship differed by gender and individual race/ethnicity. This allowed me to test whether living in a neighborhood with people of the same race/ethnicity lowers depressive symptoms, as the ethnic density hypothesis posits,(8) or whether it might act as a stressor and be associated with other negative neighborhood characteristics that are in turn linked to increases in depressive symptoms. The Specific Aims of the dissertation were as follows:

Aim 1

To examine associations of social cohesion and neighborhood stressors with depressive symptoms in a population-based multiethnic sample, using survey-based estimates of neighborhood social cohesion and neighborhood stressors.

Hypothesis A. Low levels of neighborhood social cohesion and high levels of neighborhood stressors (violence, aesthetic quality) are associated with higher levels of depressive symptoms, after adjustment for personal socioeconomic characteristics.

Hypothesis B. Low levels of neighborhood social cohesion and high levels of neighborhood stressors are associated with incident depression, after adjustment for personal socioeconomic characteristics.

Aim 2

To examine associations between neighborhood stressors (perceived violence, safety, perceived disorder, population density, physical disorder and decay) and social support (social cohesion, residential stability, reciprocal exchange, family structure and social ties) and depressive symptoms in the Chicago Community Adult Health Study.

Neighborhood characteristics were measured using participant survey responses, census-based measures and systematic social observation. This complemented Aim 1 by including a wider range of neighborhood stressors and social support mechanisms, including both objective and subjective measurements of the neighborhood environment. Hypothesis A. Low levels of neighborhood stressors and high levels of social support are associated with lower levels of depressive symptoms after adjustment for personal socioeconomic characteristics. These associations differ by gender.

Hypothesis B. Some associations between stressors and social support and depressive symptoms will remain significant after controlling for neighborhood socioeconomic characteristics (advantage and disadvantage), social support, and neighborhood stressors simultaneously. The variables that remain significantly associated with depressive symptoms differ by gender.

Aim 3

To examine associations between neighborhood racial/ethnic composition and depressive symptoms, stratified by racial/ethnic group, before and after adjustment for potential neighborhood mediators.

Hypothesis A. Living in a neighborhood with a dominant racial/ethnic composition similar to one's own is associated with depressive symptoms in MESA, and the direction of the associations varies by racial/ethnic group.

Hypothesis B. These associations are partially mediated by the neighborhood social cohesion and stressors investigated in Aim 1.

Conceptual Model

Figure 1.1 is a Directed Acyclic Graph (DAG) of the conceptual model underlying the research of this dissertation. Arrows indicate that the variable at the tail end potentially influences the variable at the head of the arrow. The box labeled gender surrounding this DAG represents the assumption that the associations' strengths will differ for men and women. All types of neighborhood conditions (social environment, physical environment, racial/ethnic composition) are associated with one another. None of these characteristics are directly associated with depressive symptoms: stressors and social support/social integration mediate the associations between each of the neighborhood conditions and depressive symptoms. Social support both directly influences depressive symptoms and buffers the association of neighborhood stressors with depressive symptoms. Sociodemographic characteristics (race, education, income, age, marital status) are potential confounders of all the associations of neighborhood conditions and depressive symptoms.

Background and Public Health Significance

Public Health Significance of Depression

Depression has been rated the fourth leading cause of disease burden worldwide, and is predicted to be the second leading cause by 2020.(9) It is estimated that almost 15% of all people will experience a period of depression in their lives.(9) The WHO World Health Study found that between 9.3 and 23% of individuals with one or more chronic diseases had comorbid depression, and that individuals with chronic diseases were significantly more likely to be depressed than those without chronic conditions.(9) Additionally, depression is associated with a greater decrease in overall health than most chronic conditions.(9) Despite this evidence, depression is not viewed in the same light as many other health conditions, and its effects are often considered separate from those of physical health conditions.(10) Depression is rarely treated as a public health problem, with its effect on the burden of poverty and ill health in developing countries receiving less attention than many infectious and chronic diseases. The key established risk factors for depression, such as female gender, being unmarried, heredity, history of mental illness, and young and old age, are almost exclusively individual-level. Additionally, treatment of clinical depression is almost exclusively focused on individual-based therapies and medications.(10)

Neighborhoods and depression

The link between environmental features and psychological well-being has been investigated since the mid-twentieth century.(11) Researchers have recently showed renewed interest in understanding the effects of neighborhood conditions on depression

and depressive symptoms,(12) particularly in how contextual characteristics of neighborhoods may be related to mental health outcomes above and beyond the compositional effects of individual characteristics. It is easy to imagine how neighborhood environments could be especially relevant to mental health, and specifically to depression and depressive symptoms. Features of neighborhoods may function as stressors. For example, living in a disadvantaged neighborhood, with a less inviting built environment and higher levels of exposure to violence, may affect mental health through stress-mediated pathways.(3) Neighborhood features may also act as buffers of individual-based sources of stress related to mental illness. Social connections and social support in neighborhoods may affect residents' vulnerability to stress and depressive symptoms.(1) Elements of the social and physical environment, characteristics of the built environment and neighborhood racial/ethnic composition might all affect depressive symptoms by acting as stressors or by affecting social connections. Below is a brief summary of each of the types of neighborhood characteristics examined in this dissertation. A more comprehensive review of the literature can be found in Chapter 2.

Social Environment

Domains of the social environment investigated in relation to depression include social cohesion, reciprocal exchange, social ties, and neighborhood violence, problems and safety. Sociologists have been studying the effects of neighborhood social environments on individual-level outcomes for a long time.(13) These social environmental characteristics can influence depressive symptoms through increasing or decreasing stress levels and neighborhood social integration and support. Social cohesion is a concept that traditionally includes the shared sense of morality and common purpose

between neighbors, social control and order, the level of social interaction between neighbors, trust between neighbors and a sense of belonging to a place.(14, 15) It is measured by asking residents, amongst other things, whether they live in a close-knit neighborhood and can trust their neighbors. Violence is a social process that involves collective aspects of neighborhood life.(16) Previous research has found that neighborhood characteristics influence violence in part through the construct of neighborhood collective efficacy.(17) Neighborhood problems and safety are measures of stressors found in neighborhood environments.

Several studies have attempted to measure social cohesion and interactions between neighbors within a neighborhood, hypothesizing that these would be potential protective factors against depression.(2, 4, 5, 6, 18) Positive social interactions are associated with lower levels of depressive symptoms in certain situations, especially for young adults. One study of adolescents found that low levels of social cohesion were associated with depression.(5) Neighborhood-level trust was associated with lower levels of depressive symptoms in another study.(19) A handful of studies have examined the link between exposure to neighborhood violence and depressive symptoms. In a study of Detroit African American women, concerns about police responsiveness and a safety stress scale both influenced depressive symptoms independent of household income.(2) In another study, perceptions of community problems were associated with greater depression amongst both African Americans and whites, while perceived community cohesion was associated with better mental health only amongst whites.(20) A study of the impact of negative neighborhood and school environments on mental health problems in adolescents concluded that a negative neighborhood environment, identified by factors

such as violence, abandoned buildings, and homeless people on the streets, contributed unique variance to mental health in the study population.(7) A comprehensive review of the literature can be found in Chapter 2.

Social environmental characteristics are often measured by asking residents of neighborhoods a series of questions about the place they live, which are then combined into a scale score. Depressive symptoms are typically measured amongst the same group of people who were asked about neighborhood violence and social cohesion. This dissertation adds to the literature about social cohesion and violence and depressive symptoms in Aim 1 through the use of objective measurements collected through an independent sample of people living in the same neighborhoods as study participants whose depressive symptoms were measured to evaluate these neighborhood characteristics and create scale scores. Many studies have used socioeconomic status as an approximation of the neighborhood environment, or have only looked at stressful neighborhood environments or social support without examining the other. This dissertation used a variety of measurements of neighborhood environments, with the aim of discovering what aspects of neighborhoods have the greatest impact on depressive symptoms. By using two different diverse study samples, I could also see whether these associations held up in study samples with unique geographic locations and demographic characteristics, which used slightly different measurements of both depressive symptoms and the social environment.

Physical Environment

Characteristics of the neighborhood physical environment that may play a role in shaping levels of depressive symptoms amongst residents include population density,

physical disorder and physical decay.(4) In this context, physical disorder involves signs of negligence and unchecked decay in a neighborhood, marked by features such as vacant or abandoned buildings and the amount of litter and graffiti in a neighborhood.(21) It has been argued that physical disorder undermines neighborhood social control.(22) Residents of neighborhoods with high levels of disorder may be less likely to visit each other, strike up conversations with neighbors, or participate in neighborhood improvements, all of which are mechanisms through which social control can be established. Not all neighborhoods characterized by disorder will lack social control, but it is more difficult to create social control in areas with physical disorder. In contrast to physical disorder, physical decay is a measure of the physical environment that captures the condition of standing structures. Fear of crime and social disorder are often found in neighborhoods with high levels of physical decay.(23) Population density can create a sense of crowding, which creates a stressful neighborhood environment.(24, 25) There is a substantial literature in the field of sociology that has examined physical and social disorder. Neighborhood disorder is distressful by itself, but might also increase levels of depressive symptoms through its influence on feelings of powerlessness and fear.(18) Neighborhoods with high levels of outsider-recorded physical disorder have been linked to fear of crime.(26) This fear is, in turn, a stressor with the potential to increase levels of depressive symptoms. In a study of subjects from neighborhoods with outward signs of disorder, there was a strong prospective association between perceived neighborhood characteristics and subsequent depressive symptoms, after adjustment for baseline depression level.(4) Physical decay has not been studied as much as physical disorder,

but might contribute to an increased fear of crime and a stressful neighborhood environment.

This dissertation used systematic social observation (SSO) assessments of neighborhood physical disorder and decay. Most of the previous studies that have looked at the association between the physical environment and depressive symptoms have used perceived physical disorder and decay measured amongst study subjects. By using objective raters to measure physical disorder and decay, it becomes possible to discern the association between the physical environment and depressive symptoms without relying on perceived evaluations. This dissertation also allowed for a comparison of the relative strength of the association between perceived and objective evaluations of the physical environment in the same study sample.

Racial/Ethnic Composition

Racial/ethnic composition was measured in this dissertation as the percentage of people in subjects' neighborhoods of the same racial/ethnic background. The racial/ethnic composition of a neighborhood may influence neighborhood stressors and social support, thereby indirectly impacting depressive symptoms. The ethnic density hypothesis, as it is often called, states that rates of mental disorder decrease as the percentage of people from the same racial/ethnic group in one's neighborhood increases.(27) This association may arise from the increased levels of social support and reduced stress that often accompany living in a neighborhood with people from a similar racial/ethnic group.(28) The strength of this association has been found to vary across racial/ethnic groups.(8) Some racial/ethnic groups, such as Hispanics living in areas with large proportions of 1st and 2nd generation immigrants, may be better able to protect the mental health of their members

through the establishment of strong social ties which can help buffer the effects of stressful, low-income neighborhoods. By contrast, in the context of the United States black segregated neighborhoods may have physical and environmental factors that place them at higher risk of depression.

The association between neighborhood racial/ethnic composition and depressive symptoms has been investigated in a handful of studies, detailed in Chapter 2. One study found that, for both black and white participants, depression was negatively associated with the percentage of white people and positively associated with percentage of black people in a neighborhood before adjustment for personal characteristics, although the association disappeared after adjustment for individual traits.(28) A study of elderly Mexican Americans found that ethnic concentration moderated the effect of neighborhood poverty on depressive symptoms, so that living in a neighborhood with a high density of Mexican Americans offset the negative association between neighborhood poverty and increased depressive symptoms.(29) Other studies have found no association between neighborhood racial/ethnic composition and depressive symptoms.(1)

This dissertation used a measure of the proportion of people living in subjects' neighborhoods of the same racial/ethnic identity to examine associations of race/ethnic composition and depressive symptoms and to determine whether any of the neighborhood characteristics from Aim 1 mediated observed associations. There are relatively few studies of the association between living near people of the same racial/ethnic background and depressive symptoms, and they typically examine a homogenous population (in terms of age and race/ethnicity). The MESA sample included subjects of

four different race/ethnicities, which allowed for an examination of the strength and direction of the association in several distinct groups. Using a wide range of clearly defined neighborhood conditions in two multiethnic samples allowed for a better understanding of the social and/or physical characteristics of neighborhoods that are in the pathway between living in a neighborhood with people of similar racial/ethnic background and depressive symptoms, and whether these associations varied by racial/ethnic group.

Significance

The extent to which neighborhood context truly affects mental health is a question with important public health implications.(30) If characteristics of one's neighborhood of residence influence risk of depression apart from individual risk factors, interventions aimed at improving neighborhood environments will be a key component in reducing the burden of depression. Despite strong theoretical rationale for neighborhood effects on depressive symptoms, to a large extent the literature in this area remains inconclusive. This likely reflects the early state of the field, the fact that the study designs, populations, definitions of neighborhoods and neighborhood features have varied widely between studies, and, perhaps most importantly, the complexities inherent in studying neighborhood health effects generally.(31) This dissertation sought to fill in the holes in the current body of literature linking neighborhood conditions to depressive symptoms.

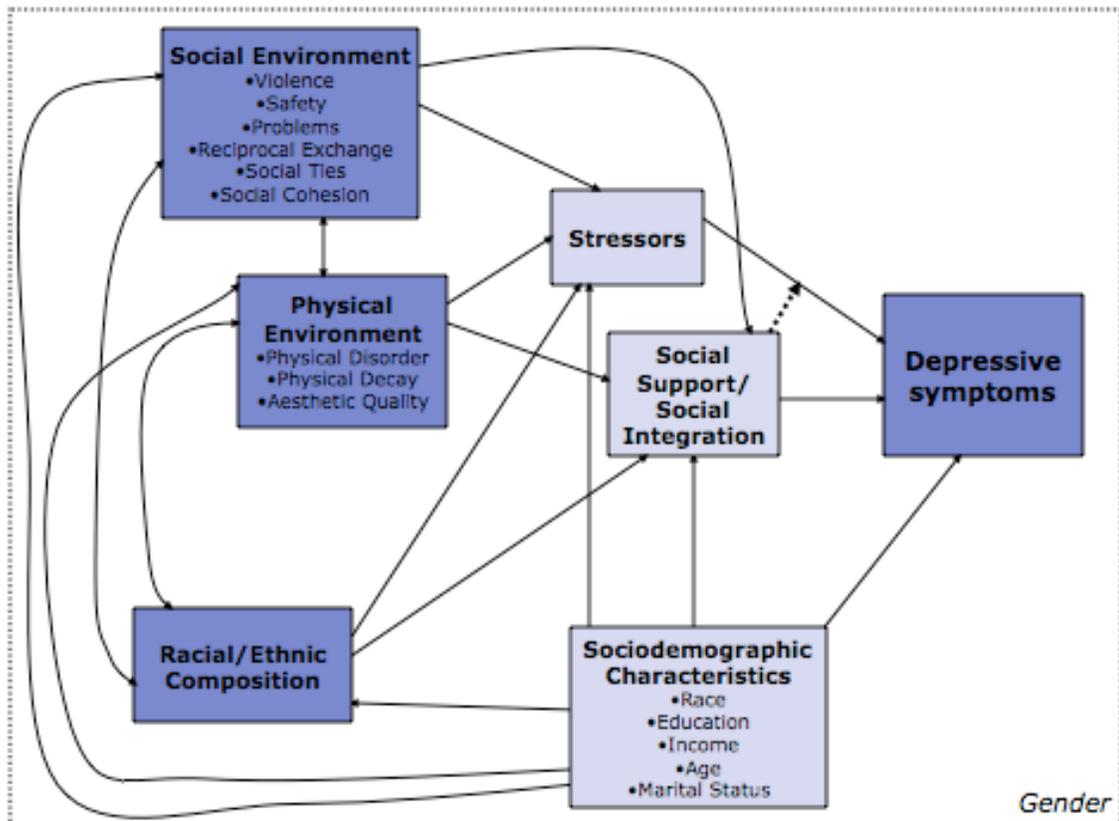


Figure 1.1. DAG of associations between neighborhood characteristics and depressive symptoms

Chapter 2: Are Neighborhood Characteristics Associated with Depressive Symptoms? A Review of Evidence

Introduction

The notion that environmental features may be related to psychological well-being and mental health has a long history. As far back as 1939, Faris and Dunham found that schizophrenia and substance abuse rates were highest amongst individuals living in socially disorganized Chicago neighborhoods.(11, 12) In *My Name is Legion*, published in 1959, Alexander Leighton explored how the expression of mental illness was shaped by local context(32) and concluded that processes underlying the sociocultural disintegration of neighborhoods may be shaping patterns of mental health and psychiatric disorder.(33)

In recent years, there has been an explosion of interest in the peer-reviewed medical and public health literature about the ways in which neighborhoods and residential environments may affect a variety of health outcomes, including mental health and depression.(34) This interest has been spurred by theoretical discussions of the ecologic determinants of health(35, 36) as well as by the growing popularity and availability of multilevel analysis,(37) a statistical technique that has been used to assess the relation between neighborhood context and health after controlling for potential individual-level confounders.(38, 39)

There are many theoretical reasons why neighborhood environments may be particularly relevant to mental health, and specifically to depression and depressive

symptoms. Features of neighborhoods such as lack of resources, disorder, violence, inadequate housing, and lack of green spaces may function as stressors.(3, 40)

Neighborhood features may also act as buffers of individual-based sources of stress related to mental illness. For example, physical and social features of neighborhoods may affect social connections and the levels of social support experienced by residents. Social support may in turn affect residents' vulnerability to stress and depressive symptoms.(1)

Despite some theoretical rationale for neighborhood effects on depressive symptoms, the results of the literature in this area are still somewhat mixed.(41) In this review we take stock of the published observational studies of neighborhoods and depression and depressive symptoms in order to identify future directions for the field. We summarize the main research questions, study populations, neighborhood definitions, neighborhood measures, depressive symptom measures, study designs, analytic techniques, and results from these studies. The review concludes by discussing the remaining gaps in our knowledge about the relationship between neighborhood context and depression, and suggests future research directions. This review complements a prior review of neighborhoods and mental health by focusing specifically on the more narrow outcome of depression and depressive symptoms, extending the review to also encompass articles published 2004-2007 (a time of increasing publications in this area), and focusing on observational studies and their limitations.(42)

Methods

Studies were primarily identified using a biomedical database (PubMed) and two databases of psychological literature (PsycINFO and PsycARTICLES). The search terms “depression,” “depressive symptoms,” or “psychological distress” were entered together with “neighborhood” or “neighborhood characteristics.” These terms were selected since we were interested in any type of neighborhood effect on either depression or depressive symptoms. These searches retrieved 79 articles in PubMed and 168 articles in PsycINFO. PsycARTICLES did not turn up any studies that were not found using the PsycINFO database. Additional studies were identified from the reference lists of the papers identified in the PubMed and PsycINFO searches. Studies included in this review are English-language cross-sectional and longitudinal studies that used at least one neighborhood-level variable in the analysis, had either depression or depressive symptoms as the outcome. All studies were published between January 1990 and August 2007. Excluded articles included reviews and opinion pieces, studies without any geographical component, studies that looked at depression or depressive symptoms only as mediators, and articles that did not differentiate between depression and other psychiatric conditions such as schizophrenia. In total, 45 reports of observational studies of the relation between depression and neighborhood characteristics were identified using these search methods.

Results

The main research questions, study populations, neighborhood definitions, neighborhood features, depression measures, study design, analytical technique, and key results of the 45 studies are described in Table 2.1.

Research questions

Of the 45 studies reviewed, the majority (n=26) focused solely on the main effects of neighborhood-level variables on depression,(1, 3, 4, 5, 6, 7, 12, 19, 29, 30, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58), three were primarily interested in how neighborhood characteristics moderate the association between individual-level risk factors and depressive symptoms, (2, 28, 59) and fifteen examined both the main effects of neighborhood conditions and the interactions of these characteristics with individual-level variables.(20, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73) One study was primarily interested in the interaction of two neighborhood characteristics.(18)

Study population

Studies have varied widely both in sample size and in the characteristics of the populations studied. The size of study populations varied from 117 to 56,428 subjects. Some of the studies restricted their populations to specific racial/ethnic groups or age categories, while others included a wide range of demographic characteristics. Twenty-nine studies examined the association between neighborhood characteristics and depressive symptoms in adult populations across broad age ranges, (2, 3, 4, 12, 18, 19, 20, 28, 30, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 60, 61, 64, 66, 67, 68, 69) ten studies focused on groups of children or teenagers,(5, 6, 7, 44, 45, 59, 62, 70, 71, 73) and six restricted their populations to people aged sixty five and over.(1, 29, 43, 63, 65, 72)

The gender distribution across most studies was relatively evenly balanced. Five of the studies excluded men from analyses,(2, 57, 60, 66, 68) while forty sampled both men and women. Eight studies restricted their study population to African Americans(2, 6, 44, 59, 60, 66, 70, 73) and one study only examined Mexican Americans.(29) The remaining studies enrolled a mixture of racial/ethnic groups, most commonly using random sampling of their study populations. The majority of studies were conducted in metropolitan or urban areas: only 14 studies included non-urban dwelling subjects in their populations.(6, 19, 29, 30, 43, 44, 47, 50, 53, 54, 62, 64, 67, 68)

Neighborhood definitions

The definition and size of a neighborhood varied widely across studies. Neighborhood definitions ranged from participant-defined areas, to census-defined areas (census blocks, tracts, or clusters of tracts). Amongst the thirty-four studies conducted in the United States the vast majority (n= 21) used census or administratively defined areas: five used census block groups (average population approximately 1000 people),(28, 59, 60, 66, 69) nine used census tracts (average population approximately 4,000),(1, 3, 12, 18, 29, 43, 58, 65, 72) and seven used clusters of block groups or tracts. (5, 44, 45, 46, 48, 49, 62) Twelve studies asked each study participant to define their own neighborhood.(2, 4, 6, 7, 19, 20, 47, 63, 68, 70, 71, 73) and one study used circular buffers of varying sizes around residences to define neighborhoods.(56)

The nine studies conducted in the UK (United Kingdom) used government defined areas as proxies for neighborhood, ranging from British electoral wards (mean population about 5,500) to larger regional units, such as the 22 regional unitary authorities of Wales (mean population 122,850).(30, 50, 51, 52, 53, 54, 55, 64, 67) Studies conducted in

Canada and the Netherlands also used administratively defined areas (census tracts in Canada (61) and boroughs in Amsterdam(51)).

Neighborhood features

The neighborhood characteristics investigated fall into two categories: structural characteristics—such as neighborhood socioeconomic and racial/ethnic composition, residential stability, and the built and service environments—and measures of social processes—such as neighborhood disorder, social cohesion and ties with neighbors, and perceived exposure to crime, violence, drug use, and graffiti. Structural characteristics were the most common features examined (33 out of the 45 studies). Twenty-five studies examined the contextual(37) effect of neighborhood socioeconomic position (after accounting for compositional differences) (1, 3, 12, 18, 28, 29, 30, 43, 44, 45, 46, 49, 50, 51, 52, 53, 54, 57, 59, 60, 61, 64, 65, 66, 67) and nine of these studies included no other type of neighborhood characteristic.(30, 46, 49, 50, 51, 53, 54, 64, 67)Racial/ethnic composition (examined in 10 studies)(1, 28, 29, 43, 44, 45, 58, 61, 65, 72) and residential mobility (examined in eight studies) (1, 3, 5, 12, 43, 45, 61, 65) were the other two structural characteristics most commonly examined. Four studies investigated the role of the built environment (7, 48, 55, 56) and one study examined the available service environment.(1)

Twenty-five of the forty-five studies examined the association between neighborhood social processes and depressive symptoms.(2, 3, 4, 5, 6, 18, 19, 20, 44, 47, 52, 57, 59, 60, 62, 63, 66, 68, 69, 70, 71, 72, 73) Of these, ten examined neighborhood disorder and related domains(3, 4, 18, 20, 62, 63, 66, 68, 69, 73), sixteen examined social interactions between neighbors (2, 4, 5, 6, 18, 19, 20, 44, 52, 57, 59, 60, 69, 71, 72, 73)

and twelve investigated exposure to violence and other hazardous conditions(2, 5, 6, 7, 44, 47, 60, 62, 69, 70, 71, 73)

Twelve studies examined both neighborhood structural characteristics and social processes. (3, 5, 18, 28, 44, 45, 52, 57, 59, 60, 61, 65, 66, 68, 72) Nine of the twelve studies looked at both neighborhood socioeconomic characteristics and social processes.(3, 18, 28, 44, 45, 52, 57, 59, 60, 61, 65, 66)

Measurement of neighborhood features

Neighborhood characteristics were measured using a variety of techniques. Census-derived neighborhood variables were the most common measures used (16 studies), (12) (28, 29, 30, 43, 46, 49, 50, 51, 53, 54, 58, 61, 64, 65, 67) followed by self-reports of neighborhood characteristics by study participants (14 studies).(2, 4, 6, 7, 19, 20, 47, 56, 57, 63, 69, 70, 71, 73) Ten studies included both census-derived measures and participant self-reports(3, 5, 18, 44, 45, 59, 60, 66, 68, 72) A small number of studies created measures by using objective raters who did not live in the neighborhoods(48, 55, 62) or by using resources such as phone books to construct neighborhood measures,(1) and investigated the measures so constructed either on their own or in combination with census measures.

Depression measures

The most common outcome measure examined was the CES-D (Center for Epidemiologic Studies-Depression) scale (either full or modified) (19 out of 45 studies).(1, 2, 3, 4, 6, 18, 28, 29, 43, 46, 47, 55, 56, 57, 63, 65, 68, 69, 72) Nine studies relied on measures approximating DSM-IV (Diagnostic and Statistical Manual of Mental Disorders) criteria, a measure of clinical depression.(12, 20, 48, 49, 53, 58, 60, 61, 66)

Studies of children or adolescents also tended to use instruments that approximated DSM criteria.(5, 7, 44, 45, 59, 62, 70, 71) Six studies, mainly carried out in the UK, used the GHQ (General Health Questionnaire),(20, 51, 52, 54, 64, 67) a scale created to assess four elements of non-psychotic distress, including depression.(74) The SF-36 (Mental health index of the Short Form Health Survey 36) was used in two studies(30, 50) and a question from a general health survey (Behavioral Risk Factors Surveillance System) was used in one study.(19)

Study designs

The majority of the studies (35) were cross-sectional in nature. Only ten of the forty-five studies used any type of follow-up or prospective analysis.(4, 45, 46, 49, 54, 62, 66, 68, 70, 71) Thirty-two studies had multilevel designs in that they included data on individuals nested within neighborhoods and collected data at both levels.(1, 3, 12, 18, 19, 28, 29, 30, 43, 44, 45, 46, 48, 49, 50, 51, 52, 53, 54, 55, 57, 58, 60, 61, 62, 64, 65, 66, 67, 68, 69, 72) Thirteen were purely individual-level studies in which individual-level reports of neighborhood characteristics were linked to individual-level outcomes in an individual-level analysis.(2, 4, 5, 6, 7, 20, 47, 56, 59, 63, 70, 71, 73)

Analytical techniques

Twenty-one of the studies used linear or logistic multilevel models to investigate the relationship between depression or depressive symptoms and area-level characteristics.(1, 3, 18, 28, 30, 43, 44, 45, 48, 49, 50, 51, 54, 57, 60, 61, 62, 65, 66, 67, 69) The remaining studies used single-level linear or logistic regression,(4, 5, 6, 7, 12, 46, 47, 55, 56, 59, 63, 64, 68, 70, 71, 72, 73, 75) structural equation modeling,(2) or tests of significance of the difference in prevalence rates between groups.(58) The four studies

that contrasted results from multilevel analysis with an analysis ignoring the multilevel structure reported similar results with both approaches.(19, 29, 52, 53) Individual-level confounders, most commonly age, gender, marital status, ethnicity, education, employment status, financial strain, and number of current physical health problems, were included in models in all 45 studies.

Study results

Thirty-seven of the forty-five studies found support for an association between neighborhood characteristics and depression or depressive symptoms after controlling for a variety of individual-level characteristics, usually a combination of race/ethnicity, age, gender, marital status, education, and income. When categorized by study design six of the seven purely longitudinal studies ,(4, 45, 46, 49, 62, 68) and twenty-nine of the thirty-five purely cross-sectional studies reported associations.(1, 2, 3, 5, 6, 7, 12, 18, 19, 20, 29, 30, 44, 47, 48, 50, 52, 53, 55, 56, 57, 58, 59, 60, 61, 63, 65, 72, 73) Three studies had both cross-sectional and prospective elements: two found a significant association with both types of analyses,(4, 71) while another only found a significant association in their cross-sectional data.(66) The six studies that reported ICCs (intraclass correlations) for depression measures generally reported ICCs in the 0.4% to 2.9% range for cross-sectional studies of adult populations,(30, 51, 52, 53, 61) 11% for children,(45) and 1% for longitudinal analyses.(62)

Differences Based on Neighborhood Characteristics and Definitions

Study results differed depending on which neighborhood characteristics were being studied. Overall, twenty-four of the forty-six different structural characteristics (52%) examined were significantly associated with depressive symptoms/depression.

Thirteen of the twenty-five studies that examined the effect of neighborhood socioeconomic position on depressive symptoms found evidence to support the presence of an association after adjustment for individual-level characteristics.(1, 2, 3, 29, 30, 45, 46, 49, 50, 53, 57, 61, 66) Four of the eight studies that examined the association between depression and residential mobility found evidence of an association.(12, 18, 61, 65) Only four of the ten studies that examined racial/ethnic composition of neighborhoods found support for the association between neighborhood context and depression.(29, 44, 58, 72) All four studies that looked at the association between depressive symptoms and the built environment (specifically the internal and external built environment, the quality of housing areas, the walking environment, and a negative neighborhood environment, identified by factors such as violence, abandoned buildings, and homeless people on the streets) found an association with depressive symptoms.(7, 48, 55, 56)

Twenty-five of the thirty-seven social processes (68%) examined in the studies were significantly associated with depression/depressive symptoms. All but one(69) of the nine studies that assessed whether individual perceptions of the conditions and (4, 71, 76)disorder in one's neighborhood affected risk of depression concluded that these factors were associated with depressive symptoms.(3, 4, 18, 20, 62, 63, 68, 73) Eleven out of sixteen studies found positive social interactions between neighbors to be a protective factor against depression.(2, 4, 5, 6, 18, 20, 57, 59, 71, 72, 73) Exposure to violence and hazardous conditions was found to be associated with depressive symptoms in six out of twelve studies.(2, 5, 6, 47, 60, 62)

Both of the studies that systematically compared results for different scales found no consistent evidence that results differed systematically by neighborhood size, although

one study suggested that small scales (smaller than electoral ward in the UK) may be most relevant to depression.(54, 56) Study results differed somewhat in the United States and in the UK. Regardless of how they defined neighborhood, UK studies found evidence for associations between neighborhood environments and depression in only two-thirds of the studies (6 out of 9), while studies in the United States, independent of the size or definition of neighborhood, found associations between at least one neighborhood characteristic and depression in 30 out of 34 studies.(1, 2, 3, 4, 5, 6, 7, 12, 18, 19, 20, 28, 29, 43, 44, 45, 46, 47, 48, 49, 56, 58, 59, 60, 61, 62, 63, 65, 66, 68, 69, 70, 71, 72, 73)

Heterogeneity in the Effects of Neighborhood-Level Variables

It has been hypothesized that the effect of neighborhood context on depression may vary by gender, age, racial/ethnic group or socioeconomic position. Of the nine studies that reported results either stratified by gender or with interaction terms between gender and neighborhood characteristics, two found that neighborhood characteristics were more strongly associated with depressive symptoms in females(6, 71) and one found a stronger association in males,(56) while others had mixed results(28, 63, 70, 73) or found no difference between genders.(30, 61) Although the number of studies of children or the elderly was generally small, there was limited evidence of more consistent associations in children or elderly persons: four of the five studies that restricted their populations to elderly and 9 of the 10 studies of children aged 18 and under found evidence of an association between neighborhood characteristics and depressive symptoms, as compared to 24 of 30 studies of adult populations. Very few studies have investigated heterogeneity by race/ethnicity.(5, 20, 28, 29) In a Baltimore study, community cohesion was associated with less depression among whites, but was not

associated with depression amongst African Americans.(20) One study found Mexican Americans had better mental health in areas with high concentrations of Mexican Americans, whereas another study found that African Americans had worse mental health in areas with higher concentrations of African Americans, although this association disappeared after adjustment for individual-level variables.(28, 29)

Five studies examined interactions of neighborhood characteristics with individual-level socioeconomic position. Three of these studies found no interaction,(28, 65, 66) while two found a significant interaction between individual-level economic status and neighborhood conditions.(64, 67) Wealthy individuals living in areas with high income inequality had higher levels of mental disorders than those living in more equal areas, while the opposite was true for poor individuals.(64) Living in a poverty area was only associated with worse mental health outcomes amongst the unemployed in another study.(67) Other sets of interactions have also been examined in a small number of studies: knowing one's neighbors was more strongly associated with higher levels of childhood anxiety and depression in poverty area neighborhoods than in wealthy neighborhoods;(59) parents' use of inductive reasoning was a protective factor for African American teenagers' levels of depressive symptoms only for those living in disordered neighborhoods;(62) and residential stability was associated with lower levels of depressive symptoms in wealthy neighborhoods and higher levels in poor neighborhoods.(18)

Longitudinal Studies

Ten of the forty-five studies used some type of follow-up or prospective analysis.(45, 46) (4, 49, 54, 62, 66, 68, 70, 71) Two studies had one year or less of

follow-up time,(4, 54) six studies had 1-2 years of follow-up,(45, 49, 62, 66, 68, 70) one study had 7-8 years of follow-up,(71) and one study followed subjects for ten years.(46) Nine of the ten studies had two waves of data,(4, 45, 46, 54, 62, 66, 68, 70, 71) while one study used three waves of data collection.(49) Four studies defined incident depression/depressive symptoms as all subjects who did not have depression or fell below a certain cutoff level of depressive symptoms at baseline, but who did have depression or were above the cutoff level at follow-up time(s), (46, 49, 54, 66) one study used a change score,(68) and five studies simply used the level/presence of depressive symptoms at follow-up, with three of these controlling for baseline levels in their models.(4, 45, 62, 70, 71) Four studies restricted their populations to children (45, 62, 70, 71) and two to women,(66, 68) while the rest enrolled representative adult populations.(4, 46, 49, 54) Each of these studies used a different definition of neighborhood: New York City community districts, census block groups, clusters of census block group areas, British electoral wards, clusters of multiple census tracts, poverty areas/non poverty areas, and participant-defined neighborhoods. Five of these studies focused on measures of neighborhood socioeconomic position and disadvantage,(45, 46, 49, 54, 66) and two of these additionally examined social cohesion and neighborhood disorder as predictors.(45, 66) Four of the five studies that examined the association between neighborhood socioeconomic status and development of depressive symptoms found evidence of an association,(45, 46, 49, 66) after controlling for combinations of age, education, sex, race/ethnicity, income, stressors, marital status, number of children, receiving government assistance, perceived health status, body mass index, smoking, and alcohol consumption, while one found no association.(54) Neighborhood disorder was

prospectively associated with depressive symptoms in four out of five studies.(4, 62, 63, 68, 70) Neighborhood cohesiveness was associated with depressive symptoms in two(45, 71) of the three studies that examined this process.(4, 45, 71)

Discussion

Of the 45 studies reviewed, 37 reported associations of at least one neighborhood characteristic with depression or depressive symptoms after controlling for individual-level characteristics. The percentage of positive results was similar in cross-sectional (82%) and longitudinal (70%) studies. The associations of depressive symptoms/depression with structural features were less consistent (52% significantly associated) than with social processes (68%). Among the structural features, measures of the built environment appeared to be more consistently associated with depression than socioeconomic deprivation, residential stability, or race composition, although only a few studies to date have investigated the built environment.

Although a wide variety of area definitions were investigated, very few studies systematically compared area definitions and no clear pattern emerged from the comparison of studies using different sized areas. Controlling for individual-level confounders often reduced the magnitude of the association between neighborhood characteristics and depression/depressive symptoms, although the association rarely disappeared all together. Interactions were investigated in only a small number of studies making it difficult to draw any conclusions about vulnerable groups, although there was some evidence of stronger effects in children and the elderly than in adult populations. The studies varied widely in neighborhood definitions, in the neighborhood-level

variables investigated and in the individual-level covariates examined, making it impossible to conduct a meta-analysis of study results. Increasing comparability across studies in the geographic areas, the variables, and the outcomes examined to conduct systematic reviews is an important need in the field.

Current limitations in this body of literature include limited theory about how neighborhoods may influence depression and depressive symptoms; the lack of consistency in the definitions of neighborhoods and the measures of neighborhood-level properties examined; the possibility of reporting bias, reverse causation, and residual confounding; the dearth of studies exploring different spatial scales; and the relative lack of longitudinal studies. Five important research directions emerge from the reviewed works. These research directions are: (1) developing theory on the processes through which specific area features may affect mental health, including theories on the most vulnerable groups (2) improving the measures of neighborhood or area-level factors necessary to test these theories empirically (3) investigation of a broad range of areas (or spatial scales) and neighborhood-person interactions; (4) addressing issues of reporting bias, reverse causation, and residual confounding and (5) increasing the use of longitudinal and quasi-experimental or experimental designs.

Developing theory on the processes through which area features may be associated with depression and depressive symptoms and empirically testing specific predictions derived from these theories is fundamental to strengthening causal inference. Empirical investigations of the processes linking neighborhood characteristics to depression will require the measurement of the specific neighborhood attributes involved. To date, the majority of studies have used measures of the socioeconomic composition of

areas as a proxy for the more specific area attributes that may be relevant. A growing number of studies have attempted to measure specific attributes of neighborhoods such as the built environment, social cohesion, disorder or crime.(2, 3, 4, 6, 20, 48, 63) It is interesting to note that findings have generally been more consistent for studies focusing on specific neighborhood attributes than those focusing on aggregate measures of socioeconomic position or deprivation. However, the measures used across studies have varied widely, making comparisons difficult. Developing standardized measurement instruments that can be applied across studies so that findings can be systematically compared will be an important advancement. One methodology that could potentially be explored further involves the use of Geographic Information Systems (GIS) to construct measures of the built environment and the physical layout of neighborhoods hypothesized to be related to mental health or to create synthetic geographical areas with optimized homogeneity of social characteristics.(77)

There is little consensus on what spatial scales (ranging from the immediate built environment of the home to broader regional characteristics) may be relevant to depression or depressive symptoms in different population groups. The development of hypotheses on relevant spatial definitions will require more sophisticated theory on how persons interact with and are affected by spatial contexts. In the absence of clear theory on the spatial scale relevant to a particular process, researchers can conduct sensitivity analyses to determine the effects of different definitions of “neighborhoods” on the results of their research.(77) The definition and size of a neighborhood varied widely across the studies in this review and few studies have examined sensitivity of results to the use of measures corresponding to different sized areas.(56, 67) The use of spatial

analytic methods is another promising arena which has not yet been extensively used in this body of literature.(78, 79, 80) These methods can be used to investigate the spatial patterning of health outcomes without relying on arbitrary defined boundaries. This spatial patterning can provide information on the spatial scale at which the relevant processes may be operating.

An important methodological challenge in investigating neighborhood effects on depression is reporting bias (sometimes also referred to as same-source bias). Reporting bias may arise for example if people who are already depressed report lower levels of social cohesion and a worse external environment because of their depression. Many of the studies in this review measured neighborhood conditions from the same sample of people from whom they took measurements on depressive symptoms. The association between social cohesion and depressive symptoms, for example, may exist because depressed people feel more alone, even though their neighborhood, objectively, does not have low social cohesion. A growing body of work on ecologic measurement has begun to develop alternative ways to use survey data or objectively collected data on the built environment (though publicly available data or systematic social observation) to characterize neighborhood environments in ways that avoid same source bias.(79, 81) Greater use of these methods in the area of neighborhood characteristics and depression is needed.

Reverse causation and residual confounding by individual-level variables are two additional methodological problems. Reverse causation would arise if people who are depressed tend to stay in or move into deprived neighborhoods. In this case the exposure to the neighborhood condition is a consequence of (and not a cause of) depression. All

cross-sectional studies are vulnerable to the problems of reverse causation. Longitudinal designs are necessary to rule out reverse causation as an explanation for cross-sectional associations. As in other neighborhood effects research, the possibility of residual confounding by individual-level variables is an important limitation of observational studies of neighborhoods and depression. Most studies in this review attempted to address this issue by controlling for a variety of individual-level variables, but there is no consensus on what the key confounders are likely to be, or on the sensitivity of results to plausible amounts of residual confounding. Other approaches sometimes used to control for multiple confounders such as propensity score analysis (80, 82) have not been used in research on neighborhoods and depression.

The majority of existing studies of neighborhoods and depression are cross-sectional. As noted above, longitudinal studies are necessary to rule out reverse causation. They are also needed to investigate time lags and cumulative effects of neighborhoods on depression. Short of the ideal randomized experiment, natural experiments or quasi-experimental designs may also provide opportunities to examine causal effects of neighborhood or area attributes on depression avoiding some of the pitfalls of observational studies. For example, a study could examine changes in depressive symptoms over time in a neighborhood in response to some source of exogenous variation such as the inauguration of a new public space, or the implementation of a new community policing approach. These interventions, which are “naturally occurring” in neighborhoods all the time, provide valuable but as yet untapped opportunities to investigate area or neighborhood effects on depression. In summary, existing observational evidence supports a role of neighborhood conditions in the

development of depression and depressive symptoms. However more refined observational work (including the study of natural experiments) is needed to determine whether the associations observed are causal and what the relevant neighborhood-level attributes and mediating variables may be.

Table 2.1 Summary of key features of 45 reviewed studies

Author, Year	Primary Research Question Addressed	Study Sample	Neighborhood Definition Used	Neighborhood Features Investigated	Depression Measure Investigated	Study Design	Key Analytical Technique	Results (Support for Neighborhood Effects on Depression?)
Anehensel et al., 2007(65)	Are depressive symptoms in older individuals associated with low SES, high concentrations of ethnic minorities, low residential stability and low proportion of residents aged 65+ in urban neighborhoods?	3,442 individuals aged >70 years living in urban areas in the United States, from AHEAD**	Census tracts	Socioeconomic disadvantage, affluence, racial/ethnic composition (proportion of African American residents, proportion of Hispanic residents), residential stability, proportion of persons >65 years (all from census)	8-item version of CES-D**	Cross-sectional	Multilevel analysis	Y and N: Depressive symptoms are associated with residential stability (β (s.e.)=0.72(0.27)) after controlling for individual-level characteristics, but not with any of the other neighborhood characteristics.
Anehensel et al., 1996(5)	Are adolescents' experiences of their neighborhood as threatening or cohesive associated with their mental health??	877 adolescents aged 12-17 from Los Angeles County	Census tracts, grouped using cluster analysis into 8 clusters	Participant-reported subjective neighborhood measures (ambient hazards, social cohesion), neighborhood stability	CDI**	Cross-sectional	Single-level linear regression	Y: Adolescents' perceptions of ambient hazards (β (s.e.)=0.022(0.008)) and negative social cohesion (β (s.e.)=-0.122(0.032)) are both associated with depressive symptoms.
Berke et al., 2007(56)	Is there an association between neighborhood walkability and depressive symptoms in older adults?	740 adults aged 65 + from King County, WA	Circular buffers of radius 100, 500, and 1000 m around each subject's home	Neighborhood Walkability, measured by the WBC**. Greater walkability was assessed, on a scale of 0 to 100, according to the probability of meeting the CDC guidelines of 150+ minutes per week of physical activity versus none.	CES-D	Cross-sectional	Single-level logistic regression	Y: For men, there was an association between neighborhood walkability and depressive symptoms (OR for the interquartile range of walkability score=0.31-0.33 for the buffer radii, $p=0.02$) after adjustment for key individual-level factors. This association was not significant in women ($p>0.68$).
Caughy et al., 2003(59)	Is there an association between how well a parent knows their neighbors and their child's internalizing behaviors? Does this association differ by neighborhood SES context?	200 African American families with a child aged 3-4.5 in Baltimore	Census block groups	Neighborhood poverty (from census), general sense of community, how well one knows one's neighbors (participant-reported)	CBCL** internalizing problems score	Cross-sectional	Single-level linear regression	Y: Low sense of community was associated overall with higher levels of internalizing problems (β (s.e.)=3.6(1.9)). In wealthy neighborhoods, knowing neighbors decreased internalizing problems; in poor neighborhoods knowing neighbors was associated with increased

Author, Year	Primary Research Question Addressed	Study Sample	Neighborhood Definition Used	Neighborhood Features Investigated	Depression Measure Investigated	Study Design	Key Analytical Technique	Results (Support for Neighborhood Effects on Depression?)
								internalizing problems.
Christie-Mizell et al., 2003(68)	Are the subjective appraisal of the neighborhood and living in an urban vs. rural area associated with maternal psychological distress? Does this differ by race?	2204 women with at least 1 child from NLSY**	Participant-defined neighborhoods (for the subjective appraisal) and type of neighborhood subjects lived in, as defined by the census(central city vs. urban vs. rural area)	Living in a SMSA**, perceived neighborhood disorder (participant-reported)	7-item version of CES-D score	Longitudinal	Single-level linear regression with change in CES-D as outcome	Y: Across all racial groups, neighborhood perceptions influence maternal distress (β (s.e.)=0.17(0.02)). Also, objective neighborhood location influences how mothers perceive their neighborhoods
Cutrona et al., 2005(66)	Are women who reside in poor and/or dangerous neighborhoods more likely to experience episodes of major depression than those in safe, affluent ones, after controlling for individual-level risk factors?	720 women from FACHS** (large-scale study of African American families who live outside large metropolitan inner cities in the United States)	Census block groups	Economic disadvantage index (from census), neighborhood-level social disorder (combination of Community Dilapidation and Community Deviance scales)	UM-CIDI**	Cross-sectional and longitudinal	Multilevel analysis	Y: Neighborhood disadvantage/social disorder was associated with recent onset of depression, after controlling for individual-level risk factors (OR=1.92 (1.04-3.52)). However, neighborhood disadvantage and disorder did not predict onset of depression at a later date.
Cutrona et al., 2000(60)	What is the effect of neighborhood context on psychological distress amongst African American women? Does community context interact with individual-level risk factors in the prediction of distress?	733 African American women from the FACHS who were the primary caregiver for a 10-12 year old child	Census neighborhood block group areas	Neighborhood cohesion and disorder (participant-reported), community economic disadvantage (from census)	General Distress and Anxious Arousal, 2 subscales from the Mini-Mood and Anxiety Symptom Questionnaire (similar to UM-CIDI)	Cross-sectional	Multilevel analysis	Y: Neighborhood disorder (β =0.38, $p<0.05$), but not cohesion or economic disadvantage, was associated with level of distress, after controlling for individual-level characteristics. There were significant interactions between some neighborhood- and individual-level characteristics in the prediction of distress.

Author, Year	Primary Research Question Addressed	Study Sample	Neighborhood Definition Used	Neighborhood Features Investigated	Depression Measure Investigated	Study Design	Key Analytical Technique	Results (Support for Neighborhood Effects on Depression?)
Dupéré and Perkins, 2007(69)	Is there variation at the block level in well-being and depression? Do community-level environmental stressors and social resources affect well-being and depression?	412 residents from 50 neighborhoods in a large city in the Mid-Atlantic region of the US	Census blocks	Neighborhood disorder, fear of crime, formal participation, informal ties with neighbors (participant-reported)	The 6-item depression factor of the CES-D scale	Cross-sectional	Multilevel analysis	N: There was no significant variation at the block-level for depression, although there was significant variation at the block-level for well-being. The community-level stressors and resources had no impact on mental health over and above individual and block socioeconomic characteristics.
Fitzpatrick et al., 2005(6)	Do bonding social ties of youth to their family, school, and community have an inverse relationship with depressive symptoms?	1538 African American middle and high school students from 1 school district in Alabama	Participant-defined neighborhoods	Exposure to violence, human capital, social capital (participant-reported)	CES-D	Cross-sectional	Single-level linear regression	Y: Adolescents exposed to threatening environments had higher rates of depression ($\beta=1.45$, $p<0.01$); social capital had an inverse relationship with depression ($\beta=-0.18$, $p<0.05$).
Forehand and Jones, 2003(70)	What is the interactive influence of neighborhood violence and co-parent conflict on child psychological adjustment?	117 African-American children aged 8-14 from an inner-city area of New Orleans with single mothers	Participant-defined neighborhoods	Neighborhood risks (physical fighting, shootings or knifings, people being killed) (participant-reported)	CDI	Longitudinal and cross-sectional	Single-level multiple regression	N: Neighborhood violence was not associated with child psychosocial adjustment ($\beta=-0.04$, $t=-0.45$). However, girls living in homes with high levels of co-parent conflict were more vulnerable to the effect of neighborhood violence (β for interaction=0.27, $p<0.05$).
Galea et al., 2005(48)	Are characteristics of the internal and external physical built environment related to depression?	1,355 residents of New York City	Community districts, NYC	Characteristics of the internal built environment and the external built environment (from census, the New York City housing and vacancy survey, and the fiscal 2002 New York City mayor's management report)	National women's study depression module, consistent with DSM-IV** criteria	Cross-sectional	Multilevel analysis	Y: Characteristics of the built environment are associated with likelihood of depression: people living in poor quality built environments were 29-58% more likely to report past 6 month depression and 36-64% more likely to report lifetime depression.
Galea et al., 2007(49)	Is incident depression associated with urban	1,120 adult residents of	Community districts, NYC	Neighborhood SES (from census)	Modified Version of	Longitudinal	Multilevel analysis	Y: Relative odds of incident depression were

Author, Year	Primary Research Question Addressed	Study Sample	Neighborhood Definition Used	Neighborhood Features Investigated	Depression Measure Investigated	Study Design	Key Analytical Technique	Results (Support for Neighborhood Effects on Depression?)
	neighborhood poverty?	New York City			SCID**, 3 rd edition			2.19(95%CI-1.04, 4.59) for participants living in low vs. high SES neighborhoods.
Gary et al., 2007(75)	Are perceptions of neighborhood characteristics associated with mental health outcomes amongst African American and white adults in Baltimore? Do these associations differ by race?	1,408 African American and white adult residents of Baltimore, MD	Participant-defined (for items relating to perceptions), blocks (for resources)	Perceptions of potential neighborhood problems, availability of a community leader, community cohesion, resources (desirable and undesirable) within the community (participant-reported)	PHQ-9** and GHQ	Cross-sectional	Single-level linear and logistic regression	Y: Perception of severe community problems was associated with depression (OR=2.2 (white), 1.9 (African American), p<0.05 (both)). Community cohesion was only associated with lower levels of depression in whites (OR=0.5, p<0.05).
Greiner et al., 2004(19)	What are the associations between level of community participation, self-reported community ratings (trust), and depressive symptoms?	4601 subjects from the Kansas BRFSS	Counties/participant-defined	Overall community ratings (neighborhood-level trust) and social participation (participant-reported)	Optional depressive symptoms question from BRFSS**	Cross-sectional	Multilevel analysis, single-level logistic regression	Y and N: Community rating was associated with depression (OR=0.65(0.57-0.75)), but community involvement was not (OR=0.99(0.71-1.36)), after adjustment.
Gutman and Sameroff, 2004(71)	What are the ecological variables that influence depression in males and females from adolescence to young adulthood? Are there gender differences in these associations?	372 youth from the 1 st (when subjects were aged 11-15) and 2 nd (7-8 years later) waves of the Philadelphia Family Management study, from 4 inner city areas of Philadelphia	Participant-defined	Neighborhood cohesiveness, neighborhood problems (participant-reported)	Youth depressive symptoms: 9 items assessing how often they felt certain symptoms in the past couple of months	Cross-sectional and prospective	Single-level linear regression	Y: Neighborhood cohesiveness in adolescence was associated with higher levels of depressive symptoms in females in adolescence and early adulthood, and with males' depressive symptoms in adolescence. Neighborhood problems were only associated with increased levels of depressive symptoms in young female adults.
Hadley-Ives et al., 2000(7)	Is the impact of the environment on mental health determined by perception of that environment in adolescents?	792 subjects from the Youth Service Project, aged 13-18 in St. Louis, MS	Participant-defined	Negative neighborhood environment (extent to which drug dealing, shootings, murder, abandoned buildings, neighbors on welfare, homeless people on the street, and prostitution exist in neighborhood), perception of	DISC-R**	Cross-sectional	Single-level linear regression	Y: Perception of neighborhood was associated with adolescent mental health ($\beta=0.04$, p<0.001).

Author, Year	Primary Research Question Addressed	Study Sample	Neighborhood Definition Used	Neighborhood Features Investigated	Depression Measure Investigated	Study Design	Key Analytical Technique	Results (Support for Neighborhood Effects on Depression?)
				violence (participant-reported)				
Henderson et al., 2005(28)	What is the relation between neighborhood socioeconomic and ethnic characteristics and depressive symptoms in young adults, and do they modify the relation between individual SES and depression?	3,437 adults aged 18-30 from the CARDIA study at 4 US sites (Chicago IL, Birmingham AL, Minneapolis MN, Oakland CA)	Census block group	6 area census variables reflecting wealth/income, education, and occupation, were summed to create a neighborhood summary score; ethnic density	CES-D	Cross-sectional	Multilevel analysis	N: Neither neighborhood socioeconomic characteristics nor ethnic density were consistently associated with depression after controlling for individual-level characteristics.
Hybels et al., 2006(43)	What is the association between neighborhood context and level of depressive symptoms in older adults?	2998 adults 65+ years old in North Carolina	Census tracts	Neighborhood SES, racial/ethnic heterogeneity, residential stability, and neighborhood age structure (from census)	CES-D	Cross-sectional	Multilevel analysis	N: None of the neighborhood characteristics was significantly associated with depressive symptoms conditional on census tract random effects, both before and after adjustment for individual characteristics.
Kubzansky et al., 2005(1)	What is the contribution of neighborhood disadvantage, neighborhood service environment, and individual characteristics to depression in the elderly?	2,109 non-institutionalized people 65 and older in New Haven, CT	Census tract	Neighborhood socioeconomic disadvantage and advantage, racial/ethnic heterogeneity, residential stability, age structure (from census), service density (services promoting social engagement, providing care, and undesirable amenities) (constructed from phonebook listings)	CES-D	Cross-sectional	Multilevel analysis	Y: Low neighborhood SES ($\beta=6.51$ (1.02, 12.00)) and presence of more elderly people ($\beta=-13.55$ (-24.76, -2.34)) were associated with depressive symptoms in the elderly after controlling for individual characteristics, but none of the other neighborhood measures were.
La Gory and Fitzpatrick, 1992(72)	What is the impact of environmental context (social networks and neighborhood characteristics) on depressive symptoms? Are there joint effects of personal competence and the residential	725 adults aged 55+ from 4 metropolitan counties in Alabama	Census tracts	Racial congruence, age density (% of people aged 55+ in the census tract) (from census), neighborhood resource accessibility (availability of automobile transport), perceived environment, social support (participant-reported)	CES-D	Cross-sectional	Single-level linear regression	Y: Being environmentally dissatisfied, having limited social supports, and living in a neighborhood with transportation problems are associated with increased levels of depressive symptoms. Significant interactions were found

Author, Year	Primary Research Question Addressed	Study Sample	Neighborhood Definition Used	Neighborhood Features Investigated	Depression Measure Investigated	Study Design	Key Analytical Technique	Results (Support for Neighborhood Effects on Depression?)
	environment?							between environmental dissatisfaction and resource accessibility and functional health ($p<0.01$).
Latkin et al., 2003(4)	Do subjects from neighborhoods with outward signs of disorder/that are decaying experience greater uncontrolled stress and symptoms of depression?	818 participants in high drug use areas in Baltimore, MD	Participant-defined neighborhood	Social support, social integration, perception of neighborhood characteristics (participant-reported)	CES-D	Cross-sectional, follow-up with depression	Single-level linear regression	Y: Strong, prospective association between negative perceived neighborhood characteristics and subsequent depressive symptoms, after adjusting for baseline depression ($\beta=0.28$, $p<0.01$).
Matheson et al., 2006(61)	Are depressive symptoms associated with neighborhood ethnic diversity, dependency, residential instability, and material deprivation? Does chronic stress explain gender differences in depression?	56,428 adults aged 18-74 living in Census Metropolitan Areas in Canada	Canadian Census Tracts	Residential instability, material deprivation, dependency, ethnic diversity (from Canadian census)	CIDI-SF MD**	Cross-sectional	Multilevel Analysis	Y: Residential instability ($OR=1.04$, $p<0.05$) and material deprivation ($OR=1.05$, $p<0.01$) were associated with depression after controlling for individual-level characteristics. Chronic stress was not associated with gender differences in depression.
Mulvaney and Kendrick, 2005(57)	What is the relationship between maternal depressive symptoms and individual- and neighborhood-level measures of deprivation, social support, and stress in mothers living in deprived areas?	846 mothers of young children living in deprived areas (Townsend deprivation scores >0) of Nottingham, UK	Enumeration districts	Social capital, stress, perceived social support, neighborhood deprivation (participant-reported)	CES-D	Cross-sectional	Multilevel analysis (random effects logistic regression)	Y: Neighborhood deprivation (OR for highest vs. lowest fifth= 2.4 ($1.28-4.48$)), lack of social support ($OR=2.51$ ($1.75-3.61$)), and self-reported stress ($OR=10.42$ ($6.29-17.28$)) were all associated with depressive symptoms in a model adjusting for all these characteristics plus social capital, receiving means-tested benefits, and having 3+ kids <5 years.
Natsuaki et al., 2007(62)	Does observed neighborhood disorder prospectively influence African American adolescents' depressive	777 African American children aged 9-12 at baseline, from	Clusters of census block group areas	Interviewers' observed neighborhood disorder at baseline	DISC-IV**	Prospective	Multilevel analysis	Y: There is an interaction between baseline neighborhood disorder, parents' use of inductive reasoning, and depressive

Author, Year	Primary Research Question Addressed	Study Sample	Neighborhood Definition Used	Neighborhood Features Investigated	Depression Measure Investigated	Study Design	Key Analytical Technique	Results (Support for Neighborhood Effects on Depression?)
	symptoms? Does it interact with parents' engagement in inductive reasoning?	Iowa and Georgia						symptoms, such that parental use of inductive reasoning was a protective factor for depressive symptoms especially for youths living in highly disordered neighborhoods (β (s.e.)=-0.14(0.07))
Ostir et al., 2003(29)	Is neighborhood poverty associated with increased depression, and is increasing proportion of older Mexican Americans associated with decreased depression?	2710 non-institutionalized Mexican Americans aged 65 years or older, from 5 southwest states	Census tract	Percent Mexican Americans in census tract, neighborhood SES (from census)	CES-D	Cross-sectional	Multilevel analysis and single-level linear regression	Y: After adjustment for individual characteristics, each 10% increase in neighborhood poverty was associated with a 0.76 (95%CI 0.06-1.47) increase in CES-D score, while each 10% increase in Mexican American population was associated with a 0.55 (95%CI 0.96-0.13) decrease.
Reijneveld and Schene, 1998(51)	Is the distribution of mental disorders associated with neighborhood SES? If this relationship exists after controlling for individual SES, is it due either to selective migration or causation?	5121 residents of Amsterdam	Boroughs, categorized by deprivation into 3 levels	Area deprivation, assessed through registered income, household income below minimum, and unemployment rate	GHQ	Cross-sectional	Multilevel analysis	N: The prevalence of mental disorders is higher in deprived areas, but can be almost fully explained by the sex and SES of residents.
Ross, 2000(3)	Is the impact of neighborhood disadvantage on adult mental health mediated by disorder in the neighborhood?	2,482 Illinois residents from the Community, Crime and Health data set	Census tract	Ross-Mirowsky Perceived Neighborhood Disorder Scale (participant-reported), objective neighborhood disadvantage from census	CES-D	Cross-sectional	Multilevel analysis	Y: Neighborhood disadvantage affects adult depression ($\beta=0.228$), although more than half of the contextual effects are really due to individual disadvantage ($\beta=0.081$ when individual-level characteristics are added). The effect of neighborhood poverty is mediated by perceived neighborhood disorder.
Ross et al.,	What are the joint effects	2,482 Illinois	Census tract	Objective neighborhood	7-item	Cross-	Multilevel	Y and N: Neighborhood

Author, Year	Primary Research Question Addressed	Study Sample	Neighborhood Definition Used	Neighborhood Features Investigated	Depression Measure Investigated	Study Design	Key Analytical Technique	Results (Support for Neighborhood Effects on Depression?)
2000(18)	of neighborhood stability and poverty on depression and what mechanisms connect objective neighborhood characteristics to depression?	residents from the Community, Crime and Health data set		characteristics (neighborhood stability, poverty, and their interaction) (from census), perceived neighborhood disorder (Ross-Mirowsky scale), informal social ties with neighbors, fear, and sense of personal powerlessness (participant-reported)	modification of CES-D	sectional	analysis	stability is associated with psychological well-being only in economically advantaged neighborhoods; it has a slight negative effect in poor neighborhoods.
Schieman et al., 2004(63)	What is the association between perceived neighborhood problems and mental health amongst older adults?	1167 men and women aged 65+ in Washington DC and 2 adjoining counties	Participants told to refer to "the area around where you live"	Neighborhood problems (a modified version of the Ross-Mirowsky Perceived Neighborhood Disorder Scale) (participant-reported)	7 items about depressive symptoms in the past week	Cross-sectional	Ordinary least squares regression, men and women separately	Y: Neighborhood problems are associated positively with depression in men (β (s.e.)=0.095(0.094)) and women (0.087(0.082)). Received support buffers this association in women.
Schulz et al., 2006(2)	Are household income and length of residence protective of mental health? Are these effects mediated through perceived financial stress, perceived discrimination, and perceived safety?	679 African American women living in Detroit	Participant-defined neighborhood	2 measures of stressful neighborhood conditions (concern about police responsiveness, safety stress scale), instrumental social support, emotional social support (participant-reported)	CES-D	Cross-sectional	Structural equation modeling	Y: Household income may be protective of mental health, both directly and indirectly (through reduced financial stress and increased social support). Length of residence is not associated with depressive symptoms.
Silver et al., 2002(12)	Do neighborhood structural characteristics affect prevalence of mental disorder, after controlling for individual SES?	11,686 residents from 5 areas of the US, in the Epidemiological Catchment Area	Census tract	9 census tract measures used to create 2 factors: neighborhood disadvantage and neighborhood residential mobility	Diagnostic Interview Schedule, DSM-III diagnoses	Cross-sectional	Single-level logistic regression	Y: depression was more prevalent in residentially mobile (OR=1.14 (1.03-1.27)) and disadvantaged neighborhoods (OR=1.14 (1.01-1.31)), after controlling for individual risk factors.
Simons et al., 2002(44)	What are the community-level correlates of childhood depressive symptoms in an African American sample?	867 African American children aged 10-12 in Georgia and Iowa.	Community groups, made up of census block group areas from cluster analysis	Community cohesion, community ethnic identification, prevalence of discrimination and crime (participant-reported), and neighborhood poverty (from census)	DISC-IV	Cross-sectional	Multilevel analysis	Y: Community ethnic identification (β =-0.392, p-value=0.04) and prevalence of discrimination (β =0.313, p-value=0.04) were associated with child depressive symptoms, after controlling for individual-

Author, Year	Primary Research Question Addressed	Study Sample	Neighborhood Definition Used	Neighborhood Features Investigated	Depression Measure Investigated	Study Design	Key Analytical Technique	Results (Support for Neighborhood Effects on Depression?)
								and community-level characteristics. The other community-level variables were not associated with depressive symptoms.
Skapinakis et al., 2005(50)	Do regional mental health differences in Wales persist after taking into account individual characteristics and regional social deprivation?	26710 people from the Welsh Health Survey (covering all of Wales)	The 22 regional unitary authorities of Wales	Welsh Index of Multiple Deprivation	SF-36**	Cross-sectional	Multilevel analysis	Y: There was a significant difference in psychiatric morbidity between regions (1.47% of variance), which was reduced but persisted after adjusting for individual-level characteristics (0.99%).
Steptoe et al., 2001(52)	Is neighborhood stress associated with psychological distress? Is the association independent of neighborhood SES, individual SES, and social capital differences?	658 subjects (survey respondents) living in the London area	U.K. postal sectors	Neighborhood problems, social cohesion, informal social control, neighborhood SES (combined participant reports and census information)	GHQ	Cross-sectional	Multilevel analysis, single-level logistic regression	Y: Highest quartile of neighborhood problems had higher distress levels (OR=2.65(1.47-4.47)), adjusted for social cohesion and control. Neither social cohesion nor social control was associated with depression.
Stevenson, 1998(73)	Do African American youth in self-reported unsafe neighborhoods have higher levels of depression? Do teens with supportive families and neighborhoods have better psychological outcomes than those with only 1 of these supports?	160 low-income, inner-city African American adolescents in a northeastern U.S. city	Participant-defined neighborhoods	Neighborhood social capital, neighborhood risk, fear of calamity (a measure of negative urban life experiences) (participant-reported)	SMDI**	Cross-sectional	Single-level linear regression	Y: Only neighborhood social capital was significantly associated ($r=-2.16, p<0.05$) with depression in multiple regression analyses.
Tweed et al., 1990(58)	What is the effect of exposure to racially dissonant residential environments on depressive psychopathology?	3481 adults aged 18+ from the eastern third of the city of Baltimore	Census tracts	Racial congruence (% of the residential area population that is the same racial/ethnic group as individuals)	Depressed mood (fulfilling criterion A of DSM-III), major depressive episode (DIS/DSM-III diagnosis)	Cross-sectional	Calculation of z-scores, summary tests of significance comparing prevalence rates of depression	Y: An inverse relationship exists between racial congruity and depressed mood.
Wainwright	Is there area level	20921	Electoral wards	Overall index of multiple	SF-36	Cross-	Multilevel	Y: Area deprivation was

Author, Year	Primary Research Question Addressed	Study Sample	Neighborhood Definition Used	Neighborhood Features Investigated	Depression Measure Investigated	Study Design	Key Analytical Technique	Results (Support for Neighborhood Effects on Depression?)
and Surtees, 2004(30)	variation in mental functional health after controlling for individual level SES? What's the extent of the area level and individual level variation?	participants in the EPIC-Norfolk study**		deprivation		sectional	analysis	associated with poor mental health, but the residual variation after adjusting for individual level risk factors was modest for men and non-existent for women.
Wainwright and Surtees, 2004(53)	What is the relative strength of the association between individual and area-level demographic and socio-economic factors and depression?	19687 participants in the EPIC-Norfolk study	Electoral wards	Overall index of multiple deprivation	DSM-IV criteria	Cross-sectional	Single-level logistic regression, multilevel analysis	Y: An association remained between area deprivation and current mood disorders, after adjusting for individual-level risk factors (OR for top vs. bottom quartile of deprivation=1.29(1.1-1.5)). Significant area-level residual variation remained.
Weich et al., 2001(64)	Do individuals in regions with the highest income inequality have a higher prevalence of depression, after adjustment for individual income?	5511 participants in BHPS (a representative sample of individuals in private households in England, Wales, and Scotland)	Standard regions	Gini coefficient (income inequality)	GHQ	Cross-sectional	Single-level linear regression	N: No significant association between Gini coefficient and depression (OR=0.99(0.87-1.13), although there was a significant interaction between individual income and Gini (p<0.01).
Weich et al., 2002(55)	Is depression most prevalent in areas characterized by derelict buildings and abundant graffiti, open public spaces and few buffers between public and private spaces?	1,887 people from 2 wards in London, UK	"Housing areas," 86 areas with homogenous housing type and form	Built Environment Site Survey Checklist, an inventory for rating housing areas carried out by an urban design postgraduate who did not live in the area	CES-D	Cross-sectional	Single-level logistic regression, linear regression	Y: There was an association between depression and characteristics of the built environment, which remained after adjusting for individual SES and internal characteristics of dwellings (OR for properties with deck access=1.28 (1.03, 1.58); OR for recent construction=1.43 (1.06-1.91)).

Author, Year	Primary Research Question Addressed	Study Sample	Neighborhood Definition Used	Neighborhood Features Investigated	Depression Measure Investigated	Study Design	Key Analytical Technique	Results (Support for Neighborhood Effects on Depression?)
Weich et al., 2003(67)	Do people living in urban areas have higher rates of depression, after adjusting for personal SES? Do people living in disadvantaged neighborhoods have higher rates of depression, after adjusting for personal SES?	8978 respondents from the BHPS in Britain, Scotland, and Wales	Electoral wards, grouped into 14 principal groups by demographic and socioeconomic composition, and households	Carstairs index of socioeconomic deprivation	GHQ	Cross-sectional	Multilevel logistic and linear regression	N: There is little independent area-level variance in the prevalence of depression and anxiety, except amongst unemployed residents. There is no association between socioeconomic deprivation and depression, but there is household-level variation.
Weich et al., 2005(54)	What is the variance in onset and maintenance of common mental disorders at individual, household and electoral ward levels? Will ward-level socioeconomic deprivation be associated with episode maintenance after controlling for individual and household factors?	BHPS** participants aged 16-74; 9518 at wave 1 and 7659 at wave 2	Electoral wards	Carstairs index of socioeconomic deprivation	GHQ	Prospective	Multilevel logistic regression	N: Differences in rates of maintenance and onset of depression and change in score between waves across electoral wards are negligible (<1%) compared to those between households and individuals. Ward level socio-economic deprivation does not influence the onset and maintenance of common mental disorders.
Xue et al., 2005(45)	Is children's mental health associated with neighborhood structural characteristics (concentrated disadvantage, residential stability, immigrant concentration)? Do collective efficacy and organizational participation underlie these effects?	2805 children from Chicago, IL	Neighborhood clusters, made up of 2-3 census tracts	Neighborhood structural measures from census loaded into 3 factor scores (Concentrated disadvantage, immigrant concentration, residential stability), informal social control, and social cohesion (participant-reported)	CBCL/4-18	Prospective	Multilevel analysis	Y: Neighborhood concentrated disadvantage was associated with the prevalence of children's mental health problems, after controlling for individual characteristics ($\beta=0.088$, $p<0.01$). This effect was accounted for by informal social control and social cohesion.
Yen and Kaplan, 1999(46)	Will poverty area residence lead to increased levels of depressive symptoms?	1737 participants in the Alameda County Study who resided in Oakland	Poverty areas and non-poverty areas	Poverty area (contiguous census tracts based on 1965 criteria)	From response to 18 questions; similar to CES-D	Longitudinal	Single-level logistic regression	Y: Living in a poverty area was associated with increased risk of depressive symptoms after adjustment for age and sex ($OR=2.09(1.49-2.99)$); this

Author, Year	Primary Research Question Addressed	Study Sample	Neighborhood Definition Used	Neighborhood Features Investigated	Depression Measure Investigated	Study Design	Key Analytical Technique	Results (Support for Neighborhood Effects on Depression?)
		County CA in 1965 and who responded in 1974						became non-significant (OR=1.21(0.76-1.93)) with additional confounders added to the model.
Yen et al., 2006(47)	What are the associations between perceived neighborhood problems and quality of life and depressive symptoms amongst adults with asthma?	435 adults with asthma in northern California	Participant-defined neighborhoods	Neighborhood problems (too much traffic, excessive noise, trash and litter, smells, smoke) (participant-reported)	CES-D	Cross-sectional	Single-level linear regression	Y: Subjects in the top quartile of neighborhood problems were more likely have depressive symptoms than the bottom quartile, after adjustment (OR=4.8(2.4-9.5).

* It is difficult to distinguish between neighborhood constructs and neighborhood measures in some studies, so they have been combined for the purposes of this table

**KEY: SES=Socioeconomic status; AHEAD=Study of Asset and Health Dynamics Among the Oldest Old; CES-D= Center for Epidemiologic Studies-Depression score; Y=Yes; N=No; CDI=Children's Depression Inventory ; WBC=Walkable and Bikeable Communities Project; CBCL=Child Behavior Checklist; SMSA=Standard metropolitan statistical area; NLSY=National Longitudinal Survey of Youth; FACHS=Family and Community Health Study; UM-CIDI=University of Michigan Composite International Diagnostic Instrument; DSM-IV=Diagnostic and Statistical Manual of Mental Disorders; SCID=Structured Clinical Interview for Diagnostic and Statistical Manual of Mental Disorders; PHQ-9=Patient Health Questionnaire; GHQ=General Health Questionnaire; BRFSS=Behavioral Risk Factors Surveillance System; DISC-R=Diagnostic Interview Schedule for Children; CARDIA=Coronary Artery Risk Development in Young Adults; CIDI-SF MD=Composite Diagnostic Interview Schedule Short Form for major depression; UK=United Kingdom; DISC-IV=Diagnostic Interview Schedule for Children, Version 4; SF-36=Mental health index of the Short Form Health Survey 36; SMDI= Multiscore Depression Index, short form; EPIC-Norfolk: European Prospective Investigation into Cancer and Nutrition in Norfolk, UK; BHPS=British Household Panel Survey

Chapter 3: Cross-Sectional and Longitudinal Associations of Neighborhood Cohesion and Stressors with Depressive Symptoms in the Multiethnic Study of Atherosclerosis (MESA)

Introduction

There has been growing interest in understanding the effects of neighborhood conditions on psychological wellbeing.(12) It has been hypothesized that contextual characteristics of neighborhoods may be related to mental health outcomes, above and beyond the effects of individual characteristics. The majority of studies of neighborhood characteristics and depressive symptoms have focused on the effects of area socioeconomic position, after controlling for individual-level characteristics. Most (1, 3, 29, 30, 45, 50, 53, 66), although not all (28, 51, 54, 67), of these studies have documented a small contextual effect of low neighborhood or area socioeconomic conditions on depressive symptoms. Although useful as an initial approximation, this approach has methodological limitations related to difficulties in isolating true contextual effects (31, 83) and the inability to identify the specific contextual characteristics that are relevant.(31)

A relatively small number of studies have investigated associations between specific features of the local environment (such as residential instability, racial/ethnic composition, perceived ambient hazards, or a poor quality physical environment) and depressive symptoms: some have documented a small but statistically significant association (1, 3, 4, 5, 6, 7, 12, 29, 48, 55, 66) while others have not.(28) Many studies

use the same study population to measure depressive symptoms and neighborhood conditions. (1, 2, 3, 4, 5, 6, 7) This can create spurious associations (sometimes referred to as same-source bias) since a depressed person may see his or her neighborhood in a more negative light than someone exhibiting no depressive symptoms. In addition, the majority of work has been cross sectional with only a small number of studies investigating longitudinal associations. (84) An important limitation of cross-sectional analyses is that they are limited in their ability to determine the direction of causality (i.e. neighborhood characteristics causing depression vs. depression causing individuals to live in certain kinds of neighborhoods). Hence, longitudinal analyses are needed.

Using data from the Multi-Ethnic Study of Atherosclerosis (MESA), a large, population-based cohort study, we examined cross sectional and prospective associations of three measures of specific neighborhood characteristics with depressive symptoms, among healthy adults aged 45-84 years. We hypothesized that low levels of neighborhood social cohesion and high levels of neighborhood stressors would be associated with higher levels of depressive symptoms as well as with increases in depressive symptoms over time, after adjustment for individual socioeconomic characteristics. In measuring neighborhood social cohesion and stressors we used validated scales and data from a survey of non-MESA participants who resided in the same neighborhoods as members of the cohort. The use of these measures avoids same-source bias and increases the validity of measures by aggregating responses across several respondents thus reducing variability due to individual subjectivity and measurement error.(78)

Methods

Study Setting and Population

Information on depressive symptoms and relevant covariates was obtained from participants in the Multi-Ethnic Study of Atherosclerosis (MESA), a ten-year longitudinal study of men and women aged 45 to 84. Participants were enrolled at six study field centers between August 1 2000 and July 30 2002 using population-based approaches. Participants were free of clinical cardiovascular disease at enrollment.(85) The participation rate among those screened and deemed eligible was 58%. Analyses reported here are restricted to participants residing at three of the six MESA sites (Baltimore MD, Forsyth County NC, and New York City NY) because these are the three sites where additional neighborhood-level data were collected. Institutional review boards at all participating study centers approved the study, and informed consent was obtained from all study participants.

Information on neighborhood characteristics was collected using a phone survey from a separate sample of persons who resided in the same geographic areas as MESA participants (henceforth referred to as the community survey).(78) The community survey was conducted by a sub-contracted firm specializing in survey research. Survey respondents serve as informants of neighborhood conditions in neighborhoods where MESA participants reside. These variables were linked to MESA participants by census tract, a method which has been used in previous studies.(78, 86) Between January and August 2004, 5988 people living in the same census tracts as the MESA participants in Baltimore, New York City, and Forsyth County were selected through random-digit-dialing with a median of 8 survey respondents per tract (range: 1-62 participants). The

purpose of the community survey was to construct measures of neighborhood-level properties for these areas, which could be linked to MESA participants. The participation rate in the survey was 46.5%. The community survey sample was approximately representative of the geographic areas sampled.(78)

Data Collection

Depressive symptoms were measured in MESA participants at baseline and at two follow-up visits, one 3-4 years after baseline and the other 4-5 years after baseline, using the 20-item Center for Epidemiologic Studies Depression (CES-D) Scale.(87) Each scale item is scored from 0-3, with a higher score representing more depressive symptoms. The potential range of this scale is 0-60, with a score of 16 often used as a screening cutoff for clinical depression.(88)

The main covariates used in the analysis included gender, age, race/ethnicity, annual income, and highest level of education achieved, all assessed at the MESA baseline exam via questionnaire. Age was categorized into four groups (45-54, 55-64, 65-74, 75-84). Race and ethnicity were classified as Caucasian, African American, and Hispanic, based on self-report using questions from the Year 2000 US Census. Total gross family income was categorized into five levels: <\$20,000, \$20,000-34,999, \$35,000-49,999, \$50,000-74,999, and \$75,000+. Education was categorized as less than high school, completed high school, some college or a trade or Associate's degree, Bachelor's degree, and graduate/professional degree.

Community survey respondents were asked to assess certain features of their neighborhood (a 1-mile area around their home). This distance was selected because it has been commonly used in prior work measuring neighborhoods. Scales were used to

assess neighborhood social cohesion (constructed from four items) (16, 78) and two domains related to the construct of neighborhood stressors: violence (four items) (16, 78) and aesthetic quality (six items).(78) The internal consistency of the three scales was high (Cronbach's alpha=0.75 (aesthetic quality), 0.83 (violence), 0.74 (social cohesion)). All three scales also had acceptable ecometric properties, i.e. they were reliable measures of area-level constructs and were related to other neighborhood-level properties in the expected direction.(78) Social cohesion has been hypothesized to be a social resource that may strengthen mental health.(4, 5) Violence and poor aesthetic quality were included as potential neighborhood stressors. The presence and perceptions of violence have been linked to psychological distress.(2, 3, 6) The physical environment has also been hypothesized to influence psychosocial stress: specific elements of a poor aesthetic environment, such as a lack of green space, have been found to be associated with increased levels of stress.(7, 48, 55, 89, 90) With the exception of the violence scale, increasing scores represent a more favorable neighborhood environment.

Data Analysis

Analyses were stratified by gender, as previous research has shown that the prevalence of depression and depressive symptoms differs between men and women,(91) and because depressive symptoms in men and women may be differentially affected by neighborhood environments.(84) We initially examined the unadjusted cross-sectional associations between each of the three neighborhood characteristics and depression at baseline using plots, smooth regression lines,(92) and by estimating CES-D means for quartiles of each neighborhood indicator and testing for a trend across categories. In these analyses, we used unconditional empirical Bayes estimates of the neighborhood score for

each census tract. Census tracts have been commonly used in similar analyses as proxies for neighborhoods.(84) Empirical Bayes estimates are obtained by calculating a weighted average of the crude mean for each neighborhood and the crude mean across all neighborhoods in the study, where the weights are proportional to the reliability of the neighborhood measure. This is better than using a simple crude mean estimate for each neighborhood census tract, as it allows neighborhoods with less reliable data to borrow information from other neighborhoods, in order to improve the estimate.(93) Each neighborhood measure was transformed into units of standard deviations (for the full sample), in order to allow comparisons across scales. Since associations with the CES-D score were similar for all three indicators, and because the three neighborhood level measures were highly correlated (Pearson Correlation Coefficients range= 0.70-0.79), we also created a summary index of the three neighborhood characteristics for each participant. As in prior work, this summary index was created by summing the z-scores of aesthetic environment, social cohesion, and violence.(28, 94) The violence scale was reversed in calculating the summary index, so that a higher score reflected less violence. Intraclass Correlation Coefficients (ICCs) for CES-D scores within neighborhoods were estimated by fitting a multilevel model with a random intercept for each neighborhood.

Linear regression was used to examine cross-sectional associations of neighborhood characteristics with depression before and after adjustment for individual-level variables. CES-D was investigated as a continuous variable because it was not highly skewed. We used marginal maximum likelihood estimation (MMLE) methods to estimate parameters, as this allows for simultaneous modeling of data from the MESA sample and the community survey sample (92) and accounts for random error in

neighborhood-level predictors due to sampling variability. These models also account for residual correlation within neighborhoods. Models included age, race/ethnicity, income, education, and neighborhood-level characteristics, both separately and in the form of the summary score. All models were fitted using SAS Proc Nlmixed.(92)

Analogous logistic regression models were used to examine the association of neighborhood conditions with the onset of depression (defined as CES-D \geq 16 or use of antidepressant medications during follow-up). All participants with a CES-D score of 16 or greater or who were on anti-depressant medications at baseline were excluded from these analyses, as well as participants with missing CES-D scores at either follow-up period. Similar results were observed when survival analysis instead of logistic regression was used. We also obtained similar results when random effects models were used to model repeat CES-D measures and changes over time associated with neighborhood characteristics using the whole sample (i.e. not restricted to those with CES-D $<$ 16 at baseline). However, because these repeat measures models cannot yet be fit with the MMLE method, only the simpler logistic regression results are presented here.

2963 participants from three study sites participated in the MESA study. Of these 2963 participants, 27 were excluded because they had no CES-D score at baseline. An additional 149 were missing information about other covariates. An additional 198 of the remaining participants were missing neighborhood-level data leaving a total of 2609 participants for cross-sectional analysis. These participants lived in 1188 census tracts, with a median of 2 residents per tract (25%=1, 75%=5). Longitudinal analyses were further restricted to 1919 participants with CES-D scores $<$ 16 at baseline who were not using anti-depressants and with CES-D information at any of the follow-up visits.

Results

Table 3.1 shows the distribution of selected individual- and neighborhood-level characteristics by gender. Approximately 13% of participants were in the oldest age category (75-84) with the rest being approximately evenly distributed across categories. The annual income and mean level of education of women were lower than those of men (Table 3.1). ICCs for CES-D scores within each neighborhood were 7.8% in women and 9.8% in men (not shown in table).

Table 3.2 shows the mean CES-D score for men and women, by quartiles of neighborhood social cohesion, violence, aesthetic environment, and the summary score. Lower levels of social cohesion and aesthetic quality and higher levels of violence were associated with higher mean CES-D scores in both men and women (p-value for trend <0.01 for all). Mean CES-D score decreased with increasing quartiles of the index summary score (p-value for trend <0.01). Associations appeared linear with no clear evidence of a threshold effect. In general, the associations were stronger in women than in men for all measures, as evidenced by the larger differences in mean scores between the top and bottom categories.

Table 3.3 shows mean differences in CES-D scores at baseline associated with individual and neighborhood level predictors after adjustment. Increasing income, older age, and higher level of education were each associated with decreasing levels of depressive symptoms for both genders (Table 3.3). Hispanic women had significantly higher mean CES-D scores than Caucasian women.

Higher neighborhood score was associated with lower CES-D scores in both men and women after adjusting for age (mean difference -1.76 (95% CI -2.45, -1.08) and -2.49 (-3.21, -1.76), respectively) (not shown in Table). These associations were reduced but remained statistically significant after additional adjustment for race/ethnicity, income, and education (mean differences -1.01 (-1.85, -0.17) and -1.08 (-1.88, -0.28) in men and women respectively) (Table 3.3). The associations of neighborhood characteristics with CES-D were consistently stronger in women than in men (p for additive interaction=0.02). When each neighborhood characteristic was examined separately, associations were similar in magnitude and in the expected direction for all three scales (data not shown).

Table 3.4 shows characteristics of participants who did and did not develop depression (defined as CESD \geq 16 or use of antidepressant medication) over the follow-up. Of the 1919 persons with no depression at baseline, 12.9 % (248) developed depression over follow-up. 31 of the 248 participants with incident depression reported taking antidepressant medications at follow-up. Baseline CES-D scores were lower in men and women who did not develop depression than in those who did. The mean five year increase in CES-D scores among those characterized as developing depression was 7.40 in men and 7.36 in women, whereas scores did not change substantially in those who did not develop depression (mean change -0.44 in men and -0.21 in women (Table 3.4). Men and women with incident depression had lower annual income and less education than those without (Table 3.4). Summary neighborhood scores were lower in participants who developed depression than in those who did not, but differences were small (Table 3.4).

Table 3.5 presents associations of individual and neighborhood characteristics with incident depression after adjustment. Younger age and lower income and education were associated with increased odds of developing depression. No associations were observed between neighborhood characteristics and development of depression in men (OR=0.96 (0.74, 1.25)). An inverse association was observed in women but confidence intervals were wide and included the null value (OR=0.89 (0.63, 1.26)). The weak longitudinal associations in women disappeared when baseline CES-D score was added to the model (data not shown). Longitudinal analyses were also conducted for each neighborhood characteristic separately. Odds ratios were consistently less than one for men and women, indicating an inverse association of better neighborhood environments with depression, but confidence intervals were wide and included the null value (data not shown).

Discussion

Neighborhood characteristics were associated with depressive symptoms in this population-based sample. In cross-sectional analyses, lower levels of neighborhood social cohesion and aesthetic quality and higher levels of neighborhood violence were associated with higher mean CES-D scores in both men and women. Mean CES-D score decreased with increasing levels of the index summary score in both men and women after adjustment for individual-level characteristics. Living in neighborhoods with better neighborhood environments was associated with slightly reduced odds of developing depression among women without depression at baseline, but confidence intervals on these estimates were wide and included the null value.

This study builds on previous research by incorporating direct measures of specific neighborhood characteristics that may affect depression. An important innovation of our study is the use of a sample of informant residents to characterize the neighborhoods of study participants. This approach to measuring neighborhood-level factors was originally developed in the social sciences(86) but has only recently been used in epidemiology.(78) It has been infrequently used to investigate neighborhood effects on mental health. This approach to measurement is particularly useful when investigating self-reported outcomes (such as depression) where same source bias is a possibility and for constructs (such as social cohesion) which can only be assessed through questionnaires. Using this approach we found that aesthetic quality, violence, and social cohesion were cross-sectionally related to depressive symptoms in the expected direction. Echeverria et al reported similar results for social cohesion using MESA participant reports of neighborhood social cohesion.(95)

Prior cross-sectional investigations of the effects of aesthetic quality, social cohesion, and violence on depression or depressive symptoms have not always yielded consistent results. Four of five studies that investigated measures related to our construct of aesthetic quality (trash and noise,(47, 63) homes well-maintained,(48, 55), and attractiveness,(7)) found a significant association. Four of seven studies that investigated effects of neighborhood social cohesion.(5) (20) (44, 45, 52, 60, 71) reported that greater social cohesion was associated with lower levels of depression or depressive symptoms. Exposure to violence and related constructs (such as fear of calamity,(73) crime,(44) and concerns about police responsiveness,(2)) were associated with depressive symptoms in eight out of fourteen studies.(2, 5, 6, 44, 47, 60, 62, 73) Variations across studies may be

due in part to differences in the neighborhood-level measures used. We used a reliable scale and employed statistical methods that account for measurement error in the neighborhood-level measures.(92)

Several prior studies have documented association of neighborhood characteristics such as neighborhood disorder and cohesiveness with incident depression or increased levels of depressive symptoms.(4, 45, 63, 68, 70, 71) We found some evidence that the neighborhood characteristics examined were also associated with incident depression (at least in women) but associations were not statistically significant. The associations we expected to find were relatively weak ones, so small sample size and short follow-up may have limited our ability to detect longitudinal associations. Exposures over long periods may be necessary to affect mental health and the short follow-up period we investigated may not be sufficient to detect an association. The use of depressive symptoms as opposed to a clinical depression measure (as used in some prior work)(12, 48, 58, 60) may also have affected our ability to detect longitudinal associations. Overall, participants were quite stable over follow-up (80 % did not move between baseline and the time of the last CES-D measurement). Time varying neighborhood exposures were not available so only baseline measures of neighborhood characteristics were investigated.

Cross-sectional associations may be biased because people who are depressed tend to stay in neighborhoods with negative characteristics, while those with better mental and physical health are more likely to move out of such areas. However, in our data, most participants reported living in the same neighborhood for a median 17 of years at baseline. If neighborhood characteristics are relatively constant over time (and we have

evidence that at least the census characteristics of MESA neighborhoods were highly correlated over the 20 years prior to the MESA exam) the cross-sectional associations may reflect the effects of these cumulative long-term exposures on the development of depression better than the longitudinal analyses.

Causal inference from an observational study is dependent on the exchangeability of exposed and unexposed participants. We addressed this problem to the extent possible in an observational design by controlling for a set of individual-level factors that may be associated with both depressive symptoms and neighborhood environments. People who have high levels of depressive symptoms may be less likely than those with lower levels to participate in health-related studies. If participation is also associated with neighborhood characteristics such that participation rates are differentially lower among depressed persons living in disadvantaged neighborhoods, we may have underestimated the association between neighborhoods and depressive symptoms.

The use of census tracts as proxies for the geographic area relevant to depression is a limitation of our study. It is plausible that smaller geographic areas are more relevant than the census tracts we examined. This misspecification of the relevant geographic area could have resulted in underestimates of the effects of interest. Other potentially important characteristics that differed between our three study sites, such as rurality, were not considered in this study. This is a potential limitation of our results, although an interaction term between study site and our neighborhood variables was non-significant. We also were unable to examine interactions between neighborhood characteristics and life events: it may be that stressful neighborhood conditions interact with negative life events to cause depression.(66)

Although the cross-sectional associations we detected may appear small, they are non-trivial. Neighborhoods (crudely defined by census tracts) accounted for 9.8% and 7.8% of the total variance in men and women respectively, whereas the individual-level variables examined explained 11.8 % and 4.7% of the variance. In the full cross-sectional model, the associations between neighborhood characteristics and depressive symptoms are roughly the same magnitude as the associations of CES-D with individual-level education and income (comparing the lowest to the highest groups) (Table 3.3). Interestingly our results are consistent with results of the Moving To Opportunity randomized trial, which found that adults and female youth who moved from poor to non-poor neighborhoods experienced mental health benefits.(96)

Depression has both health and economic consequences, and worsens the health outcomes of co-morbid conditions.(9, 10) If neighborhood features influence risk of depression apart from individual risk factors, interventions aimed at improving neighborhood environments will be a key component in reducing the burden of depression. Our results show that aesthetic quality, violence and social cohesion are important candidates for future investigation.

Table 3.1 Selected individual- and neighborhood-level characteristics of MESA study participants at baseline (2000-2003), by gender

		All Participants (n=2609)	Men (n=1196)	Women (n=1413)
Individual level characteristics	Study Site (% distribution)			
	Forsyth County, NC	32.0	32.5	31.6
	New York, NY	34.8	33.1	36.1
	Baltimore, MD	33.2	34.4	32.3
	Race/Ethnicity (% distribution)			
	White	42.3	44.9	40.2
	African American	41.6	39.2	43.7
	Hispanic	16.0	15.9	16.2
	Age (years) (% distribution)			
	45-54	28.1	26.5	29.6
	55-64	28.4	28.4	28.4
	65-74	31.0	32.2	29.9
	75-84	12.5	13.0	12.1
	Annual Income (dollars) (% distribution)			
	<20,000	19.0	13.7	23.5
	20,000-34,999	20.9	16.8	24.3
	35,000-49,999	18.1	17.7	18.5
	50,000-74,999	20.1	23.0	17.6
	75,000+	21.9	28.7	16.1
	Education (% distribution)			
<High School	13.6	13.4	13.7	
Completed High School	20.6	18.3	22.5	
Some College/Associate/Trade	29.3	25.6	32.4	
Bachelor's Degree	18.3	20.7	16.3	
Graduate/Professional Degree	18.3	22.0	15.1	
Neighborhood level characteristics	Social Cohesion (mean (s.d.))*	3.18 (0.32)	3.20 (0.31)	3.17 (0.32)
	Violence (mean (s.d.))**	1.92 (0.39)	1.90 (0.38)	1.93 (0.39)
	Aesthetic Environment (mean (s.d.))***	3.85 (0.45)	3.87 (0.44)	3.83 (0.45)
	Summary Index (mean (s.d.))****	0.02 (1.00)	0.07 (0.99)	-0.03 (1.01)

*Social Cohesion scale includes the following items: 1. People around here are willing to help their neighbors. 2. People in my neighborhood generally get along with each other. 3. People in my neighborhood can be trusted. 4. People in my neighborhood share the same values

** Violence scale includes the following items: During the past six months, how often: 1. was there a fight in your neighborhood in which a weapon was used 2. were there gang fights in your neighborhood 3. was there a sexual assault or rape in your neighborhood 4. was there a robbery or mugging in your neighborhood. A higher score indicates a less favorable environment for the violence scale

***Aesthetic Environment scale includes the following items: 1. There is a lot of trash and litter on the street in my neighborhood. 2. There is a lot of noise in my neighborhood. 3. In my neighborhood the buildings and homes are well-maintained. 4. The buildings and houses in my neighborhood are interesting. 5. My neighborhood is attractive.

**** Summary index based on summed Z-scores for empirical Bayes estimates of social cohesion, violence, and aesthetic environment. A higher score indicates a more favorable neighborhood environment.

Table 3.2. Mean baseline CES-D score (Standard Errors) by quartiles of neighborhood characteristics* (n=2609), the MESA Study 2000-2002

Neighborhood Characteristic	Quartile**	Mean CES-D Score: MEN	Mean CES-D Score: WOMEN
Social Cohesion	1 st	7.96 (7.82)	10.54 (9.22)
	2 nd	6.62 (6.07)	8.59 (8.05)
	3 rd	6.22 (6.49)	8.43 (8.43)
	4 th (most favorable)	4.98 (5.27)	6.46 (6.46)
	p-value, trend	<0.01	<0.01
Violence	1 st (most favorable)	4.90 (5.14)	6.60 (6.51)
	2 nd	5.56 (5.40)	7.68 (7.09)
	3 rd	7.67 (7.83)	8.96 (8.45)
	4 th	7.72 (7.03)	10.81 (9.03)
	p-value, trend	<0.01	<0.01
Aesthetic Environment	1 st	8.22 (7.69)	10.95 (9.33)
	2 nd	6.86 (6.47)	8.60 (7.87)
	3 rd	5.69 (5.94)	8.16 (7.45)
	4 th (most favorable)	5.13 (5.63)	6.32 (6.23)
	p-value, trend	<0.01	<0.01
Summary Index (Z Score)	1 st	8.00 (7.49)	10.56 (9.20)
	2 nd	7.03 (6.92)	9.07 (8.07)
	3 rd	5.64 (5.67)	7.64 (7.34)
	4 th (most favorable)	5.06 (5.47)	6.55 (6.30)
	p-value, trend	<0.01	<0.01

*Neighborhood characteristics were measured using empirical Bayes estimators

**A higher quartile is more favorable for the social cohesion, aesthetic environment, and summary index scales, while it is less favorable for the violence scale

Table 3.3. Mean baseline CES-D score (Standard Errors) by quartiles of neighborhood characteristics* (n=2609), the MESA Study 2000-2002

		MEN*	WOMEN*
Race/Ethnicity	Hispanic	0.28 (-1.13, 1.68)	1.32 (-0.12, 2.76)
	African American	-0.59 (-1.48, 0.31)	-0.62 (-1.57, 0.33)
	White	Ref.	Ref.
Age	45-54	2.62 (1.36, 3.88)	3.21 (1.76, 4.67)
	55-64	1.50 (0.27, 2.74)	1.20 (-0.22, 2.63)
	65-74	1.08 (-0.10, 2.26)	-1.19 (-2.55, 0.17)
	75-84	Ref.	Ref.
	p-value, trend	<0.01	<0.01
Annual Income	<20,000	2.24 (0.78, 3.70)	4.94 (3.34, 6.53)
	20,000-34,999	2.08 (0.84, 3.32)	2.94 (1.51, 4.37)
	35,000-49,999	0.56 (-0.59, 1.70)	2.11 (0.71, 3.52)
	50,000-74,999	0.22 (-0.80, 1.23)	1.18 (-0.22, 2.58)
	75,000+	Ref.	Ref.
	p-value, trend	<0.01	<0.01
Education	<High School	0.57 (-0.93, 2.06)	2.58 (0.88, 4.28)
	Completed High School	0.60 (-0.62, 1.82)	1.07 (-0.33, 2.47)
	Some College/Associate/Trade	-0.17 (-1.28, 0.94)	0.48 (-0.78, 1.75)
	Bachelor's Degree	0.29 (-0.81, 1.38)	0.00 (-1.42, 1.41)
	Graduate/Professional Degree	Ref.	Ref.
	p-value, trend	0.24	<0.01
Neighborhood Score	per SD	-1.01 (-1.85, -0.17)	-1.08 (-1.88, -0.28)

* Models include race/ethnicity, age, income, highest education achieved, and neighborhood summary score. Estimates are therefore adjusted for all the variables in the table. Mean differences for categorical variables are differences as compared to the reference group for each variable.

Table 3.4. Selected characteristics of MESA participants who did and did not develop depression (CES-D score ≥ 16 or use of anti-depressant medications) over 4-5 year follow-up amongst those with CES-D <16 at baseline (n=1919)

	MEN			WOMEN		
	Developed depression (n=98)	Did not develop depression (n=835)	p-value*	Developed depression (n=150)	Did not develop depression (n=836)	p-value*
CES-D at baseline (mean (s.d.))	8.11 (4.17)	4.66 (3.75)	<0.01	9.12 (4.24)	4.95 (3.85)	<0.01
5-year CES-D change (mean (s.d.))	11.73 (0.43)	-0.44 (0.19)	<0.01	12.33 (0.38)	-0.21 (0.22)	<0.01
Race/Ethnicity (% distribution)						
White	22.5	14.3	0.03	24.0	12.8	<0.01
African American	42.9	38.8		38.0	47.0	
Hispanic	34.7	47.0		38.0	40.2	
Age (years) (% distribution)						
45-54	33.7	25.2	0.33	34.0	26.3	0.23
55-64	27.6	29.8		27.3	28.2	
65-74	28.6	34.3		28.0	34.3	
75-84	10.2	10.8		10.7	11.1	
Annual Income (dollars) (% distribution)						
<20,000	22.5	11.1	<0.01	26.7	19.6	0.19
20,000-34,999	24.5	14.9		25.3	24.5	
35,000-49,999	13.3	18.2		17.3	18.9	
50,000-74,999	19.4	22.9		18.0	17.9	
75,000+	20.4	32.9		12.7	19.0	
Education (% distribution)						
<High School	28.6	10.5	<0.01	18.7	9.1	<0.01
Completed High School	15.3	17.7		18.7	23.3	
Some College/Associate/Trade	20.4	26.6		34.7	32.8	
Bachelor's Degree	17.4	21.3		17.3	17.5	
Graduate/Professional Degree	18.4	23.8		10.7	17.3	
Social Cohesion (mean (s.d.))	3.13 (0.29)	3.22 (0.32)	0.01	3.13 (0.30)	3.18 (0.31)	0.04
Violence (mean (s.d.))	2.00 (0.37)	1.88 (0.39)	<0.01	2.01 (0.39)	1.92 (0.38)	<0.01
Aesthetic Environment (mean (s.d.))	3.81 (0.42)	3.90 (0.43)	0.04	3.75 (0.44)	3.85 (0.45)	0.01
Summary Index (mean (s.d.))	-0.14 (0.92)	0.14 (0.99)	0.01	-0.20 (0.97)	0.04 (0.99)	0.01

* p-value compares those who did and did not develop incident depression

Table 3.5. Relative odds of incident depression (defined as CES-D score of 16 or above or using anti-depressant medications) over 4-5 year follow-up amongst MESA participants with CES-D scores below 16 at baseline (95% Confidence Intervals) (n=1919)

		MEN (n=933)*	WOMEN (n=986)*
Race/Ethnicity	Hispanic	0.76 (0.35, 1.70)	1.14 (0.63, 2.07)
	African American	1.13 (0.66, 1.92)	0.66 (0.43, 1.02)
	White	Ref.	Ref.
Age	45-54	2.17 (0.96, 4.87)	1.98 (1.01, 3.89)
	55-64	1.34 (0.60, 3.01)	1.39 (0.71, 2.71)
	65-74	0.98 (0.45, 2.15)	0.98 (0.52, 1.86)
	75-84	Ref.	Ref.
Annual Income	<20,000	2.97 (1.31, 6.72)	2.15 (1.03, 4.50)
	20,000-34,999	2.51 (1.20, 5.26)	1.68 (0.87, 3.26)
	35,000-49,999	1.13 (0.52, 2.46)	1.45 (0.74, 2.81)
	50,000-74,999	1.37 (0.70, 2.69)	1.62 (0.85, 3.10)
	75,000+	Ref.	Ref.
Education	<High School	2.14 (0.95, 4.82)	2.46 (1.13, 5.38)
	Completed High School	0.82 (0.38, 1.78)	1.10 (0.55, 2.21)
	Some College/Associate/Trade	0.69 (0.34, 1.41)	1.52 (0.83, 2.81)
	Bachelor's Degree	0.84 (0.41, 1.73)	1.60 (0.82, 3.14)
	Graduate/Professional Degree	Ref.	Ref.
Neighborhood Score	per SD	0.96 (0.74, 1.25)	0.89 (0.63, 1.26)

* Models include race/ethnicity, age, income, highest education achieved, and neighborhood summary score

Chapter 4: Neighborhood Stressors and Social Support as Predictors of Depressive Symptoms in the Chicago Community Adult Health Study

Introduction

Evidence continues to grow that depression and depressive symptoms are associated with neighborhood environments.(97) Elements of neighborhoods can be both harmful and protective of mental health. Stressful neighborhood environments are linked to increased levels of depressive symptoms,(4, 52, 57) while social support can be beneficial both by itself and as a buffer against the negative effects of neighborhood stressors.(1, 2, 6) Features of neighborhoods have been found to be associated with depressive symptoms independent of neighborhood socioeconomic features such as disadvantage and affluence.(57) In fact, several studies have found that neighborhood stressors and social support are associated with depressive symptoms, while neighborhood socioeconomic status is not.(3, 45, 60, 65) These neighborhood factors are likely operating in complex ways, and the strength and direction of associations can be dependent on other individual-level and neighborhood conditions.

Features of neighborhoods may operate as stressors with consequences for mental health. Characteristics of the neighborhood physical environment, such as physical disorder, physical decay, and high population density, can increase feelings of distress directly and through increased feelings of powerlessness and fear.(22, 26) Physical disorder, marked by features such as vacant or abandoned buildings and the amount of litter and graffiti in a neighborhood,(21) may undermine neighborhood social control,

making residents of neighborhoods with high levels of disorder less likely visit each other, strike up conversations with neighbors, or participate in neighborhood improvements.(22) Physical decay, a measure of the physical environment that captures the condition of standing structures, is often found in neighborhoods with high levels of social disorder and fear of crime.(23) It differs from physical disorder in that it also encompasses physical problems with buildings and so captures the stress felt from living in an ugly, uninviting environment in addition to being a marker of social disorder.(98) People living in crowded, dense areas may find their neighborhood environment stressful.(24, 25) These stressors can in turn affect levels of depressive symptoms. Perceptions of neighborhood environments as unsafe, violent, and highly disordered are also associated with depressive symptoms.(7, 47, 68) For example, a study of subjects from neighborhoods with outward signs of disorder found there was a strong prospective association between perceived neighborhood characteristics and subsequent depressive symptoms, after adjustment for baseline depression levels.(4)

Some social features of neighborhoods, such as social ties, reciprocal exchange, and social cohesion, may affect social connections and the levels of social support experienced by residents. Social support may in turn affect residents' vulnerability to stress and depressive symptoms.(1) Social cohesion, a measure that includes social control and order, the level of social interaction between neighbors, trust between neighbors, social capital and a sense of belonging to a place, has been found to be associated with depressive symptoms.(5) The reciprocal exchange of help and information between neighbors is associated with decreased mental health problems.(99) Neighborhood family structure, in particular the proportion of female-headed households

and the percentage of married residents, influences both formal and informal social control, which in turn are associated with depressive symptoms.(100) A lack of residential stability in a neighborhood can reduce the number and strength of informal social ties, leading to a lack of informal social control, which in turn can impact violence and depression.(17, 18) Residential stability may be operating in complex ways. For example, Ross and colleagues found that residential stability was protective of mental health in wealthy neighborhoods, while it was associated with worse mental health in poor neighborhoods.(18) Several studies have found that highly stable neighborhoods are associated with decreased levels of depressive symptoms,(12, 61) while one concluded that, for elderly populations, the opposite held true.(65)

A careful examination of which aspects of the neighborhood environment are associated with mental health, either by themselves or in combination, will allow us to hone in on which aspects of the places people live influence depressive symptoms. Depression and depressive symptoms affect millions of people in the United States, and policies targeting reduction of these conditions is an important public health goal. In Chapter 5 of my dissertation, I examined the associations between depressive symptoms and neighborhood features in the Chicago Community Adult Health Study. Figure 4.1 outlines the hypothesized associations between the various neighborhood physical and social environmental characteristics examined in this chapter and depressive symptoms. I used measures of neighborhood physical environments quantified through SSO, social environments measured using neighborhood surveys, and census-derived scales to investigate the associations between depressive symptoms and stressful neighborhood environments and social support. Although physical neighborhood characteristics can

plausibly affect mental health, they have not been investigated much.(48, 55) By using objective raters to measure physical disorder and decay, I examined the association between the physical environment and depressive symptoms separate from individuals' perceived evaluations of their neighborhood. Combining these measures with those of average area perceptions of violence and disorder, I was able to compare the strength of the association between depressive symptoms and rater-assessed, survey-based and perceived disorder in a neighborhood. As a final step, I combined multiple types of neighborhood variables (stressors, social support, socioeconomic characteristics) into one model in order to see which, if any, of these features had an independent effect on depressive symptoms in this population.

Methods

Study Setting and Population

Data came from the Chicago Community Adult Health Study (CCAHS), a stratified, multistage probability sample of 3,105 people 18 years of age and older living in Chicago, IL. This sample was drawn from 343 neighborhood clusters, defined through the Project on Human Development in Chicago Neighborhoods (PHDCN).(17) Clusters typically consist of two census tracts, and have meaningful physical and social borders. The sample had an average of 9.1 subjects per neighborhood cluster (range: 1-21). Neighborhood clusters were used as the primary neighborhood definition, although block-groups were used in some analyses. For example, Intraclass Correlation Coefficients (ICCs) were calculated at both the block group and neighborhood cluster level in order to ascertain whether there was higher correlation between subjects in the

same block group than between those in the same neighborhood cluster. One person was interviewed per household, with a final response rate of 72%.

Sample weights were used in all data analyses in order to handle differential rates of selection and participation and coverage by neighborhood cluster. The weighted sample represents the city of Chicago from the 2000 census in terms of key demographic covariates (age, race, gender). The sample weight used is a multiplicative combination of three weights: one to adjust for oversampling of cases in focal vs. non-focal areas at a ratio of 2:1, one to adjust for whether a participant was selected for intensive non-response follow-up at the end of the survey vs. those eligible but not so selected at a ratio of 1:2, and one non-response and post-stratification weight, defined as the inverse of the ratio of the proportion of respondents in each neighborhood cluster to the proportion of the eligible population in each neighborhood by age, sex, and race/ethnicity. The weight was centered to have a mean of 1.0, with a standard deviation of 0.7, a minimum of 0.2, and a maximum of 5.4.(101)

Data Collection and Variables

The main outcome, subjects' depressive symptoms, was measured by an 11-item version of the Center for Epidemiologic Studies (CES-D)(87) depression scale in the CCAHS. This modified version of the CES-D was developed and validated for use in the Established Populations for Epidemiological Studies of the Elderly (EPESSE).(102) Each scale item in the 11-item modification is scored from 1-4, with a higher score representing more depressive symptoms.(103) The average score on the eleven questions was used in all analyses (range: 1-3.82). This shortened version of the CES-D scale has

been found to have good internal consistency and strong correlations with the original version of the CES-D.(104)

All neighborhood variables were transformed to z-score units, so that they had a mean of 0 and standard deviation 1. This was done in order to compare the relative strength of associations between depressive symptoms and different neighborhood covariates. Four sets of neighborhood-level variables were investigated: rater-assessed (referred to as “objective”), survey-based, participant-reported and US Census-derived.

Two objective characteristics of the physical environment, physical disorder and physical decay, were measured using systematic social observation (SSO), a method for making observations about physical characteristics of neighborhoods in a systematic manner. Observations were collected from May 2001 to March 2003.(105) Raters, who did not live in the neighborhoods, filled out a form resembling a questionnaire for every block on which at least one study participant lived. A block includes four streets and eight street sides (Figure 4.2). I used variables measured at the street level aggregated up to neighborhood clusters. There were 6631 observations at the street level, with an average of 19.4 observations per neighborhood cluster.(105) Physical disorder is a nine-item scale replicated from the PHDCN. It captures the extent of graffiti, litter, abandoned cars, broken glass, and other similar types of negative neighborhood contamination. Physical decay is a 5-item scale, also replicated from the PHDCN. It captures the deterioration and abandonment of residential, commercial, and recreational buildings on a block face (Table 4.1). Another objective neighborhood measure, the violent crime rate from the years 2000-2002 (a summary of the burglary, robbery, and homicide rates), was taken from the Chicago police department and used in analyses.

Survey-based measures of perceived neighborhood disorder and violence, safety, reciprocal exchange, social ties and social cohesion were recorded directly from study participants in the CCAHS as a part of a community survey administered to the 3105 study participants. Perceived violence, perceived disorder and social cohesion were each measured from five items, reciprocal exchange was measured from four items, and social ties from two items. Each item's response was scored from 1-4, with the exception of social ties, where responses were score from 1-5. Table 4.2 lists each item in these scales. The measure of perceived disorder combined aspects of both the disorder and decay scales from the SSO data. Each community survey variable was aggregated and averaged at the neighborhood cluster level, and an empirical Bayes scale score was estimated to adjust for missing items and to improve neighborhood-level estimates by borrowing information across clusters. This was done by fitting an unconditional three-level hierarchical linear model for each scale, with item dummies predicting the scale score at level one and no predictors at levels two and three. The empirical Bayes level two residual from this model was added to the fitted value to produce the neighborhood cluster scale score. Analyses were also conducted using community survey variables as individual-level predictors, where each study participant's own response to the community survey was used. A measure of neighborhood safety, an average of participant responses to two questions, was also used at the neighborhood cluster level. These questions (and responses) were: "Is there any place—within 3 blocks of your current home—where you are afraid to walk alone at night?" (yes, no, unsure/depends) and "How safe is it to walk around alone in your neighborhood after dark?" (completely safe, fairly safe, somewhat dangerous, extremely dangerous).

Five neighborhood census-derived variables were used in analyses. These were calculated as the mean of the standardized items in each scale. Two variables, affluence and disorder, represented neighborhood socioeconomic conditions. Affluence included the percent of residents with a Bachelor's degree or higher, median home value (\$) for owner-occupied housing units, percent of the population <18 years, and % residents with professional/managerial occupations. Disadvantage used measures of % of residents with annual incomes <\$10,000, % residents with incomes >\$50,000 (reverse coded), the unemployment rate, poverty rate, % unoccupied homes and public assistance rate. I also used census-derived measures of residential stability, family structure and population density. Residential stability consisted of two items: the % of residents in the same home for at least 5 years and the % of owner-occupied homes. Family structure was made up of two items: the percentage of female-headed households with children and the proportion of people aged 15 and above who were married. Population density was measured as the number of people per square kilometer.

Additional covariates in the analysis included age, gender, race/ethnicity, income, marital status and highest level of education achieved. Age was used as a continuous variable, with a squared term to account for the non-linearity of the age-depressive symptoms relationship. Race categories included non-Hispanic white, non-Hispanic African American, non-Hispanic other and Hispanic. Education was categorized into four groups (0-11 years, 12 years, 13-15 years, 16+ years), and income was put into six categories (\$0-5000, \$5000-9999, \$10000-29999, \$30000-49999, ≥\$50000, and missing). Marital status was categorized into five groups: married, separated, divorced, widowed and never married.

Data Analysis

All analyses were stratified by gender, as it has been found that neighborhood conditions impact men and women differently.(106) None of the thirteen interactions between neighborhood factors and gender were statistically significant in final models, but this may be due to the lack of power to detect such an effect. Analyses were still stratified, to remain consistent with the literature. All analyses were also conducted using the survey weights described above. I first examined the distributions (for categorical variables) or mean/standard deviation (continuous variables) of every covariate used in analyses. Unadjusted associations between each of the neighborhood characteristics and depressive symptoms were then examined, using scatter plots, lowess curves, and by estimating depressive symptom means for quartiles of each neighborhood variable and testing for a trend across categories. All neighborhood-depressive symptom associations appeared roughly linear. The bivariate associations between depressive symptoms and individual-level covariates were then estimated. ICCs were calculated for null models and models with individual-level predictors only at both the block group and neighborhood cluster level, in order to compare the strength of correlations at these two levels.

In order to examine associations of neighborhood characteristics with depression before and after adjustment for individual-level sociodemographic variables, and to determine the contribution of neighborhood and individual variables to within- and between-neighborhood differences in depressive symptoms, I fit a series of two level multilevel models with a random intercept for each neighborhood using HLM Version 6.06. A null model with no predictors and a model with individual-level variables (age, race/ethnicity, income, marital status and education) were run for both men and women.

Next, I estimated a set of models with each neighborhood variable alone, and then further adjusted for the individual-level covariates. A set of full models with one neighborhood stressor and one neighborhood social support variable were then created. Variables were selected for these models if they were statistically significantly associated at the $p < 0.05$ level with depressive symptoms in either gender in the models with both neighborhood- and individual-level covariates. These models were also run controlling for a neighborhood socioeconomic variable, neighborhood affluence, since disadvantage was highly correlated with the neighborhood stressor variables (correlation coefficient ranged from 0.6-0.82). I tried all possible combinations of these variables, with one from each of the neighborhood variable types. No correlations between any of the variables combined in models were greater than 0.5, with most being significantly lower than this. A model was run for both men and women with all neighborhood variables from the models combining stressors and social support included. The variance inflation factor (VIF) in OLS models ranged from 1.58 to 4.79, which led me to believe that the variables were not so highly correlated as to prevent including all of them in a model simultaneously.

A set of models were run for the neighborhood survey variables: models with neighborhood-cluster level estimates, models with individual-level estimates, and models with both of these variables included. Objective measures of neighborhood violence (police-recorded crime rate from 2000-2002) and disorder (the SSO disorder measure) were put into models with individual-level perceived violence and disorder, respectively. I estimated the between- and within-neighborhood variability and calculated the intraclass correlation coefficient (ICC) for all model. All preliminary analyses were run using STATA version 9, and all models were run in HLM version 6.06.

Results

Table 4.3 shows the distribution of individual- and neighborhood-level covariates using survey weights. 44% of men and 39% of women were married, while 41% and 33% respectively reported having never married (Table 4.3). A greater percentage of men (31%) than women (22%) reported an annual income over \$50,000. Women lived in less affluent and dense neighborhoods than their male counterparts.

Table 4.4 shows mean CES-D scores for men and women, by quartiles of each neighborhood characteristic. Subjects living in neighborhoods with less physical disorder, higher perceived violence, better safety, greater reciprocal exchange, less crowding, more disadvantage, and more residential stability had lower levels of depressive symptoms. These patterns were similar amongst men and women, although women tended to show stronger, more consistent associations than men. Continuous neighborhood variables showed similar patterns as the neighborhood quartiles, with 16 of the 24 comparisons reaching statistical significance ($p < 0.05$) (Table 4.4).

Table 4.5 shows the bivariate associations between depressive symptoms and individual-level covariates. Overall, men had lower levels of depressive symptoms (mean=1.75) than women (mean=1.88). Married men and women had lower levels of depressive symptoms than separated, divorced, widowed, and never married individuals. Hispanic men reported lower CES-D scores than any other gender and racial/ethnic group (Table 4.5). Subjects with lower incomes and less education reported higher levels of depressive symptoms.

The ICCs for null models (no predictors) at the neighborhood cluster level were 7.1% and 7.4% for women and men respectively. These were reduced by about half when controlling for individual-level covariates, to 3.9% (women) and 3.3% (men). The correlations between subjects living in the same neighborhood block group were stronger than those between participants in the same neighborhood cluster. The ICCs at the block group level were 12.3% and 11.3% for the null model and 8.1% and 8.0% for men and women after adding individual-level covariates.

Table 4.6 shows the associations between depressive symptoms and individual-level covariates, adjusted for all other individual-level variables and including a random intercept for each neighborhood cluster. The qualitative relationships between depressive symptoms and individual-level variables were the same as in the simple bivariate analyses. The size of the difference in CES-D score between married and other individuals increased, while the difference in depressive symptoms shrank between the various income and education categories (Table 4.6).

Table 4.7 shows the mean difference in depressive symptoms per one standard deviation increase in each neighborhood variable, both without and with adjustment for individual-level covariates. Before adjustment for individual-level variables, increased physical disorder and decay, disadvantage, perceived violence and disorder, and decreased safety, family stability, social cohesion, reciprocal exchange and residential stability were significantly associated with increased CES-D scores amongst women. Similar associations were found in men, with the exception of safety and reciprocal exchange, which were not statistically significant. After adjustment for individual-level covariates, perceived violence, social cohesion, reciprocal exchange, family stability and

residential stability remained significantly associated with depressive symptoms amongst women (Table 4.7). For men, neighborhood stressors had a stronger association with depressive symptoms than social supports: perceived violence and disorder and family stability were the only variables that remained significantly associated with depressive symptoms.

Table 4.8 shows the mean difference in depressive symptoms per one standard deviation increase in neighborhood variables in models with one neighborhood stressor and one neighborhood social support variable. Neighborhood social cohesion, reciprocal exchange, and residential stability remained significantly associated with depressive symptoms in women after controlling for neighborhood stressors, which did not have a significant effect (Table 4.8). Perceived violence and family stability remained associated with depressive symptoms in men, although when controlling for these variables simultaneously, violence no longer remained significant. Models run with all neighborhood variables at once found nothing to be significantly associated with depressive symptoms in women, and only family stability to be associated in men (Table 4.8). Estimates of these same models, with neighborhood affluence included, were qualitatively similar to the findings presented in Table 4.8 (data not shown).

Table 4.9 shows estimates of the associations between depressive symptoms and the community survey variables (social cohesion, reciprocal exchange, perceived violence, perceived disorder, social ties), using each variable at the individual-level, neighborhood cluster-level, and both levels simultaneously. Correlations between individual-level social support and corresponding neighborhood cluster-level social support variables were relatively low (0.38-0.44). The correlations for violence and

disorder were slightly higher (0.64 and 0.53, respectively). The strength of the associations for the social support measures (social cohesion, reciprocal exchange, social ties) were similar at the individual- and neighborhood-cluster levels. When controlling for both at the same time, however, the neighborhood-cluster estimate of social cohesion was reduced in both men and women (Table 4.9). Individual-level perceptions of violence and disorder had a stronger association than those at the neighborhood-cluster level. When controlling for both levels simultaneously, the neighborhood cluster-level associations disappeared. Table 4.9 also shows the results of models run using objective measures of neighborhood violence and disorder combined with individual-level perceived violence and disorder. These results were quite similar to the ones using individual- and neighborhood-cluster level perceived violence and disorder (Table 4.9). The violence rate, by itself, was associated with increased levels of depressive symptoms in women but not men (data not show).

Discussion

Neighborhood stressors and social support were cross-sectionally associated with depressive symptoms in this population of 3105 men and women living in Chicago. The majority of social support variables were associated with decreased depressive symptoms in women, while the majority of neighborhood stressors were associated with increased levels of depressive symptoms in men. Controlling simultaneously for one neighborhood stressor and one neighborhood social support variable slightly decreased the strength of some associations, but did not qualitatively change the results from analyses controlling for one variable at a time. These results also did not change when controlling for

measures of neighborhood socioeconomic status. Associations between perceived violence and disorder and depressive symptoms were stronger for the participant reported measures than for the neighborhood cluster measures.

This aim built on previous studies by expanding the number of neighborhood-level variables examined in the same study population. By using multiple dimensions of neighborhood stressors, social support mechanisms, and socioeconomic features, I was able to see whether protective support or harmful stress had a greater association with depressive symptoms, and whether this varied by gender. Neighborhood dimensions were measured in a variety of ways, using SSO, a community survey administered to study participants aggregated to the neighborhood cluster level (survey-based measures), individual-level participant-based measures from the same community survey, and census information. Each of these measures has different strengths and limitations. The use of SSO data eliminates the possibility of same-source bias, as it is collected by objective raters. Census-based survey measures also avoid same-source bias, but may be more indirect, upstream indicators of neighborhood support and stress. Survey-based estimates of disorder and other neighborhood conditions are more proximally measuring how people feel about their neighborhood environment, while still aggregating over multiple respondents to ensure that same-source bias is less of a concern. They can also assess properties of neighborhoods that cannot be observed by raters, such as perceptions of neighborhood environments. Participant-based measures of these neighborhood survey scales are the most direct measure of each person's relation to their neighborhood, but these measures are most likely to be biased by underlying, unrelated feelings of depression. Neighborhood stressors and social support were both measured using

multiple neighborhood measurement techniques, which let me see that (1) the rater-assessed neighborhood stressors had weaker associations with depressive symptoms than the participant-based measures and (2) both census- and survey-based measures of social support had strong associations with depressive symptoms.

In models controlling for individual-level covariates, four of five social support variables were associated with decreased levels of depressive symptoms in women. The only statistically significant social support measure for men was family structure, a measure of the percentage of female-headed households with children and the proportion of married people aged 15+, which was associated with decreased levels of depressive symptoms in both genders. It makes sense that social support had a stronger effect amongst women, as they tend to have better connections with others and are better able to utilize formal and informal social structures. Conversely, men were more harmed by increased levels of perceived violence and disorder in their neighborhoods than women. Men tend to be more actively involved in violence and criminal behaviors, so this, too, makes sense. (100) Perceived violence, but not perceived disorder, had an effect on both genders' depressive symptoms. Both men and women had higher levels of depressive symptoms living in socioeconomically disadvantaged neighborhoods. Interestingly, neighborhood affluence was not associated with depressive symptoms in either gender. All the conclusions mentioned above did not change when simultaneously controlling for a neighborhood stressor and social support measure. This indicates that neighborhood stressors and social support mechanisms may be operating independently from one another (and from neighborhood socioeconomic affluence). Controlling for all these variables at once did reduce almost all the associations. While the variables are not so

highly correlated as to prevent running these full models, the correlation coefficients did range from 0.06 to 0.82, meaning that the findings from these models may be biased due to collinearity problems.

When simultaneously controlling for individual-level and neighborhood cluster-level perceived violence and disorder, the neighborhood cluster coefficients became non-significant. This indicates that perceptions of neighborhood stressors are likely operating on an individual basis. Many of these survey-based measures must operate through perceptions of the neighborhood environment, so in a sense it is not surprising that the “neighborhood” effects disappear when the more proximally measured perception is included in the model. These individual-level results, however, have their own set of problems. If a depressed person is more likely to see their neighborhood environment in a negative light, regardless of the actual condition of the neighborhood, the strong association between perceived neighborhood stressors and depressive symptoms will not be causal in nature. Controlling for more objective measures of neighborhood violence and disorder did not change the strength of the associations between depressive symptoms and individual-level perceptions of these conditions. It is interesting to note that, apart from social cohesion in men, the associations between the neighborhood-cluster level social support variables and depressive symptoms did not change when controlling for individual-level measures. This indicates that these are “true” neighborhood constructs, operating independently from individuals’ perceptions of their social neighborhood environments.

The results from this aim fall in line with the majority of similar previously published studies. The literature review in Chapter 2 of this dissertation found the vast

majority of studies that looked at perceptions of negative neighborhood environments, such as violence and disorder, had a significant association with depressive symptoms. Roughly half of all studies that looked at residential stability found this characteristic to be associated with depressive symptoms. Overall, 68% of studies that looked at neighborhood social processes found that these characteristics were associated with depressive symptoms.(97) Therefore, I expected to find neighborhood stressors associated with increased levels of depressive symptoms and neighborhood social support mechanisms associated with decreased levels. This study added to the current body of literature by using a variety of techniques to measure stressors and social support. I found that, for neighborhood stress variables, perceptions of neighborhood environments had the strongest associations with depressive symptoms. These more proximal measurements of whether people find their neighborhoods stressful seem to be most likely to increase feelings of depression. Census-based measures of neighborhood social support (residential stability and family structure) had just as strong an effect on depressive symptoms as survey-based and participant-reported measures. It may be that structural characteristics within neighborhoods can create opportunities for neighbors to help one another and feel tied to those around them. It also could be that these census-based characteristics are not proxying social support at all, but represent something else about neighborhoods. The difference between how neighborhood stressors and social support act in neighborhoods has not been discussed in any studies I have come across.

There are several important limitations to this study. First of all, the CCAHS enrolled 3105 participants, a fairly big sample size for this type of study but potentially not large enough to have the power to detect cross-level interactions. For example, it may

be that the association between depressive symptoms and reciprocal exchange is weaker amongst poor people as compared to wealthy people living in neighborhoods with equivalent levels of reciprocal exchange. Even though none of the interactions between gender and neighborhood covariates were statistically significant, I stratified all analyses since the strength of these associations differed by gender. With a larger sample size, I could have more accurately measured whether any of these interactions were truly different by gender. All analyses in this aim were cross-sectional. If these neighborhood features operate over the course of years, or decades, to alter mental health, this study would be unable to discern what time frame may be of most importance. I used neighborhood clusters to represent neighborhoods in this study. These neighborhoods were carefully constructed, and likely represent “true” neighborhoods, but the boundaries may be too large to pick up the strength of associations that would be found in the geographic areas most directly relevant to depressive symptoms. This was hinted at when the ICCs in null models were much larger at the block group level than the neighborhood cluster level. This finding can be interpreted to mean that correlations in depressive symptoms are stronger amongst people living in the same block groups than amongst people living in the same neighborhood clusters. However, block groups could not be used in this analysis, as there were only 1 or 2 residents in many of the block groups, as compared to a mean of 9 subjects in neighborhood clusters, so that the survey-based measures would be averaged over very few participants. Similarly, there were many fewer streets per block group than neighborhood cluster rated in the SSO data, a potential problem when creating accurate measures of physical disorder and decay.

While it may seem that the size of the associations between neighborhood environments and depressive symptoms in this study were fairly small, they are similar in magnitude to those between important individual-level predictors and depressive symptoms. For example, the mean difference in depressive symptoms for a woman with <12 years of education vs. 16+ years is 0.07; the difference for men and women ranges from 0.06 to 0.30 when comparing married individuals to all others. Compare these to coefficients as large as 0.12 for perceived violence for men, and it becomes clear that the importance of these associations are similar. These findings indicated that neighborhood environments play an important role for both men and women in shaping their mental health. Reducing the presence of violence and disorder in neighborhoods and/or working to create social support systems similar to ones that work for women could help lower depressive symptoms in men.

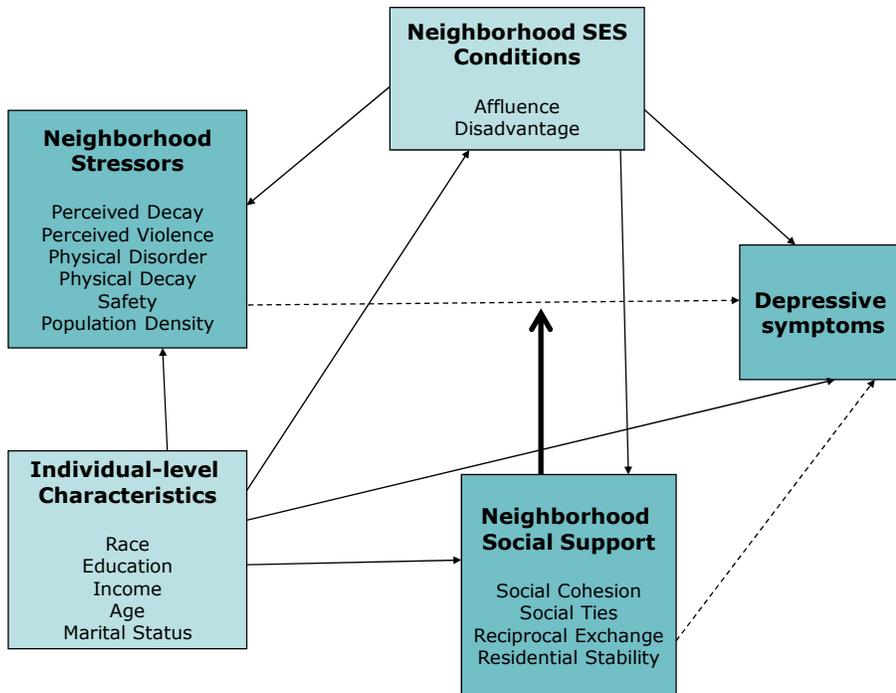


Figure 4.1. DAG of associations studied in Chapter 4

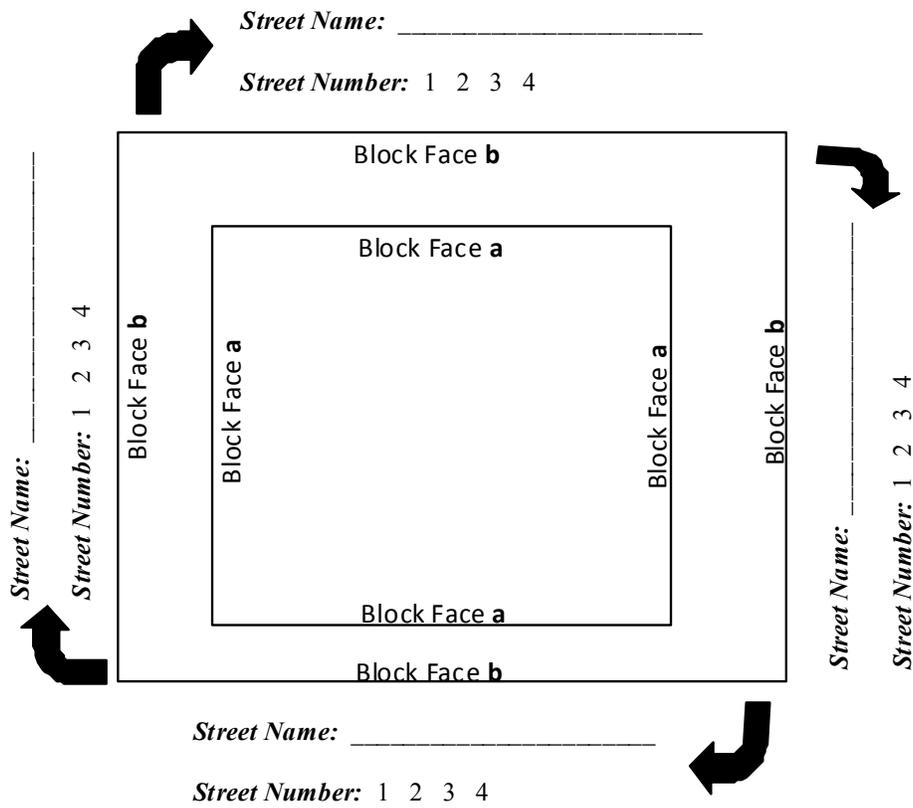


Figure 4.2. Diagram of SSO data collection on blocks and streets

Table 4.1. SSO variable items

<p>Physical Disorder</p>	<ol style="list-style-type: none"> 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
<p>Physical Decay</p>	<ol style="list-style-type: none"> 1. Residential buildings in poor/badly deteriorated condition 2. Abandoned, burned out, or boarded up house/building 3. Commercial buildings in poor/badly deteriorated condition 4. Vacant, but still useable house/building 5. Recreational buildings in poor/badly deteriorated condition 6. Condition of street is fair or very poor

Table 4.2. Neighborhood scale scores from the CCAHS community survey

Perceived Disorder	<ol style="list-style-type: none"> 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 the street in your neighborhood?
Perceived Violence	<p>During the past six months, how often:</p> <ol style="list-style-type: none"> 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?
Social Cohesion	<ol style="list-style-type: none"> 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
Reciprocal Exchange	<ol style="list-style-type: none"> 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?
Number of Social Ties	<ol style="list-style-type: none"> 1. Not counting those who live with you, how many of your relatives or in-laws live in your neighborhood? 2. How many friends do you have who live in your neighborhood?

Table 4.3. Selected individual- and neighborhood-level characteristics of CMB study participants, by gender

		All Participants (n=3105)	Men (n=1235)	Women (n=1870)
Individual- level characteristics	Marital Status (% distribution)			
	Married	41.8	44.5	39.4
	Separated	4.0	3.3	4.7
	Divorced	10.8	9.0	12.4
	Widowed	6.7	2.8	10.3
	Never Married	36.7	40.6	33.3
	Race/Ethnicity (% distribution)			
	Hispanic	25.8	26.5	25.2
	Non-Hispanic White	38.4	40.2	36.7
	Non-Hispanic Black	32.1	28.8	35.0
	Other	3.8	4.5	3.1
	Annual Income (dollars) (% distribution)			
	<5,000	3.0	3.0	3.0
	5,000-9,999	7.1	6.2	7.9
	10,000-29,999	26.2	23.6	28.5
	30,000-49,999	18.4	19.3	17.6
	50,000+	26.5	31.3	22.1
	Missing	18.8	16.5	20.8
	Education (years) (% distribution)			
	<12	23.4	22.4	24.4
12	23.8	24.8	22.8	
13-15	24.9	23.6	26.1	
16+	27.9	29.3	26.7	
	Age (years) (mean (s.e.))	42.5 (0.42)	41.5 (0.58)	43.4 (0.51)
Neighborhood- level characteristics	Physical Disorder (mean (s.e.))	-2.09 (0.09)	-2.15 (0.10)	-2.03 (0.09)
	Physical Decay (mean (s.e.))	-3.27 (0.04)	-3.29 (0.05)	-3.25 (0.05)
	Safety (mean (s.e.))	-0.09 (0.03)	-0.13 (0.03)	-0.06 (0.03)
	Perceived Disorder (mean (s.e.))	2.49 (0.02)	2.48 (0.03)	2.49 (0.02)
	Perceived Violence (mean (s.e.))	1.83 (0.01)	1.82 (0.02)	1.84 (0.01)
	Social Ties in Neighborhood (mean (s.e.))	2.63 (0.01)	2.63 (0.01)	2.63 (0.01)
	Reciprocal Exchange (mean (s.e.))	2.86 (0.01)	2.86 (0.01)	2.86 (0.01)
	Social Cohesion (mean (s.e.))	3.05 (0.01)	3.05 (0.01)	3.05 (0.01)
	Family Structure*	0.18 (0.05)	0.22 (0.05)	0.15 (0.05)
	Population Density (people/sq kilometer)	7487.8 (288.5)	7872.9 (351.3)	7141.2 (269)
	Disadvantage	-0.24 (0.04)	-0.29 (0.05)	-0.19 (0.04)
	Affluence	0.24 (0.07)	0.31 (0.09)	0.17 (0.07)
Residential Stability	-0.05 (0.06)	-0.11 (0.07)	0.01 (0.06)	

* Family structure=% female-headed households with children + % married people aged 15+

Table 4.4. Mean CES-D score (Standard Errors) by neighborhood characteristics* (n=3105)

Neighborhood Characteristic	Quartile	Mean CES-D Score: Men (n=1235)	Mean CES-D Score: Women (n=1856)
Physical Disorder	1 st (most favorable)	1.72 (1.65, 1.80)	1.77 (1.70, 1.84)
	2 nd	1.71 (1.61, 1.82)	1.83 (1.73, 1.92)
	3 rd	1.75 (1.65, 1.85)	1.94 (1.84, 2.03)
	4 th	1.82 (1.71, 1.93)	1.96 (1.87, 2.05)
	p-value	0.24	<0.01
	continuous (p-value)	0.04 (0.05)	0.08 (<0.01)
Physical Decay	1 st (most favorable)	1.76 (1.69, 1.83)	1.85 (1.79, 1.92)
	2 nd	1.64 (1.54, 1.74)	1.77 (1.68, 1.87)
	3 rd	1.74 (1.64, 1.84)	1.92 (1.82, 2.01)
	4 th	1.87 (1.76, 1.97)	1.96 (1.87, 2.05)
	p-value	<0.01	<0.01
	continuous (p-value)	0.05 (0.02)	0.06 (<0.01)
Perceived Violence	1 st (most favorable)	1.70 (1.63, 1.78)	1.74 (1.67, 1.81)
	2 nd	1.71 (1.61, 1.82)	1.85 (1.76, 1.95)
	3 rd	1.74 (1.63, 1.85)	1.91 (1.82, 2.01)
	4 th	1.85 (1.74, 1.95)	1.98 (1.89, 2.07)
	p-value	0.02	<0.01
	continuous (p-value)	0.08 (<0.01)	0.10 (<0.01)
Perceived Disorder	1 st (most favorable)	1.66 (1.59, 1.74)	1.72 (1.65, 1.79)
	2 nd	1.77 (1.66, 1.89)	1.90 (1.80, 2.00)
	3 rd	1.70 (1.60, 1.80)	1.91 (1.82, 2.01)
	4 th	1.87 (1.76, 1.97)	1.98 (1.89, 2.07)
	p-value	<0.01	<0.01
	continuous (p-value)	0.07 (<0.01)	0.10 (<0.01)
Safety	1 st (most favorable)	1.74 (1.66, 1.82)	1.73 (1.66, 1.79)
	2 nd	1.75 (1.64, 1.86)	1.89 (1.80, 1.98)
	3 rd	1.72 (1.61, 1.83)	1.94 (1.85, 2.03)
	4 th	1.79 (1.69, 1.90)	1.92 (1.83, 2.01)
	p-value	0.49	<0.01
	continuous (p-value)	0.03 (0.24)	0.07 (<0.01)
Population Density	1 st (least crowded)	1.75 (1.68, 1.82)	1.80 (1.74, 1.87)
	2 nd	1.73 (1.63, 1.84)	1.87 (1.78, 1.96)
	3 rd	1.71 (1.60, 1.81)	1.89 (1.80, 1.98)
	4 th	1.80 (1.70, 1.90)	1.94 (1.84, 1.93)
	p-value	0.30	0.03
	continuous (p-value)	0.03 (0.10)	0.03 (0.04)
Social Ties	1 st (least favorable)	1.75 (1.69, 1.82)	1.95 (1.89, 2.00)
	2 nd	1.78 (1.68, 1.88)	1.84 (1.75, 1.93)
	3 rd	1.73 (1.63, 1.83)	1.85 (1.76, 1.93)
	4 th	1.73 (1.64, 1.83)	1.86 (1.78, 1.95)
	p-value	0.78	0.06
	continuous (p-value)	-0.01 (0.65)	-0.02 (0.23)

Reciprocal Exchange	1 st (least favorable)	1.77 (1.71, 1.84)	1.90 (1.84, 1.97)
	2 nd	1.78 (1.68, 1.89)	1.96 (1.87, 2.05)
	3 rd	1.74 (1.64, 1.85)	1.84 (1.75, 1.93)
	4 th	1.70 (1.60, 1.79)	1.80 (1.71, 1.89)
	p-value	0.31	0.01
	continuous (p-value)	-0.02 (0.17)	-0.05 (<0.01)
Social Cohesion	1 st (least favorable)	1.86 (1.79, 1.93)	1.99 (1.94, 2.05)
	2 nd	1.78 (1.68, 1.89)	1.88 (1.80, 1.97)
	3 rd	1.65 (1.55, 1.75)	1.87 (1.78, 1.96)
	4 th	1.71 (1.61, 1.81)	1.75 (1.67, 1.84)
	p-value	<0.01	<0.01
	continuous (p-value)	-0.06 (<0.01)	-0.09 (<0.01)
Family Structure	1 st (least favorable)	1.88 (1.81, 1.96)	2.00 (1.94, 2.05)
	2 nd	1.76 (1.66, 1.87)	1.89 (1.80, 1.98)
	3 rd	1.75 (1.65, 1.86)	1.84 (1.76, 1.93)
	4 th	1.61 (1.50, 1.71)	1.76 (1.67, 1.84)
	p-value	<0.01	<0.01
	continuous (p-value)	-0.12 (<0.01)	-0.10 (<0.01)
Residential Stability	1 st (least stable)	1.79 (1.71, 1.86)	1.94 (1.87, 2.01)
	2 nd	1.80 (1.69, 1.90)	1.90 (1.81, 1.99)
	3 rd	1.69 (1.59, 1.79)	1.89 (1.80, 1.98)
	4 th	1.72 (1.61, 1.82)	1.78 (1.69, 1.87)
	p-value	0.12	0.01
	continuous (p-value)	-0.03 (0.07)	-0.06 (<0.01)
Disadvantage	1 st (most favorable)	1.72 (1.64, 1.80)	1.72 (1.65, 1.79)
	2 nd	1.72 (1.61, 1.83)	1.87 (1.77, 1.97)
	3 rd	1.69 (1.58, 1.79)	1.89 (1.79, 1.98)
	4 th	1.88 (1.77, 1.99)	2.00 (1.91, 2.09)
	p-value	<0.01	<0.01
	continuous (p-value)	0.09 (<0.01)	0.11 (<0.01)
Affluence	1 st (least favorable)	1.81 (1.73, 1.89)	1.99 (1.93, 2.04)
	2 nd	1.72 (1.62, 1.82)	1.84 (1.76, 1.92)
	3 rd	1.71 (1.60, 1.82)	1.83 (1.74, 1.91)
	4 th	1.76 (1.65, 1.86)	1.83 (1.74, 1.93)
	p-value	0.24	<0.01
	continuous (p-value)	0.004 (0.82)	-0.03 (0.11)

Table 4.5. Mean CES-D Score (Standard Deviation) by selected demographic characteristics (n=3105)

		Mean CES-D Score: Men (n=1235)	Mean CES-D Score: Women (n=1870)
OVERALL		1.75 (0.02)	1.88 (0.02)
Marital Status	Married	1.61 (1.55, 1.66)	1.76 (1.71, 1.82)
	Separated	1.87 (1.68, 2.07)	1.96 (1.82, 2.10)
	Divorced	1.96 (1.82, 2.09)	1.94 (1.83, 2.04)
	Widowed	1.97 (1.77, 2.17)	1.95 (1.84, 2.06)
	Never Married	1.84 (1.76, 1.91)	1.95 (1.87, 2.02)
	p-value	<0.01	<0.01
	Race/Ethnicity	White	1.74 (1.65, 1.83)
African American		1.88 (1.79, 1.97)	1.95 (1.87, 2.04)
Hispanic		1.62 (1.56, 1.69)	1.92 (1.85, 2.00)
Other		1.74 (1.49, 1.98)	1.71 (1.46, 1.96)
p-value		<0.01	<0.01
Annual Income (\$)		<5,000	2.00 (1.85, 2.16)
	5,000-9,999	1.95 (1.71, 2.19)	2.11 (1.91, 2.31)
	10,000-29,999	1.84 (1.67, 2.02)	2.02 (1.85, 2.19)
	30,000-49,999	1.70 (1.52, 1.87)	1.87 (1.69, 2.05)
	50,000+	1.67 (1.50, 1.84)	1.71 (1.53, 1.88)
	Missing	1.70 (1.52, 1.88)	1.75 (2.57, 1.93)
	p-value	<0.01	<0.01
Education (years)	<12	1.73 (1.66, 1.80)	2.00 (1.93, 2.07)
	12	1.79 (1.69, 1.90)	1.93 (1.83, 2.03)
	13-15	1.78 (1.68, 1.89)	1.85 (1.76, 1.95)
	16+	1.70 (1.60, 1.79)	1.74 (1.65, 1.83)
	p-value	0.21	<0.01
Age (10 years)		-0.015 (-0.037, 0.008)	-0.015 (-0.034, 0.004)
	p-value	0.20	0.13
Age^2		0.00 (-0.001, 0.001)	0.00 (-0.001, 0.001)
	p-value	0.41	0.58

Table 4.6. Adjusted mean differences in Center for Epidemiologic Studies-Depression (CES-D) score associated with individual-level characteristics, CMB study (n=3105)

		Men (n=1235)	Women (n=1870)
Marital Status	Married	Ref.	Ref.
	Separated	0.20 (0.01, 0.39)*	0.06 (-0.09, 0.22)
	Divorced	0.30 (0.15, 0.44)*	0.12 (0.02, 0.22)*
	Widowed	0.30 (0.08, 0.52)*	0.19 (0.05, 0.33)*
	Never Married	0.18 (0.08, 0.28)*	0.12 (0.03, 0.20)*
Race/Ethnicity	White	Ref.	Ref.
	African American	0.08 (-0.01, 0.17)	0.05 (-0.02, 0.13)
	Hispanic	-0.14 (-0.25, -0.04)*	0.04 (-0.06, 0.13)
	Other	0.01 (-0.22, 0.24)	-0.08 (-0.29, 0.13)
Annual Income (\$)	<5,000	0.09 (-0.12, 0.31)	0.15 (-0.01, 0.32)
	5,000-9,999	0.18 (-0.02, 0.38)	0.26 (0.10, 0.42)*
	10,000-29,999	0.10 (0.00, 0.20)*	0.23 (0.13, 0.33)*
	30,000-49,999	-0.01 (-0.10, 0.09)	0.11 (0.01, 0.21)*
	50,000+	Ref.	Ref.
	Missing	0.00 (-0.11, 0.12)	0.00 (-0.10, 0.11)
Education (years)	<12	0.07 (-0.05, 0.19)	0.20 (0.10, 0.30)*
	12	0.04 (-0.02, 0.09)	0.07 (0.03, 0.12)*
	13-15	0.03 (-0.01, 0.06)	0.02 (0.00, 0.05)
	16+	Ref.	Ref.
Age (10 years)		-0.01 (-0.04, 0.02)	-0.01 (-0.03, 0.02)
	Age^2	0.00 (-0.001, 0.001)	-0.002 (-0.003, -0.001)*
ICC		3.3%*	3.9%*

* p<0.05

^ Model includes all variables listed in table

Table 4.7. Adjusted mean differences in Center for Epidemiologic Studies-Depression (CES-D) score associated with neighborhood-level characteristics, CMB study (n=3105)

	WOMEN				MEN			
	NV only	ICC	NV + IV**	ICC	NV only	ICC	NV + IV	ICC
<i>STRESSORS</i>								
Physical Disorder (SSO)	0.08 (0.05, 0.12)*	5.1%	0.03 (0.00, 0.07)	3.6%	0.04 (0.00, 0.09)*	7.0%	0.02 (-0.02, 0.06)	3.3%
Physical Decay (SSO)	0.05 (0.02, 0.09)*	6.1%	-0.01 (-0.04, 0.03)	4.0%	0.05 (0.00, 0.09)*	7.0%	0.01 (-0.03, 0.06)	3.4%
Perceived Violence	0.09 (0.06, 0.13)*	4.5%	0.04 (0.01, 0.07)*	3.5%	0.08 (0.04, 0.12)*	6.0%	0.05 (0.01, 0.08)*	3.1%
Perceived Disorder	0.10 (0.07, 0.13)*	4.3%	0.04 (0.00, 0.07)	3.6%	0.07 (0.04, 0.11)*	6.2%	0.04 (0.00, 0.08)*	3.1%
Safety	0.07 (0.03, 0.10)*	5.9%	0.02 (-0.02, 0.05)	3.9%	0.03 (-0.02, 0.08)	7.6%	0.00 (-0.04, 0.05)	3.4%
Population Density	0.03 (-0.01, 0.07)	6.7%	0.02 (-0.01, 0.06)	3.6%	0.03(-0.00, 0.06)	7.2%	0.02 (-0.01, 0.05)	3.3%
<i>SOCIAL SUPPORT</i>								
Social Cohesion	-0.09 (-0.12, -0.06)*	4.4%	-0.05 (-0.08, -0.02)*	3.0%	-0.06 (-0.10, -0.02)*	7.0%	-0.03 (-0.07, 0.00)	3.5%
Reciprocal Exchange	-0.05 (-0.08, -0.02)*	6.4%	-0.03 (-0.06, 0.00)*	3.5%	-0.03 (-0.06, 0.01)	7.5%	-0.02 (-0.05, 0.01)	3.4%
Social Ties	-0.02 (-0.05, 0.01)	7.1%	-0.02 (-0.05, 0.01)	3.7%	-0.01 (-0.04, 0.03)	7.5%	0.00 (-0.03, 0.04)	3.4%
Residential Stability	-0.05 (-0.09, -0.02)*	6.0%	-0.05 (-0.08, -0.02)*	3.0%	-0.04 (-0.08, 0.00)*	7.5%	-0.03 (-0.06, 0.01)	3.6%
Family Structure	-0.10 (-0.13, -0.07)*	4.4%	-0.06 (-0.10, -0.02)*	3.2%	-0.13 (-0.17, -0.08)*	4.0%	-0.08 (-0.13, -0.03)*	2.8%
<i>SOCIOECONOMIC FACTORS</i>								
Disadvantage	0.10 (0.07, 0.14)*	4.4%	0.03 (-0.01, 0.08)	3.6%	0.09 (0.04, 0.14)*	5.6%	0.04 (-0.01, 0.09)	3.1%
Affluence	-0.03 (-0.07, 0.01)	7.0%	0.03 (-0.01, 0.07)	3.6%	0.01 (-0.04, 0.05)	7.6%	0.02 (-0.02, 0.07)	3.5%
No Neighborhood Var.	.	7.1%	.	3.9%	.	7.4%	.	3.3%

* p < 0.05; ^ All neighborhood variables are in z-score units (per 1 SD increase); ** Individual level variables= marital status, age, education, income, race/ethnicity

Table 4.8. Adjusted mean differences in Center for Epidemiologic Studies-Depression (CES-D) score associated with neighborhood-level characteristics, groups of stressors and social support (n=3105)

	WOMEN								All Variables
Perceived Violence	0.02 (-0.02, 0.06)	0.04 (0.01, 0.07)*	0.02 (-0.02, 0.06)	0.02 (-0.01, 0.06)					0.02 (-0.03, 0.08)
Perceived Disorder					0.01 (-0.03, 0.06)	0.03 (0.00, 0.07)	0.01 (-0.03, 0.06)	0.02 (-0.03, 0.06)	-0.01 (-0.08, 0.05)
Family Structure				-0.04 (-0.09, 0.01)				-0.05 (-0.10, 0.00)	-0.03 (-0.08, 0.03)
Social Cohesion	-0.04 (-0.08, 0.00)*				-0.05 (-0.08, -0.01)*				-0.02 (-0.07, 0.03)
Reciprocal Exchange		-0.03 (-0.06, 0.00)*				-0.03 (-0.06, 0.00)*			-0.01 (-0.05, 0.02)
Residential Stability			-0.04 (-0.07, 0.00)*				-0.04 (-0.08, -0.01)*		-0.02 (-0.06, 0.02)
ICC	3.0%	3.2%	3.0%	3.2%	3.1%	3.3%	3.0%	3.2%	2.9%
	MEN								
Perceived Violence	0.04 (0.00, 0.08)	0.05 (0.01, 0.08)*	0.04 (0.00, 0.08)*	0.02 (-0.02, 0.07)					0.04 (-0.02, 0.10)
Perceived Disorder					0.03 (-0.02, 0.08)	0.04 (0.00, 0.08)	0.03 (-0.01, 0.08)	0.01 (-0.03, 0.06)	-0.01 (-0.08, 0.06)
Family Structure				-0.06 (-0.12, 0.00)*				-0.07 (-0.12, -0.01)*	-0.07 (-0.13, -0.01)*
Social Cohesion	-0.02 (-0.06, 0.03)				-0.02 (-0.06, 0.02)				0.00 (-0.05, 0.06)
Reciprocal Exchange		-0.02 (-0.05, 0.01)				-0.02 (-0.05, 0.02)			-0.02 (-0.06, 0.02)
Residential Stability			-0.01 (-0.05, 0.03)				-0.01 (-0.05, 0.03)		0.01 (-0.03, 0.06)
ICC	3.3%	3.3%	3.4%		3.4%	3.3%	3.4%	2.9%	3.0%

Table 4.9. Adjusted mean differences in Center for Epidemiologic Studies-Depression (CES-D) score associated with neighborhood- and individual-level neighborhood survey characteristics (n=3105)

		WOMEN	MEN
Variable	Level	Neighborhood Est.	Neighborhood Est.
Perceived Violence	Neighborhood Cluster (NC)	0.04 (0.01, 0.07)*	0.05 (0.01, 0.08)*
	Individual	0.09 (0.05, 0.13)*	0.12 (0.08, 0.16)*
	Both-NC	-0.01 (-0.05, 0.03)	-0.02 (-0.06, 0.03)
	Both-Individual	0.09 (0.05, 0.13)*	0.13 (0.08, 0.17)
	Objective Violence (w/individual)	0.00 (-0.01, 0.00)	0.00 (-0.01, 0.01)
	Individual (w/objective violence)	0.09 (0.05, 0.12)*	0.12 (0.08, 0.16)*
Perceived Disorder	NC	0.04 (0.00, 0.07)	0.04 (0.00, 0.08)*
	Individual	0.08 (0.05, 0.13)*	0.10 (0.06, 0.14)*
	Both-NC	-0.03 (-0.08, 0.02)	-0.02 (-0.07, 0.02)
	Both-Individual	0.09 (0.05, 0.13)*	0.11 (0.06, 0.16)*
	Disorder (SSO) (w/individual)	0.00 (-0.04, 0.04)	-0.02 (-0.06, 0.03)
	Individual (w/ objective disorder)	0.08 (0.04, 0.11)*	0.10 (0.06, 0.14)*
Social Cohesion	NC	-0.05 (-0.08, -0.02)*	-0.03 (-0.07, 0.00)
	Individual	-0.05 (-0.09, -0.02)*	-0.08 (-0.12, -0.04)*
	Both-NC	-0.03 (-0.07, 0.00)	0.001 (-0.04, 0.04)
	Both-Individual	-0.04 (-0.08, 0.00)*	-0.08 (-0.12, -0.04)*
Reciprocal Exchange	NC	-0.03 (-0.06, 0.00)*	-0.02 (-0.05, 0.01)
	Individual	-0.03 (-0.06, 0.00)	-0.02 (-0.05, 0.02)
	Both-NC	-0.02 (-0.06, 0.01)	-0.01 (-0.05, 0.02)
	Both-Individual	-0.02 (-0.05, 0.02)	-0.01 (-0.05, 0.03)
Social Ties	NC	-0.02 (-0.05, 0.01)	0.00 (-0.03, 0.04)
	Individual	-0.01 (-0.03, 0.02)	-0.04 (-0.08, 0.00)*
	Both-NC	-0.02 (-0.06, 0.01)	0.02 (-0.01, 0.06)
	Both-Individual	0.00 (-0.03, 0.03)	-0.05 (-0.09, -0.01)*

* p < 0.05

Chapter 5: Is Neighborhood Racial/Ethnic Composition Associated with Depressive Symptoms? The Multi-Ethnic Study of Atherosclerosis

Introduction

It has been hypothesized that the racial/ethnic composition of a neighborhood may be related to the presence of depressive symptoms in residents. The ethnic density hypothesis, as it is often called, states that rates of mental disorder decrease as the percentage of people from the same racial/ethnic group in one's neighborhood increases.(27) This association may arise due to differences in social support or sources of stressors across neighborhoods with different race/ethnic composition.(28) For example, immigrants living in neighborhoods with large proportions of immigrants may have stronger social ties and better access to resources distributed through dense networks than immigrants living in neighborhoods where they are the minority. These social resources and ties may buffer the effects of stressors associated with adapting to a new environment, and reduce rates of depression.

On the other hand, neighborhood segregation by race/ethnicity resulting from factors such as institutional racism, forced segregation due to overt and more inconspicuous discrimination in housing opportunities, and differential economic opportunities by race may result in detrimental physical and environmental neighborhood exposures, which in turn place residents in segregated neighborhoods at higher risk of depression.(107) Residential segregation can negatively affect health through a whole host of adverse residential conditions that may impact health and well-being, especially

conditions that occur in neighborhoods with high concentrations of impoverished households.(107) For example, in the US there is a strong association between some measures of neighborhood race/ethnic composition (such as percent African American) and adverse residential environments which can act as stressors,(108) including higher crime, worse safety,(109) and higher poverty.(107) Because the relative importance of different processes may differ for different race/ethnic groups, the direction of the association between race/ethnic composition and depressive symptoms may vary by race/ethnicity. Associations may also not be linear: for example it may be that the protective social factors only become apparent above a certain concentration.

The association between neighborhood racial/ethnic composition and depressive symptoms has been investigated in a handful of studies. One study found that, for both black and white participants, depression was not associated with neighborhood racial composition after adjustment for individual-level income and education.(28) A study of elderly Mexican Americans found that ethnic concentration moderated the effect of neighborhood poverty on depressive symptoms, such that living in a neighborhood with a high density of Mexican Americans weakened the negative association between neighborhood poverty and increased depressive symptoms.(29) Other studies have found no association between neighborhood racial/ethnic composition and depressive symptoms.(1) It is still not clear what factors drive the association between neighborhood racial/ethnic composition and depressive symptoms, or whether these factors differ between racial/ethnic groups.

We used data from the Multi-Ethnic Study of Atherosclerosis (MESA) to investigate the ethnic density hypothesis through the examination of cross-sectional

associations of neighborhood racial/ethnic composition with depressive symptoms amongst healthy adults aged 45-84 years. We conducted separate analyses for Hispanic women, Hispanic men, African American women, African American men, Chinese women, Chinese men, white women, and white men. We then examined if any of the observed associations were explained by neighborhood-level social cohesion and stressors or socioeconomic factors.

Methods

Study Setting and Population

Study participants were participants in the Multi-Ethnic Study of Atherosclerosis (MESA), a ten-year longitudinal study of men and women aged 45 to 84. Participants were enrolled at six study field centers (Baltimore MD, New York NY, Chicago IL, Los Angeles CA, Minneapolis MN, and Forsyth County NC) between August 1 2000 and July 30 2002 using a variety of population-based approaches. Participants were free of clinically evident cardiovascular disease at the time of enrollment.(85) The data used in this study came from the baseline examination data collected during 2000-2002. Institutional review boards at all participating study centers approved the study, and informed consent was obtained from all study participants.

Data Collection and Variables

The primary outcome for this study was subjects' depressive symptoms, measured in MESA participants at baseline using the 20-item Center for Epidemiologic Studies Depression (CES-D) Scale.(87) Each scale item is scored from 0-3, with a higher score representing more depressive symptoms. The potential range of this scale is 0-60, with a

score of 16 often used as the cutoff for clinical depression. The CES-D scale was used as a continuous variable, since it was not highly skewed.

The main exposure variable was a census-derived measure of the percentage of people of the same race/ethnicity in a study participant's census tract. We used four different census racial/ethnic group classifications: African American, Hispanic, white, and Asian. Each of these variables was transformed into units of 10% increase.

Additional neighborhood characteristics were assessed through a questionnaire administered to MESA participants. Four neighborhood dimensions linked to depressive symptoms in prior work(5, 6, 7, 106) were examined as possible confounders or mediators of the race/ethnic composition effect. These dimensions were social cohesion (constructed from five items) and three domains related to the construct of neighborhood stressors (neighborhood safety (three items), neighborhood problems (seven items), and aesthetic quality (two items)).(17, 78, 110) For each MESA participant we created a measure for his or her neighborhood based on the mean responses of all other MESA participants residing within one mile of the participant. Each neighborhood measure was transformed into units of standard deviations (for the full sample), in order to allow comparisons across scales and measurements. We also investigated two neighborhood socioeconomic status variables that were created using factor analysis of nineteen variables from the 2000 US census.(93) The first factor score consisted of six items representing housing and income/wealth (% vacant housing, % of homes with no telephone, % of homes with no vehicle, % unemployed, median household income, and % poverty) (Factor 1). This factor explained 61% of variance. The second factor score

used three measures to represent education, occupation, and income/wealth (Factor 2), and explained 22% of variance.

The other covariates used in the analysis included gender, age, race/ethnicity, annual income, highest level of education achieved, marital status, and nativity, all assessed at the MESA baseline exam. Age was categorized into four groups (45-54, 55-64, 65-74, 75-84). Race and ethnicity were classified as Caucasian, African American, Chinese, and Hispanic, based on self-report using questions from the Year 2000 US Census. Total gross family income was categorized into five levels: <\$20,000, \$20,000-34,999, \$35,000-49,999, \$50,000-74,999, and \$75,000+. Education was categorized as: less than high school, completed high school, some college or a trade or Associate's degree, Bachelor's degree, and graduate/professional degree. Marital status was categorized as: married/living as married, widowed, divorced/separated, single, and prefer not to say. Four categories of nativity were used: foreign-born and in the US less than 10 years, foreign-born and in the US 10-19 years, foreign-born and in the US 20+ years, and US-born.

Data Analysis

Analyses were stratified by gender, in order to allow for potential differences in the association between depressive symptoms and neighborhood characteristics. Analyses were also stratified by race/ethnicity, as the main exposure of interest (% people of the same racial/ethnic background in participants' census tracts) differed for each racial/ethnic group. We examined the distribution of all individual-level and neighborhood-level covariates, by gender and racial/ethnic group.

In order to determine whether the associations between CES-D score and % racial/ethnic composition were linear, we used scatter plots and generalized additive models (GAMs) to look at the shape of the associations and test for non-linearity. We fit a series of two-level multilevel models with a random intercept for each neighborhood, in order to investigate whether the percent of people of the same racial/ethnic background was associated with depressive symptoms. Models included age, income, education, and % racial/ethnic concentration. Models for Hispanic and Chinese subjects additionally adjusted for nativity. The final step of the analysis was to examine whether any association(s) we saw between living in a neighborhood with a higher percentage of people with African American, Hispanic, white, or Asian racial/ethnic background was explained by any other neighborhood factors (social cohesion, neighborhood problems, neighborhood safety, aesthetic quality, neighborhood socioeconomic status). We added these variables to our models, first one at a time, and then in combination, to see whether any of the observed relationships between percent racial/ethnic groups and depressive symptoms remained. All models were also run adjusting for study site, and results were compared between analyses with and without study site. Additionally, cross-level interactions between subjects' education and income and neighborhood racial/ethnic composition were examined, but since only one of the sixteen interactions was statistically significant, final models are presented without any interaction terms. All models were fitted using SAS Proc Mixed.

In sensitivity analyses we used propensity score matching in order to examine the robustness of our results to alternate ways of adjusting for confounding and to restrict comparisons to persons with overlapping covariate distributions. Each of our eight

gender- and racial/ethnic group-specific groups were split into tertiles of the percent of people of the same racial/ethnic group in subjects' census tracts. Participants in the middle tertile were dropped, while those in the bottom and top tertile were matched on age, income, education, marital status, and nativity (for Hispanic and Chinese subjects only) using caliper matching of 0.2. Paired t-tests for CES-D scores were then performed for these matched pairs, and p-values were examined.

There were 6191 MESA participants from all six study sites enrolled at baseline, of which 5952 were not missing information on gender, age, race/ethnicity, income, education, or CES-D score. 140 participants were additionally excluded for missing information on the % of specific racial/ethnic groups (from census) in their census tract. 44 Chinese and 97 Hispanic men and women were missing information on nativity, and were excluded from analyses. Additionally, we excluded four subjects who lived in areas with <5 people of the same racial/ethnic group enrolled in MESA (two Chinese in New York and two Hispanics in Forsyth County), as there were at least 50 participants in all other racial/ethnic-, gender-, and site-specific groups. This left a total of 5667 study participants.

Results

Table 5.1 shows the distribution of study participants' individual- and neighborhood-level characteristics. Hispanics were only enrolled in New York, Minneapolis, and Los Angeles, and Chinese subjects only came from Chicago and Los Angeles (with over 60% enrolled in Los Angeles). White participants were enrolled at all six sites, and African Americans participated in every location except Minneapolis.

Chinese and Hispanic women reported the lowest incomes, and white men the highest (Table 5.1). 37% of Hispanic males and 44% of Hispanic females reported less than a high school education, while 35% of white males and 23% of Chinese males had a graduate/professional degree. The majority of study subjects were married, with African American women as a low outlier (only 35% reported being married/living as married, as compared with 91% of Chinese men and 62% overall). As expected, there was little variation in nativity for African American and white participants (>90% were U.S. born), while Chinese and Hispanic populations were mainly foreign-born (>95% of Chinese and >60% of Hispanics were born outside of the United States). Each racial/ethnic group had the highest mean neighborhood race/ethnic concentration for their own racial/ethnic group, with whites and African Americans living in neighborhoods with an average concentration of 61-66% of their own racial/ethnic group.

Table 5.2 shows the mean CES-D score for each of the gender and racial/ethnic groups by individual-level demographic characteristics. Within each racial/ethnic group, men had lower CES-D scores than women (Table 5.2). Hispanic and white men and women living in New York had higher CES-D scores than their counterparts in other study sites. Chinese subjects in Chicago had significantly higher levels of depressive symptoms than those in Los Angeles. Income was strongly inversely associated with depressive symptoms in all groups except Chinese participants and Hispanic men (Table 5.2). Lower levels of depressive symptoms were strongly associated with higher levels of education amongst African American men and women and white women. Married study participants had lower CES-D scores than separated, divorced, widowed, and never married individuals across all groups, with the exception of Chinese men. Hispanic

women born in the U.S. had much lower CES-D score than those born outside the U.S., while the opposite held true for Chinese women: those born in the U.S. had higher levels of depressive symptoms (Table 5.2).

Figure 5.1 shows the mean age-adjusted CES-D score for each of the eight gender and racial/ethnic groups, stratified by quartiles of the % same racial/ethnic group in subjects' census tracts. Among African American men, those living in tracts with a greater % of African Americans had higher CES-D scores ($p=0.12$) (Figure 5.1). Hispanic women living in areas with more Hispanic residents tended to have higher CES-D scores, although a drop was observed in the highest quartile. Among Chinese women the middle categories had the lowest CES-D scores. No clear patterns were observed for the other race/ethnic and gender groups, and none of the associations were statistically significant at a $p<0.05$ level.

The GAM plots adjusted for education, age, income, and nativity (Hispanic and Chinese subjects only) largely confirmed the patterns observed in Figure 5.1. There was no clear association between CES-D score and % racial/ethnic composition for Hispanic men, African American women, Chinese men and white men and women (data not shown). There was a positive, linear association for African American men. Hispanic women and Chinese women showed non-linear associations: a U-shaped relationship was observed in Chinese women (Chinese women living in neighborhoods with average Asian concentrations of 44% had the lowest CES-D scores) (p -value for deviance test from linearity=0.02), while an inverted U shape was observed in Hispanic women (Hispanic women in neighborhoods with average concentrations of 50% had the highest CES-D scores) (p -value for deviance test from linearity=0.17). Controlling for site in the

GAM plots reduced the non-linear association for Hispanic and Chinese women, and created an inverted U shaped association in Chinese men, although none of the tests for deviance from linearity were statistically significant. Given that non-linearities were not consistent across models and were often non-statistically significant, all associations were subsequently modeled as linear.

Table 5.3 shows the associations between % Racial/Ethnic composition and the other neighborhood characteristics (safety, problems, aesthetic quality, social cohesion, neighborhood SES), for each racial/ethnic group. Increased neighborhood problems and decreased social cohesion, aesthetic quality, and safety were associated with an increased % of African Americans (amongst African American subjects), increased % Hispanics (Hispanic subjects), increased % Asian (Chinese subjects), and decreased % white (white subjects). Worse neighborhood socioeconomic characteristics were associated with increased % African American and Hispanic and decreased % white (results for Chinese subjects were not consistent) (Table 5.3).

Table 5.4 shows mean differences in CES-D score associated with a 10% increase in racial/ethnic concentration in Hispanic, African American, white and Chinese men and women, after adjustment for individual- and other neighborhood-level covariates. Among Hispanic women, higher neighborhood concentrations of the same racial/ethnic group were associated with lower CES-D levels after adjustment for individual-level factors, with the association becoming significant after additional adjustment for the neighborhood SES Factor 1 score (mean difference for a 10% increase -0.39 (95% CI - 0.40, -0.02)). Among Hispanic men, greater % Hispanics in the tract was also associated with lower CES-D, although this association was only statistically significant after

adjustment for SES Factor 1 and 2 (mean difference after adjusting for Factor 2 score - 0.33 (-0.65, -0.01)). A greater concentration of African Americans had no association with depressive symptoms in African American women, although adjusting for neighborhood safety created a non-significant negative association (mean difference for a 10% increase -0.14 (95% CI -0.32, 0.05)). Higher concentrations of the same racial/ethnic group in subjects' census tracts were associated with increased CES-D levels for African American men (mean difference for a 10% increase 0.26 (95% CI 0.12, 0.41)). This association remained largely unchanged after adjustment for other neighborhood level variables. A slight, non-significant negative association was observed in white men and women, with adjustment for SES Factor 2 increasing the strength of the association (mean difference for a 10% increase in white concentration -0.21 (95% CI -0.40, -0.02), women and -0.16 (-0.33, 0.01), men). Chinese women living in neighborhoods with higher concentrations of Asians had non-significantly lower CES-D scores (mean difference -0.35 (-0.76, 0.06)). This association was reduced in a model controlling for all neighborhood variables (mean difference -0.14 (-0.56, 0.28)). No associations were observed for Chinese men, and adjustment for other neighborhood factors did not change the strength of the association.

Controlling for study site weakened the negative association observed in Hispanic men, eliminated the association in Chinese women, and created a positive, non-statistically significant association for Chinese men. There was no change in the strength of associations for Hispanic women, African American or white study participants. Global significance tests for interaction by study site were non-significant for all eight race/ethnicity and gender groups (data not shown).

The results of propensity score matched analyses were qualitatively similar to those observed in regression analyses (Table 5.5). 44-83% of the subjects in the bottom and top tertiles were matched across groups. The only statistically significant association between race/ethnic composition and depression was observed in African American men: those in the highest tertile of African American census tract concentration had a mean CES-D score 2.00 (95% CI 0.77, 3.23) higher than those in the lowest (after matching on propensity scores based on age, marital status, income, and education). Differences between tertiles were not statistically significant for any of the other groups, but the directions of the (non-significant) associations remained the same as in regression analyses.

Discussion

Depression was associated with neighborhood racial/ethnic group concentration in African American men, Hispanic men and women and Chinese women. Living in a neighborhood with a higher concentration of African Americans was associated with higher mean CES-D scores in African American men. This association was not explained by other neighborhood characteristics, such as neighborhood aesthetic environment, safety, social cohesion, or the neighborhood socioeconomic environment. Higher neighborhood concentrations of the same racial/ethnic group were associated with lower CES-D levels for Hispanic women and men after adjustment for neighborhood socioeconomic characteristics. Greater concentrations of Asians were also associated with lower CES-D scores in Chinese women, although these associations were not statistically significant at the 0.05 level.

This study is one of the first to look at the association of neighborhood racial/ethnic composition and depressive symptoms amongst eight distinctive racial/ethnic and gender groups. The diverse study sample allowed us to examine the associations within groups and compare the strength and direction of the associations between groups. The large number of other neighborhood characteristics available in MESA, all of which have been linked to depressive symptoms in other studies, allowed us to examine whether any associations were due, in part or wholly, to other neighborhood conditions associated with neighborhood racial/ethnic composition. For example, neighborhood poverty may be associated with neighborhoods with a high proportion of African American residents, and the observed association between % African American in a census tract and higher CES-D score may actually be due to neighborhood poverty. However, in the majority of groups in this study, no individual or combination of other neighborhood characteristics explained much of the association between % race/ethnicity and CES-D score.

Our results using propensity score matching were qualitatively similar to the results from multilevel models. It has been argued that it is difficult to study neighborhood effects on health outcomes, since people who live in different types of neighborhoods may not be directly comparable in terms of other, individual-level, risk factors.(111) However, we were able to match the majority of our study subjects in each racial/ethnic and gender group to people living in neighborhoods with difference racial/ethnic concentrations based on their individual income, education, marital status, nativity and age. This makes us more confident that our main regression results are not strongly affected by extrapolations beyond the range observed in the data.

Three of ten prior studies that examined the association between neighborhood racial/ethnic concentration and depression/depressive symptoms found a significant protective association between living in an environment with a higher concentration of people of the same racial/ethnic background, community ethnic identification, or high racial congruity and depressive symptoms/depression(29, 44, 58, 84). Three studies looked at clinical depression and seven at depressive symptoms. Increased ethnic density had a protective effect on depressive symptoms amongst elderly Mexican Americans living in the southwest, while community ethnic identification lowered levels of clinical depression amongst elderly African Americans living in Baltimore.(29, 44) Similarly, there was a protective association between racial congruity and depressed mood in a population of adults aged 18+ in Baltimore.(58) None of the three studies that examined the association between depression/depressive symptoms and racial/ethnic heterogeneity/ethnic diversity (using elderly populations in the United States and adult populations in Canada) found a significant association.(1, 43, 61) Immigrant concentration was not associated with depression amongst children living in Chicago(45). Racial congruity was not associated with depressive symptoms in an elderly population living in Alabama(58, 72) and ethnic density was not associated with depressive symptoms amongst 18-30 year olds or in elderly national samples(28, 29, 65), despite the fact that these measures of neighborhood racial/ethnic composition were protective in other studies. These 10 studies are arguably measuring different aspects of neighborhood environments, and a diversity of findings may plausibly be expected.

Our study found that living in a neighborhood with a high concentration of people of the same racial/ethnic background was associated with increased depressive symptoms

in African American men and decreased depressive symptoms in Hispanics and Chinese women. Our analyses are most directly comparable to the studies that examined ethnic density and racial congruity as predictors of depression. Two of these five studies found an association, one for elderly Mexican Americans and one for white and African American adults. Both these studies found that a higher % of the same racial/ethnic group was protective of depression. The three studies that did not find an association looked at % Hispanic and % African American for all racial/ethnic groups together,(28, 29, 65), % African American and % white for both whites and African Americans (they found associations that disappeared after adjustment for neighborhood SES characteristics),(28, 29, 65) and racial congruity for elderly whites and African Americans.(58, 72) The fact that racial/ethnic heterogeneity has not been found to be associated with depression/depressive symptoms does not contradict the findings of this study, as we did not explicitly look at this neighborhood feature.

In our analyses, the specific neighborhood-level measures investigated as explanatory variables (including neighborhood social cohesion, safety, problems, aesthetic environment, and SES conditions) did not fully explain the associations observed despite the fact that they were linked to depression in prior work in the same cohort and were all independently associated with % of each racial/ethnic composition group. In African American men positive associations of % African American with depression persisted after adjustment for neighborhood characteristics. Several factors could explain this fact. First, measurement error in the neighborhood-level measures is clearly present and could explain why we did not identify much of a change in estimates of the race/ethnic composition after adjustment. In addition we may not have measured

the neighborhood-level constructs that are most relevant. Clearly, % African American in a census tract is likely to be proxying a variety of social characteristics. For example, African American men living in neighborhoods with high concentrations of African Americans are exposed to neighborhood stressors we did not investigate in this study, such as the collective reinforcement of discrimination or residential stability and job opportunities within a neighborhood. In Hispanic women and men, race/ethnic composition effects often became stronger after adjustment for other neighborhood characteristics. This occurs because neighborhoods with greater % Hispanic have worse neighborhood conditions (Table 5.3), so when I adjusted for these characteristics the protective effects grow stronger. This is consistent with the ethnic density hypothesis. The associations in Chinese women were not modified much by adjustment, which may be due to the fact that % Asian was not as strongly related to the other neighborhood features as % Hispanic.

Including study site in our models changed the results for several of the study groups, reducing associations for Chinese women and Hispanic men and increasing them for Chinese men. However, we present main results unadjusted for site due to the fact that it is difficult for us to explain what, precisely, study site represents. If study site is correlated with specific neighborhood characteristics, adjusting for site could explain away some of the variance of interest. However, if site is linked to CES-D score for other reasons, we would want to control for site in our models. Data was only available for Chinese participants at two study sites (Chicago and Los Angeles), and CES-D scores were much higher in Chicago than Los Angeles, but the reason behind this is unclear.

While we had a large overall sample size, when broken down by race/ethnicity and gender some of our groups had sample sizes under 350, which may have been inadequate to accurately examine the associations of interest. There was an indication that the associations in this data may be non-linear, particularly amongst Hispanic and Chinese women, but the small sample size and non-consistent patterning made it difficult for us to fully explore the shape of the associations. The potential non-linearity of the associations needs to be further explored. MESA included subjects in six different study sites. It is plausible that the meaning and implications for health of neighborhood race/ethnic composition varies across sites. For example, a neighborhood with a majority of Hispanic residents in New York City may have very different social interactions than one in Minneapolis. The white residents were sampled from six unique geographic locations, while the Chinese came from only two. Unfortunately limited sample size made it difficult to examine heterogeneity by site, although no interaction terms were statistically significant. Finally, it is always a weakness of neighborhood studies that use census-defined boundaries that the true neighborhood definition, as it relates to mental health, is not being accurately reflected in the study design. Trash on the streets, for example, could only matter to a person on the street where they live, while violence may have an influence several miles around their residence.

We documented associations of neighborhood race/ethnic composition with depressive symptoms in African American men and to some extent in Hispanics and in Chinese women. Future work needs to more fully examine the processes generating these associations. There is a need to look at each of our eight gender and racial/ethnic groups, and determine what it is about the neighborhood racial/ethnic makeup that is causing

increased/decreased CES-D scores within each group. Future studies would do well to incorporate larger sample sizes and measurement of a wider range of other neighborhood characteristics. This study, with its diversity of findings, raises many questions about the impact of neighborhood context on mental health. It is clear that the neighborhoods in which people live affect levels of depressive symptoms. It is still unknown, however, what specific pieces of the neighborhood environment explain these associations, and what we can do as public health practitioners to create residential contexts conducive to physical and mental well being.

Table 5.1. Selected individual- and neighborhood-level characteristics of study participants, by gender and race/ethnicity

		Hispanic			White		African American		Chinese	
		All Participants (n=5667)	Men (n=571)	Women (n=608)	Men (n=1130)	Women (n=1192)	Men (n=669)	Women (n=837)	Men (n=321)	Women (n=339)
Individual-Level Characteristics	Study Site (% distribution)									
	Forsyth County, NC (3)	15.0	.	.	21.9	21.9	22.6	22.8	.	.
	New York, NY (4)	16.1	31.7	34.4	8.0	9.1	19.9	22.9	.	.
	Baltimore, MD (5)	15.8	.	.	20.4	18.4	28.9	30.0	.	.
	Minneapolis, MN (6)	15.9	31.0	28.6	23.8	23.6
	Chicago, IL (7)	17.9	.	.	20.6	22.2	18.7	16.6	36.8	40.1
	Los Angeles, CA (8)	19.3	37.3	37.0	5.4	4.8	10.0	7.7	63.2	59.9
	Age (years) (% distribution)									
	45-54	29.2	30.1	30.4	26.7	29.6	30.6	30.9	26.8	27.1
	55-64	28.4	28.9	27.6	27.7	28.4	28.7	29.4	28.0	28.9
	65-74	29.5	26.8	27.8	31.5	29.0	29.6	29.3	30.2	31.0
	75-84	12.9	14.2	14.1	14.1	12.9	11.1	10.4	15.0	13.0
	Annual Income (dollars) (% distribution)									
	<20,000	21.9	30.8	42.8	6.4	13.4	15.7	23.7	35.2	45.4
	20,000-34,999	20.6	28.2	29.9	11.5	18.5	18.2	25.6	19.9	21.8
	35,000-49,999	16.3	17.0	14.0	16.5	17.8	17.6	19.0	11.5	8.6
	50,000-74,999	17.4	12.6	8.7	21.6	19.0	23.2	18.8	12.8	10.3
	75,000+	23.9	11.4	4.6	44.2	31.3	25.3	13.0	20.6	13.9
	Education (% distribution)									
	<High School	15.6	37.0	44.2	3.6	5.4	10.6	9.4	15.0	29.5
	Completed High School	18.3	19.8	23.9	12.2	20.6	17.9	19.4	12.8	21.5
	Some College/Associate/Trade	28.8	29.8	23.9	24.0	31.4	34.8	36.1	20.3	21.2
	Bachelor's Degree	18.4	7.0	4.9	25.5	20.8	19.4	18.0	29.0	19.2
	Graduate/Professional Degree	18.9	6.5	3.1	34.7	21.9	17.2	17.1	23.1	8.6
	Marital Status (% distribution)									
	Married/Living as Married	61.7	70.4	49.7	76.5	57.6	61.0	35.1	90.7	72.9
	Widowed	12.3	7.0	17.9	4.9	15.4	6.7	24.0	2.5	16.5
Divorced/Separated	16.7	16.3	23.4	9.7	17.0	19.6	27.6	5.0	6.8	
Never Married	8.5	5.3	8.1	8.8	9.2	11.7	11.6	1.9	3.8	
Prefer not to Say	0.8	1.1	1.0	0.2	0.8	1.1	1.7	.	.	
Nativity										
Foreign-Born and in the U.S. <10 Years	3.5	4.9	7.1	0.2	0.3	0.3	0.2	16.5	18.6	
Foreign-Born and in the U.S. 10-19 Years	6.2	8.2	9.4	0.7	0.6	1.5	1.1	30.8	33.6	
Foreign-Born and in the U.S. 20+ Years	19.0	47.3	51.3	3.6	5.2	6.3	5.3	47.7	44.3	
U.S. Born	70.3	39.6	32.2	93.9	92.6	90.0	91.3	5.0	3.5	
Missing	1.2	0.0	0.0	1.6	1.3	1.9	2.2	0.0	0.0	
Neighborhood-Level Characteristics	% African American (mean (s.d.))	25.2 (31.6)	9.5 (14.6)	9.7 (13.9)	15.6 (20.5)	15.2 (19.8)	64.3 (31.4)	61.0 (32.2)	2.2 (5.0)	2.9 (6.4)
	% Hispanic (mean (s.d.))	21.2 (25.9)	47.9 (31.8)	49.9 (30.4)	10.7 (14.3)	12.4 (16.3)	11.9 (18.1)	14.3 (21.2)	24.0 (20.9)	23.0 (20.8)
	% White (mean (s.d.))	42.0 (33.0)	31.1 (31.8)	28.2 (28.6)	65.7 (23.3)	64.1 (23.9)	20.0 (27.3)	20.8 (27.6)	33.4 (28.9)	31.8 (27.8)
	% Asian (mean (s.d.))	9.3 (16.0)	9.0 (13.4)	9.4 (13.3)	5.5 (7.2)	5.9 (7.8)	1.9 (4.9)	2.0 (4.2)	38.3 (23.0)	40.1 (24.3)
	Factor1 Score ((mean (s.d.))	0.21 (1.03)	0.67 (1.13)	0.81 (1.01)	-0.29 (0.77)	-0.24 (0.74)	0.57 (1.02)	0.69 (1.00)	-0.11 (1.00)	0.00 (0.94)
	Factor2 Score (mean (s.d.))	-0.39 (1.27)	0.27 (1.06)	0.31 (1.03)	-1.02 (1.28)	-0.97 (1.31)	0.04 (0.94)	0.08 (0.98)	-0.56 (1.12)	-0.50 (1.09)
	Social Cohesion (mean (s.d.))	3.52 (0.21)	3.45 (0.22)	3.44 (0.21)	3.59 (0.21)	3.57 (0.19)	3.55 (0.22)	3.52 (0.21)	3.46 (0.15)	3.46 (0.15)
	Neighborhood Problems (mean (s.d.))	1.51 (0.22)	1.57 (0.23)	1.58 (0.22)	1.48 (0.19)	1.48 (0.18)	1.57 (0.21)	1.59 (0.21)	1.30 (0.17)	1.32 (0.17)
	Neighborhood Safety (mean (s.d.))	3.61 (0.40)	3.44 (0.34)	3.45 (0.33)	3.77 (0.40)	3.76 (0.39)	3.47 (0.38)	3.45 (0.37)	3.75 (0.34)	3.72 (0.31)
	Aesthetic Quality (mean (s.d.))	3.39 (0.31)	3.30 (0.35)	3.29 (0.33)	3.43 (0.28)	3.42 (0.27)	3.34 (0.31)	3.30 (0.31)	3.65 (0.22)	3.61 (0.22)

Table 5.2. Mean baseline CES-D score (Standard Deviation) by selected demographic characteristics (n=5667)

Individual-Level Characteristic		AFRICAN AMERICAN WOMEN (n=837)	AFRICAN AMERICAN MEN (n=669)	HISPANIC WOMEN (n=608)	HISPANIC MEN (n=571)	WHITE WOMEN (n=1192)	WHITE MEN (n=1130)	CHINESE WOMEN (n=339)	CHINESE MEN (n=321)
OVERALL		8.17 (7.70)	6.04 (5.96)	10.87 (9.65)	7.79 (7.69)	7.65 (7.22)	5.90 (6.07)	7.17 (7.41)	5.07 (5.41)
Study Site	Forsyth County, NC (3)	7.69 (8.10)	5.30 (5.25)	.	.	6.78 (6.69)	5.34 (5.35)	.	.
	New York, NY (4)	9.23 (8.07)	7.66 (6.60)	12.08 (10.05)	8.50 (8.01)	8.79 (8.02)	8.56 (8.95)	.	.
	Baltimore, MD (5)	8.04 (7.18)	6.34 (6.01)	.	.	7.20 (6.82)	5.53 (5.61)	.	.
	Minneapolis, MN (6)	.	.	9.95 (8.25)	8.27 (7.32)	8.52 (7.31)	5.97 (5.54)	.	.
	Chicago, IL (7)	8.22 (7.68)	6.46 (6.29)	.	.	7.44 (7.36)	5.85 (6.28)	9.44 (7.40)	7.32 (5.82)
	Los Angeles, CA (8)	6.84 (7.17)	2.90 (3.70)	10.47 (10.17)	6.78 (7.64)	8.00 (7.87)	5.54 (5.88)	5.65 (7.03)	3.76 (4.69)
	p-value	0.17	<0.01	0.07	0.05	0.04	<0.01	<0.01	<0.01
Age (years)	45-54	9.09 (8.86)	6.64 (6.50)	11.92 (10.09)	8.59 (8.60)	8.25 (8.12)	7.15 (7.32)	8.20 (7.93)	6.17 (6.10)
	55-64	8.19 (7.30)	5.57 (5.73)	10.64 (8.97)	6.90 (6.42)	7.00 (6.73)	5.83 (6.10)	7.41 (8.22)	5.58 (5.57)
	65-74	7.11 (6.36)	6.00 (5.85)	10.61 (9.70)	8.20 (8.51)	7.27 (6.83)	5.22 (5.29)	6.46 (6.53)	4.24 (4.79)
	75-84	8.34 (8.27)	5.74 (5.22)	9.59 (9.77)	7.10 (6.15)	8.58 (6.75)	5.21 (4.53)	6.20 (6.21)	3.83 (4.54)
	p-value, trend	0.03	0.25	0.06	0.33	0.83	<0.01	0.06	<0.01
Annual Income (dollars)	<20,000	10.59 (8.95)	8.41 (8.79)	12.19 (10.68)	8.10 (8.12)	11.52 (8.39)	7.76 (6.50)	7.17 (7.53)	4.67 (4.99)
	20,000-34,999	8.79 (7.76)	7.22 (5.71)	10.44 (8.17)	8.16 (8.13)	8.65 (7.41)	6.66 (4.91)	7.46 (7.57)	4.97 (6.52)
	35,000-49,999	7.62 (7.58)	5.82 (5.30)	9.27 (8.77)	7.18 (6.53)	7.80 (7.29)	6.16 (6.56)	5.07 (5.48)	4.51 (3.78)
	50,000-74,999	5.86 (4.99)	4.93 (4.68)	10.28 (9.43)	8.35 (8.63)	7.45 (6.80)	6.15 (6.25)	8.83 (9.47)	6.71 (6.05)
	75,000+	6.70 (7.21)	4.91 (4.85)	7.46 (9.96)	6.31 (5.56)	5.45 (5.86)	5.23 (5.92)	6.79 (5.85)	5.15 (5.22)
p-value, trend	<0.01	<0.01	<0.01	0.19	<0.01	<0.01	0.99	0.25	
Education	<High School	10.08 (8.35)	7.69 (7.70)	12.14 (10.17)	7.83 (8.05)	11.84 (8.04)	7.71 (6.49)	7.06 (7.67)	6.42 (6.26)
	Completed High School	9.30 (7.95)	6.99 (6.87)	9.19 (7.86)	7.86 (7.60)	8.63 (6.85)	6.35 (5.32)	6.25 (6.63)	5.49 (5.62)
	Some College/Associate/Trade	8.49 (7.92)	6.18 (5.62)	11.24 (10.40)	8.28 (7.79)	7.18 (6.93)	5.33 (5.05)	8.32 (8.63)	4.42 (4.46)
	Bachelor's Degree	7.44 (7.33)	5.02 (4.90)	6.87 (6.67)	7.63 (7.84)	7.35 (7.73)	6.21 (7.23)	7.05 (6.48)	3.83 (4.51)
	Graduate/Professional Degree	5.92 (6.32)	4.91 (5.11)	9.37 (9.57)	5.24 (4.57)	6.68 (6.83)	5.73 (5.96)	7.31 (7.18)	6.11 (6.16)
p-value, trend	<0.01	<0.01	0.02	0.32	<0.01	0.28	0.62	0.41	
Marital Status	Married/Living as Married	7.07 (6.75)	5.62 (5.63)	10.75 (10.25)	7.24 (7.20)	6.55 (6.57)	5.34 (5.71)	6.49 (6.69)	4.99 (5.31)
	Widowed	7.94 (7.56)	7.07 (7.73)	10.72 (9.90)	9.28 (6.91)	9.39 (7.42)	6.85 (5.47)	8.39 (9.25)	4.63 (3.11)
	Divorced/Separated	9.32 (8.20)	6.56 (5.73)	11.20 (8.25)	9.45 (9.80)	8.90 (7.93)	7.47 (7.00)	8.87 (7.38)	6.81 (7.73)
	Never Married	9.21 (9.07)	6.76 (6.60)	11.41 (9.64)	8.13 (7.23)	8.82 (8.02)	8.28 (7.13)	11.92 (9.53)	4.83 (5.74)
	Prefer not to Say	8.43 (6.72)	6.57 (8.46)	8.00 (4.56)	6.83 (7.41)	13.50 (8.20)	18.00 (8.49)	.	.
p-value	0.01	0.24	0.92	0.09	<0.01	<0.01	0.02	0.62	
Nativity	Foreign-Born & in U.S. <10 yrs	4.00 (0.00)	5.50 (7.78)	12.79 (9.39)	6.75 (7.10)	18.00 (14.00)	14.00 (1.41)	6.86 (7.02)	3.58 (4.75)
	Foreign-Born & in U.S. 10-19 yrs	6.67 (3.97)	10.10 (7.23)	12.86 (11.91)	7.32 (6.79)	6.14 (3.63)	6.88 (5.08)	6.57 (7.00)	4.81 (5.28)
	Foreign-Born & in U.S. 20+ yrs	9.09 (7.22)	7.76 (7.52)	11.65 (10.08)	8.44 (8.33)	7.87 (6.54)	6.59 (6.17)	7.41 (7.74)	5.74 (5.72)
	U.S. Born	7.99 (7.63)	5.86 (5.77)	8.63 (7.72)	7.23 (7.11)	7.55 (7.11)	5.86 (6.06)	11.50 (8.35)	5.25 (4.42)
	Missing	n=18	n=13	.	.	n=16	n=18	.	.
p-value	0.63	0.03	<0.01	0.28	0.08	0.23	0.16	0.09	

Figure 5.1. Mean age-adjusted baseline CES-D score by quartiles of percent racial/ethnic group in census tract (n=5667)

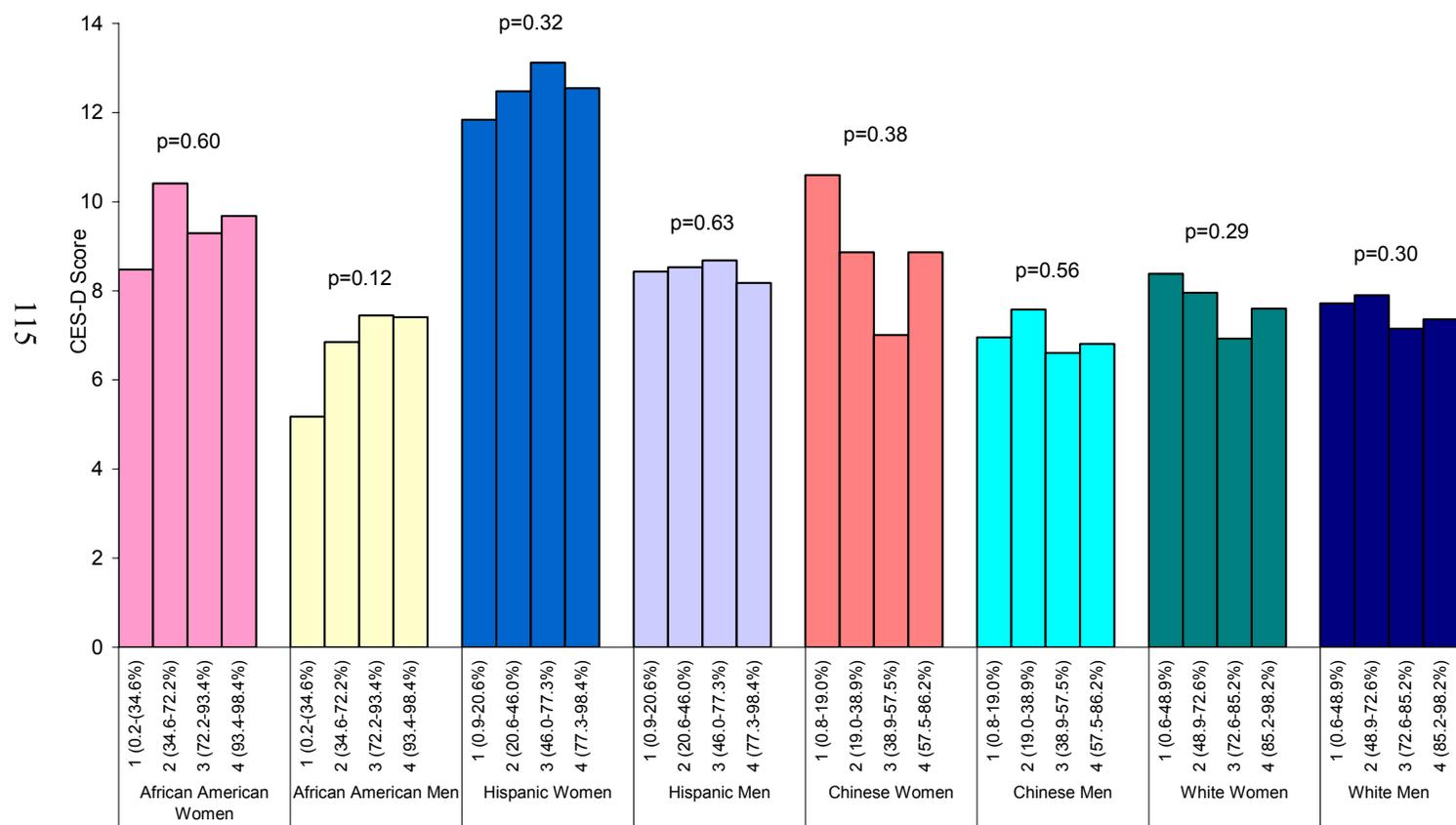


Table 5.3. Bivariate associations between % racial/ethnic composition and other neighborhood variables, for each racial/ethnic group

Neighborhood Variable	% African American	% White	% Hispanic	% Chinese
Factor1 Score	0.65 (0.50, 0.81)*	-1.99 (-2.09, -1.89)*	2.13 (2.01, 2.25)*	1.22 (1.05, 1.38)*
Factor2 Score	1.65 (1.45, 1.84)*	-1.07 (-1.15, -0.98)*	2.70 (2.55, 2.85)*	-0.09 (-0.13, -0.05)*
Social Cohesion	-0.13 (-0.29, 0.03)	0.36 (0.26, 0.46)*	-0.38 (-0.55, -0.21)*	-0.76 (-1.01, -0.52)*
Neighborhood Problems	0.95 (0.80, 1.11)*	-1.04 (-1.15, -0.94)*	0.67 (0.50, 0.83)*	0.25 (0.02, 0.49)*
Neighborhood Safety	-1.46 (-1.62, -1.30)*	1.44 (1.36, 1.52)*	-2.07 (-2.24, -1.89)*	-1.03 (-1.23, -0.82)*
Aesthetic Quality	-0.63 (-0.79, -0.47)*	0.82 (0.72, 0.93)*	-0.50 (-0.66, -0.34)*	-0.44 (-0.70, -0.19)*

* p<0.05

Table 5.4. Adjusted mean differences in Center for Epidemiologic Studies-Depression (CES-D) score associated with 10% increase in people of the same racial/ethnic group in subjects' census tracts, by race/ethnicity and gender

Adjustment Variables**	Mean difference (s.d.) per 10% increase in same racial/ethnic group, WOMEN	Mean difference (s.d.) per 10% increase in same racial/ethnic group, MEN
Hispanics		
Individual-level variables [^]	-0.10 (-0.36, 0.17)	-0.16 (-0.40, 0.08)
+ Aesthetic Environment 1 mile	-0.16 (-0.43, 0.11)	-0.15 (-0.38, 0.09)
+ Social Cohesion 1 mile	-0.15 (-0.42, 0.12)	-0.12 (-0.36, 0.12)
+ Neighborhood Problems 1 mile	-0.17 (-0.44, 0.10)	-0.15 (-0.38, 0.09)
+ Neighborhood Safety 1 mile	-0.25 (-0.57, 0.07)	-0.25 (-0.52, 0.02)
+ Factor1 Score	-0.39 (-0.75, -0.04)*	-0.31 (-0.61, -0.00)*
+ Factor2 Score	-0.01 (-0.41, 0.38)	-0.33 (-0.65, -0.01)*
+ ALL neighborhood variables	-0.21 (-0.65, 0.24)	-0.25 (-0.61, 0.12)
African Americans		
Individual-level variables	0.00 (-0.17, 0.17)	0.26 (0.12, 0.41)*
Aesthetic Environment 1 mile	-0.05 (-0.22, 0.12)	0.23 (0.08, 0.37)*
Social Cohesion 1 mile	-0.01 (-0.17, 0.16)	0.26 (0.11, 0.40)*
Neighborhood Problems 1 mile	-0.06 (-0.24, 0.12)	0.24 (0.09, 0.38)*
Neighborhood Safety 1 mile	-0.14 (-0.32, 0.05)	0.26 (0.10, 0.42)*
Factor1 Score	-0.04 (-0.22, 0.13)	0.26 (0.11, 0.40)*
Factor2 Score	-0.06 (-0.24, 0.12)	0.28 (0.12, 0.44)*
ALL neighborhood variables	-0.05 (-0.27, 0.16)	0.31 (0.13, 0.48)*
Whites		
Individual-level variables	-0.04 (-0.21, 0.13)	-0.07 (-0.22, 0.08)
Aesthetic Environment 1 mile	0.01 (-0.17, 0.19)	0.07 (-0.10, 0.24)
Social Cohesion 1 mile	0.01 (-0.16, 0.18)	-0.03 (-0.18, 0.13)
Neighborhood Problems 1 mile	-0.01 (-0.19, 0.18)	0.05 (-0.12, 0.22)
Neighborhood Safety 1 mile	0.01 (-0.21, 0.22)	0.06 (-0.13, 0.25)
Factor1 Score	0.01 (-0.20, 0.22)	0.11 (-0.08, 0.30)
Factor2 Score	-0.21 (-0.40, -0.02)*	-0.16 (-0.33, 0.01)
ALL neighborhood variables	-0.08 (-0.33, 0.16)	0.02 (-0.20, 0.23)
Chinese		
Individual-level variables	-0.35 (-0.76, 0.06)	-0.04 (-0.34, 0.26)
Aesthetic Environment 1 mile	-0.30 (-0.69, 0.08)	-0.05 (-0.34, 0.24)
Social Cohesion 1 mile	-0.33 (-0.75, 0.10)	-0.08 (-0.38, 0.23)
Neighborhood Problems 1 mile	-0.28 (-0.67, 0.11)	-0.03 (-0.34, 0.27)
Neighborhood Safety 1 mile	-0.31 (-0.74, 0.12)	-0.01 (-0.32, 0.30)
Factor1 Score	-0.31 (-0.75, 0.13)	0.04 (-0.29, 0.36)
Factor2 Score	-0.29 (-0.71, 0.12)	-0.01 (-0.32, 0.30)
ALL neighborhood variables	-0.14 (-0.56, 0.28)	0.03 (-0.28, 0.33)

* p<0.05

[^]All models adjusted for individual-level age, income, education, and neighborhood % same racial/ethnic group, in addition to other (listed) neighborhood factors; Hispanic and Chinese models additionally adjusted for nativity

**All neighborhood factors are in units of z-scores

Table 5.5. Results from propensity score matching**

Group	n (max pairs)	# of Matched Pairs	Mean (95% CI)	p-value
Hispanic Women	658 (219)	128	-0.64 (-3.05, 1.77)	0.60
Hispanic Men	618 (200)	87	0.69 (-1.71, 3.09)	0.57
African American Women	837 (277)	230	-0.49 (-1.92, 0.93)	0.50
African American Men	669 (223)	174	2.00 (0.77, 3.23)	<0.01*
White Women	1192 (404)	286	-0.61 (-1.73, 0.52)	0.29
White Men	1130 (377)	265	-0.33 (-1.29, 0.64)	0.51
Chinese Women	356 (117)	57	-1.11 (-4.20, 1.99)	0.48
Chinese Men	348 (115)	61	-0.92 (-2.64, 0.80)	0.29

** Caliper=0.2; individuals matched on acculturation, education, income, age, marital status

* p<0.05

Chapter 6: Conclusions and Future Directions

Summary of findings from Chapters 3-5

Chapter 3 concluded that neighborhood social cohesion, aesthetic quality and violence were cross-sectionally associated with the presence of depressive symptoms in MESA study participants. Lower levels of social cohesion and aesthetic quality and higher levels of violence were associated with higher mean CES-D score in men and women (p-value for trend <0.01, adjusted mean difference in CES-D per 1 SD increase in summary score -1.01 (95% CI: -1.85, -0.17) and -1.08 (-1.88, -0.28) in men and women respectively). Associations of neighborhood characteristics with incident depression were in the expected direction for women but confidence intervals were wide (OR of incident depression 0.89 (0.63, 1.26)). No association was seen for men (OR=0.96 (0.74, 1.25)).

The main finding of Chapter 4 was that neighborhood stressors and social support were cross-sectionally associated with depressive symptoms in the CCAHS. After controlling for individual-level covariates, the majority of social support variables (social cohesion, reciprocal exchange, family structure and residential stability) were associated with decreased depressive symptoms in women, while only one neighborhood stressor (perceived violence) was associated with increased depressive symptoms. Amongst men, a larger number of neighborhood stressors (perceived violence, perceived disorder) were associated with increased levels of depressive symptoms than social support variables (family structure) were associated with lower depressive symptoms, after controlling for

individual-level factors. Controlling simultaneously for one neighborhood stressor and one neighborhood social support variable slightly decreased the strength of some associations, but did not qualitatively change the results from analyses controlling for one variable at a time. These results also did not change after controlling for measures of neighborhood socioeconomic status. Associations between perceived violence and disorder and depressive symptoms were stronger for individual's self-reported measures than for the measures aggregated to neighborhood clusters.

In answer to the hypotheses in Chapter 5, living in a neighborhood with a higher percentage of residents of the same racial/ethnic background was associated with increased levels of depressive symptoms amongst African American men (mean difference in CES-D score per 10% increase in African Americans in census tract 0.26 (0.12, 0.41)) and decreased CES-D scores amongst Hispanic men and women and Chinese women, although the decreases were not statistically significant at the $p < 0.05$ level. Adjusting for other neighborhood characteristics such as social cohesion, the aesthetic environment, neighborhood safety and the socioeconomic environment strengthened the protective associations amongst Hispanics (mean difference in CES-D score per 10% increase in Hispanics in census tract after adjustment for neighborhood SES -0.39(-0.75, -0.04) (women) and -0.31(-0.61, 0.00) (men)), but did not explain the association in African American men, which remained robust.

The findings from these three studies corroborate the hypothesis that neighborhood environments do, indeed, influence depressive symptoms. Results were similar in Chapters 3 and 4, which both found that increased levels of neighborhood stressors and decreased levels of social support were associated with higher CES-D

scores. While Chapter 3 used a summary score that combined three neighborhood conditions (two stressors and social cohesion), Chapter 4 first examined each variable one at a time before using multiple neighborhood variables in models. This allowed for a more nuanced examination of which neighborhood environmental condition(s) had the most significant associations with depressive symptoms, which let me see the differences between genders. The neighborhood variables in Chapter 3 were highly correlated, making it difficult to examine them simultaneously without creating some sort of summary score. A particular strength of Chapter 3 compared with Chapter 4 was that neighborhood conditions were measured on a group of individuals who were not MESA study participants, eliminating the possibility of same-source bias. While each chapter had its own strengths and weaknesses, the fact that results were qualitatively similar in these two analyses makes me more confident in the results of each individual study.

The results from Chapter 5, particularly for African American men, are more difficult to interpret than those from Chapters 3 and 4. While the additional neighborhood variables controlled for in this chapter were found to be associated with depressive symptoms in Chapter 3, they did not explain the association between percent African American in census tracts and increased depressive symptoms in African American men. It is possible that this association was due to other unmeasured neighborhood characteristics, such as the collective reinforcement of discrimination or residential stability and job opportunities within a neighborhood. The protective associations between depressive symptoms and increased racial/ethnic concentration in Hispanic men and women and Chinese women may be due in part to informal, unquantified social support mechanisms that can help lessen feelings of depression. It may be that the type of

neighborhood support theorized by the ethnic density hypothesis to be protective of depressive symptoms was not fully captured by a measure of social cohesion, as the protective associations remained when adjusting for this variable. Some of the other social support variables used in Chapter 5 may have explained some part of these associations. The results for Hispanics are a nice illustration of how positive and negative neighborhood environments can simultaneously affect depressive symptoms. Hispanics tended to live in neighborhoods with low levels of affluence and high levels of disadvantage. After adjusting for neighborhood socioeconomic status, the positive effect of living near a greater proportion of Hispanics became almost three times as strong. Clearly, the negative effect of living in a disadvantaged neighborhood was masking the strength of the benefit derived from living near a greater percentage of Hispanics.

While the strength of associations between neighborhood environments and depressive symptoms in all three chapters may appear small, the relative magnitude of these associations is similar to those between well-established individual-level risk factors (such as education, age, and income) and depressive symptoms. In the MESA study, individuals earning less than \$20,000 a year had CES-D scores 2.24 (men) and 4.94 (women) higher than those earning more than \$75,000/year and those with less than a high school education had CES-D scores 0.57 (men) and 2.58 (women) higher than those with a graduate/professional degree in models simultaneously adjusting for individual- and neighborhood-level characteristics. In comparison, a one standard deviation increase in depressive symptoms was associated with a 1.01 (men) and 1.08 (women) decrease in depressive symptoms. Similar results were seen in the CCAHS in models adjusting for individual-level covariates: individuals earning \$5,000-9,999

annually had scores 0.18 (men) and 0.26 (women) higher than those earning more than \$50,000, while those with less than 12 years of education had scores 0.07(men) and 0.20 (women) higher than those with 16+ years. The associations with 1 standard deviation change in neighborhood-level variables ranged from 0.01 to 0.10 when adjusting for individual-level variables. It seems, therefore, that neighborhood-level risk factors for increased depressive symptoms should be considered equally with individual-level ones when thinking about ways to decrease depressive symptoms in populations.

Study Limitations

Limitations of cross-sectional data

All analyses, with the exception of the longitudinal portion of Chapter 3, were cross-sectional. This can be a problem when drawing conclusions about causality between depression and neighborhood characteristics. Cross-sectional data only gives a snapshot of associations at one point in time, and limits our ability to understand causal relationships. It may be that people who are depressed tend to stay in neighborhoods with negative characteristics, while those with better mental health are more likely to move out of such areas. I was unable to determine whether or not this was the case without using longitudinal data. Cross-sectional data also limited my ability to test the time lag between neighborhood conditions and onset of depressive symptoms. The issues of reverse causality and duration of exposure can only be assessed using longitudinal data.

Time lags

These analyses did not differentiate between the onset, maintenance, and length of depressive symptoms. I was therefore unable to determine whether neighborhood context

is linked to first episode of depression, or tends to exert more influence on people who have already experienced depressive symptoms in the past. Exposure to negative environments may have the greatest effect on future risk of depression at early stages of life; past neighborhood conditions could therefore be more relevant than current ones (or those in the recent past). The available data did not allow for an examination of whether there was a time lag between neighborhood conditions and depressive symptoms, and if so, how long that lag is.

Residual confounding by individual-level variables

Statistical inference in an observational study is dependent on the exchangeability of exposed and unexposed subjects. People may be selected into particular neighborhoods based on characteristics that could also be related to depressive symptoms. It was important to have subjects with similar individual-level characteristics in neighborhoods with both high and low-quality characteristics in these studies. If all Hispanic subjects, for example, lived in neighborhoods with high levels of social cohesion, I would have been extrapolating data for this group for neighborhoods with low social cohesion to regions with little or no data. This can potentially lead to biased estimates.(31) I examined this problem in Chapter 5 by using propensity score matching to ensure that subjects living in neighborhoods with low and high racial/ethnic concentrations had similar individual-level covariate characteristics. Over half of all MESA participants were matched in this manner.

Lack of power to detect interactions

It is quite possible that the effect of neighborhood conditions varies by individual-level characteristics, such as education and income. For example, a violent neighborhood

can take a greater toll on poor residents who feel they lack the resources to leave that particular living environment. It is also possible that neighborhood conditions work together to influence depressive symptoms. For example, a greater % of African Americans in a census tract may only increase levels of depression in socioeconomically disadvantaged neighborhoods. There may even be three-way interactions: wealthy people in poor neighborhoods with a greater % of African Americans could have the highest levels of depressive symptoms, for example. While the sample size of each analysis was relatively large, after stratifying by gender (and further by race/ethnicity in Chapter 5) the data might not have had the power to detect statistically significant interactions, even if they truly existed.

Generalizability and selection bias

People who have high levels of depressive symptoms may be less likely than those with lower levels to participate in health-related studies. This would mean that the MESA and CCAHS study populations were not representative of the larger populations they attempted to capture. If people with high levels of depressive symptoms tended to not participate in MESA and the CCAHS, and if persons with depressive symptoms who did not participate were also more likely to live in certain types of neighborhoods, this self-selection bias may have attenuated associations in these studies. While both MESA and the CCAHS tried to include diverse samples of people in their studies, the associations in these two data sets could not be generalizable to all populations. For example, the majority of locations in these studies are in urban environments. Factors such as social cohesion and physical decay may operate over different spatial scales or with different strengths in rural and urban areas.

Relevant spatial scale

The definition of the relevant neighborhood size most likely to influence patterns of depressive symptoms is an important consideration, since previously published studies that defined neighborhood at smaller geographical scales tended to find a stronger association between neighborhood characteristics and risk of depression than those that used larger areas.(54) If smaller geographic areas would have had a stronger association with depressive symptoms, it could be that the mechanisms that create these associations operate over small geographic areas than those used in this dissertation. I looked at null models at both the block group and neighborhood cluster scale in the CCAHS, and found that correlations between participants in the same block group were stronger than those in the same neighborhood cluster. Unfortunately, analyses with neighborhood variables could not be run at the block group level, as there were very few study participants in each block group. It would be interesting to conduct analyses at a smaller spatial scale in order to compare the strength of associations.

Measuring depressive symptoms and depression

Depressive symptoms are an important health outcome above and beyond their use as an approximation of and screening tool for clinical depression. As depressive symptoms are much more common than clinical depression, the population attributable risk of self-reported physical and emotional health and time lost from work for depressive symptoms is greater than that for major depression.(112) Minor depression, often defined as depressive symptoms without negative affect, is believed to play a unique and important role in the spectrum of depressive illnesses. While there is some overlap between people with minor and major (clinical) depression, fewer than half of all people

with minor depression have had prior major depression (or will experience it in the future).(113, 114) Depressive symptoms are therefore interesting by themselves as a public health problem.

There is a fair amount of natural variation in levels of depressive symptoms within subjects. Depressive symptoms vary over time, and are sometimes associated with the seasons of the year. Not all measurements were taken at the same time, and follow-up measures in MESA were also not taken at the same time of year as the baseline measures. The measure of change in depressive symptoms used in Chapter 3 could have been confounded by the time of year each measurement was taken. There may be measurement error in the measures of depressive symptoms, and the level of measurement error may vary between studies. MESA and the CCAHS used different scales to measure depressive symptoms, although one is an abbreviated version of the other. They may not be directly comparable with one another or with other studies that used different scales to measure depressive symptoms. Both of these studies used measures of depressive symptoms, a condition separate from clinical depression. The literature in this field has looked at both depressive symptoms and depression. Neighborhood features that increase feelings of depression may not be associated with clinical depression, and visa versa. The CCAHS has a measure of clinical depression, and future analyses may compare the associations between neighborhoods and depression vs. depressive symptoms.

Measuring neighborhood properties

The scales used to measure neighborhood conditions do not perfectly represent the physical and social characteristics they are meant to capture. While similar scales have been used in other studies, there are slight differences between scales used in MESA

and CCAHS, and the scales do not have perfect reliability and internal consistency. The measures from the neighborhood survey in the CCAHS measure one's perceived neighborhood. Using self-report for both neighborhood conditions and depressive symptoms can cause same-source bias, which could bias the associations away from the null. There are likely other variables left out of these analyses, such as other types of neighborhood stressors and social relationships, which, if we knew better (or had available data), could explain away some of the residual confounding or help explain the associations this dissertation sought to elucidate. Additionally, some of the neighborhood characteristics may not operate in a linear fashion. For example, living in a neighborhood with a greater % of people of the same racial/ethnic background could exhibit a threshold effect, where the protective effect of social networks does not kick in until the majority of the neighborhood is of the same race/ethnicity. There was some evidence of this type of relationship for Hispanic women, but the difference in slopes using a knot at 50% Hispanic concentration was not statistically significant.

Public Health and Policy/Research Implications

The neighborhood environment, both physical and social, is associated with depressive symptoms. The findings in the three chapters of this dissertation consistently illustrate that neighborhood stressors and social support are associated with residents' levels of depressive symptoms. It is clear, however, that the effect of where you live on your mental health is incredibly complex and can work in multiple directions. Certain genders and racial/ethnic groups appear to be more susceptible to both the negative and

positive elements of neighborhood environments. A number of interesting research questions and public health implications arise from the results presented in these studies.

Chapter 5 seemed to confirm the ethnic density hypothesis for recent immigrant populations. Hispanic and, to a lesser extent, Chinese residents' levels of depressive symptoms decreased when they lived in neighborhoods with a greater concentration of Hispanics and Asians, respectively. It remains unclear exactly why living in these neighborhoods, which are more likely to be socioeconomically disadvantaged and with higher levels of violence and physical disorder, lowers levels of depressive symptoms in these populations. The supportive atmosphere of these residential environments was not captured in full by any of the neighborhood variables used in analyses. It will be interesting to see if, over time, the protective effects remain in communities where residents have been living in the United States for several generations.

One important enhancement to the work done in this dissertation would be to have a study with the power to detect cross-level interactions, as I rather strongly believe that these probably play a key role in the overall associations between neighborhoods and depressive symptoms. An investigation of whether two or more neighborhood conditions interact to create negative neighborhood environments would let us see whether there are certain populations who are particularly vulnerable to depression based on their neighborhood. It may be that neighborhood conditions cluster together, and that areas with high levels of two, or three, or four types of stressors are the ones that place their residents at the greatest risk of depression and depressive symptoms. There may also be important interactions between neighborhood stressors and social support variables. Social support may independently affect depressive symptoms or it may work only as a

buffer against stressful neighborhood environments. Individual-level emotional support may interact with neighborhood stressors and support variables, placing individuals with low support at the greatest risk and/or those with high support at the lowest risk for depression and depressive symptoms.

There is a need for longitudinal studies and natural experiments, both of which would better indicated whether the associations between depressive symptoms and neighborhood environments are causal. Longitudinal studies are necessary to rule out reverse causation and to investigate time lags and cumulative effects of neighborhoods on depression. Natural experiments or quasi-experimental designs provide opportunities to examine causal effects of neighborhood or area attributes on depression while avoiding some of the pitfalls of observational studies. For example, a study could examine changes in depressive symptoms over time in a neighborhood in response to some source of exogenous variation such as the inauguration of a new public space or the implementation of a new community policing approach. These interventions, which are “naturally occurring” in neighborhoods all the time, provide valuable but as yet untapped opportunities to investigate area or neighborhood effects on depression.

It may be useful to try incorporating biological markers of stress into this line of research. This would let us test whether those people most affected by stressors in their neighborhood environment (with the strongest associations between increasing levels of depressive symptoms and neighborhood stressors) show the biological effects of these stressful environments. Knowing what biological effect neighborhood stressors have on the body, and if these are in turn linked to depressive symptoms, would strengthen the causal argument that neighborhood environments contribute to depression.

It seems possible to change the neighborhood environment in order to help reduce residents' levels of depressive symptoms. The gender differences observed in each of these studies illustrate that women seem to be helped more by social circumstances, while men are more susceptible to negative neighborhood environments. While this may be linked to the fact that men tend to be more involved in the disorder and violence in their neighborhoods, while women rely more on social connections, there is nothing to say that men could not benefit from social support in the way that many women seem to. Thinking of ways to help men cope with stressful environments, either in similar or different ways than women, may be a concrete, positive step towards reducing the burden of depressive symptoms.

Many of the neighborhood stressors and social support mechanisms investigated in this dissertation are linked not only to depressive symptoms but also to CVD and other chronic diseases. In turn, depression and these chronic conditions can work in synergy to create a larger health burden than they would alone. Considering treatments for depression separate from thinking of ways to improve other health outcomes through the neighborhood environment may be incorrect, and a broader approach may be more warranted.

Despite the limitations inherent in using observational studies to ask causal questions, the studies in this dissertation illustrate the importance of considering risk factors beyond the traditional individual-level ones for depression and depressive symptoms. The growing worldwide burden of depression and mental illness cannot solely be taken care of by medications and individualized therapies. One of the goals of public

health is to intervene on populations; focusing on the impact of risk factors at the neighborhood level widens the potential impact of mental health interventions.

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