

**Traumatic events, neighborhood conditions, and changes in depression severity
among adult Detroit residents**

by

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Dedication

To Joe, Lucia, and Cecilia

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Table of Contents

Dedication	ii
Acknowledgements	iii
List of Figures.....	v
List of Tables	vii
List of Abbreviations	ix
Abstract.....	x
Chapter 1: Introduction	1
Background.....	1
Specific aims and hypotheses	9
Chapter 2: Exposure to traumatic events and changes in depression severity: Results from a prospective cohort study in an urban area	14
Background.....	14
Methods.....	19
Results.....	29
Discussion	33
Chapter 3: Lifetime traumatic events, stress sensitization, and changes in depression severity in the Detroit Neighborhood Health Study	54
Background.....	54
Methods.....	58
Results.....	69
Discussion.....	72
Chapter 4: Do neighborhood conditions and traumatic events work together to increase depression severity? Evidence from the Detroit Neighborhood Health Study.....	93
Background	93
Methods.....	95
Results.....	110
Discussion.....	112
Chapter 5: Conclusions and future directions	130
Summary of findings.....	131
Study limitations	134
Public health implications.....	139
Future research directions.....	141
References	144

List of Figures

Figure 1.1 Relations of interest in each study aim using data from the Detroit Neighborhood Health Study and Detroit neighborhoods.....	13
Figure 2.1 Ratio of mean past month depression severity at Wave 2 among those with each type of traumatic event compared to those with no traumatic events between Waves 1 and 2, by depression severity (PHQ-9 score) at Wave 1	52
Figure 2.2 Ratio of mean past month depression severity at Wave 2 among those with greater numbers of traumatic events compared to those with no traumatic events between Waves 1 and 2, by depression severity (PHQ-9 score) at Wave 1	53
Figure 3.1 Slope of the relation between the number of traumatic events between Waves 1 and 2 and the log of the past month PHQ-9 score at Wave 2, by the total number of prior lifetime traumatic events	87
Figure 3.2 Slope of the relation between the number of traumatic events between Waves 1 and 2 and the log of the past month PHQ-9 score at Wave 2, by the number of childhood abuse events	88
Figure 3.3 Slope of the relation between the number of traumatic events between Waves 1 and 2 and the log of the past month PHQ-9 score at Wave 2, by the number of prior assaultive violence events	89
Figure 3.4 Slope of the relation between the number of traumatic events between Waves 1 and 2 and the log of the past month PHQ-9 score at Wave 2, by the number of prior injuries or shocking experiences	90
Figure 3.5 Slope of the relation between the number of traumatic events between Waves 1 and 2 and the log of the past month PHQ-9 score at Wave 2, by the number of prior learning of traumatic events to others	91
Figure 3.6 Slope of the relation between the number of traumatic events between Waves 1 and 2 and the log of the past month PHQ-9 score at Wave 2, by the prior history of sudden, unexpected death of a loved one.....	92
Figure 4.1 Ratio of mean past month depression severity at Wave 2 among those with each type of traumatic event compared to those with no traumatic events between Waves 1 and 2, by neighborhood disadvantage at Wave 1	127
Figure 4.2 Ratio of mean past month depression severity at Wave 2 among those with each type of traumatic event compared to those with no traumatic events between Waves 1 and 2, by neighborhood homicide rate at Wave 1	128

Figure 4.3 Ratio of mean past month depression severity at Wave 2 among those with each type of traumatic event compared to those with no traumatic events between Waves 1 and 2, by neighborhood social cohesion at Wave 1 129

List of Tables

Table 2.1 Characteristics of the study population at Wave 1, Detroit Neighborhood Health Study.....	43
Table 2.2 Percentage reporting traumatic events between Waves 1 and 2, Detroit Neighborhood Health Study (n = 1,054 included in both waves)	45
Table 2.3 Bivariable associations between demographics, socioeconomic status, lifetime traumatic events and stressors, and social support at Wave 1 and traumatic events between Waves 1 and 2 (n = 1,054).....	46
Table 2.4 Estimated ratio of average past month PHQ-9 score at Wave 2, comparing covariate levels (Mean Ratio and 95% CI), by choice of traumatic event measure and covariates: Results of negative binomial regression analyses (n = 1,054)	48
Table 2.5 Results of adjusted Wald F tests for statistical interactions between potential effect measure modifiers and traumatic event exposure between Waves 1 and 2, from adjusted negative binomial regression analyses of past month PHQ-9 score at Wave 2 (n = 1,054).....	51
Table 3.1 Demographic characteristics, socioeconomic status, and lifetime psychopathology, Detroit Neighborhood Health Study (n = 1,054 included in both Waves 1 and 2)	80
Table 3.2 Percentage reporting traumatic events in their lifetime prior to Wave 1 and between Waves 1 and 2 (n = 1,054).....	81
Table 3.3 Spearman rank correlations and descriptive statistics for measures of lifetime traumatic events prior to Wave 1 and recent traumatic events between Waves 1 and 2 (n = 1,054)	82
Table 3.4 Mean number of each type of lifetime traumatic event prior to Wave 1 by demographic characteristics, socioeconomic status, and lifetime psychopathology (n = 1,054)	83
Table 3.5 Estimated ratio of average past month PHQ-9 score at Wave 2, comparing covariate levels (Mean Ratio and 95% CI): Results of negative binomial regression analyses (n = 1,054).....	85
Table 4.1 Descriptive statistics for Detroit Neighborhood Health Study participants who had been living in their current neighborhood for at least one year at baseline (n = 1,037).....	120
Table 4.2 Descriptive statistics for neighborhood conditions in the city of Detroit (n = 54 Master Planning neighborhoods)	121

Table 4.3 Pearson correlation coefficients for neighborhood conditions in the city of Detroit (n = 54 Master Planning neighborhoods)	122
Table 4.4 Bivariable associations between neighborhood conditions, exposure to traumatic events between Waves 1 and 2, and depression severity (PHQ-9 score) at Waves 1 and 2 (n = 1,037).....	123
Table 4.5 Estimated odds ratio or incidence rate ratio for traumatic event exposure, per one standard deviation increase in each neighborhood condition: Results of multilevel logistic and negative binomial regression models predicting exposure to traumatic events between Waves 1 and 2 (n = 1,037).....	125
Table 4.6 Estimated ratio of average past month PHQ-9 score at Wave 2, per one standard deviation increase in each neighborhood condition: Results of negative binomial regression analyses (n = 1,037).....	126

List of Abbreviations

ACS	American Community Survey
CI	Confidence interval
DNHS	Detroit Neighborhood Health Study
GAD	Generalized anxiety disorder
ICC	Intraclass correlation coefficient
NWS	National Women's Study
PCL-C	PTSD Checklist-Civilian version
PHQ-9	Patient Health Questionnaire-9
PTSD	Posttraumatic stress disorder
SD	Standard deviation
SE	Standard error
SES	Socioeconomic status
SRRS	Social Readjustment Rating Scale

Abstract

Depression is a leading cause of disability in the U.S., affecting 2-9% of the adult population each year. Although numerous studies have examined the social origins of depression, questions remain about the influence of traumatic events and neighborhood conditions on depressive symptoms. This dissertation uses data from the Detroit Neighborhood Health Study (DNHS) to examine (1) the effects of different types of recent traumatic events on changes in depression severity over a one-year period and whether individual characteristics like initial depression severity influence these relations; (2) the effects of prior traumatic events including childhood abuse on changes in current depression severity and responses to subsequent traumatic events; and (3) the effects of neighborhood disadvantage, crime, physical disorder, and social cohesion on exposure to traumatic events and changes in depression severity.

The first analysis found higher increases in depression severity among those exposed to assaultive violence and other injuries and shocking experiences during follow-up, as well as those experiencing multiple traumatic events; associations were stronger among individuals with lower depression severity at baseline. The second analysis found positive associations between the number of lifetime traumatic events prior to baseline (especially childhood abuse events) and depression severity at follow-up, adjusting for baseline depression severity, traumatic event exposure during follow-up, and other

potential confounders including prior psychopathology. Evidence for a stress sensitization effect was also found, such that individuals with a history of childhood abuse, prior assaultive violence, and greater total number of prior traumatic events exhibited greater depression severity than participants without such adverse histories when exposed to low numbers of recent traumatic events. The third analysis found only minimal associations between neighborhood conditions and traumatic event exposure. However, living in socioeconomically disadvantaged and less cohesive neighborhoods was positively associated with depression severity at follow-up, and modified relations between trauma exposure and depression severity. These findings confirm the influence of traumatic events and neighborhood conditions on depression severity and highlight the importance of considering the context in which traumatic events occur (including the individual's prior history of depression, traumatic event exposure, and neighborhood environment) when assessing need for intervention after trauma exposure.

Chapter 1

Introduction

Depression is a leading cause of disability in the U.S., affecting 2-9% of the adult population each year (1-4). Although numerous studies have examined the social origins of depression, questions remain about the influence of traumatic events and neighborhood conditions on depressive symptoms. This dissertation uses data from the Detroit Neighborhood Health Study (DNHS) to examine the influence of recent and prior traumatic events on changes in depression severity over a one-year follow-up period, to assess potential modifiers of these effects, and to consider the role of different neighborhood conditions in traumatic event exposure and depression severity.

Background

Burden of depression

Depression is a significant mental health problem worldwide, accounting for over 12% of total years lived with disability (5) and ranking as the leading cause of disability in the Americas (5, 6). Depression affects a substantial proportion of the U.S. population, with estimates of the lifetime prevalence of major depression ranging from 3.0% to 16.2% and past-year prevalence estimates ranging from 1.7% to 8.6% in U.S. samples over the last three decades (1-4). Depression can be quite debilitating, often resulting in

impaired functioning in social, relationship, household, and work roles, as well as poor physical health and increased mortality (2, 4, 7-10).

A large body of work has enumerated the individual-level risk factors for depression, including demographic characteristics (e.g., female gender, White race, being widowed, divorced, or separated), socioeconomic status (e.g., unemployment, lower education and income), health status, and family history of depression (4, 9, 11, 12). In addition, much research, especially since the 1960s, has focused on the social origins of depression. This work has included more intensive study of the influence of social factors including financial hardship and the quality of social relationships on the onset of depression, as well as the study of “stressful life events” (13-18) and, more recently, neighborhood characteristics (19, 20).

Stressful life events and depression

Assessment of stressful life events was the subject of a great deal of study in the 1960s and 1970s. Checklists, like Holmes and Rahe’s Social Readjustment Rating Scale (SRRS) (21), were introduced and widely critiqued for their inclusion of both positive (e.g., marriage) and negative (e.g., death of spouse) events as well as items that could be early symptoms of depression (e.g., sleeping problems), and for their failure to include major stressful events (e.g., rape) (22). In their seminal work on the social origins of depression, Brown and Harris (14) introduced a method of contextual threat assessment, by which narrative accounts of each life event are collected and rated by an independent team to develop an “objective” threat rating reflecting the impact the event would have for a “typical person” under the same circumstances (23). Dohrenwend and colleagues

used a similar method to collect information on the circumstances of life events to identify a smaller subset of “fateful loss” events that were “outside the control of the person and that cause[d] significant negative disruption in the person’s life” (e.g., miscarriage or stillbirth, death of family member) (18) (p. 461). Other efforts to distinguish between life events that were “independent” or “dependent” on an individual’s behaviors (including depressive symptoms) followed, with evidence of relations between independent life events and onset of depression (17).

By the end of the 20th century, research on stressful life events had largely evolved from a series of methodologically inferior studies offering inconsistent evidence for the influence of stressful life events on depression (22, 24-27) to generally well-accepted findings that independent, undesirable life events have a causal role in the onset and recurrence of depression (17, 18, 28). The importance of focusing on more severe life events characterized by independence from an individual’s behaviors and depressive symptoms also prompted interest in the study specifically of traumatic events as risk factors for depression, as such events could serve as “natural experiments” in which exposure to the event is randomly distributed in the population (e.g., natural disasters) (22, 28).

Traumatic events and depression

Traumatic events are extreme occurrences that are “outside the range of usual human experience” (29), including “violent encounters with nature, technology, or humankind” (p. 409) (30). The American Psychiatric Association currently defines exposure to a traumatic event as “direct personal experience of an event that involves

actual or threatened death or serious injury, or other threat to one's physical integrity; or witnessing an event that involves death, injury, or a threat to the physical integrity of another person; or learning about unexpected or violent death, serious harm, or threat of death or injury experienced by a family member or close associate" (31). Thus, traumatic events encompass a range of experiences from sexual assault to natural disasters, from witnessing a car accident to learning of a close friend's serious injury in a car accident, and are distinguished from other types of stressful experiences, like divorce and job loss, by threatened death or physical injury to self or others.

Of course, such events are not actually "randomly distributed" in the population, with numerous studies demonstrating that individuals of lower socioeconomic status, prior history of mental health problems, and prior history of childhood abuse or other traumatic experiences are more vulnerable to experiencing traumatic events (25, 32-35). Nevertheless, the severe nature of traumatic experiences may prompt depressive reactions, in addition to the re-experiencing, avoidance, and arousal symptoms that characterize acute stress and posttraumatic stress disorders (36). In particular, the unpredictable and uncontrollable nature of traumatic events may lead to feelings of fear and loss of control and the corresponding feelings of helplessness and hopelessness that often mark the descent into depression (36-38).

Although numerous studies have found evidence of high levels of depression resulting from specific traumatic events, including childhood physical and sexual abuse (39), natural and manmade disasters (40-43), and exposure to combat and ongoing terrorism (44-47), most studies of traumatic events and depression suffer from a major limitation: because of the unpredictable nature of traumatic events, data collection begins

after traumatic event exposure, with no pre-trauma measures of depression available. Since individuals with a history of mental health problems may be more vulnerable to experiencing traumatic events (17, 25, 33, 48), pre-existing psychological symptoms may at least partly explain observed higher levels of depression prevalence and severity among those exposed to traumatic events (49). The lack of longitudinal studies of specific traumatic event exposures and changes in depressive symptoms also signals a lack of information on the relative effects of different types of traumatic events (e.g., violent victimization versus serious injury in a car accident) and numbers of traumatic events (e.g., multiple versus single events) on depression. These questions have only been assessed using lifetime measures of traumatic events and lifetime depression (44, 50-57). Furthermore, few studies have assessed potential modifiers of relations between traumatic events and depression.

Potential effect measure modifiers of relations between traumatic events and depression

Social factors that may modify the relation between negative life events and depression were enumerated by Brown and Harris in their study of the social origins of depression; these factors included unemployment, the presence of an intimate relationship, and having several young children at home (14). In their conception, and that of others at the time (58, 59), these conditions served as “vulnerability” factors, “contribut[ing] to depression only in the presence of a provoking agent”, that is, a negative life event (p. 179) (14). More recent work has focused on the role of social support, coping strategies, socioeconomic status (SES), and neighborhood conditions in increasing or decreasing the likelihood that exposure to traumatic events leads to

depression or other negative mental health consequences (20, 22, 60-64), while allowing that these factors may have effects on depression in the absence of traumatic events.(65).

This work has generally found that individuals with higher levels of social support and better coping strategies report less severe psychological symptoms after exposure to traumatic events than those with lower social support and inferior coping abilities (56, 66, 67), whereas individuals of lower SES develop more symptoms of psychological distress after exposure to traumatic events than individuals of higher SES (63). Related to these findings is the suggestion that chronic strains, like financial or marital problems, and acute negative life events may have a “synergistic effect” on mental health (60, 68), although no studies to date have empirically tested this claim.

Large bodies of research have been developed around two additional potential modifiers of relations between negative life events and depression: prior depression and prior adversity. Several researchers have highlighted the need to consider prior history of depression, since stressful life events may have different effects on first-onset and recurrent depression (22, 26, 69). Although some work has suggested that life events only lead to depression among individuals who have previously been depressed (26), suggesting that life events matter more for recurrence than for onset of depression (22), other studies have found stressful life events to matter only for initial episodes of depression (28). This latter finding is in keeping with Post’s 1992 “kindling” hypothesis, which posits that stressful life events are critical for initial episodes of major depression but become less associated with depression once multiple depressive episodes have been experienced (28, 70-72). This change in the relation between stress and depression over time may reflect changes in neurobiology that occur after multiple depressive episodes,

through which individuals basically become more vulnerable to depression, with life events no longer necessary to precipitate a depressive episode (22, 28, 70-72).

A related concept is the sensitization hypothesis, which holds that prior exposure to adversity (e.g., childhood abuse) lowers the amount of future stress required to produce an adverse psychological reaction like the onset or recurrence of depression (23, 73-75). Evidence for a sensitization effect of early life adversity has been found in animal studies as well as clinical studies, in which changes in the neurobiological systems that control responses to stress, including the hypothalamic-pituitary-adrenal (HPA) axis and the corticotropin-releasing factor (CRF) systems, have been observed among those with adverse early life experiences like maternal neglect or childhood maltreatment compared to those without such experiences (75-77). A number of recent observational studies have also found evidence for the sensitization hypothesis in relation to childhood adversity increasing risk of depression in response to subsequent stress (23, 73, 78, 79). However, few studies have assessed the sensitization hypothesis in the context of prior traumatic events aside from childhood abuse and in the context of subsequent traumatic events, rather than subsequent exposure to more mild stressors.

Neighborhood conditions and depression

A large body of recent literature has examined the relations between neighborhood conditions and depressive symptoms (80-82). Neighborhood conditions of primary interest include socioeconomic and demographic indicators like measures of poverty and racial/ethnic heterogeneity; crime, violence, and safety; features of the social

environment, including ties with neighbors; and features of the physical environment, including cleanliness, walkability, and housing conditions (80-82).

Chronic exposure to adverse neighborhood conditions may erode feelings of optimism and control over one's life, contributing to the sense of hopelessness and despair that is associated with depression (19, 20). The neighborhood environment may also contribute to depression specifically through its association with exposure to traumatic events. Several studies have demonstrated increased risk of directly experiencing or witnessing interpersonal violence, as well as experiencing childhood physical abuse, among residents of neighborhoods with higher levels of disadvantage and crime (83-87). Thus, one potential mechanism through which neighborhood conditions may influence depressive symptoms is increased exposure to violence and other traumatic events (88-90). The neighborhood context may also, or alternately, modify the impact of negative life events on mental health, such that people who live under adverse neighborhood conditions are more likely to experience mental health problems after traumatic or stressful life events than those who live in more advantageous circumstances (19, 20, 91).

Recent reviews of the literature on neighborhood conditions and depression have identified some inconsistencies in observed associations between different neighborhood characteristics and depression (80-82). Neighborhood physical and social disorder, including measures of informal social control and social cohesion, have been most consistently found to be associated with depression, with more inconsistent results for neighborhood disadvantage and objective measures of neighborhood crime (80, 81, 86, 90, 92-95). These conflicting results highlight the importance of considering a variety of

neighborhood characteristics when assessing mediation and effect measure modification in conjunction with traumatic event exposure and in relation to depression.

Specific aims and hypotheses

Given the outstanding questions noted above about relations between traumatic event exposure, neighborhood conditions, and depressive symptoms, this dissertation examines the following specific aims and hypotheses using data from the Detroit Neighborhood Health Study, a longitudinal study of traumatic events and psychopathology among a representative sample of adults living in the city of Detroit. The DNHS includes over 1,000 primarily African American participants who reported their depressive symptoms at baseline and a 12-month follow-up using the Patient Health Questionnaire-9 (PHQ-9); traumatic events occurring between the baseline and follow-up interviews and prior to the baseline interview (including childhood abuse) were assessed. Neighborhood disadvantage, crime, physical disorder, and social cohesion were assessed using Census and survey data, as well as data collected through a systematic assessment of Detroit neighborhoods. The main relations of interest in each of the three study aims are illustrated in Figure 1.1.

Aim 1

To examine the effects of traumatic events during a one-year follow-up period on changes in depression severity during that period, including the effects of specific types and number of traumatic events, and to assess whether traumatic events were differentially associated with changes in depression severity among those with differing

levels of social support, socioeconomic status (SES), other forms of chronic stress, and initial levels of depression severity.

Hypothesis 1: Individuals exposed to at least one traumatic event during the follow-up period will exhibit a greater increase in depression severity than individuals not exposed to a traumatic event.

Hypothesis 2: Individuals exposed to assaultive violence traumatic events will exhibit greater increases in depression severity than individuals exposed only to traumatic events of a non-assaultive nature (e.g., serious motor vehicle accidents, sudden death of a loved one).

Hypothesis 3: Individuals exposed to multiple traumatic events will exhibit a greater increase in depression severity than individuals exposed to no traumatic events or only one traumatic event.

Hypothesis 4: Traumatic events will be more strongly associated with changes in depression severity among those with low (vs. high) social support, low (vs. high) SES, more chronic stressors including financial and family problems, and higher initial levels of depression severity.

Aim 2

To examine the effects of prior lifetime traumatic events, including the effects of specific types and number of prior traumatic events, on changes in current depression severity, and to assess whether prior traumatic events exert a sensitization effect, lowering the threshold of future trauma required to elicit depressive responses.

Hypothesis 1: The total number of prior traumatic events will not be associated with changes in depression severity over a one-year follow-up period when adjusting for traumatic event exposure during that follow-up period.

Hypothesis 2: The numbers of childhood abuse events and prior assaultive violence events will be positively associated with changes in depression severity during the follow-up period, adjusting for the number of other types of prior traumatic events and for the number of recent traumatic events.

Hypothesis 3: Childhood abuse and prior assaultive violence will exhibit a sensitizing effect on depression severity following recent traumatic events.

Hypothesis 4: The number of prior non-assaultive events (e.g., injuries, learning of traumas to others, and sudden, unexpected death of a loved one) will not exhibit a sensitizing effect on depression severity after subsequent traumatic events.

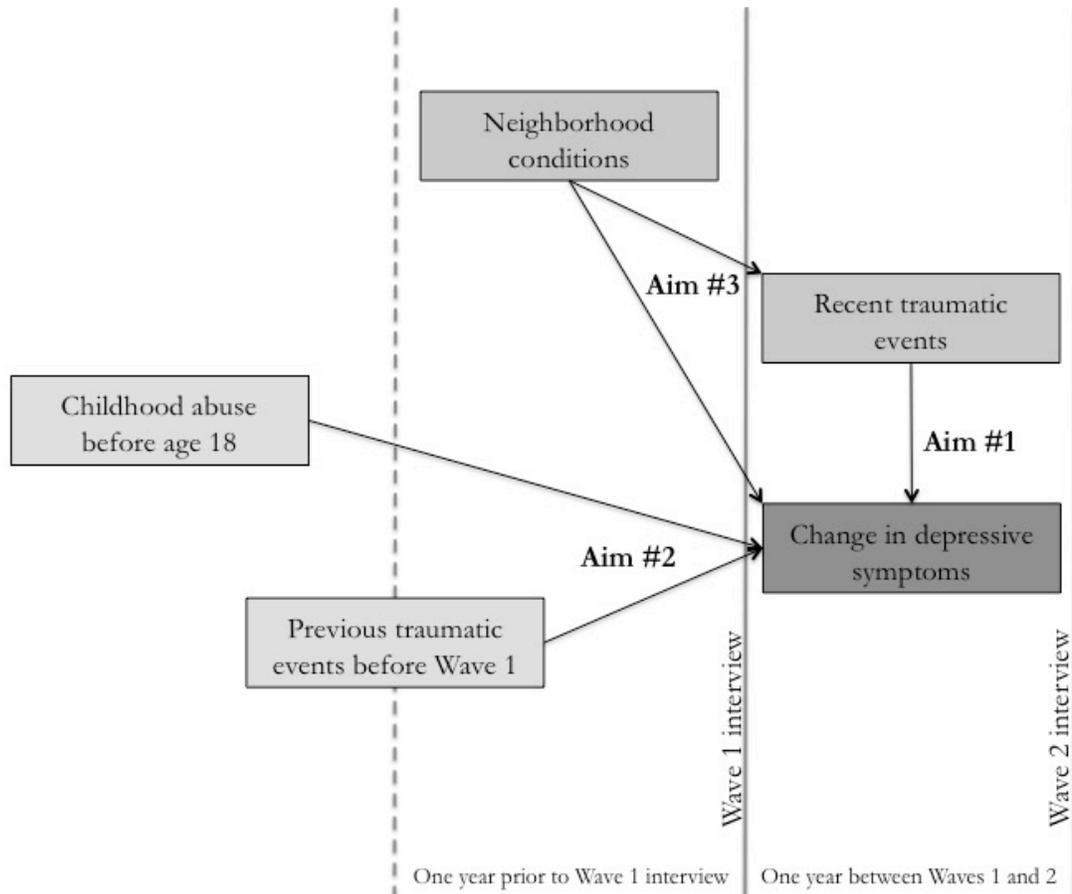
Aim 3

To examine the effects of neighborhood conditions on changes in depression severity, including indirect effects operating through exposure to traumatic events and modifying effects of neighborhood conditions on the relation between traumatic events and changes in depression severity.

Hypothesis #1: Exposure to traumatic events will mediate the effects of neighborhood disadvantage and of neighborhood crime on changes in depression severity.

Hypothesis #2: Effects of traumatic event exposure on changes in depression severity will be stronger among residents of neighborhoods characterized by high levels of disadvantage, crime, physical disorder, and low levels of social cohesion.

Figure 1.1 Relations of interest in each study aim using data from the Detroit Neighborhood Health Study and Detroit neighborhoods



Chapter 2

Exposure to traumatic events and changes in depression severity: Results from a prospective cohort study in an urban area

Background

Depression affects a substantial proportion of the U.S. population, with estimates of the lifetime prevalence of major depressive disorder ranging from 3.0% to 16.2% and past-year prevalence estimates ranging from 1.7% to 8.6% in U.S. samples over the last three decades (1-4). Depression is a leading cause of disability (5, 6), often resulting in impaired functioning in social, relationship, household, and work roles, as well as poor physical health and increased mortality (2, 4, 8-10, 96). Annual costs of depression, including medical costs for treatment and hospitalization as well as work-related costs in reduced productivity and absenteeism, have been estimated at \$83.1 billion (97).

Much research, especially since the 1960s, has focused on the social origins of depression. This work has included intensive study of the influence of social factors including financial hardships and the quality of social relationships on the onset of depression, as well as the role of stressful “life events” in depression (13-18). Although beset by methodological difficulties (22, 24-27), this work has generally found associations between stressful life events and depression onset (17, 98, 99), and has highlighted the importance of distinguishing less severe events that may have truly minimal impact on mental health from more severe events with the potential for long-term consequences (18, 52, 60, 100-102).

Traumatic events are examples of such severe, undesirable events with the potential for long-term consequences. Traditionally defined as extreme occurrences that are “outside the range of usual human experience” (29), traumatic events include “direct personal experience of an event that involves actual or threatened death or serious injury, or other threat to one’s physical integrity,” as well as witnessing such an event or learning that such an event occurred to a close friend or relative (31). Despite their extreme nature, traumatic events are commonly reported in U.S. populations, with estimates of lifetime exposure to at least one traumatic event ranging from 39% among young adults aged 21-30 years (103) to 51-69% in U.S. and regional samples also including older adults (30, 104, 105) to 89% among adults aged 18-45 years in the Detroit metropolitan area (106).

Numerous studies have assessed depressive symptoms after specific traumatic events, including childhood physical and sexual abuse (39), natural and manmade disasters (40-43), and exposure to combat and ongoing terrorism (44-47). Because of the unpredictable nature of exposure to traumatic events, nearly all studies of traumatic events and depressive symptoms have commenced after the traumatic event occurred, with study participants retrospectively reporting information about their trauma exposures at the same time that their psychological symptoms are assessed. These studies then compare depression and other psychological symptoms in participants exposed to the given traumatic event with an unexposed comparison group or compare psychological symptoms across individuals with varying levels of exposure to the traumatic event. Evidence of a higher prevalence of depression, or greater depression

severity, has been observed among those most directly exposed to traumatic events in many of these studies (38, 43, 107).

However, as previously noted for retrospective studies of stressful life events and depression (22, 24, 25), the lack of pre-trauma measures of depression in these studies is a major limitation that impedes our ability to draw conclusions about the causal role of traumatic events in depression. Many studies have demonstrated that individuals with a history of mental health problems are more vulnerable to experiencing traumatic events (17, 25, 33, 48). Therefore, pre-existing psychological symptoms may at least partly explain observed higher levels of depression prevalence and severity among those exposed to traumatic events (49). Studies including measures of depression collected prior to traumatic event exposure are needed to more conclusively evaluate the relation between traumatic events and depression (108, 109).

A few studies have been able to take advantage of a pre-existing study population, part of which was victim to a natural disaster after an initial mental health assessment had already been conducted; follow-up assessments of these populations have been able to assess changes in psychological symptoms after disaster exposure (110-115). Other studies have assessed changes in depressive symptoms after prospectively measured exposure to violent victimization (49, 116). However, results from these studies have been conflicting and do not allow consideration of the effects of other types of traumatic events beyond disaster and victimization on changes in depression severity.

In addition to the basic question of whether exposure to a traumatic event increases depressive symptoms, little information is available to judge whether different types of traumatic events, as well as multiple versus single events, may result in greater

changes in depressive symptoms. A few studies have compared the prevalence of lifetime major depression across individuals with different types of lifetime traumatic events (50, 51). Similarly, numerous studies have investigated the “cumulative effects” of trauma by comparing the prevalence of lifetime psychopathology associated with differing numbers of lifetime traumatic events (44, 52-57). However, this research has been criticized for its limited ability to isolate the effects of specific types of events and avoid confounding by exposure to other types of events (117). Furthermore, the focus on lifetime events and symptoms has precluded consideration of changes in depression associated with different types and numbers of traumatic events occurring in a given time period.

Finally, a number of personal characteristics may increase or decrease vulnerability to adverse mental health after exposure to traumatic events. For example, several studies have found that individuals with higher levels of social support and better coping strategies report less severe psychological symptoms after exposure to traumatic events than those with lower social support and inferior coping abilities (56, 66, 67). Others have found that individuals of lower SES develop more symptoms of psychological distress after exposure to traumatic events than individuals of higher SES (63), while still others have suggested that chronic strains, like financial or marital problems, and acute negative life events may have a “synergistic effect” on mental health (60, 68, 118). A prior history of depression has also been found to be an important effect modifier of the relation between negative life events and depression (25, 119), although it is unclear whether individuals with or without prior depression are most at risk when exposed to traumatic events. Some studies have demonstrated that life events only lead

to depression among individuals who have previously been depressed (26), suggesting that life events matter more for recurrence than for onset of depression (22). However, other studies have found the opposite: life events (severe ones, in particular) predict depression onset but matter less for recurrence (28, 120).

Given these outstanding questions about the influence of traumatic events on changes in depressive symptoms, the objective of this study was to examine the effects of traumatic events during a one-year follow-up period on changes in depressive symptoms during that period, including the effects of specific types and number of traumatic events, and to assess whether traumatic events were differentially associated with changes in depressive symptoms among those with differing levels of social support, socioeconomic status (SES), other forms of chronic stress, and initial levels of depressive symptoms. We investigated these questions using data from the first two waves of the Detroit Neighborhood Health Study (DNHS), which allowed prospective assessment of traumatic events during a one-year period and assessment of change in depressive symptoms relative to pre-trauma measures of depression.

We hypothesized that individuals exposed to at least one traumatic event during the follow-up period would exhibit a greater increase in depression severity than individuals not exposed to a traumatic event. Based on studies finding the highest prevalence of mental health problems like PTSD among those with experiences of interpersonal violence (e.g., sexual and physical assault) (30, 104, 117, 121) and finding consistent dose-response relations between the number of traumatic events and increases in mental health problems (50, 52, 53, 57, 117, 122-124), we further hypothesized that individuals exposed to assaultive violence traumatic events would exhibit greater

increases in depression severity than individuals exposed only to traumatic events of a non-assaultive nature (e.g., serious motor vehicle accidents, sudden death of a loved one), and that individuals exposed to multiple traumatic events would exhibit a greater increase in depression severity than individuals exposed to no events or only single events.

Finally, given theoretical and empirical evidence that social support, SES, chronic strains, and prior history of depression may modify relations between negative life events and depression (22, 60, 61, 63, 64), we hypothesized that traumatic events would be more strongly associated with increased depression severity among those with low (vs. high) social support, low (vs. high) SES, more chronic stressors including financial and family problems, and higher initial levels of depression severity.

Methods

Study population

This investigation uses data from the first two waves of the Detroit Neighborhood Health Study (DNHS), a community-based cohort study of adult residents of the city of Detroit, Michigan. Eligible participants were 18 years of age or older and were living in the city of Detroit (i.e., not in Hamtramck or Highland Park) at the time of the baseline interview. We sampled 7,041 households in the city of Detroit, identifying telephone numbers from the U.S. Postal Service Delivery Sequence File, which covers the whole Detroit population including non-telephone and cellular-phone-only households, and from a random-digit-dial frame including Detroit households with unlisted telephone numbers. Selected households with at least one listed landline telephone number were contacted via telephone regarding study participation; the remaining households were

invited to participate via a mailed letter. The adult in the household with a birthday closest to the interview date was selected as the study participant (125). After the study was described and any questions answered, oral informed consent was obtained from participants. The study was approved by the Institutional Review Board of the University of Michigan.

Telephone interviews were conducted with 1,547 participants, resulting in a cooperation rate of 53.0% and a response rate of 33.1% (126).¹ The baseline (Wave 1) interview took place between September 9, 2008 and February 3, 2009 and lasted 40 minutes on average. 1,054 Wave 1 participants (68.1%) completed a follow-up interview (Wave 2) approximately one year later, between September 21, 2009 and April 12, 2010, which also lasted 40 minutes on average. Analyses were restricted to the 1,054 individuals who participated in both Wave 1 and Wave 2.

Measures

Depressive symptoms

Depressive symptoms were assessed using the Patient Health Questionnaire-9 (PHQ-9) (127-129), which includes nine items corresponding to the nine DSM-IV criteria for major depressive disorder (31). During the Wave 1 interview, study participants were asked whether there was ever a two-week period in their lifetime in which they were bothered by each of these nine symptoms (e.g., “Little interest or pleasure in doing

¹ Participation rates were calculated as follows, where I = completed interviews, Q = quota-outs [contacted persons not interviewed because the quota for their gender had been filled], S = screen-outs [contacted persons who screened out of the interview], R = refusals, Inc = Incomplete interviews, NC = non-contacted households which were never successfully reached, and NS = non-screened callbacks [households where contact was made but eligibility screening was never completed]. Cooperation rate = $(I + Q + S) / (I + Q + S + R + Inc) = 2,332/4,402$. Response rate = $(I + Q + S) / (I + Q + R + Inc + NC + NS) = 2,332/7,401$.

things”, “Feeling tired or having little energy”). If so, they were asked how often in that two-week period they were bothered by each of the symptoms (1 = several days; 2 = more than half the days; 3 = nearly every day) and whether that occurred in the past 30 days. At the Wave 2 interview, the PHQ-9 was repeated with symptoms assessed for a two-week period since the last interview and in the past 30 days. The total PHQ-9 score in the past 30 days at Waves 1 and 2 was calculated by summing respondent frequency ratings of the nine items (coded 0-3) for a total score ranging from 0 to 27. Cronbach’s alpha for the past month PHQ-9 scale was 0.87 at Wave 1 and 0.85 at Wave 2 in the study sample.

The PHQ-9 has been found to have excellent internal consistency, test-retest reliability, criterion validity (compared to a diagnostic interview conducted by a mental health professional) and construct validity (with increasing PHQ-9 scores reflecting increasing functional impairment, disability, and health care utilization) in primary care settings (127, 130) as well as in the general population (131). The PHQ-9 score indicates depression severity, with scores of 0-4 reflecting minimal or no depression, scores of 5-9 reflecting mild depression, 10-14 moderate, 15-19 moderately severe, and 20-27 severe depression (127). A PHQ-9 score of 10 or higher was associated with 88% sensitivity and 88% specificity for a diagnosis of major depression among 580 primary care patients (127). Additional studies have found that the PHQ-9 functions similarly across racial/ethnic groups, with high internal consistency and similar mean total scores across groups (132), and that the PHQ-9 can be reliably administered over the telephone (133). Finally, changes in the PHQ-9 total score have been shown to reflect changes in

depression diagnostic status according to structured clinical interviews, demonstrating the utility of the PHQ-9 for longitudinal research (134).

Traumatic events

Information about nineteen potentially traumatic events experienced by participants in their lifetime was obtained during the Wave 1 interview using a subset of DSM-IV Criterion A traumatic events that has been used in prior research in the Detroit metropolitan area (121). These events can be grouped into four broad categories, following the example of Breslau and colleagues (121): (1) “assaultive violence” events are characterized by intentional violence by a perpetrator towards the study participant (e.g., rape or other sexual assault; having been shot or stabbed); (2) “other injuries or shocking experiences” are encountered directly by the participant but do not involve violence directed at the participant, rather involving an external threat like technology, nature, illness, or injury (e.g., serious motor vehicle accident, natural disaster), or witnessing violence directed at someone else; (3) “learning of traumatic events to close friends or relatives” (e.g., learning that a close friend or relative was seriously physically attacked) was added as a qualifying traumatic event in the DSM-IV (135), and is distinguished from events that were experienced directly by participants; and (4) the “sudden, unexpected death of a close friend or relative”, which is often considered separately from other traumatic events because of its high period prevalence in the population (106, 121). The total number of traumatic events participants reported to have occurred in their lifetime prior to the Wave 1 interview was grouped into four categories for analyses: 0, 1-3, 4-6, and 7 or more events.

During the Wave 2 interview, respondents were asked whether any of these nineteen traumatic events had occurred since the last interview. Three measures of interest were created from the number of traumatic events reported to have occurred between Waves 1 and 2. First, we created a dichotomous variable indicating whether any of the nineteen traumatic events had occurred. Second, a 5-category nominal variable identifying the type of most severe traumatic event that occurred was created, using the four broad categories listed above and a fifth category for those who did not experience a traumatic event during the follow-up period. Individuals who reported events of more than one type during this period (e.g., assaultive violence and sudden death of a loved one) were assigned to the category deemed to be most severe, with severity in descending order as follows: assaultive violence, other injuries or shocking experiences, learning of traumatic events to others, and sudden death of someone close. This procedure was similar to categorization methods used in other studies, which generally distinguish between those who have experienced traumatic loss only, non-interpersonal events only, and interpersonal violence (50, 51, 117, 136). Third, a count of the number of distinct traumatic events reported (e.g., rape, motor vehicle accident, natural disaster), regardless of type, was created and grouped into four categories: 0, 1, 2, and 3 or more events.

Non-traumatic stressors

During the Wave 1 interview, participants were asked to report the occurrence of nine non-traumatic stressors in their lifetime; these stressors were modified from lists used in previous studies (85, 137). Stressors included the serious drug or alcohol problem of a parent or other family member, a divorce or “break up” with a significant other, losing one’s job, being unemployed and looking for work for three months or

longer, emotional mistreatment, stressful legal problems, serious financial problems, and problems getting access to adequate healthcare. The number of lifetime stressors was categorized as 0, 1-2, 3-5, and 6 or more. These questions were repeated during the Wave 2 interview in order to collect information on stressors that had occurred since the previous interview, with the addition of one question on home foreclosure. A count of stressors that occurred between the Wave 1 and Wave 2 interviews was created and grouped into 0, 1, and 2 or more stressors.

Social support

Social support in the twelve months prior to the Wave 1 interview was assessed with three items from the Postdeployment Social Support Scale (138), assessing respondent agreement with the following statements: “Among my friends or relatives, there is someone who makes me feel better when I am feeling down”; “Among my friends or relatives, there is someone I go to when I need good advice”; and “My friends or relatives would lend me money if I needed it”. Response choices were “strongly agree”, “somewhat agree”, “somewhat disagree”, and “strongly disagree”. Cronbach’s alpha for the social support scale was 0.64 in the study sample. DNHS participants with total social support scores in the bottom third of the sample were categorized as having low levels of social support.

Socio-demographic characteristics

The DNHS Wave 1 interview also collected information on the demographic characteristics of study participants, including gender, age, marital status, and race/ethnicity. Socioeconomic characteristics of participants were also assessed, including educational attainment and household income. A composite measure of

socioeconomic status was created by averaging education level and household income, each measured on a four-point scale (education: 1 < high school, 2 high school degree or equivalent, 3 some college, 4 college degree or graduate work; household income: 1 < \$15,000, 2 \$15,000-\$34,999, 3 \$35,000-\$49,999, 4 \$50,000 or more).

Statistical analyses

First, we compared the baseline characteristics of the analysis sample (i.e., n = 1,054 who participated in both Waves 1 and 2) to the full baseline sample (n = 1,547). Second, we calculated the percentage of DNHS participants who reported experiencing each of the nineteen traumatic events between Waves 1 and 2, as well as the summary measures of traumatic events. Third, we conducted bivariable chi-square tests of the associations between the covariates of interest (i.e., socio-demographic characteristics, lifetime traumatic events and stressors, and low social support) and each of the three measures of traumatic events during the follow-up period (i.e., any traumatic event, type of traumatic event, and number of traumatic events).

Fourth, we used negative binomial regression models to assess associations between traumatic events during the follow-up period and changes in depression severity between Waves 1 and 2. The outcome of these models was the total PHQ-9 score in the past month at Wave 2; controlling for the total PHQ-9 score in the past month at Wave 1 allowed us to examine associations with change in depression severity. The PHQ-9 score at Wave 2 was skewed right, with a mean of 3.44 but a median of 0 (indeed, approximately 50% of the scores were zero). A linear regression model was not appropriate because of the skewed distribution of the PHQ-9 score, and transformations could not improve the normality of the distribution because of the large proportion of

zero values. Negative binomial models have been proposed for use with discrete outcome data like symptom scores (139) and have been used in several other studies of depressive symptoms measured by the PHQ-9 (47, 140, 141). The PHQ-9 score also exhibited overdispersion, in which the variance is greater than the mean, suggesting that negative binomial models would be more appropriate than Poisson models, which can also be used for discrete outcome data but which assume variance equal to the mean (139, 142). Results of a likelihood ratio test comparing the negative binomial model to a Poisson model confirmed the choice of the negative binomial model (log likelihood for Poisson (P) model = -3407.08, log likelihood for negative binomial (NB) model = -2035.73; $-2 \times (-LL(P) - LL(NB)) = 2742.70$, $p < 0.001$). The exponentiated regression coefficients ($e^{\hat{\beta}}$) from the fitted negative binomial models can be interpreted as the ratio of the average PHQ-9 score among those in one category of the predictor versus the reference category (for a categorical predictor), or the ratio of the average PHQ-9 score among those separated by one unit of a continuous predictor. We will use the term “mean ratio” to refer to these estimates hereafter.

In addition to the Wave 1 PHQ-9 score, all models included adjustment for gender, race (African American; other race), age (18-24; 25-34; 35-44; 45-54; 55-64; 65 or greater), marital status (married; divorced, separated, or widowed; never married), educational attainment (less than high school; high school degree or equivalent; some college; college degree or graduate work), and annual household income at baseline (<\$15,000; \$15,000-\$34,999; \$35,000-\$49,999; \$50,000 or more; 118 respondents with missing income information were included in a separate category). All of these characteristics have been found to be associated with greater exposure to traumatic

events, overall or of certain types (30, 104, 121), as well as with levels of depressive symptoms (4, 9, 11, 12). A prior history of traumatic events has been found to increase the likelihood of experiencing future traumatic events (35, 56, 143) and to be associated with depressive symptoms later in life (22, 39, 136, 144-147), so the total number of lifetime traumatic events prior to Wave 1 (0; 1-3; 4-6; 7 or more) was also included as a potential confounder in the models. Similarly, a history of acute and chronic non-traumatic stressors may increase vulnerability to traumatic events (148) and is associated with increased depression (52), so the total number of lifetime stressors prior to Wave 1 (0; 1-2; 3-5; 6 or more) was included in adjusted models. Lastly, low social support may increase or decrease exposure to traumatic events; for example, individuals with few strong social connections may be at greater risk of being violently victimized (149, 150), whereas the same individuals may be at lower risk for the traumatic loss of someone close or discovering that a close member of their social network has experienced a traumatic event (151). Low social support is also a consistent predictor of depression (56, 64, 65, 152, 153) and thus was included in adjusted models as a potential confounder of relations between recent traumatic events and changes in depressive symptoms.

We considered possible effect measure modification by including product terms for the statistical interaction between traumatic events during follow-up and each potential modifier of interest: low social support at baseline, low SES at baseline using the composite measure of SES, number of non-traumatic stressors during the follow-up period, and depression severity at baseline, as reflected in the Wave 1 past month PHQ-9 score. Separate models were fitted to assess statistical interactions between each of the four potential modifiers with each of the three measures of traumatic events between

Waves 1 and 2, for a total of twelve models. These models also included adjustment for Wave 1 PHQ-9 score, baseline demographics and SES, lifetime traumatic events and stressors prior to Wave 1, and social support in the year prior to Wave 1. Departure from homogeneity of the ratio of the mean PHQ-9 scores for each traumatic-event measure across levels of each potential modifier was assessed using an adjusted Wald F test with the null hypothesis that all product terms in the model had coefficients of 0; this test approximates the likelihood ratio test comparing models with and without the product terms, but it is more appropriate than the likelihood ratio test when using complex survey data (154). Because of limited power to detect interactions, a p-value less than 0.15 associated with the F statistic was used as an indicator of departure from multiplicativity.

All analyses were weighted to account for differential probabilities of selection into the study across participants, by number and types of telephone numbers and number of adults in households. Post-stratification weights were also incorporated to ensure comparability between the study sample and the population of the city of Detroit on socio-demographic characteristics (gender, age, race/ethnicity, marital status, educational attainment, and household size), housing tenure, and type of telephone service, using data from the 2005-2007 American Community Survey (155). Finally, attrition weights were developed using the inverse probability of censoring method (156) to account for differences between respondents who participated in the Wave 2 interview and the full baseline sample. Weighted percentages, means, and associations are thus approximately unbiased estimates of the percentages, means, and associations in the underlying source population or sampling frame (i.e., all adult residents in the city of Detroit at the time of the baseline interview). All analyses were conducted in Stata (Version 10.1, Stata

Corporation, College Station, TX), appropriately accounting for the weights and the complex sampling design.

Results

After applying sampling, post-stratification, and attrition weights, the Wave 2 sample was similar to the full baseline sample on all socio-demographic characteristics, baseline reports of lifetime traumatic events, stressors, and social support, and mean PHQ-9 score and depression severity in their lifetime and in the month prior to the baseline interview (Table 2.1). Using weighted estimates from the sample who participated in both waves of data collection ($n = 1,054$), we can infer that the majority of the source population was African American (86.7%), with 52.8% female, and a mean age of 44.3 years (Table 2.1). Nearly half (44.9%) had never been married, with 26.2% divorced, separated, or widowed. Over forty percent (41.8%) had more than a high school education, but only 34.9% reported household income of \$35,000 or greater in the year prior to the Wave 1 interview. About one quarter of the source population had experienced seven or more traumatic events (28.4%) and six or more stressors (25.4%) in their lifetime prior to the time of the baseline interview.

Exposure to traumatic events in the roughly one-year period between the Wave 1 and Wave 2 interviews was common, with more than half of the source population (54.3%) experiencing at least one traumatic event during the follow-up period (Table 2.2). The sudden, unexpected death of a close friend or relative was most frequently reported (38.1%), followed by learning of traumatic events to close friends or relatives (19.4%), other injuries or shocking experiences (17.7%, including 6.7% who reported

witnessing someone being killed or seriously injured), and assaultive violence events (7.3%, including 4.8% who reported being mugged or threatened with a weapon).

Overall, 33.4% of adult Detroit residents experienced one traumatic event during the follow-up period, 11.1% experienced two events, and 9.8% experienced three or more distinct events.

Table 2.3 shows unadjusted associations between demographics, socioeconomic status, lifetime traumatic events and stressors, and social support at baseline with three measures of traumatic events during the one-year period between Waves 1 and 2. Larger percentages of individuals with a history of traumatic events and stressors prior to the time of the Wave 1 interview experienced a traumatic event during follow-up (e.g., 66.6% of those with seven or more prior traumatic events vs. 38.2% of those with no prior history of traumatic events). Younger individuals were more likely than older individuals to fall victim to assaultive violence events during follow-up (16.8% of 18-24 year-olds vs. 1.3% of those 65 years or older), as were never married individuals (11.5% vs. 3.2% of married individuals). Never married individuals also learned of traumatic events to close friends or relatives more frequently than those who were married (12.2% vs. 7.1%). Individuals with the highest education level were the least likely to experience most types of trauma, including the sudden death of a loved one (17.2% vs. 23.3% for those with the lowest education), other injury or shocking event (10.4% vs. 15.0% for those with the lowest education), and assaultive violence (1.6% vs. 4.1%, 10.0% and 7.9% for those with less than a high school, a high school degree or equivalent, and some college education, respectively). Similarly, individuals in the highest income category experienced a lower frequency of assaultive violence events during follow-up (1.6% vs.

13.5% for those in the lowest income group). Finally, larger proportions of those with a prior history of more traumatic events and stressors experienced three or more traumatic events during follow-up (e.g., 20.0% for those with seven or more prior traumatic events vs. 0.9% among those with no prior history of trauma).

The mean PHQ-9 score in the past month was 2.82 (standard error [SE] 0.27) at Wave 1 and 3.44 (SE 0.27) at Wave 2. Experiencing a traumatic event during the follow-up period was positively associated with depression severity at Wave 2 in models adjusting only for the Wave 1 PHQ-9 score (mean ratio = 2.12, 95% Confidence Interval [CI] 1.54-2.91) as well as for all potential confounders (mean ratio = 1.75, 95% CI 1.30-2.36) (Table 2.4, Models 1 and 2). An exponentiated regression coefficient (i.e., mean ratio) of 1.75 indicates that the mean past month PHQ-9 score among those exposed to at least one traumatic event during follow-up was 1.75 times higher than the mean PHQ-9 score of those not exposed to any traumatic events during follow-up, controlling for all other covariates in the model, including the Wave 1 PHQ-9 score. As for type of traumatic events during follow-up, individuals reporting assaultive violence (mean ratio = 2.54, 95% CI 1.44-4.77) as well as those reporting other injuries and shocking events (mean ratio = 2.52, 95% CI 1.70-3.73) exhibited increased depression severity, when compared to those with no traumatic event exposure during follow-up (Table 2.4, Model 3). Participants reporting two (mean ratio = 2.26, 95% CI 1.39-3.68) and three or more traumatic events during follow-up (mean ratio = 2.72, 95% CI 1.73-4.30) demonstrated increased depression severity compared to those with no traumatic event exposure, adjusting for baseline demographics, socioeconomic status, social support, and lifetime histories of traumatic events and stressors (Table 2.4, Model 4). Individuals reporting

only one traumatic event during follow-up also exhibited increased depression severity when compared to those with no traumatic events (mean ratio = 1.32, 95% CI 0.94-1.87; $p = 0.11$). For all three traumatic event exposures, the magnitude of the associations between traumatic events and depression severity at Wave 2 was reduced when adjusting for potential confounders (Table 2.4, Models 2-4 compared to Model 1).

Regarding potential effect measure modification of the relation between traumatic event exposure and depression severity, no evidence of departure from multiplicativity on the mean-ratio scale was found when including product terms for the statistical interaction between each of the three measures of traumatic events between Waves 1 and 2 and the following covariates: (1) social support at baseline; (2) SES at baseline using a composite measure of education and household income; and (3) number of stressors between Waves 1 and 2 (Table 2.5). Departure from multiplicativity on the mean-ratio scale was observed when assessing the statistical interaction between depression severity at Wave 1 and traumatic events during follow-up (Table 2.5). In particular, a negative statistical interaction between the Wave 1 PHQ-9 score and any traumatic event was found, such that the positive association between experiencing a traumatic event during follow-up and depression severity at Wave 2 was stronger among those with a lower level of depression severity at Wave 1. Figure 2.1 displays the ratio of the mean Wave 2 PHQ-9 score among individuals reporting each type of traumatic event to the mean score among those with no trauma exposure during follow-up, contrasting those with a PHQ-9 score at baseline in the 10th vs. 90th percentile of the distribution (corresponding to scores of 0 and 10, respectively). The association between the most severe types of traumatic events (assaultive violence and injuries or other shocking experiences) and increased

depression severity was greatest among those with lower depression severity at Wave 1. Similarly, the positive association between number of traumatic events and depression severity was strongest among those with lower depression severity at baseline, as shown in Figure 2.2.

Discussion

In this study of 1,054 adult residents of the city of Detroit who participated in two interviews approximately one year apart, we found positive associations between exposure to traumatic events during the follow-up period and depression severity, as measured by the PHQ-9 score in the month prior to the follow-up interview, controlling for baseline PHQ-9 score and other potential confounders. Increases in depression severity were highest for those who experienced assaultive violence events like sexual assault and being threatened with a weapon and for those who experienced other injuries and shocking events like a serious accident or witnessed violence. The number of traumatic events experienced during follow-up was also positively associated with depression severity, controlling for baseline depression severity and other potential confounders. Finally, the positive association between traumatic event exposure and change in depression severity was stronger among those with lower depression severity at baseline.

Study participants reported fairly high levels of exposure to traumatic events during the one-year follow-up period, with more than half experiencing at least one event. Although few studies have reported estimates of the incidence of traumatic events during a specific period, existing estimates suggest that exposure to traumatic events was

unusually high in our study population. For example, Norris (30) found that 21.0% of adults from four cities in the southeastern U.S. had experienced a traumatic event in the past year, whereas Breslau et al. (32) reported that 19.0% of young adults experienced a traumatic event during a three-year follow-up period. The high incidence of past-year traumatic events in our study was driven largely by a high percentage (over one third) of individuals reporting the sudden, unexpected death of a close friend or relative. Other studies including the one by Norris (30) have used a more restricted category of “tragic death”, defined as the death of a close friend or family member from an accident, homicide, or suicide; 4.9% of participants in the Norris (30) study reported such a tragic death in the year prior to the interview. Reports of assaultive violence in the past year (7.3% of the sample) were also higher in the present study than in previous reports. For example, 4.8% of women in the National Women’s Study (NWS) reported new incidents of physical or sexual assault in a two-year follow-up period (157), whereas 2.8% of men and women in Norris’s study reported physical or sexual assault in the past year (30). Thus, higher incidence of traumatic events in this study may reflect both the assessment of an expanded range of events compared to other studies, as well as greater exposure to violence (personally, as witnesses, and occurring to loved ones) resulting from the location of study participants in an urban area with relatively high levels of violence. Indeed, other authors have noted the high lifetime prevalence of exposure to violence among residents of the city of Detroit (121, 158).

Correlates of exposure to traumatic events during the one-year follow-up period were consistent with other studies, as men, younger individuals, non-married individuals, and those of lower socioeconomic status were more likely to report experiencing

assaultive violence and multiple traumatic events during follow-up (30, 32, 157, 159). Strong associations between a prior history of traumatic events and the occurrence of new traumatic events during the follow-up period were also observed, consistent with other studies that have found prior traumatic events to be a risk factor for subsequent events (32, 160, 161). A history of non-traumatic stressors was also associated with traumatic events during follow-up; this is consistent with some evidence that individuals experiencing financial hardship and other chronic strains are more prone to experience negative life events including trauma (148, 162). The relations between prior traumatic event and stressor exposure and subsequent traumatic experiences are complex and reflect a variety of mechanisms at play, including increased risk of subsequent trauma associated with substance use and other risky behaviors more frequently practiced by those with a history of trauma and stress (157, 161), as well as chronic strains resulting from acute events (162, 163), which then increase exposure to subsequent events (e.g., financial decline after an accident or disaster necessitating a move to a lower income neighborhood with higher rates of violence).

Using a measure of pre-trauma depression severity, we showed that traumatic event exposure was associated with increased depression severity in this study, even when controlling for baseline demographic and socioeconomic characteristics as well as lifetime history of traumatic events and stressors. Although this finding seems intuitive and logical, although only a small number of prior prospective studies have investigated the influence of traumatic events like assault on changes in depression status or severity, with somewhat conflicting results. For example, new experiences of violence (physical or sexual assault or witnessed violence) during a two-year follow-up period were not

associated with past-year major depression in the National Women's Study, when controlling for baseline major depression, demographic characteristics, and lifetime exposure to violence (116). However, new exposure to violence was associated with increases in PTSD and substance use problems in that sample (116, 157). In a study among children aged 10-16 years, victimization during a 15-month follow-up period was associated with the presence of depression at follow-up, even when controlling for prior history of depression assessed at baseline (49). Complementing research on the mental health effects of new assaults, a larger number of prospective studies have assessed relations between exposure to natural and manmade disasters and changes in mental health adjusting for pre-disaster measures of mental health. These studies have generally found associations between greater exposure to the disaster and increased depressive symptoms (110-114, 164), although a few studies have found little or no association between disaster exposure and depression (115) or have found associations to be largely limited to specific subgroups like those with pre-existing depression (165). One limitation of those studies is that measures of disaster exposure are usually comprised of a mix of traumatic experiences (e.g., death of family members, injury or threat of death to self, witnessing horrific scenes) and non-traumatic stressors resulting from the disaster (e.g., property damage, relocation), so they have not been able to isolate the effects of traumatic experiences and have generally found only weak associations between disaster exposure and increased depression. Our study advances this prior work by including pre-trauma measures of depression severity, along with a broader range of traumatic experiences beyond violent victimization and natural disaster, to demonstrate a clear

association between incident traumatic events and changes in depression severity in an urban population with a lifetime history of exposure to numerous traumatic events.

The assessment of a broad range of traumatic events in this study also allowed us to compare the effects of different types of trauma on increases in depression severity. Previous studies have found the prevalence of PTSD, depression, and other mental health problems following exposure to trauma to vary according to the type and severity of the traumatic event. However, those studies have largely focused on lifetime exposure to traumatic events, as well as lifetime mental health problems. Assaultive violence events have been consistently linked to the highest prevalence of PTSD, depression, and other mental health problems (30, 50, 51, 104, 117, 121, 166-168), while learning of traumatic events to others has been found to result in less severe psychological consequences (121, 169, 170). Traumatic loss or the sudden, unexpected death of someone close, has generally been found to be associated with lower prevalence of lifetime PTSD than other traumatic events (30, 121, 168), although rates of mental health problems are usually higher among those with a history of traumatic loss compared to those with no lifetime trauma exposure (50, 167). Results for other types of personal traumatic events like car accidents and witnessed violence have been less consistent, with some studies finding no elevated odds of lifetime PTSD or depression associated with accidents and witnessed violence (167) and other studies finding a higher lifetime prevalence of PTSD and depression among those with exposure to accidents or witnessed violence compared to those with no traumatic events (51). Our study extends these findings to show that assaultive violence and other injuries are associated with greater increases in depression severity over a one-year period when compared to those with no trauma exposure, while

those who experienced traumatic events only indirectly (i.e., learning of traumas to others, sudden death of a loved one) experienced increases in depression severity that were more similar to those with no trauma exposure. These results highlight the central importance of directly experienced traumatic events, beyond just interpersonal violence, as risk factors for increased mental health problems.

Similarly, our findings corroborate previous findings of dose-response relations between the number of lifetime traumatic events and the prevalence of lifetime depression (52), the number of depressive symptoms or depression severity (44, 53-56) and the persistence of depression (57), while extending that work to demonstrate the strong positive relation between the number of incident traumatic events during a one-year follow-up period and change in depression severity. Some studies of incident stressful life events more generally have found similar relations in terms of greater increases in depression associated with multiple events in a given period (171) and it is not surprising that individuals experiencing a higher burden of trauma would experience a greater decline in psychological health.

Other consistent predictors of increased depression severity included female gender, prior history of four or more traumatic events, and low levels of social support at baseline; additionally, participants in middle income categories had decreased depressive symptoms compared to those in the lowest income category. These results are similar to findings of other studies investigating individual-level risk factors for depression (4, 9, 11, 12). Wave 1 depression severity was a strong predictor of depression severity at Wave 2, as expected from previous studies demonstrating stability in symptom levels over time (25, 98, 172, 173).

Numerous studies have examined the buffering (modifying) effects of social resources, including social support and socioeconomic status, after exposure to negative life events like traumatic experiences (14, 56, 58, 59, 61-64, 174). Although many studies have found interactions between traumatic events and social support on depression, such that individuals with higher levels of social integration or perceived availability of social support experience fewer symptoms of psychopathology after a traumatic event than individuals exposed to the same type of event but with low levels of social support, others have found only main effects of social support on depression, depending on the type of support measured (153, 175, 176). Few studies have assessed potential effect measure modification of relations between trauma exposure and depression by chronic strains, with researchers sometimes promoting (60) and sometimes discouraging (162) the nearly impossible task of separating acute and chronic stressors given their interrelatedness, or viewing chronic stressors as mediators of the relation between acute events and mental health (163). Although we found no evidence of departure from multiplicativity when examining statistical interactions between traumatic event exposure and social support, SES, and non-traumatic stressors in predicting changes in depression severity, these results should be interpreted with caution because of low power to detect statistical interactions in this study. Further investigations could be explicitly designed to test these potential interactions to better understand who is most vulnerable to increased depression after traumatic event exposure.

We did find different associations between traumatic event exposure and increased depression severity across levels of baseline depression severity, such that positive associations between any traumatic event, assaultive violence events and other

injuries, and greater numbers of traumatic events and increased depression severity were stronger among those with lower depression severity at baseline. Many studies have suggested that individuals with pre-existing depression or greater initial depression severity are more vulnerable to recurrences of depression after subsequent exposure to traumatic events (22, 26). Our results are contrary to this, with previously asymptomatic individuals exhibiting the strongest relations between traumatic event exposure and increased depression in the present study. There is some previous support for this finding, including the kindling hypothesis, which holds that social factors like stressful life events are only critical for initial episodes of major depression, becoming less predictive of depression once multiple depressive episodes have been experienced (see Hammen, 2005, Monroe and Harkness, 2005 and Stroud et al., 2008 for a review) (28, 70, 71), and other studies finding stressful life events to be more critical for depression onset than recurrence (48, 177). Some studies have suggested that the nature of the life events in question is critical, with mild events associated with depression recurrence while severe events are associated with depression onset (120). Since we restricted our study to events of a severe nature, our results support this hypothesis; additional confirmation of these findings in other studies would help resolve these conflicting bodies of evidence about whether individuals with low or high pre-trauma levels of depression are more vulnerable to increased depression after trauma exposure.

There are several limitations of this study that should be considered when interpreting the results. First, about 30% of the Wave 1 DNHS participants did not complete the Wave 2 interview. Baseline participants lost to follow-up were younger, less educated, more likely to be unemployed, and unmarried (178). Inverse probability of

censoring weights (156) were calculated to address these differences between the participants at follow-up and the full baseline sample, but this method may not fully control for the bias due to selective attrition. Second, the study questions did not assess the exact timing of traumatic events or onset of depressive symptoms during the follow-up period; therefore, some temporal ambiguity exists, with the possibility that some traumatic events reported to have occurred between Waves 1 and 2 were actually experienced after the onset of depressive symptoms during follow-up. Using a measure of depressive symptoms that is focused on the 30 days prior to the Wave 2 interview ensured that the vast majority of traumatic events experienced by the study population during the one-year follow-up period would likely have occurred prior to the time for which depression was assessed, although it's possible that changes in depressive symptoms may have preceded traumatic events. Third, information on the number of times a specific traumatic event occurred in the participant's lifetime or during the follow-up period was not collected, potentially leading to misclassification of the number of traumatic events experienced by study participants. Fourth, the recall and reporting of traumatic events prior to the Wave 1 interview and since the Wave 1 interview may have been influenced by the participant's level of depressive symptoms at Wave 1 and Wave 2, respectively (179). However, the traumatic events assessed in this study are objective events of serious magnitude; therefore, reporting of such events is less likely to be influenced by changing perceptions of past experiences influenced by current depressive symptoms (180). Fifth, the study had low power to detect statistical interactions, suggesting that our failure to find departure from multiplicativity when examining the effects of traumatic events jointly with social support, socioeconomic status, and chronic

strains should not be taken as definitive evidence for a lack of statistical interaction between these factors in predicting changes in depression severity. Additionally, considering twelve possible statistical interactions at $p < 0.15$ increased the probability of a Type I error, or rejection of the null hypothesis when it is, in fact, true. Finally, we used a slightly nontraditional administration of the PHQ-9, asking about symptoms in the respondent's lifetime and whether each symptom occurred in the past month, rather than referring only to the past two weeks. The PHQ-9 was designed as a measure of current depression and estimates for the past month are usually considered "current"; furthermore, other studies have demonstrated the PHQ-9 can be used as a measure of lifetime depression (181).

Despite these limitations, this study demonstrates a clear association between traumatic event exposure and increased depression severity, using a prospective design including pre-trauma measures of depression among a representative sample of an urban population exposed to high levels of traumatic events. The use of a broad assessment of multiple types of traumatic events highlighted the influence of directly experienced traumatic events and multiple traumatic events on increased depression severity over a one-year follow-up period, suggesting that individuals with these trauma histories should be targeted for interventions aimed at alleviating depressive symptoms.

Table 2.1 Characteristics of the study population at Wave 1, Detroit Neighborhood Health Study

	Included in Wave 1 sample		Included in both Waves 1 and 2	
	n	Weighted %	n	Weighted %
Total	1547		1054	
Demographic characteristics				
Sex				
Male	650	46.0	426	47.2
Female	897	54.0	628	52.8
Race				
White and other races	241	13.8	169	13.3
African American	1306	86.2	885	86.7
Age				
18-24 years	132	20.0	56	19.4
25-34 years	142	12.5	78	12.6
35-44 years	260	14.8	163	14.9
45-54 years	352	23.9	245	24.1
55-64 years	345	15.7	261	15.6
≥ 65 years	303	13.1	244	13.4
Marital status				
Married	406	28.8	280	28.8
Divorced, separated, or widowed	550	26.4	414	26.2
Never been married	591	44.9	360	44.9
Socioeconomic status				
Education				
< High school	201	15.4	133	15.2
High school or equivalent	490	43.3	301	42.9
Some college	521	26.5	370	26.8
College degree or graduate work	335	14.7	250	15.0
Household income in past year				
< \$15,000	452	29.8	296	29.1
\$15,000 - \$34,999	363	23.0	260	23.5
\$35,000 - \$49,999	200	14.3	141	15.6
≥ \$50,000	343	20.2	239	19.3
Missing	189	12.7	118	12.5
Lifetime traumatic events and stressors				
Number of lifetime traumatic events				
0	193	13.6	117	13.0
1-3	517	31.7	370	33.0
4-6	411	26.0	289	25.6
7 or more	425	28.7	278	28.4
Number of lifetime stressors				
0	252	17.8	166	17.2
1-2	392	23.2	276	24.0
3-5	531	35.3	351	33.3
6 or more	371	23.7	261	25.4
Social support at Wave 1				
Low social support in past 12 months				
No	1094	71.7	747	72.1
Yes	452	28.3	306	27.9

Depression severity at Wave 1				
PHQ-9 score, lifetime (Mean, SE)		4.89 (0.24)		4.93 (0.31)
Depression severity, lifetime ^a				
Minimal	933	63.1	630	61.3
Mild	284	16.2	195	17.8
Moderate	166	10.1	117	10.5
Moderately severe	100	7.3	71	6.8
Severe	56	3.4	38	3.6
PHQ-9 score, past month (Mean, SE)		2.84 (0.21)		2.82 (0.27)
Depression severity, past month ^a				
Minimal	1206	78.4	831	78.9
Mild	170	10.5	112	10.2
Moderate	77	5.3	55	5.2
Moderately severe	50	3.3	34	3.0
Severe	28	2.6	14	2.7

^a PHQ-9 score of 0-4 indicates minimal depression during the time period of interest, whereas a score of 5-9 indicates mild depression, 10-14 moderate, 15-19 moderately severe, and 20-27 severe depression

Table 2.2 Percentage reporting traumatic events between Waves 1 and 2, Detroit Neighborhood Health Study (n = 1,054 included in both waves)

	n	Weighted %	Standard error of weighted %
Assaultive violence	58	7.3	1.5
Military combat or exposure to war	6	0.7	0.4
Raped	2	0.1	0.04
Other kind of sexual assault or unwanted sexual contact	12	1.5	0.7
Shot or stabbed	2	0.3	0.3
Held captive, tortured, or kidnapped	1	0.04	0.04
Mugged, held up, or threatened with a weapon	37	4.8	1.2
Badly beaten up	12	1.3	0.6
Other injury or shocking experience	178	17.7	2.0
Serious car or motor vehicle crash	26	3.4	1.1
Any other kind of serious accident or injury	34	4.1	1.0
Fire, flood, earthquake, or other natural disaster	15	1.3	0.5
Diagnosed with a life-threatening illness or had a serious operation	53	3.5	0.7
Child of yours diagnosed with a life-threatening illness	22	1.1	0.3
Witnessed someone being killed or seriously injured	54	6.7	1.4
Unexpectedly discovered a dead body	21	1.5	0.5
Learning about traumas to others	185	19.4	2.1
Learned that a close friend or relative was raped or sexually assaulted	56	6.8	1.4
Learned that a close friend or relative was seriously physically attacked	90	8.8	1.4
Learned that a close friend or relative was seriously injured in a motor vehicle crash	76	7.5	1.3
Learned that a close friend or relative was seriously injured in any other accident	44	5.2	1.2
Sudden, unexpected death of a close friend or relative	394	38.1	2.5
Any traumatic event	539	54.3	2.5
Number of traumatic events (Mean, SE)			0.97 (0.07)
0	515	45.7	2.5
1	320	33.4	2.4
2	124	11.1	1.6
3 or more	95	9.8	1.5

Table 2.3 Bivariable associations between demographics, socioeconomic status, lifetime traumatic events and stressors, and social support at Wave 1 and traumatic events between Waves 1 and 2 (n = 1,054)

	Any traumatic event		Type of traumatic event					Number of traumatic events			
	Any traumatic event (n = 539)	p-value ^a	No trauma (n = 515)	Sudden death of someone close (n = 217)	Learned of trauma to someone close (n = 115)	Other injury or shocking event (n = 149)	Assaultive violence (n = 58)	1 event (n = 320)	2 events (n = 124)	3 or more events (n = 95)	p-value ^a
	%		%	%	%	%	%	%	%	%	
Total	54.3		45.7	22.8	10.0	14.3	7.3	33.4	11.1	9.8	
Demographic characteristics											
Sex											
Male	54.5	0.954	45.5	19.3	9.3	15.3	10.6	29.8	13.1	11.7	0.270
Female	54.2		45.8	25.9	10.6	13.4	4.4	36.7	9.3	8.1	
Race											
White and other races	49.3	0.453	50.7	20.1	7.4	18.7	3.0	30.0	9.4	9.9	0.911
Black	55.1		44.9	23.3	10.3	13.6	8.0	34.0	11.3	9.8	
Age											
18-24 years	62.4	0.126	37.6	27.5	10.3	7.8	16.8	39.0	12.9	10.6	0.520
25-34 years	48.3		51.7	11.8	13.1	15.1	8.4	24.1	10.3	14.0	
35-44 years	49.1		50.9	16.6	14.9	13.8	3.8	30.5	9.5	9.1	
45-54 years	61.2		38.8	26.1	9.7	19.1	6.3	34.8	15.1	11.3	
55-64 years	54.9		45.1	26.5	8.3	15.2	4.9	36.6	9.0	9.3	
≥ 65 years	42.4		57.6	23.3	3.7	14.0	1.3	31.8	6.8	3.8	
Marital status											
Married	50.2	0.454	49.8	20.5	7.1	19.3	3.2	29.7	10.0	10.5	0.720
Div, sep, or widowed	53.8		46.2	27.4	9.2	12.6	4.6	36.8	10.3	6.8	
Never been married	57.3		42.7	21.6	12.2	12.1	11.5	33.9	12.3	11.1	

Socioeconomic status												
Education												
< High school	48.8	0.148	51.2	23.3	6.4	15.0	4.1	0.037	29.2	8.2	11.4	0.222
High school or equivalent	55.2		44.8	22.1	6.5	16.6	10.0		31.9	14.6	8.7	
Some college	61.1		38.9	26.7	14.2	12.3	7.9		39.2	9.2	12.7	
College degree or grad work	45.1		54.9	17.2	15.9	10.4	1.6		31.8	7.2	6.1	
Household income in past year												
< \$15,000	59.0	0.586	41.0	28.1	6.6	10.8	13.5	0.010	38.9	5.6	14.4	0.012
\$15,000 - \$34,999	57.0		43.0	14.9	14.1	17.9	10.1		24.2	18.8	14.0	
\$35,000 - \$49,999	48.2		51.8	21.3	7.9	15.3	3.6		33.1	12.2	2.9	
≥ \$50,000	52.3		41.7	23.6	14.7	12.4	1.6		35.5	9.3	7.4	
Missing	49.1		50.9	25.9	5.1	17.2	1.0		35.1	10.8	3.3	
Lifetime traumas and stressors												
No. lifetime traumatic events												
0	38.2	0.005	61.8	25.9	1.2	4.6	6.5	<0.001	34.2	3.1	0.9	<0.001
1-3	50.4		49.6	26.9	8.4	13.4	1.7		37.7	8.4	4.3	
4-6	52.3		47.7	19.3	12.5	8.8	11.7		30.2	13.5	8.6	
7 or more	66.6		33.4	20.2	13.0	23.7	9.7		31.5	15.1	20.0	
No. lifetime stressors												
0	43.2	0.003	56.8	24.9	6.5	5.8	6.0	0.010	33.4	7.6	2.3	<0.001
1-2	45.7		54.3	23.1	9.8	11.1	1.8		33.6	8.5	3.6	
3-5	55.4		44.6	22.7	9.8	14.7	8.1		32.9	11.9	10.6	
6 or more	68.6		31.4	21.2	12.7	22.5	12.3		34.0	14.9	19.7	
Social support at Wave 1												
Low social support, past 12 mos												
No	53.3	0.530	46.7	23.8	9.2	13.4	6.9	0.732	34.7	10.5	8.2	0.311
Yes	56.7		43.3	19.9	11.9	16.6	8.3		30.0	12.8	13.9	

^a p-values are from two-tailed Chi-square tests

Table 2.4 Estimated ratio of average past month PHQ-9 score at Wave 2, comparing covariate levels (Mean Ratio and 95% CI), by choice of traumatic event measure and covariates: Results of negative binomial regression analyses (n = 1,054)^a

	Model 1: Separate models adjusted only for Wave 1 PHQ-9 score		Adjusted Model 2 with any traumatic event		Adjusted Model 3 with type of traumatic event		Adjusted Model 4 with number of traumatic events	
	Mean Ratio ^b	95% CI	Mean Ratio ^b	95% CI	Mean Ratio ^b	95% CI	Mean Ratio ^b	95% CI
Wave 1 PHQ-9 score	1.13	(1.10-1.16)	1.10	(1.07-1.12)	1.10	(1.07-1.13)	1.09	(1.06-1.12)
Traumatic events between Waves 1 and 2								
Any traumatic event								
No	1	(ref)	1	(ref)	--	--	--	--
Yes	2.12	(1.54-2.91)	1.75	(1.30-2.36)	--	--	--	--
Type of traumatic event								
No traumatic events	1	(ref)	--	--	1	(ref)	--	--
Sudden death of someone close	1.55	(1.01-2.38)	--	--	1.16	(0.78-1.73)	--	--
Learned of trauma to someone close	1.49	(0.92-2.39)	--	--	1.45	(0.89-2.36)	--	--
Other injury or shocking event	2.91	(1.90-4.47)	--	--	2.52	(1.70-3.73)	--	--
Assaultive violence	3.17	(1.78-5.65)	--	--	2.54	(1.44-4.47)	--	--
Number of traumatic events								
0 traumatic events	1	(ref)	--	--	--	--	1	(ref)
1 traumatic event	1.67	(1.14-2.46)	--	--	--	--	1.32	(0.94-1.87)
2 traumatic events	2.62	(1.55-4.42)	--	--	--	--	2.26	(1.39-3.68)
3 or more traumatic events	3.05	(2.03-4.58)	--	--	--	--	2.73	(1.73-4.30)
Demographic characteristics								
Gender								
Male	1	(ref)	1	(ref)	1	(ref)	1	(ref)
Female	1.13	(0.80-1.62)	1.57	(1.16-2.12)	1.75	(1.30-2.36)	1.73	(1.28-2.33)
Race								
White or other race	1	(ref)	1	(ref)	1	(ref)	1	(ref)
African American	0.78	(0.46-1.31)	0.77	(0.49-1.21)	0.80	(0.51-1.24)	0.77	(0.50-1.20)
Age								
18-24 years	1	(ref)	1	(ref)	1	(ref)	1	(ref)
25-34 years	0.64	(0.31-1.33)	0.79	(0.39-1.58)	0.68	(0.34-1.34)	0.71	(0.36-1.41)

35-44 years	0.60	(0.33-1.07)	0.68	(0.38-1.24)	0.65	(0.35-1.22)	0.73	(0.40-1.33)
45-54 years	1.05	(0.59-1.88)	1.32	(0.73-2.39)	1.25	(0.69-2.23)	1.38	(0.77-2.47)
55-64 years	0.87	(0.51-1.49)	1.13	(0.62-2.06)	1.14	(0.63-2.06)	1.25	(0.69-2.27)
≥ 65 years	0.48	(0.27-0.86)	0.70	(0.36-1.35)	0.70	(0.36-1.33)	0.78	(0.41-1.50)
Marital status								
Married	1	(ref)	1	(ref)	1	(ref)	1	(ref)
Divorced, separated, or widowed	0.78	(0.54-1.13)	0.89	(0.61-1.29)	0.90	(0.62-1.30)	0.90	(0.62-1.31)
Never been married	1.13	(0.75-1.69)	1.10	(0.75-1.61)	1.15	(0.78-1.69)	1.23	(0.82-1.82)
Socioeconomic status								
Education								
< High school	1	(ref)	1	(ref)	1	(ref)	1	(ref)
High school or equivalent	1.05	(0.65-1.71)	1.25	(0.84-1.88)	1.25	(0.84-1.87)	1.31	(0.88-1.96)
Some college	0.89	(0.56-1.40)	1.05	(0.69-1.60)	1.07	(0.71-1.62)	1.10	(0.73-1.66)
College degree or graduate work	0.61	(0.35-1.05)	0.76	(0.46-1.26)	0.78	(0.46-1.31)	0.81	(0.49-1.35)
Household income								
<\$15,000	1	(ref)	1	(ref)	1	(ref)	1	(ref)
\$15,000 - \$34,999	0.80	(0.52-1.22)	0.74	(0.51-1.08)	0.67	(0.46-0.97)	0.68	(0.47-0.99)
\$35,000 - \$49,999	0.61	(0.31-1.17)	0.55	(0.32-0.93)	0.50	(0.29-0.87)	0.55	(0.32-0.95)
≥ \$50,000	0.69	(0.46-1.03)	0.79	(0.50-1.25)	0.86	(0.53-1.39)	0.83	(0.52-1.33)
Missing	1.02	(0.54-1.92)	1.16	(0.65-2.08)	1.01	(0.59-1.71)	1.13	(0.66-1.94)
Lifetime traumatic events and stressors								
No. lifetime traumatic events								
0	1	(ref)	1	(ref)	1	(ref)	1	(ref)
1-3	1.57	(0.72-3.41)	1.79	(0.86-3.70)	1.89	(0.93-3.81)	1.84	(0.91-3.69)
4-6	1.91	(0.90-4.06)	2.57	(1.21-5.44)	2.63	(1.26-5.48)	2.61	(1.25-5.41)
7 or more	2.84	(1.35-5.96)	3.10	(1.38-6.97)	2.92	(1.32-6.46)	3.03	(1.37-6.68)
No. lifetime stressors								
0	1	(ref)	1	(ref)	1	(ref)	1	(ref)
1-2	0.99	(0.52-1.89)	0.73	(0.42-1.29)	0.69	(0.41-1.18)	0.72	(0.43-1.22)
3-5	1.27	(0.73-2.20)	0.72	(0.41-1.26)	0.68	(0.39-1.20)	0.71	(0.41-1.23)
6 or more	1.80	(1.02-3.18)	0.83	(0.44-1.57)	0.81	(0.43-1.54)	0.82	(0.43-1.55)
Low social support in past 12 months								
No	1	(ref)	1	(ref)	1	(ref)	1	(ref)
Yes	1.50	(1.07-2.12)	1.53	(1.14-2.06)	1.50	(1.11-2.02)	1.47	(1.09-1.98)

^a Results in the first column (labeled “Model 1”) are from separate models including each listed covariate in turn (e.g., any traumatic event), and also adjusting for Wave 1 PHQ-9 score; Models 2-4 are adjusted for all the covariates listed in the table.

^b Ratio of the mean past month Wave 2 PHQ-9 score in the category of interest compared to the reference category, or the ratio of the mean past month Wave 2 PHQ-9 score among those separated by one unit of a continuous predictor. Mean ratios are calculated by exponentiating the regression coefficients from negative binomial models.

Table 2.5 Results of adjusted Wald F tests for statistical interactions between potential effect measure modifiers and traumatic event exposure between Waves 1 and 2, from adjusted negative binomial regression analyses of past month PHQ-9 score at Wave 2 (n = 1,054)^a

Potential effect measure modifier	Measure of traumatic event exposure between Waves 1 and 2	F statistic	p-value
Low social support in the past 12 months at Wave 1	Any traumatic event	F(1,1027) = 0.95	0.33
	Type of traumatic event	F(4,1024) = 1.51	0.20
	Number of traumatic events	F(3,1025) = 0.91	0.43
Socioeconomic status	Any traumatic event	F(1,1027) = 0.76	0.38
	Type of traumatic event	F(4,1024) = 1.56	0.18
	Number of traumatic events	F(3,1025) = 1.35	0.26
Number of non-traumatic stressors between Waves 1 and 2	Any traumatic event	F(2,1026) = 1.08	0.34
	Type of traumatic event	F(8,1020) = 0.43	0.90
	Number of traumatic events	F(6,1022) = 0.38	0.89
Wave 1 past month PHQ-9 score	Any traumatic event	F(1,1027) = 2.44	0.12
	Type of traumatic event	F(4,1024) = 3.34	0.01
	Number of traumatic events	F(3,1025) = 2.92	0.03

^a Product terms for interactions were included in models adjusted for Wave 1 PHQ-9 score, gender, race, age, marital status, education level, household income, number of lifetime traumatic events and stressors, social support in the past 12 months at Wave 1, and the appropriate measure of traumatic event exposure (except when assessing interactions with SES, in which education and household income were replaced by the composite SES measure).

Figure 2.1 Ratio of mean past month depression severity at Wave 2 among those with each type of traumatic event compared to those with no traumatic events between Waves 1 and 2, by depression severity (PHQ-9 score) at Wave 1

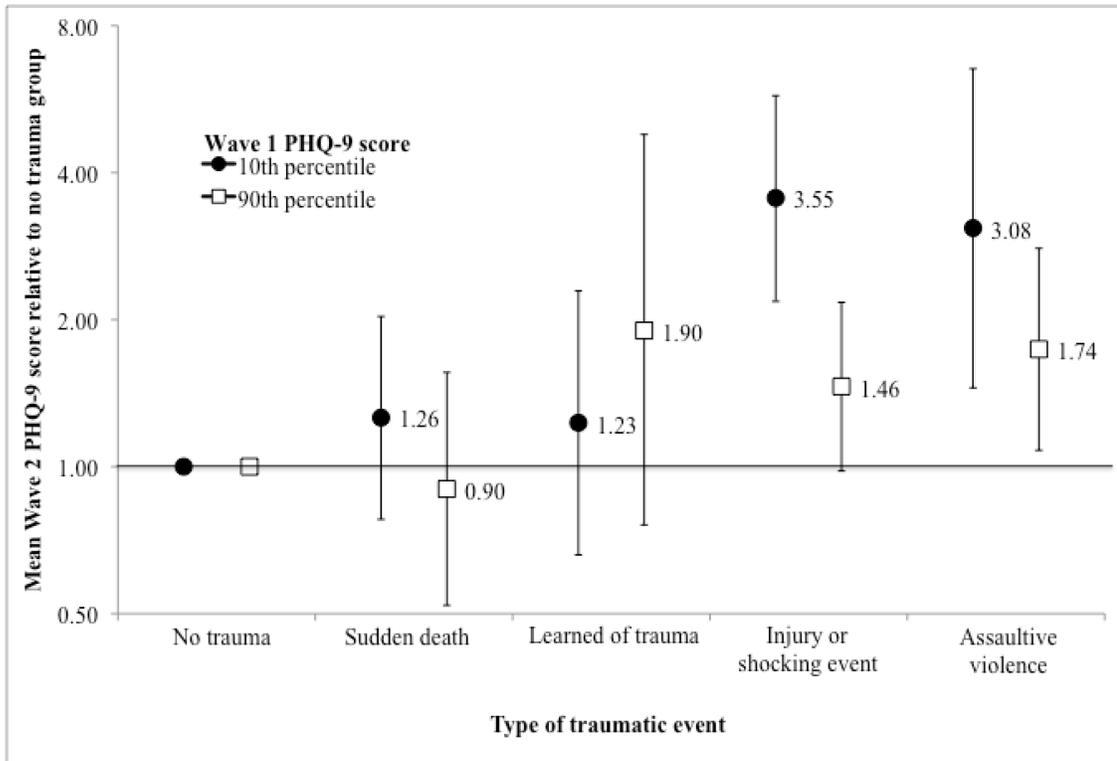
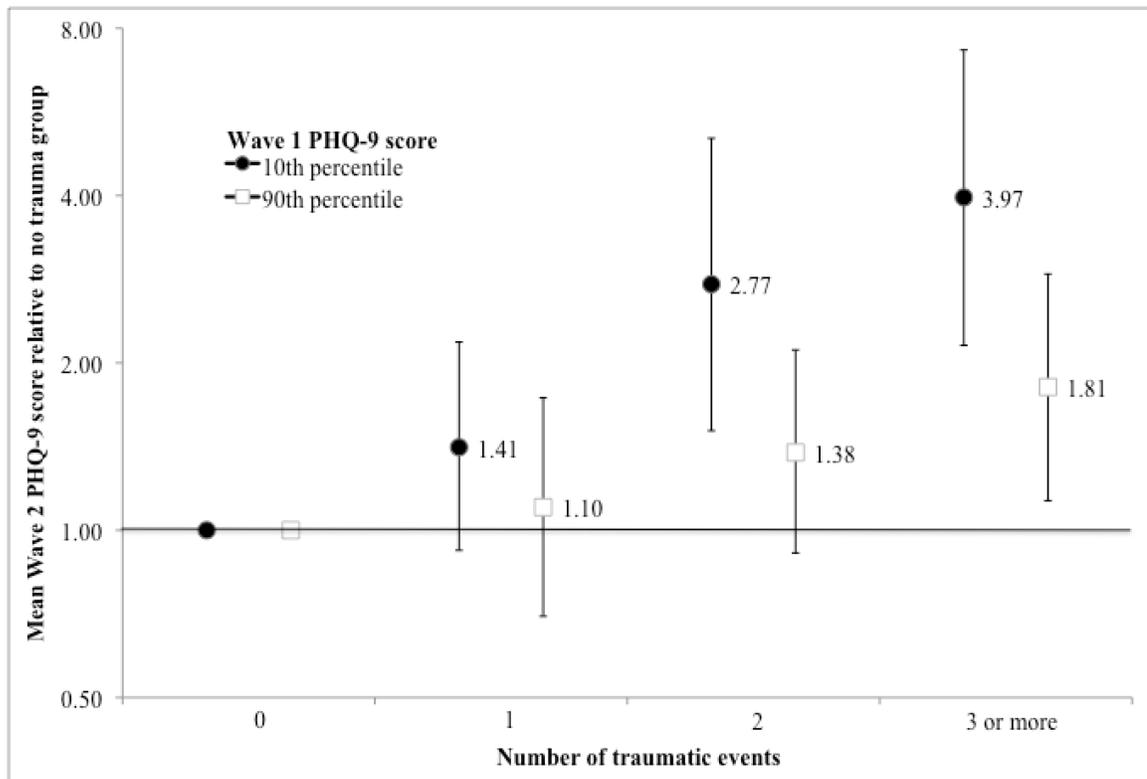


Figure 2.2 Ratio of mean past month depression severity at Wave 2 among those with greater numbers of traumatic events compared to those with no traumatic events between Waves 1 and 2, by depression severity (PHQ-9 score) at Wave 1



Chapter 3

Lifetime traumatic events, stress sensitization, and changes in depression severity in the Detroit Neighborhood Health Study

Background

Most adults are exposed to one or more traumatic events in their lifetime, including life-threatening interpersonal violence, serious injuries resulting from motor vehicle and other accidents, and the sudden and unexpected death of a loved one (30, 104, 105, 121). Although the majority of individuals faced with such events demonstrate extraordinary resilience, exhibiting only fleeting mental health problems or no discernable psychological response (182), some individuals experience lasting mental health consequences of traumatic events. Numerous studies have demonstrated enduring effects of childhood physical and sexual abuse on depression in adulthood (39, 145, 147, 183, 184). Other studies of lifetime interpersonal violence have demonstrated effects of prior exposure to violence (particularly multiple types of prior violence exposure) on later depression, even when controlling for other violent events that occurred in the interim (116).

Many theories have been proposed and tested to explain the long-term effects of childhood and other early exposure to traumatic events on mental health later in life. Explanations include exposure to other adversities in childhood, like parental neglect or problem drinking, which increases risk for both childhood abuse and later depression

(185, 186); increased substance use and other negative behaviors that are used to “cope” with early trauma but increase risk for later depression (187); the tendency of childhood abuse victims to be “revictimized” at later points in their life, increasing risk for depression and other psychopathology in adulthood (34, 160, 161); early onset of psychopathology in the aftermath of early trauma, which then predisposes individuals to later psychopathology (69); and long-term changes in biological responses to stress produced by early exposure to adversity, which result in heightened reactions to subsequent stressors in a process known as “stress sensitization” (23, 73, 79, 188).

Stress sensitization in the context of stressful life events and depression is generally defined as the process whereby individuals with a history of prior adversity become more likely to experience adverse psychological reactions in response to lower levels of subsequent stress over time (23, 188). Under the “sensitization hypothesis,” prior exposure to adversity lowers the amount of future stress required to produce an adverse psychological reaction like the onset or recurrence of depression (23, 73-75). Evidence for a sensitization effect of early life adversity has been found in animal studies as well as clinical studies, in which changes in the neurobiological systems that control responses to stress, including the hypothalamic-pituitary-adrenal (HPA) axis and the corticotropin-releasing factor (CRF) systems, have been observed among those with adverse early life experiences like maternal neglect or childhood maltreatment compared to those without such experiences (75-77). A number of recent observational studies have also found evidence for the sensitization hypothesis in relation to childhood adversity increasing risk of depression in response to subsequent stress (23, 73, 78, 79). However, studies of the sensitization hypothesis specifically in relation to prior and

recent traumatic events have been less conclusive (189-191), with some researchers arguing that prior psychopathology rather than prior traumatic experiences increases risk for psychopathology after later traumatic event exposure (190, 191).

Our study extends this previous work on the mental health consequences of prior lifetime adversity by examining two related questions in a community-based cohort study of adult residents of the city of Detroit. First, are prior lifetime traumatic events, including different types of prior traumatic events, associated with changes in recent depressive symptoms, adjusting for recent traumatic events, lifetime history of psychopathology, and other potential confounders in this population? Second, do different types of prior traumatic events exert a sensitization effect, lowering the threshold of future trauma required to elicit depressive responses in individuals with a history of such prior events in this population, also adjusting for a lifetime history of psychopathology?

The first question builds on existing research into the effects of childhood abuse and lifetime interpersonal violence to consider the effects of other types of prior traumatic events on recent depression, to address the possibility of confounding of the relation between prior trauma and later depression by prior psychopathology (69), and to investigate the effects of prior traumatic events while simultaneously adjusting for recent traumatic events, which have been hypothesized to serve as one of the major pathways through which prior events may exert their influence on depression later in life (34). Based on inconsistent evidence for long-term effects of prior traumatic events as a whole on recent depression (52), we hypothesized that the total number of prior traumatic events would not be associated with changes in depression severity over a one-year follow-up

period when controlling for traumatic event exposure during that period. However, given fairly robust evidence for lasting effects of childhood physical and sexual abuse and adult violent victimization on mental health (22, 39, 136, 144-146, 192), we hypothesized that numbers of childhood abuse events and prior assaultive violence events would be positively associated with changes in depression severity during the follow-up period, adjusting for the numbers of other types of prior traumatic events and for the number of recent traumatic events.

The second question applies the sensitization hypothesis specifically to prior and recent events of a life-threatening nature, rather than broader measures of prior adversity (which often include childhood adversities like parental divorce or separation) and subsequent stress (which often range from losing one's job to experiencing a traumatic event like sexual assault). Distinguishing different types of prior traumatic events has been identified as critical for adequately investigating the sensitizing influence of these prior events, with prior interpersonal violence most likely to have sensitizing effects (189). Considering the influence of prior psychopathology on the observed effects has also been suggested as a crucial test (190, 191). Given prior evidence for the sensitization hypothesis when assessing depressive symptoms and posttraumatic stress disorder (PTSD) after subsequent stress or trauma among those with and without a prior history of childhood adversity or adulthood interpersonal violence (23, 78, 189), we hypothesized that childhood abuse and prior assaultive violence events would exhibit a sensitizing effect on depressive symptoms following recent traumatic events. By contrast, we hypothesized that the number of prior non-assaultive events (e.g., injuries,

learning of traumas to others, and sudden death) would not exhibit a sensitizing effect on depressive symptoms.

Methods

Study population

This investigation uses data from the first two waves of the Detroit Neighborhood Health Study (DNHS), a community-based cohort study of adult residents of the city of Detroit, Michigan. Eligible participants were 18 years of age or older and were living in the city of Detroit (i.e., not in Hamtramck or Highland Park) at the time of the baseline interview. We sampled 7,041 households in the city of Detroit, identifying telephone numbers from the U.S. Postal Service Delivery Sequence File, which covers the whole Detroit population including non-telephone and cellular-phone-only households, and from a random-digit-dial frame including Detroit households with unlisted telephone numbers. Selected households with at least one listed landline telephone number were contacted via telephone regarding study participation; the remaining households were invited to participate via a mailed letter. The adult in the household with a birthday closest to the interview date was selected as the study participant (125). After the study was described and any questions answered, oral informed consent was obtained from participants. The study was approved by the Institutional Review Board of the University of Michigan.

Telephone interviews were conducted with 1,547 participants, resulting in a cooperation rate of 53.0% and a response rate of 33.1% (126).² The baseline (Wave 1) interview took place between September 9, 2008 and February 3, 2009 and lasted 40 minutes on average. 1,054 Wave 1 participants (68.1%) completed a follow-up interview (Wave 2) approximately one year later, between September 21, 2009 and April 12, 2010, which also lasted 40 minutes on average. Analyses were restricted to the 1,054 individuals who participated in both Wave 1 and Wave 2.

Measures

Depressive symptoms

Depressive symptoms were assessed using the Patient Health Questionnaire-9 (PHQ-9) (127-129), which includes nine items corresponding to the nine DSM-IV criteria for major depressive disorder (31). During the Wave 1 interview, study participants were asked whether there was ever a two-week period in their lifetime in which they were bothered by each of these nine symptoms (e.g., “Little interest or pleasure in doing things”, “Feeling tired or having little energy”). If so, they were asked how often in that two-week period they were bothered by each of the symptoms (1 = several days; 2 = more than half the days; 3 = nearly every day) and whether that occurred in the past 30 days. At the Wave 2 interview, the PHQ-9 was repeated with symptoms assessed for a two-week period since the last interview and in the past 30 days. The total PHQ-9 score

² Participation rates were calculated as follows, where I = completed interviews, Q = quota-outs [contacted persons not interviewed because the quota for their gender had been filled], S = screen-outs [contacted persons who screened out of the interview], R = refusals, Inc = Incomplete interviews, NC = non-contacted households which were never successfully reached, and NS = non-screened callbacks [households where contact was made but eligibility screening was never completed]. Cooperation rate = $(I + Q + S) / (I + Q + S + R + Inc) = 2,332/4,402$. Response rate = $(I + Q + S) / (I + Q + R + Inc + NC + NS) = 2,332/7,401$.

in the past 30 days at Waves 1 and 2 was calculated by summing respondent frequency ratings of the nine items (coded 0-3) for a total score ranging from 0 to 27. Cronbach's alpha for the past month PHQ-9 scale was 0.87 at Wave 1 and 0.85 at Wave 2 in the study sample. The total PHQ-9 score in the respondent's lifetime prior to the Wave 1 interview was also calculated (Cronbach's alpha was 0.84 for this scale). Participants with a lifetime PHQ-9 score ≥ 10 (Kroenke et al., 2001) and onset of symptoms prior to the year of the Wave 1 interview were considered cases of probable lifetime depression.

The PHQ-9 has been found to have excellent internal consistency, test-retest reliability, criterion validity (compared to a diagnostic interview conducted by a mental health professional) and construct validity (with increasing PHQ-9 scores reflecting increasing functional impairment, disability, and health care utilization) in primary care settings (127, 130) as well as in the general population (131). The PHQ-9 score indicates depression severity, with scores of 0-4 reflecting minimal or no depression, scores of 5-9 reflecting mild depression, 10-14 moderate, 15-19 moderately severe, and 20-27 severe depression (127). A PHQ-9 score of 10 or higher was associated with 88% sensitivity and 88% specificity for a diagnosis of major depression among 580 primary care patients (127). Additional studies have found that the PHQ-9 functions similarly across racial/ethnic groups, with high internal consistency and similar mean total scores across groups (132), and that the PHQ-9 can be reliably administered over the telephone (133). Finally, changes in the PHQ-9 total score have been shown to reflect changes in depression diagnostic status according to structured clinical interviews, demonstrating the utility of the PHQ-9 for longitudinal research (134).

Traumatic events

Information about nineteen potentially traumatic events experienced by participants in their lifetime was obtained during the Wave 1 interview using a subset of DSM-IV Criterion A traumatic events that has been used in prior research in the Detroit metropolitan area (121). These events can be grouped into four broad categories, following the example of Breslau and colleagues (121): (1) “assaultive violence” events are characterized by intentional violence by a perpetrator towards the study participant (e.g., rape or other sexual assault; having been shot or stabbed); (2) “other injuries or shocking experiences” are encountered directly by the participant but do not involve violence directed at the participant, rather involving an external threat like technology, nature, illness, or injury (e.g., serious motor vehicle accident, natural disaster), or witnessing violence directed at someone else; (3) “learning of traumatic events to close friends or relatives” (e.g., learning that a close friend or relative was seriously physically attacked) was added as a qualifying traumatic event in the DSM-IV (135), and is distinguished from events that were experienced directly by participants; and (4) the “sudden, unexpected death of a close friend or relative”, which is often considered separately from other traumatic events because of its high period prevalence in the population (106, 121).

During the Wave 2 interview, respondents were asked whether any of these nineteen traumatic events had occurred since the last interview. A count of the number of distinct traumatic events reported to have occurred between the Wave 1 and 2 interviews (e.g., rape, motor vehicle accident, natural disaster), regardless of type, was created. These events are referred to as “recent traumatic events” (as opposed to “prior traumatic events” which occurred in the participant’s lifetime prior to the baseline interview).

Also during the Wave 2 interview, study participants were asked a series of questions about physically and verbally abusive behaviors perpetrated by family members during their childhood. Childhood physical abuse (before the age of 18) was assessed with six items adapted from the Conflict Tactics Scales – Parent to Child (193), including “Did your parent, step-parent, or adult guardian ever kick, bite or punch you?”, “hit you with something that hurt your body”, “choke or burn you”, or “physically attack you in some other way”. Response choices were “never”, “once”, “a few times”, or “more than few times.” Severe childhood physical abuse was indicated by responses of “a few times” or “more than a few times” to items assessing the frequency of being kicked, bitten, or punched or being physically attacked in some other way; being choked or burned was considered severe abuse regardless of frequency (193). Participants were also asked whether they had experienced unwanted sexual contact before the age of 18 years old, with questions adapted from Wyatt’s Interview Guide (194). Childhood sexual abuse was indicated by responses of “Yes” to either of the following items: “Were you ever touched in a sexual way by an adult or an older child, or were you forced to touch an adult or an older child in a sexual way when you did not want to?” and “Did an adult or older child ever force you or attempt to force you into any sexual activity by threatening you, holding you down or hurting you in some way when you did not want to?”. These retrospective measures of childhood physical and sexual abuse have previously been used in a number of studies, including the Adverse Childhood Experiences Study (122) and the Nurses’ Health Study II (195, 196).

A count of the total number of lifetime traumatic events prior to the baseline interview was created, including the nineteen events listed above along with the two

measures of childhood abuse (physical and sexual abuse). The numbers of each type of prior traumatic event were also created, including childhood abuse (0-2), assaultive violence (0-7), other injuries or shocking events (0-7), learning of traumas to others (0-4), and the sudden, unexpected death of a loved one (yes or no).

Lifetime psychopathology

Posttraumatic stress disorder in the participant's lifetime was assessed at Wave 1 using the PTSD Checklist-Civilian version (PCL-C), which consists of 17 items corresponding to criteria B (re-experiencing), C (avoidance), and D (arousal) symptoms (197-200). Participants reported how much they were bothered by each symptom (with choices ranging from "not at all" to "extremely") in reference to the lifetime traumatic event reported to be their "worst"; symptoms were counted if respondents were at least "moderately" bothered by them (198, 200). Participants who reported more than one traumatic event in their lifetime at the Wave 1 interview were also asked about one other traumatic event, randomly selected by computer from the traumatic events other than the one deemed the "worst." Participants met criteria for lifetime probable PTSD prior to Wave 1 if they endorsed one or more re-experiencing symptom, three or more avoidance symptoms, and two or more arousal symptoms for either their worst lifetime traumatic event or for the randomly selected traumatic event (158). The PCL-C has demonstrated excellent internal consistency (Cronbach's alpha was 0.93 in our study sample) and substantial agreement with clinical diagnoses of PTSD and symptom ratings (197, 199, 200).

Generalized anxiety disorder in the participant's lifetime was assessed using the GAD-7 scale at Wave 1 (201). Respondents were asked to report whether there was ever

a two-week period in their lifetime in which they were bothered by each of seven symptoms (e.g., “Feeling nervous, anxious, or on edge?”). If so, they were asked how often in the two-week period they were bothered by each of the symptoms (1 = several days; 2 = more than half the days; 3 = nearly every day). The total GAD-7 score was calculated by summing respondent frequency ratings of the seven items, for a total score ranging from 0-21 (Cronbach’s alpha was 0.87 for the total GAD-7 scale in our sample). Participants with lifetime probable GAD were identified as those with a GAD-7 total lifetime score ≥ 10 (201). The GAD-7 has demonstrated good test-retest reliability and excellent internal consistency; a cutpoint of 10 was associated with 89% sensitivity and 82% specificity for a diagnosis of GAD using the Structured Clinical Interview for DSM-IV (201).

Socio-demographic characteristics

The DNHS Wave 1 interview also collected information on the demographic characteristics of study participants, including gender, age, marital status, and race/ethnicity. Socioeconomic characteristics of participants were also assessed, including educational attainment and household income.

Statistical analyses

First, we examined descriptive statistics for the demographic characteristics, socioeconomic status, and history of psychopathology prior to Wave 1 of the analysis sample (i.e., $n = 1,054$ who participated in both Waves 1 and 2). Second, we calculated the percentage of DNHS participants who reported experiencing each of the twenty-one lifetime traumatic events prior to Wave 1 and nineteen traumatic events between Waves 1 and 2. Third, we calculated the count of each type of prior traumatic event, as well as the

number of recent traumatic events occurring between Waves 1 and 2; descriptive statistics, including Spearman rank correlation coefficients (ρ), for these counts were examined. Fourth, we ran one-way analysis of variance (ANOVA) tests comparing the mean numbers of each type of prior traumatic event across categories of demographics, socioeconomic status, and lifetime history of psychopathology, including prior probable depression, PTSD, and GAD.

Fifth, we used negative binomial regression models to assess associations between lifetime traumatic events prior to Wave 1 and changes in depression severity between Waves 1 and 2. The outcome of these models was the total PHQ-9 score in the past month at Wave 2; controlling for the total PHQ-9 score in the past month at Wave 1 allowed us to examine associations with change in depression severity. The PHQ-9 score at Wave 2 was skewed right, with a mean of 3.44 but a median of 0 (indeed, approximately 50% of the scores were zero). A linear regression model was not appropriate because of the skewed distribution of the PHQ-9 score, and transformations could not improve the normality of the distribution because of the large proportion of zero values. Negative binomial models have been proposed for use with discrete outcome data like symptom scores (139) and have been used in several other studies of depressive symptoms measured by the PHQ-9 (47, 140, 141). The PHQ-9 score also exhibited overdispersion, in which the variance is greater than the mean, suggesting that negative binomial models would be more appropriate than Poisson models, which can also be used for discrete outcome data but which assume variance equal to the mean (139, 142). Results of a likelihood ratio test comparing the negative binomial model to a Poisson model confirmed the choice of the negative binomial model (log likelihood for

Poisson (P) model = -3407.08, log likelihood for negative binomial (NB) model = -2035.73; $-2 \times (-LL(P) - LL(NB)) = 2742.70$, $p < 0.001$). The exponentiated regression coefficients ($e^{\hat{\beta}}$) from the fitted negative binomial models can be interpreted as the ratio of the average PHQ-9 score among those in one category of the predictor versus the reference category (for a categorical predictor), or the ratio of the average PHQ-9 score among those separated by one unit of a continuous predictor. We will use the term “mean ratio” to refer to these estimates hereafter.

In addition to the Wave 1 PHQ-9 score, all models included adjustment for gender, race (African American; other race), age (18-24; 25-34; 35-44; 45-54; 55-64; 65 or greater), marital status (married; divorced, separated, or widowed; never married), educational attainment (less than high school; high school degree or equivalent; some college; college degree or graduate work), and annual household income at baseline (<\$15,000; \$15,000-\$34,999; \$35,000-\$49,999; \$50,000 or more; 118 respondents with missing income information were included in a separate category). All of these characteristics have been found to be associated with greater exposure to traumatic events, overall or of certain types (30, 104, 121), as well as with levels of depressive symptoms (4, 9, 11, 12). Lifetime probable depression, PTSD, and GAD were also included in models to assess the possibility that prior psychopathology is strongly associated with subsequent depression and would alter the observed association between prior traumatic events and later depression (39, 190).

We tested the “sensitization hypothesis” by including a product term for the statistical interaction between the number of lifetime traumatic events prior to Wave 1 and the number of recent traumatic events between Waves 1 and 2 in the final adjusted

model; both main predictors were treated as interval variables in the models. Product terms for the interactions between each of the five types of lifetime traumatic event and the total number of recent traumatic events were included in separate models, for a total of six models. These models also included adjustment for Wave 1 PHQ-9 score, baseline demographics and SES, lifetime history of depression, PTSD, and GAD prior to Wave 1, and (for models including interactions with one type of lifetime trauma) the numbers of each other type of lifetime traumatic event. Departure from homogeneity of the ratio of the mean PHQ-9 scores for an increase of one recent traumatic event across numbers of lifetime traumatic events was assessed using an adjusted Wald F test with the null hypothesis that all product terms in the model had coefficients of 0; this test approximates the likelihood ratio test comparing models with and without the product terms, but it is more appropriate than the likelihood ratio test when using complex survey data (154). Because of limited power to detect interactions, a p-value less than 0.15 associated with the F statistic was used as an indicator of departure from multiplicativity.

Although many studies testing the sensitization hypothesis have used regression models including a statistical interaction between prior and recent stress, there has been some inconsistency in how the results of these models have been interpreted. For example, both negative (23, 73) and positive coefficients (78, 202) for the product term have been touted as evidence of sensitization, in keeping with a more general definition of “sensitization” to indicate changes in responses to subsequent stress resulting from prior adversity. In keeping with our more limited definition, that “stress sensitization” refers to the process by which individuals with a history of adversity have a lowered threshold of stress required to produce depressive responses, we expected evidence of

sensitization in the form of positive main effects for the number of both prior and recent traumatic events on current depression severity but a negative statistical interaction (heterogeneity of the mean ratio) between prior and recent traumatic events in predicting changes in depression severity (23, 73). That is, we expect the adjusted mean ratio of the PHQ-9 score at Wave 2, comparing participants with several vs. no recent traumatic events, to be greater for participants with no traumatic events before Wave 1 than for participants with several traumatic events before Wave 1. Such a negative statistical interaction is consistent with the idea underlying the sensitization hypothesis, that differences between individuals with and without a prior history of trauma will be evident in their responses to lower levels of stress, while both groups would be expected to react to high levels of stress (23, 73, 79). Thus, we expected to find positive main effects but a negative statistical interaction between prior and recent traumatic events when examining childhood abuse and prior assaultive violence, but since we hypothesized that the number of prior non-assaultive events (e.g., injuries, learning of traumas to others, and sudden death) would not exhibit a sensitizing effect, we expected to find no evidence of a statistical interaction between these types of prior traumatic events and the number of recent traumatic events in multiple regression models predicting depression severity. To further characterize stress sensitization effects, we estimated slopes of the relation between the number of recent traumatic events and the log of the past month PHQ-9 score from each fully adjusted model including a product term for the interaction between prior and recent traumatic events and graphed these lines for different numbers of prior traumatic events (corresponding to the 10th and 90th percentiles).

All analyses were weighted to account for differential probabilities of selection into the study across participants, by number and types of telephone numbers and number of adults in households. Post-stratification weights were also incorporated to ensure comparability between the study sample and the population of the city of Detroit on socio-demographic characteristics (gender, age, race/ethnicity, marital status, educational attainment, and household size), housing tenure, and type of telephone service, using data from the 2005-2007 American Community Survey (155). Finally, attrition weights were developed using the inverse probability of censoring method (156) to account for differences between respondents who participated in the Wave 2 interview and the full baseline sample. Weighted percentages, means, and associations are thus approximately unbiased estimates of the percentages, means, and associations in the underlying source population or sampling frame (i.e., all adult residents in the city of Detroit at the time of the baseline interview). All analyses were conducted in Stata (Version 10.1, Stata Corporation, College Station, TX), appropriately accounting for the weights and the complex sampling design.

Results

Table 3.1 shows the weighted percentages of demographic characteristics and socioeconomic status indicators in the sample, corresponding to distributions in the source population. For lifetime psychopathology, 14.6% of the source population had a lifetime history of probable depression prior to the time of the Wave 1 interview, whereas 13.8% and 11.1% had a lifetime history of PTSD and GAD, respectively.

Lifetime exposure to traumatic events in the source population was high, with 21.6% experiencing childhood physical or sexual abuse and 51.4% experiencing some type of assaultive violence including being mugged (34.0%) or badly beaten up (14.9%) (Table 3.2). Nearly two thirds (63.7%) of adult residents of the city of Detroit had experienced some other injury or shocking experience in their lifetime, including witnessing someone being killed or seriously injured (32.0%) and being in a serious motor vehicle accident (24.1%). Learning of a traumatic event to a close friend or relative was also common, with 62.9% of the source population experiencing this at least once, and nearly 70% experiencing the sudden, unexpected death of a close friend or relative in their lifetime. Overall, 87.7% of adults in the city of Detroit had experienced at least one traumatic event in their lifetime prior to the time of the Wave 1 interview. Exposure to more than one lifetime traumatic event was common in this population, who experienced an average of 4.66 (SD 3.61) lifetime events (Table 3.3). Numbers of different types of prior traumatic events were fairly highly correlated in this population, with correlation coefficients ranging from 0.16-0.50 (Table 3.3). Numbers of lifetime traumatic events were also correlated with the number of traumatic events experienced by individuals during the one-year follow-up period between Waves 1 and 2 ($\rho = 0.25$ for the correlation between the total number of prior and recent traumatic events).

Table 3.4 shows unadjusted associations between demographic characteristics, SES, and lifetime psychopathology with numbers of different types of prior traumatic events. Females experienced more childhood abuse events than males (0.35 vs. 0.15). Numbers of lifetime events generally increased with age, although the oldest individuals often reported the lowest number of events (e.g., total numbers of lifetime events were

3.78 for 18-24 year olds, 4.95 for 25-34 and 35-44 year olds, 5.48 for 45-54 year olds, 5.12 for 55-64 year olds, and 3.41 for those 65 years and older). Numbers of lifetime events generally decreased with increasing education and household income, although patterns were not entirely consistent. However, individuals with a probable history of depression, PTSD, and GAD all had consistently higher exposure to all types of lifetime traumatic events than those without a probable history of one of these disorders.

Number of lifetime traumatic events prior to Wave 1 was positively associated with depression severity at Wave 2 (mean ratio = 1.08 per event, 95% confidence interval [CI] 1.03-1.13), when controlling for Wave 1 depression severity, number of traumatic events between Waves 1 and 2, and demographic and socioeconomic characteristics (Table 3.5, Model 1). The association remained, only slightly attenuated, when also controlling for prior history of probable depression, PTSD, and GAD (mean ratio = 1.07 per number of lifetime traumatic events, 95% CI 1.01-1.12) (Model 2). When modeling the numbers of different types of lifetime traumatic events simultaneously, the strongest adjusted association with depression severity at Wave 2 was for number of childhood abuse events (mean ratio = 1.38 per childhood abuse event, 95% CI 1.05-1.83) (Model 3), though positive associations were observed for the numbers of other types of lifetime events as well (mean ratio = 1.10 per lifetime assaultive violence event, 95% CI 0.98-1.25; mean ratio = 1.04 per lifetime injury or shocking event, 95% CI 0.92-1.17; mean ratio = 1.07 per lifetime learning of trauma to others, 95% CI 0.94-1.22; and mean ratio = 1.08 for lifetime experience of the sudden death of a loved one compared to no such experience, 95% CI 0.74-1.58). The magnitudes of these associations were only slightly reduced by controlling for prior psychopathology in addition to the Wave 1 PHQ-9 score,

the number of traumatic events between Waves 1 and 2, and baseline demographics and SES (e.g., mean ratio = 1.36 per childhood abuse event, 95% CI 1.03-1.79) (Model 4).

To evaluate the sensitization hypothesis, negative binomial regression models were fitted with product terms for the statistical interaction between the number of total or each type of prior traumatic events and the number of recent traumatic events during the one-year follow-up period. The estimated slopes of the relation between the number of traumatic events between Waves 1 and 2 and the log of the past month PHQ-9 score at Wave 2 are plotted in Figures 3.1-3.6, with separate figures from each adjusted model including one product term. Estimated slopes are presented for numbers of prior traumatic events corresponding to the 10th and 90th percentiles of the distributions of each type of lifetime event. Departure from multiplicativity on the mean-ratio scale was observed for all interactions between numbers of lifetime and recent traumatic events. Specifically, negative statistical interactions were found, such that the slope of the relation between greater numbers of recent traumatic events and the log of the depression severity score was smaller among those with higher numbers of prior traumatic events. Besides the negative product term, numbers of both prior traumatic events and recent traumatic events were positively associated with depression severity, as expected.

Discussion

In this longitudinal study of adult residents of the city of Detroit, we found positive associations between the number of prior and recent traumatic events and depression severity, as measured by the PHQ-9 score in the month prior to the follow-up interview, controlling for the baseline PHQ-9 score and other potential confounders

including prior psychopathology. When separating prior traumatic events by type, associations with depression severity were most pronounced for childhood abuse events. We also found evidence for a stress sensitization effect of prior traumatic events, controlling for baseline depression severity, baseline demographics and SES, and a prior history of psychopathology. Specifically, study participants with a history of childhood abuse, prior assaultive violence, and greater total number of prior traumatic events exhibited greater depression severity than participants without such adverse histories when exposed to low numbers of recent traumatic events.

We estimated that nearly all adults in the source population had been exposed to at least one traumatic event in their lifetime, with many being exposed to more than one such event. This is similar to other estimates from the Detroit metropolitan area (121). In particular, history of prior assaultive violence was high compared to other studies reporting lifetime prevalence of these events in community-based samples (30, 104, 121). These estimates suggest that this population may be at particular risk for depression, PTSD, and other anxiety disorders, as well as substance use problems (51, 121), and such disorders were already fairly prevalent in this population at the start of the study.

Experiencing more than one traumatic event was common, and the number of lifetime traumatic events experienced prior to the baseline interview was positively correlated with the number of traumatic events experienced during the follow-up period. This finding is consistent with numerous studies showing that prior traumatic events are associated with future events, including evidence that childhood victims of violence often end up re-victimized later in adulthood (32, 34, 160, 161). Females had experienced greater numbers of childhood abuse events than males, consistent with previous evidence

from studies of childhood sexual abuse (183). Higher socioeconomic status was generally associated with a smaller number of prior traumatic events, consistent with prior research finding low SES to be a risk factor for traumatic experiences (121). Prior history of depression, PTSD, and GAD was strongly associated with a larger number of prior traumatic events, although it is unclear in this study if prior psychopathology preceded or followed prior traumatic events. The number of lifetime traumatic events prior to Wave 1 (overall and of each type) generally increased with age through the middle age groups, but the oldest age groups had experienced the lowest numbers of lifetime events. This finding may indicate the presence of secular trends consistent with period or birth-cohort effects, suggesting that exposure to traumatic events has changed over time in the Detroit population.

The number of lifetime traumatic events prior to the baseline interview, and the number of childhood abuse events specifically, were positively associated with depression severity at Wave 2, controlling for depression severity at Wave 1 and other potential confounders including prior psychopathology. Thus, our hypothesis that the total number of lifetime events would not be associated with later depression was not supported, whereas evidence of prior childhood abuse and assaultive violence on later depression was found, in line with our hypothesis regarding different types of prior traumatic events. These findings confirm the lasting effects of childhood abuse events on depression later in life (39, 145, 147, 183, 184). Some studies have suggested that other traumatic events in adulthood may mediate relations between childhood abuse and adult depression; for example, Banyard et al. found that childhood sexual abuse was strongly correlated with adult trauma and sexual assault and that associations between childhood

sexual abuse and adult depression were greatly diminished when adjusting for those other traumatic events (34). However, other studies have found associations between childhood abuse and adult mental health outcomes even when adjusting for more recent revictimization experiences (203), as in our study. Recent traumatic events occurring during the follow-up period also remained associated with depression severity, even when controlling for different types of lifetime traumatic events, in contrast with some prior studies (116). These results confirm the importance of interventions for childhood abuse survivors at early ages to reduce the mental health consequences of abuse as well as the probability of revictimization and its attendant mental health consequences (34, 203).

We found some evidence for a sensitization effect of lifetime traumatic events, such that individuals with higher total numbers of prior traumatic events, as well as higher numbers of childhood abuse and prior assaultive violence events, exhibited greater depression severity when exposed to lower numbers of recent traumatic events. This is consistent with our hypotheses as well as early formulations of the stress sensitization hypothesis (23, 73, 188), which posits that early adversity results in changes in neurobiological responses to subsequent stress, leading early victims of adversity to exhibit a lowered threshold for reacting to subsequent stress. These estimated effects persisted when adjusting for numbers of other types of prior traumatic events as well as baseline demographics and SES and prior psychopathology. Although positive main effects and a negative statistical interaction (i.e., our operational definition of stress sensitization) were found when considering number of prior injuries and shocking events, prior history of learning of traumas to others, and prior history of traumatic loss in

relation to recent traumatic events, examining plots of the relations between number of recent traumatic events and depression severity by number of these prior events revealed relations that were less consistent with expected associations under the sensitization hypothesis. Specifically, differences between the groups with and without prior history of trauma were more pronounced at higher (rather than lower) levels of subsequent trauma for these indicators, and the association between prior trauma and depression was unexpectedly inverse (suggesting a protective effect) at higher levels of recent traumas (see Figures 3.5 for learning of traumas to others and 3.6 for death of a loved one).

Testing the sensitization hypothesis has been fraught with ambiguity in many studies, which tend to employ a more general definition of sensitization as the process by which early adversity heightens vulnerability to adverse mental health reactions after subsequent stress (78, 202), rather than focusing on differences between those with and without early adversity in their responses particularly to low levels of subsequent stress. Our results reinforce the idea that interactions between prior and recent traumatic events need not only take the form of higher than expected rates of mental health problems in the group with both prior and recent events (23), and extend prior work to suggest that prior assaultive violence in adulthood as well as in childhood may sensitize individuals to the mental health effects of subsequent stress. Although most clinical and observational studies of stress sensitization have focused on changes resulting from adversity specifically in childhood, the literature on neurobiological changes associated with exposure to trauma seems to suggest that these effects are not limited to those who are young at the time of the trauma exposure (77), although changes may be more dramatic when trauma occurs during key developmental periods (36, 77).

This study focused on previous and recent traumatic events, which generally involved life-threatening experiences of oneself or close family or friends; other studies of the stress sensitization hypothesis have generally focused on broader measures of childhood adversity, including parental divorce and mental health or substance use problems of family members, and stressful life events in adulthood, including unemployment, financial problems, or marital dissolution (23, 78). Some studies have found particular sensitivity to everyday life stressors (e.g., work stress, health problems) in childhood abuse survivors, suggesting that sensitization effects may be particularly salient for subsequent minor stressors (in addition to lower numbers of subsequent severe events) (23, 204). Recent studies finding greater psychological responses among victims of non-traumatic stressors, compared to victims of traumatic events (101, 205) may be missing an important piece of the puzzle by failing to fully take note of the prior history of adverse experiences among participants, which is necessary to fully understand relations between severe and non-severe stressors and mental health.

There are several limitations of this study that should be considered when interpreting the results. First, about 30% of the Wave 1 DNHS participants did not complete the Wave 2 interview. Baseline participants lost to follow-up were younger, less educated, more likely to be unemployed, and unmarried (178). Inverse probability of censoring weights (156) were calculated to address these differences between the participants at follow-up and the full baseline sample, but this method may not fully control for the bias due to selective attrition. Second, the study questionnaire did not assess the exact timing of traumatic events or onset of depressive symptoms during the follow-up period; therefore, some temporal ambiguity exists, with the possibility that

some traumatic events reported to have occurred between Waves 1 and 2 were actually experienced after the onset of depressive symptoms during follow-up. Using a measure of depressive symptoms that is focused on the 30 days prior to the Wave 2 interview ensured that the vast majority of traumatic events experienced by the study population during the one-year follow-up period would likely have occurred prior to the time for which depression was assessed, yet changes in depressive symptoms may still have preceded traumatic events. Third, information on the number of times a specific traumatic event occurred in the participant's lifetime or during the follow-up period was not collected, potentially leading to misclassification of the number of traumatic events experienced by study participants. In particular, we did not distinguish between ongoing and single-occurrence childhood abuse and we counted each type of traumatic event (e.g., rape) only once although it may have occurred multiple times in the participant's lifetime. Fourth, the recall and reporting of traumatic events prior to the Wave 1 interview and since the Wave 1 interview may have been influenced by the participant's level of depressive symptoms at Wave 1 and Wave 2, respectively (179). However, the traumatic events assessed in this study are objective events of serious magnitude; therefore, reporting of such events is less likely to be influenced by changing perceptions of past experiences influenced by current depressive symptoms (180). Finally, we used a slightly nontraditional administration of the PHQ-9, asking about symptoms in the respondent's lifetime and whether each symptom occurred in the past month, rather than referring only to the past two weeks. The PHQ-9 was designed as a measure of current depression, and estimates for the past month are usually considered "current";

furthermore, other studies have demonstrated the PHQ-9 can be used as a measure of lifetime depression (181).

Notwithstanding these limitations, this study used a unique community-based sample of adults in a major urban area with a history of a diverse array of lifetime trauma exposure to show that total numbers of prior traumatic events, and childhood abuse specifically, are associated with depression severity later in life. Early interventions with childhood abuse victims and others exposed to traumatic events early in life could decrease the negative consequences of these events, which also include increased potential for revictimization. Prior experiences of trauma should be assessed when considering risk of depression after subsequent traumatic events, as childhood abuse and prior assaultive violence, as well as the cumulative burden of trauma, may sensitize individuals to the effects of subsequent trauma. Clinical studies suggest that depression treatment effectiveness may vary according to early adversity, perhaps due to the neurobiological changes that occur in response to traumatic events (75), so a full consideration of patients' prior traumatic experiences may be particularly salient in improving depression treatment practices and patient outcomes.

Table 3.1 Demographic characteristics, socioeconomic status, and lifetime psychopathology, Detroit Neighborhood Health Study (n = 1,054 included in both Waves 1 and 2)

	n	Weighted %
Demographic characteristics		
Sex		
Male	426	47.2
Female	628	52.8
Race		
White and other races	163	13.0
Black	885	87.0
Age		
18-24 years	56	19.4
25-34 years	78	12.6
35-44 years	163	14.9
45-54 years	245	24.1
55-64 years	261	15.6
≥ 65 years	244	13.4
Marital status		
Married	280	28.8
Divorced, separated, or widowed	414	26.2
Never been married	360	44.9
Socioeconomic status		
Education		
< High school	133	15.2
High school or equivalent	301	42.9
Some college	370	26.8
College degree or grad work	250	15.0
Household income in past year		
< \$15,000	296	29.1
\$15,000 - \$34,999	260	23.5
\$35,000 - \$49,999	141	15.6
≥ \$50,000	239	19.3
Missing	118	12.5
Lifetime psychopathology prior to Wave 1		
Depression	167	14.6
Posttraumatic stress disorder	146	13.8
Generalized anxiety disorder	115	11.1

Table 3.2 Percentage of sample reporting traumatic events in their lifetime prior to Wave 1 and between Waves 1 and 2 (n = 1,054)

	Lifetime traumatic events prior to Wave 1			Recent traumatic events between Waves 1 and 2		
	n	Weighted %	s.e. of weighted %	n	Weighted %	s.e. of weighted %
Childhood abuse	247	21.6	2.2	--	--	--
Childhood physical abuse	95	10.2	1.7	--	--	--
Childhood sexual abuse	196	15.4	1.7	--	--	--
Assaultive violence	547	51.4	2.5	58	7.3	1.5
Military combat or exposure to war	121	9.5	1.3	6	0.7	0.4
Raped	110	7.4	1.1	2	0.1	0.04
Other kind of sexual assault or unwanted sexual contact	145	12.5	1.6	12	1.5	0.7
Shot or stabbed	108	12.4	1.8	2	0.3	0.3
Held captive, tortured, or kidnapped	48	3.4	0.8	1	0.04	0.04
Mugged, held up, or threatened with a weapon	352	34.0	2.4	37	4.8	1.2
Badly beaten up	143	14.9	2.0	12	1.3	0.6
Other injury or shocking experience	708	63.7	2.5	178	17.7	2.0
Serious car or motor vehicle crash	275	24.1	2.1	26	3.4	1.1
Any other kind of serious accident or injury	153	15.4	1.9	34	4.1	1.0
Fire, flood, earthquake, or other natural disaster	183	16.4	1.8	15	1.3	0.5
Diagnosed with a life-threatening illness or had a serious operation	321	24.7	2.0	53	3.5	0.7
Child of yours diagnosed with a life-threatening illness	78	4.5	0.8	22	1.1	0.3
Witnessed someone being killed or seriously injured	312	32.0	2.4	54	6.7	1.4
Unexpectedly discovered a dead body	142	14.0	1.8	21	1.5	0.5
Learning of traumas to others	639	62.9	2.4	185	19.4	2.1
Learned that a close friend or relative was raped or sexually assaulted	343	36.5	2.5	56	6.8	1.4
Learned that a close friend or relative was seriously physically attacked	377	37.4	2.5	90	8.8	1.4
Learned that a close friend or relative was seriously injured in a motor vehicle crash	446	44.8	2.5	76	7.5	1.3
Learned that a close friend or relative was seriously injured in any other accident	271	27.5	2.3	44	5.2	1.2
Sudden, unexpected death of a close friend or relative	761	69.8	2.4	394	38.1	2.5
Any traumatic event	946	87.7	1.8	539	54.3	2.5

Table 3.3 Spearman rank correlations and descriptive statistics for measures of lifetime traumatic events prior to Wave 1 and recent traumatic events between Waves 1 and 2 (n = 1,054)^a

	1	2	3	4	5	6	Mean (SD)	IQR ^b
1 Number of total lifetime traumatic events							4.66 (3.61)	2-7
2 Number of childhood abuse events in lifetime	0.42						0.25 (0.52)	0
3 Number of assaultive violence events in lifetime	0.73	0.29					0.94 (1.18)	0-2
4 Number of other injuries or shocking events in lifetime	0.79	0.22	0.46				1.31 (1.36)	0-2
5 Number of learning of traumas to others in lifetime	0.82	0.24	0.45	0.50			1.46 (1.41)	0-3
6 Sudden, unexpected death of loved one in lifetime	0.57	0.16	0.28	0.36	0.41		0.70 (0.46)	0-1
7 Number of traumatic events between Waves 1 and 2	0.25	0.21	0.17	0.17	0.22	0.11	0.97 (1.35)	0-1

^a p < 0.001 for all Spearman rank correlation coefficients

^b Interquartile Range (25th and 75th percentiles)

Table 3.4 Mean number of each type of lifetime traumatic event prior to Wave 1 by demographic characteristics, socioeconomic status, and lifetime psychopathology (n = 1,054)^a

	Total number of lifetime traumatic events	Number of childhood abuse events in lifetime	Number of assaultive violence events in lifetime	Number of other injuries or shocking experiences in lifetime	Number of learning of trauma to others in lifetime	Sudden, unexpected death of a loved in lifetime
	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)
Demographic characteristics						
Sex						
Male	4.78 (0.29)	0.15 (0.03)***	0.98 (0.08)	1.40 (0.10)	1.53 (0.11)	0.70 (0.04)
Female	4.56 (0.23)	0.35 (0.04)	0.90 (0.08)	1.23 (0.09)	1.39 (0.09)	0.70 (0.03)
Race						
White and other races	4.43 (0.60)	0.22 (0.07)	0.89 (0.18)	1.25 (0.17)	1.46 (0.21)	0.60 (0.07)
Black	4.69 (0.19)	0.26 (0.03)	0.95 (0.06)	1.32 (0.07)	1.46 (0.08)	0.71 (0.03)
Age						
18-24 years	3.78 (0.55)***	0.25 (0.08)**	0.61 (0.16)***	0.94 (0.19)*	1.36 (0.20)***	0.63 (0.08)
25-34 years	4.95 (0.58)	0.23 (0.07)	1.03 (0.19)	1.22 (0.21)	1.85 (0.24)	0.61 (0.08)
35-44 years	4.95 (0.39)	0.28 (0.06)	1.19 (0.14)	1.31 (0.16)	1.43 (0.16)	0.76 (0.05)
45-54 years	5.48 (0.37)	0.28 (0.05)	1.14 (0.12)	1.56 (0.13)	1.74 (0.14)	0.75 (0.04)
55-64 years	5.12 (0.35)	0.35 (0.07)	1.09 (0.11)	1.56 (0.14)	1.40 (0.14)	0.71 (0.04)
≥ 65 years	3.41 (0.27)	0.11 (0.04)	0.56 (0.07)	1.21 (0.13)	0.84 (0.10)	0.71 (0.04)
Marital status						
Married	4.98 (0.32)	0.25 (0.05)	1.08 (0.11)	1.45 (0.13)	1.49 (0.12)*	0.71 (0.04)
Divorced, separated, or widowed	4.24 (0.26)	0.26 (0.04)	0.82 (0.07)	1.28 (0.10)	1.19 (0.10)	0.70 (0.04)
Never been married	4.70 (0.32)	0.26 (0.04)	0.92 (0.10)	1.24 (0.11)	1.59 (0.12)	0.69 (0.04)

Socioeconomic status

Education

< High school	4.85 (0.52)	0.25 (0.07)	1.02 (0.17)	1.39 (0.20)	1.49 (0.19)	0.71 (0.06)
High school or equivalent	4.47 (0.31)	0.26 (0.04)	0.96 (0.10)	1.20 (0.11)	1.36 (0.13)	0.69 (0.04)
Some college	5.08 (0.32)	0.29 (0.05)	1.00 (0.10)	1.51 (0.12)	1.57 (0.11)	0.72 (0.04)
College degree or grad work	4.26 (0.30)	0.19 (0.04)	0.70 (0.08)	1.21 (0.11)	1.49 (0.13)	0.67 (0.05)

Household income in past year

< \$15,000	5.17 (0.41)**	0.37 (0.05)***	1.23 (0.13)***	1.47 (0.15)**	1.41 (0.14)	0.69 (0.04)*
\$15,000 - \$34,999	5.18 (0.33)	0.29 (0.06)	1.05 (0.12)	1.46 (0.13)	1.67 (0.15)	0.71 (0.05)
\$35,000 - \$49,999	3.98 (0.44)	0.06 (0.02)	0.71 (0.12)	1.15 (0.15)	1.32 (0.19)	0.75 (0.06)
≥ \$50,000	4.75 (0.28)	0.24 (0.05)	0.81 (0.08)	1.34 (0.11)	1.57 (0.12)	0.78 (0.04)
Missing	3.20 (0.43)	0.19 (0.06)	0.56 (0.11)	0.79 (0.16)	1.15 (0.21)	0.52 (0.08)

Lifetime psychopathology

Depression

No	4.14 (0.19)***	0.20 (0.03)***	0.81 (0.06)***	1.13 (0.07)***	1.33 (0.08)***	0.67 (0.03)***
Yes	7.71 (0.40)	0.58 (0.08)	1.72 (0.15)	2.34 (0.17)	2.20 (0.14)	0.86 (0.04)

PTSD

No	4.14 (0.18)***	0.20 (0.02)***	0.81 (0.06)***	1.15 (0.07)***	1.32 (0.08)***	0.66 (0.03)***
Yes	7.89 (0.37)	0.58 (0.09)	1.76 (0.16)	2.33 (0.17)	2.28 (0.17)	0.95 (0.02)

Generalized anxiety disorder

No	4.23 (0.18)***	0.20 (0.02)***	0.83 (0.06)***	1.18 (0.07)***	1.35 (0.07)***	0.67 (0.03)***
Yes	8.12 (0.47)	0.66 (0.10)	1.84 (0.18)	2.36 (0.21)	2.34 (0.18)	0.91 (0.03)

^a p-value from one-way analysis of variance (ANOVA): * p < 0.05, ** p < 0.01, *** p < 0.001

Table 3.5 Estimated ratio of average past month PHQ-9 score at Wave 2, comparing covariate levels (Mean Ratio and 95% CI): Results of negative binomial regression analyses (n = 1,054)

	Adjusted models with total number of lifetime traumatic events prior to Wave 1				Adjusted models with numbers of each type of lifetime traumatic event prior to Wave 1			
	Model 1		Model 2		Model 3		Model 4	
	Mean Ratio ^a	95% CI	Mean Ratio ^a	95% CI	Mean Ratio ^a	95% CI	Mean Ratio ^a	95% CI
Wave 1 PHQ-9 score	1.10	(1.07-1.13)	1.08	(1.04-1.11)	1.09	(1.06-1.12)	1.08	(1.04-1.11)
Lifetime traumatic events prior to Wave 1								
Number of lifetime events	1.08	(1.03-1.13)	1.07	(1.01-1.12)	--	--	--	--
Number of childhood abuse events	--	--	--	--	1.38	(1.05-1.83)	1.36	(1.03-1.79)
Number of assaultive violence events	--	--	--	--	1.10	(0.98-1.25)	1.10	(0.98-1.24)
Number of other injuries or shocks	--	--	--	--	1.04	(0.92-1.17)	1.02	(0.90-1.15)
Number of learning of traumas to others	--	--	--	--	1.07	(0.94-1.22)	1.06	(0.93-1.21)
Sudden, unexpected death of a loved one	--	--	--	--	1.08	(0.74-1.58)	1.10	(0.75-1.60)
Number of traumatic events between Waves 1 and 2	1.31	(1.17-1.46)	1.31	(1.18-1.46)	1.30	(1.17-1.44)	1.30	(1.17-1.45)
Demographic characteristics								
Gender								
Male	1	(ref)	1	(ref)	1	(ref)	1	(ref)
Female	1.51	(1.11-2.05)	1.52	(1.11-2.08)	1.42	(1.04-1.93)	1.42	(1.04-1.95)
Race								
White or other race	1	(ref)	1	(ref)	1	(ref)	1	(ref)
African American	0.78	(0.50-1.20)	0.75	(0.48-1.17)	0.75	(0.48-1.17)	0.73	(0.47-1.14)
Age								
18-24 years	1	(ref)	1	(ref)	1	(ref)	1	(ref)
25-34 years	0.60	(0.31-1.18)	0.59	(0.30-1.16)	0.62	(0.32-1.22)	0.61	(0.31-1.20)
35-44 years	0.82	(0.44-1.52)	0.84	(0.46-1.56)	0.85	(0.46-1.57)	0.87	(0.47-1.60)
45-54 years	1.47	(0.82-2.64)	1.47	(0.82-2.65)	1.51	(0.84-2.73)	1.52	(0.84-2.76)
55-64 years	1.41	(0.76-2.59)	1.37	(0.74-2.53)	1.53	(0.82-2.85)	1.49	(0.80-2.79)
≥ 65 years	0.85	(0.45-1.61)	0.84	(0.44-1.61)	0.98	(0.51-1.89)	0.98	(0.50-1.91)
Marital status								
Married	1	(ref)	1	(ref)	1	(ref)	1	(ref)
Divorced, separated, or widowed	0.92	(0.63-1.34)	0.87	(0.59-1.27)	0.90	(0.63-1.31)	0.86	(0.59-1.26)
Never been married	1.33	(0.88-2.01)	1.28	(0.83-1.96)	1.40	(0.92-2.11)	1.35	(0.89-2.06)

Socioeconomic status

Education

< High school	1	(ref)	1	(ref)	1	(ref)	1	(ref)
High school or equivalent	1.36	(0.94-1.98)	1.36	(0.93-1.99)	1.33	(0.92-1.94)	1.33	(0.91-1.94)
Some college	1.09	(0.73-1.63)	1.02	(0.69-1.52)	1.05	(0.71-1.56)	1.00	(0.67-1.48)
College degree or graduate work	0.82	(0.50-1.35)	0.80	(0.49-1.33)	0.82	(0.50-1.36)	0.81	(0.49-1.34)

Household income in past year

<\$15,000	1	(ref)	1	(ref)	1	(ref)	1	(ref)
\$15,000 - \$34,999	0.75	(0.50-1.13)	0.77	(0.52-1.16)	0.78	(0.52-1.16)	0.80	(0.54-1.20)
\$35,000 - \$49,999	0.63	(0.37-1.06)	0.60	(0.36-1.00)	0.68	(0.39-1.16)	0.65	(0.38-1.09)
≥ \$50,000	0.90	(0.55-1.46)	0.89	(0.54-1.47)	0.92	(0.56-1.52)	0.93	(0.56-1.54)
Missing	1.10	(0.64-1.88)	1.09	(0.64-1.86)	1.11	(0.66-1.86)	1.12	(0.67-1.86)

Psychopathology in lifetime prior to Wave 1

Depression

No	--	--	1	(ref)	--	--	1	(ref)
Yes	--	--	1.46	(0.92-2.31)	--	--	1.43	(0.90-2.26)

Posttraumatic stress disorder

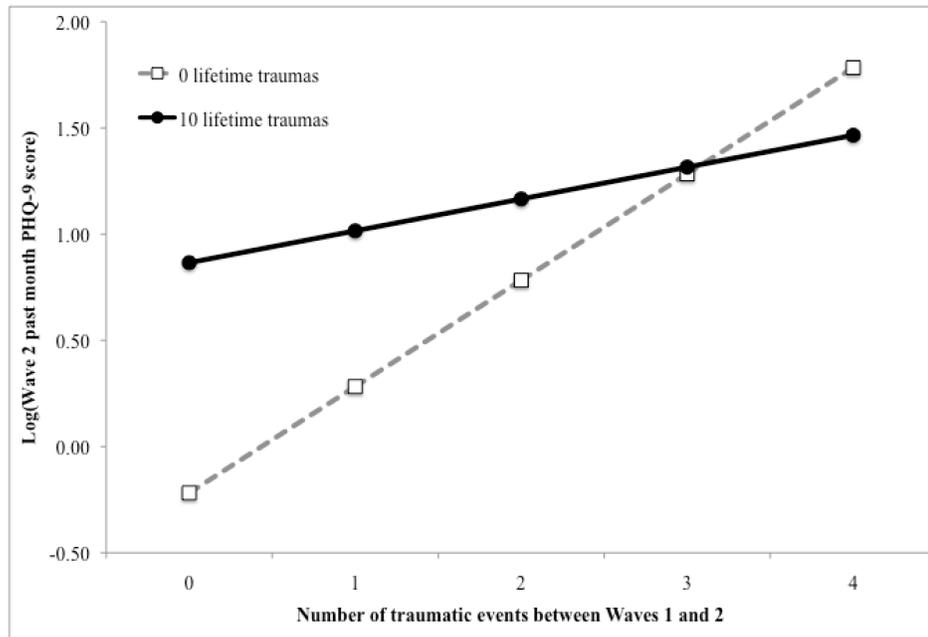
No	--	--	1	(ref)	--	--	1	(ref)
Yes	--	--	1.18	(0.81-1.73)	--	--	1.21	(0.83-1.76)

Generalized anxiety disorder

No	--	--	1	(ref)	--	--	1	(ref)
Yes	--	--	0.91	(0.61-1.36)	--	--	0.84	(0.57-1.24)

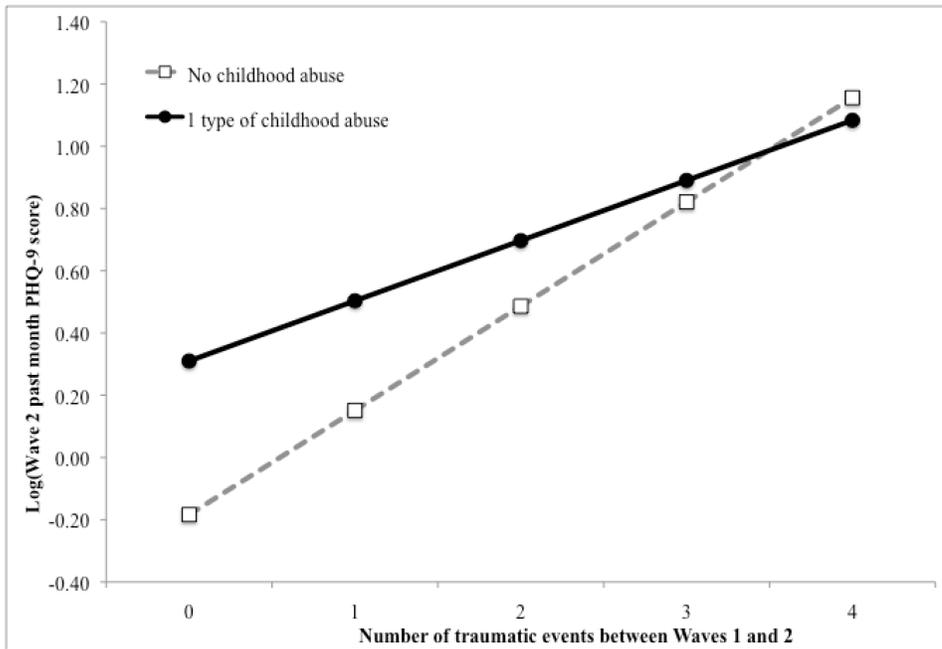
^a Ratio of the mean past month PHQ-9 score at Wave 2 among those in one category of the predictor versus the reference category (for a categorical predictor) or the ratio of the mean past month PHQ-9 score at Wave 2 among those separated by one unit of a continuous predictor. Mean ratios are calculated by exponentiating the regression coefficients from adjusted negative binomial models

Figure 3.1 Slope of the relation between the number of traumatic events between Waves 1 and 2 and the log of the past month PHQ-9 score at Wave 2, by the total number of prior lifetime traumatic events^a



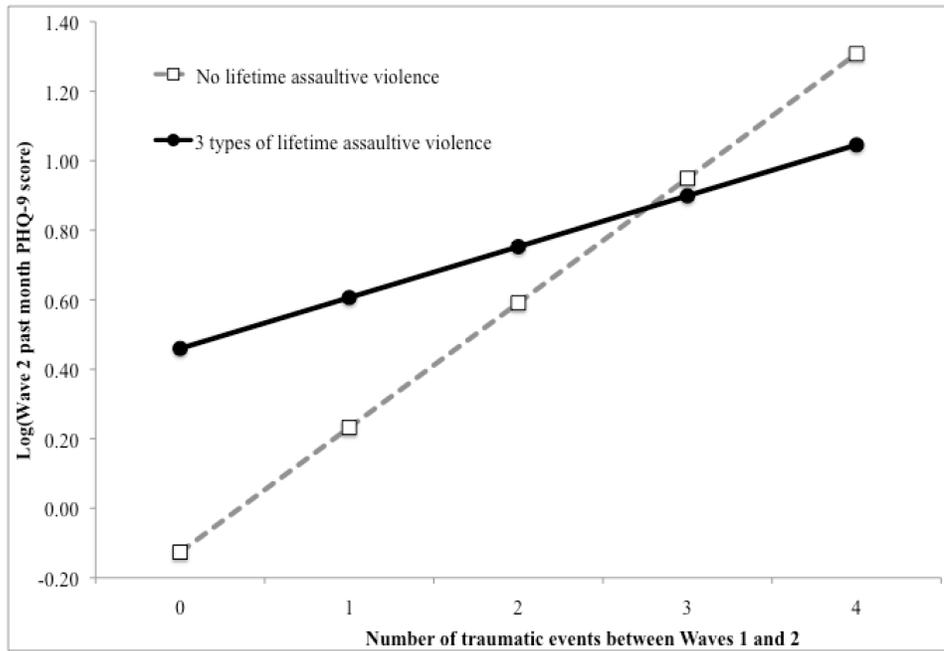
^a Adjusted Wald F test for interaction: $F(1,1028) = 12.32$ ($p < 0.001$)

Figure 3.2 Slope of the relation between the number of traumatic events between Waves 1 and 2 and the log of the past month PHQ-9 score at Wave 2, by the number of childhood abuse events^a



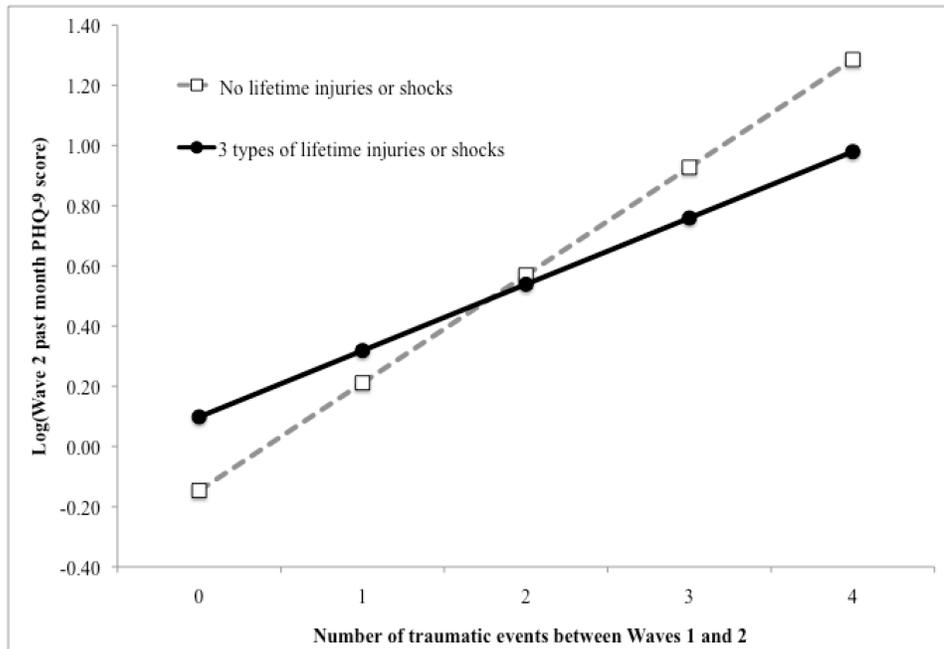
^a Adjusted Wald F test for interaction: $F(1,1026) = 4.67$ ($p = 0.031$)

Figure 3.3 Slope of the relation between the number of traumatic events between Waves 1 and 2 and the log of the past month PHQ-9 score at Wave 2, by the number of prior assaultive violence events^a



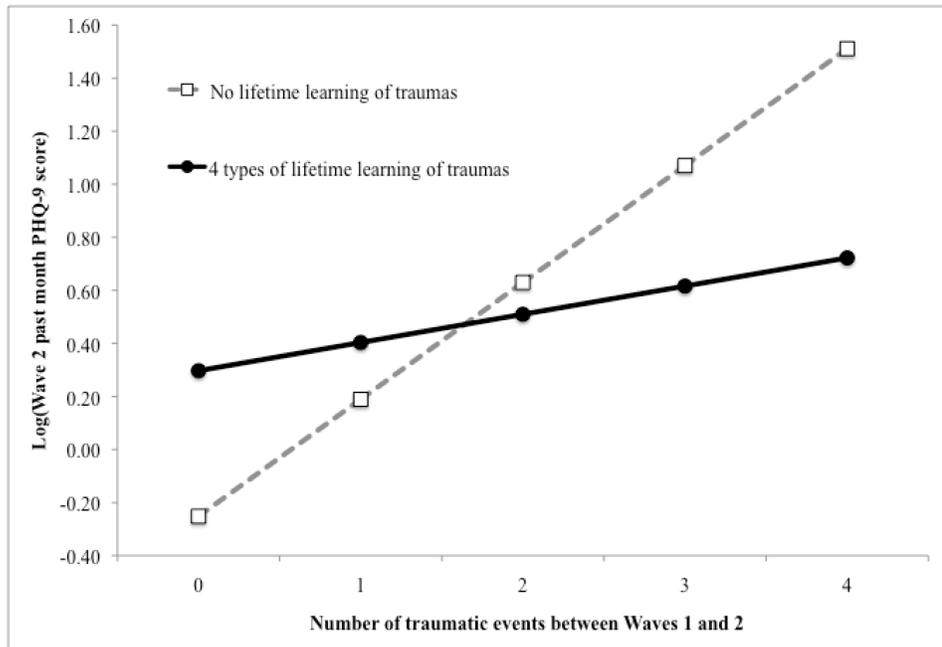
^a Adjusted Wald F test for interaction: $F(1,1026) = 5.48$ ($p = 0.020$)

Figure 3.4 Slope of the relation between the number of traumatic events between Waves 1 and 2 and the log of the past month PHQ-9 score at Wave 2, by the number of prior injuries or shocking experiences^a



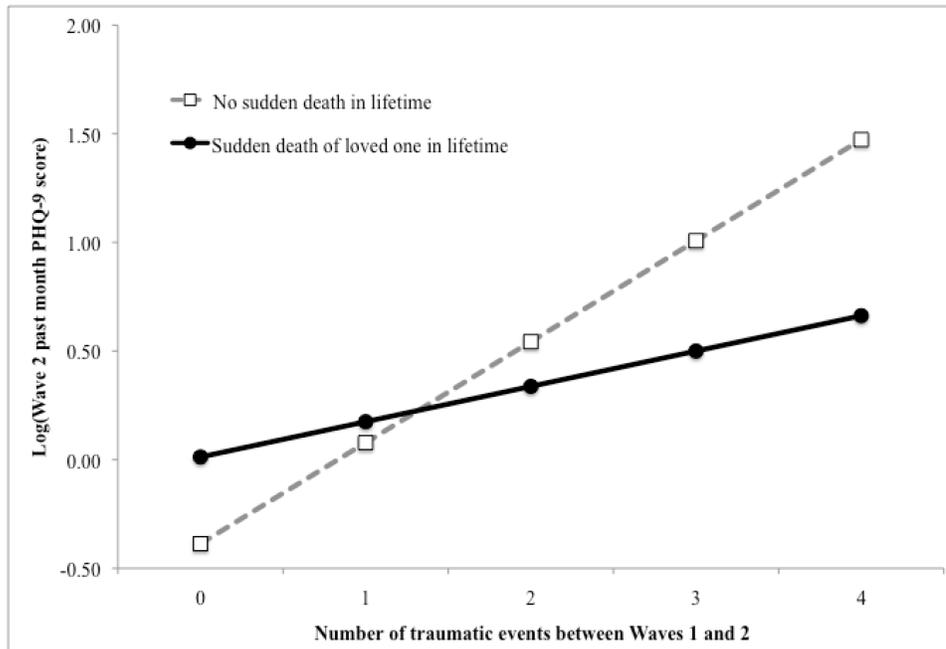
^a Adjusted Wald F test for interaction: $F(1,1026) = 2.83$ ($p = 0.093$)

Figure 3.5 Slope of the relation between the number of traumatic events between Waves 1 and 2 and the log of the past month PHQ-9 score at Wave 2, by the number of prior learning of traumatic events to others^a



^a Adjusted Wald F test for interaction: $F(1,1026) = 9.56$ ($p = 0.002$)

Figure 3.6 Slope of the relation between the number of traumatic events between Waves 1 and 2 and the log of the past month PHQ-9 score at Wave 2, by the prior history of sudden, unexpected death of a loved one^a



^a Adjusted Wald F test for interaction: $F(1,1026) = 8.32$ ($p = 0.004$)

Chapter 4

Do neighborhood conditions and traumatic events work together to increase depression severity? Evidence from the Detroit Neighborhood Health Study

Background

A large body of literature dating back decades has recognized the influence of environmental factors on mental health (206, 207), with a spate of studies in the past ten years investigating the effects of neighborhood conditions like poverty, disorder, and social cohesion on depressive symptoms (20, 86, 88-90, 95). Although reviews of these studies have identified some inconsistencies in estimated effects of particular types of neighborhood characteristics, the overall evidence supports the notion that adverse neighborhood conditions are associated with depression (80-82).

The mechanisms through which neighborhood conditions influence depression are still poorly understood (80), but some research suggests that exposure to traumatic events may play a key role. In particular, several researchers have hypothesized that adverse neighborhood conditions increase residents' exposure to traumatic events, which in turn increases risk of negative mental health outcomes (88-90). In support of this proposition, some empirical studies have demonstrated relations between living in areas with higher levels of neighborhood disadvantage or crime and increased risk of directly experiencing or witnessing interpersonal violence, as well as experiencing childhood physical abuse (83-87). On the other hand, researchers have also proposed that the neighborhood

context may modify the impact of traumatic events on mental health, such that individuals living in adverse neighborhood conditions are more likely than individuals living in more favorable settings to experience mental health problems in response to traumatic events (19, 20, 91). Indeed, some studies have found that exposure to negative life events leads to higher levels of psychological distress among residents of areas with higher levels of neighborhood crime, disadvantage, and disorder (20, 208).

These hypotheses reflect two possible ways in which neighborhood conditions and traumatic event exposure may “work together” to affect depressive symptoms: (1) traumatic events may mediate the relation between neighborhood conditions and depression, and (2) neighborhood conditions may modify the relation between traumatic event exposure and depression. A mediator (or intermediate variable) is a variable that is on the causal pathway between an exposure and outcome (209). Thus, if traumatic event exposure is a mediator of the effect of neighborhood conditions on depression, adverse neighborhood conditions would cause depression at least in part by increasing residents’ exposure to traumatic events. By contrast, effect measure modification is present when the effect of an exposure on an outcome is heterogeneous across strata of the potential modifier on the scale of interest (e.g., risk difference or risk ratio) (209). Thus, if adverse neighborhood conditions modify the relation between traumatic events and depression, traumatic events would be more likely to cause depression in certain kinds of neighborhoods.

The objective of this study was to investigate how neighborhood characteristics and traumatic event exposure work together to influence depression severity, particularly assessing mediation and effect measure modification in the joint effects of neighborhood

characteristics and traumatic event exposure on depression severity. In particular, we assessed the influence of neighborhood disadvantage, crime, physical disorder, and social cohesion on changes in depression severity during a one-year follow-up period, also considering traumatic events that occurred during that period, among adult residents of the city of Detroit. Although previous studies have examined some pieces of these relations, ours is the first investigation of which we are aware to use longitudinal data to systematically assess relations between a range of neighborhood characteristics, a variety of prospectively assessed traumatic events, and depression severity at follow-up, adjusting for baseline depression severity, in a community-based sample of men and women.

Based on previous findings that neighborhood disadvantage and crime increase residents' exposure to interpersonal violence and other traumatic events (83-87), we hypothesized that exposure to traumatic events would mediate the effects of neighborhood disadvantage and of neighborhood crime on changes in depressive symptoms. We also hypothesized that each neighborhood condition would modify the effect of traumatic event exposure on changes in depressive symptoms, such that effects of trauma exposure would be stronger among residents of neighborhoods characterized by high levels of disadvantage, crime, physical disorder, and low levels of social cohesion.

Methods

Study population

This investigation uses data from the first two waves of the Detroit Neighborhood Health Study (DNHS), a community-based cohort study of adult residents of the city of Detroit, Michigan. Eligible participants were 18 years of age or older and were living in the city of Detroit (i.e., not in Hamtramck or Highland Park) at the time of the baseline interview. We sampled 7,041 households in the city of Detroit, identifying telephone numbers from the U.S. Postal Service Delivery Sequence File, which covers the whole Detroit population including non-telephone and cellular-phone-only households, and from a random-digit-dial frame including Detroit households with unlisted telephone numbers. Selected households with at least one listed landline telephone number were contacted via telephone regarding study participation; the remaining households were invited to participate via a mailed letter. The adult in the household with a birthday closest to the interview date was selected as the study participant (125). After the study was described and any questions answered, oral informed consent was obtained from participants. The study was approved by the Institutional Review Board of the University of Michigan.

Telephone interviews were conducted with 1,547 participants, resulting in a cooperation rate of 53.0% and a response rate of 33.1% (126).³ The baseline (Wave 1) interview took place between September 9, 2008 and February 3, 2009, and lasted 40 minutes on average. 1,054 Wave 1 participants (68.1%) completed a follow-up interview

³ Participation rates were calculated as follows, where I = completed interviews, Q = quota-outs [contacted persons not interviewed because the quota for their gender had been filled], S = screen-outs [contacted persons who screened out of the interview], R = refusals, Inc = Incomplete interviews, NC = non-contacted households which were never successfully reached, and NS = non-screened callbacks [households where contact was made but eligibility screening was never completed]. Cooperation rate = $(I + Q + S) / (I + Q + S + R + Inc) = 2,332/4,402$. Response rate = $(I + Q + S) / (I + Q + R + Inc + NC + NS) = 2,332/7,401$.

(Wave 2) approximately one year later, between September 21, 2009 and April 12, 2010, which also lasted 40 minutes on average. Analyses were restricted to the 1,037 individuals who participated in both Wave 1 and Wave 2 and who reported that they had been living in their current neighborhood for at least one year at the time of the Wave 1 interview.

Measures

Depressive symptoms

Depressive symptoms were assessed using the Patient Health Questionnaire-9 (PHQ-9) (127-129), which includes nine items corresponding to the nine DSM-IV criteria for major depressive disorder (31). During the Wave 1 interview, study participants were asked whether there was ever a two-week period in their lifetime in which they were bothered by each of these nine symptoms (e.g., “Little interest or pleasure in doing things”, “Feeling tired or having little energy”). If so, they were asked how often in that two-week period they were bothered by each of the symptoms (1 = several days; 2 = more than half the days; 3 = nearly every day) and whether that occurred in the past 30 days. At the Wave 2 interview, the PHQ-9 was repeated with symptoms assessed for a two-week period since the last interview and in the past 30 days. The total PHQ-9 score in the past 30 days at Waves 1 and 2 was calculated by summing respondent frequency ratings of the nine items (coded 0-3) for a total score ranging from 0 to 27. Cronbach’s alpha for the past month PHQ-9 scale was 0.87 at Wave 1 and 0.85 at Wave 2 in the study sample.

The PHQ-9 has been found to have excellent internal consistency, test-retest reliability, criterion validity (compared to a diagnostic interview conducted by a mental

health professional) and construct validity (with increasing PHQ-9 scores reflecting increasing functional impairment, disability, and health care utilization) in primary care settings (127, 130) as well as in the general population (131). The PHQ-9 score indicates depression severity, with scores of 0-4 reflecting minimal or no depression, scores of 5-9 reflecting mild depression, 10-14 moderate, 15-19 moderately severe, and 20-27 severe depression (127). A PHQ-9 score of 10 or higher was associated with 88% sensitivity and 88% specificity for a diagnosis of major depression among 580 primary care patients (127). Additional studies have found that the PHQ-9 functions similarly across racial/ethnic groups, with high internal consistency and similar mean total scores across groups (132), and that the PHQ-9 can be reliably administered over the telephone (133). Finally, changes in the PHQ-9 total score have been shown to reflect changes in depression diagnostic status according to structured clinical interviews, demonstrating the utility of the PHQ-9 for longitudinal research (134).

Neighborhood characteristics

The City of Detroit Planning and Development Department defined 54 neighborhoods in the city of Detroit in the 2004 Master Plan (210). These neighborhoods, known as “Master Planning neighborhoods,” are aggregations of older neighborhoods first outlined in Detroit’s 1951 Master Plan and are used to determine the distribution of city resources (211). The Master Plan neighborhood divisions are recognized by city planners as matching long-established community boundaries as well as the service areas of local community organizations, and they were recently organized into ten clusters as part of the City of Detroit’s Community Reinvestment Strategy (212). Furthermore, these neighborhoods are aggregations of census tracts, allowing them to be

easily characterized using U.S. Census data. During the Wave 1 interview, DNHS participants provided their current residential address and information on how long they had lived in Detroit and in their current neighborhood, defined in the interview as “the area within a 20-minute walk from your house.” Addresses were linked to Master Planning neighborhoods in Detroit using ArcMap software (Version 9.2, ESRI, Redlands, CA). Participants who reported living in their current neighborhood for less than one year at the time of the Wave 1 interview ($n = 17$) were excluded from these analyses. There were, on average, 19 DNHS participants per Detroit neighborhood (range 1-44).

Four neighborhood conditions were of interest in these analyses: neighborhood disadvantage, violence, physical disorder, and social cohesion. For neighborhood disadvantage, indicators of area socioeconomic status (SES) were obtained at the census tract level from the 2000 U.S. Census (213) and aggregated to the neighborhood level. Consistent with other research on neighborhood disadvantage and mental health (214-216), we created a summary measure of neighborhood disadvantage including six indicators of area SES that were highly correlated with each other and that loaded onto a single factor in principal components analysis: percent of the population living below the poverty level (factor loading 0.96), percent of the population receiving public assistance (factor loading 0.86), percent of households with less than \$30,000 in annual income (factor loading 0.92), unemployment rate (factor loading 0.86), percent of the population aged 25 years and older without a high school degree or equivalent (factor loading 0.80), and percent of families headed by a single female with dependent children (factor loading 0.68). The neighborhood disadvantage score was created by summing these six measures, weighted by their respective factor loadings. Cronbach’s alpha for the

neighborhood disadvantage scale was 0.90. We also created another version of the neighborhood disadvantage scale, using available data closer to the years of the DNHS interviews (5-year estimates from the American Community Survey (ACS), for 2006-2010), in order to capture changes in the socioeconomic environment that may have occurred between the 2000 U.S. Census and the DNHS surveys. Results of analyses using this more recent measure were nearly identical to those when using neighborhood disadvantage from the 2000 Census. Since there is some temporal ambiguity when using the more recent ACS measure, which overlaps in time with the DNHS surveys, we present only the results using the neighborhood disadvantage measure developed from 2000 U.S. Census data.

Neighborhood crime was operationalized as the homicide rate per 100,000 persons in each neighborhood in the year 2004. Data on violent crimes in each census tract in the city of Detroit for the year 2004 were obtained from the Urban Safety Program of the Wayne State University Center for Urban Studies (217). We focused on homicide since it is more reliably reported than other types of violent crimes like assault and rape (218). The number of homicides in 2004 was aggregated to the neighborhood level, and rates were calculated using the 2000 U.S. Census population as the denominator.

Neighborhood physical disorder was characterized through a systematic assessment of Detroit neighborhoods conducted by DNHS staff in the summer of 2008. A sample of census block groups was selected from each of the 54 Detroit neighborhoods; the number of sampled block groups was proportional to the total population of the neighborhood and ranged from one to four, with a total of 138 block

groups selected across the city. Trained evaluators walked around each selected block and coded nineteen conditions, including the presence of graffiti, cleanliness of streets and sidewalks, and traffic volume; these items were adapted from a systematic neighborhood assessment previously conducted in New York City (219). Factor analysis of the 19 items was conducted at the block group level, revealing a physical disorder factor comprised of the following four items: (1) presence of buildings with broken windows, boarded up windows, or boarded up doors; (2) presence of buildings with outside damage that can only be corrected by major repairs such as siding, shingles, boards, brick, concrete, and stucco; (3) presence of entirely vacant buildings; and (4) presence of empty, vacant lots. We used ordinary kriging methods (220, 221) within ArcMap (Version 9.2, ESRI, Redlands, CA) to interpolate values for the physical disorder factor score for block groups in the city that were not included in the assessment, and these predicted values were averaged across all block groups in each neighborhood to create neighborhood-specific physical disorder scores (178).

Neighborhood social cohesion was assessed with five items asked of study participants during the DNHS Wave 1 interview, including “This is a close-knit or unified neighborhood” and “People around here are willing to help their neighbors,” with responses ranging from “strongly disagree” to “strongly agree.” These items comprise the “social cohesion and trust” scale developed by Sampson and colleagues in their study of neighborhood collective efficacy and crime (218). This scale has demonstrated high levels of internal consistency and test-retest reliability (222, 223), and has been used in prior studies assessing relations between the neighborhood environment and depressive symptoms (90). All items were coded so that higher scores indicated higher levels of

social cohesion, and responses to the five items were averaged for each participant (Cronbach's alpha for the social cohesion scale in this sample was 0.67). Social cohesion ratings on this composite scale were then aggregated to the neighborhood level by taking the average of ratings for all participants residing in the neighborhood. Responses from all DNHS participants who had been living in their neighborhood for at least one year at baseline ($n = 1,513$) were used to create this measure of neighborhood social cohesion, with an average of 28 respondents for each neighborhood (range 2-67).

Traumatic events

Information about nineteen potentially traumatic events experienced by participants in their lifetime was obtained during the Wave 1 interview using a subset of DSM-IV Criterion A traumatic events that has been used in prior research in the Detroit metropolitan area (121). These events can be grouped into four broad categories, following the example of Breslau and colleagues (121): (1) "assaultive violence" events are characterized by intentional violence by a perpetrator towards the study participant (e.g., rape or other sexual assault; having been shot or stabbed); (2) "other injuries or shocking experiences" are encountered directly by the participant but do not involve violence directed at the participant, rather involving an external threat like technology, nature, illness, or injury (e.g., serious motor vehicle accident, natural disaster), or witnessing violence directed at someone else; (3) "learning of traumatic events to close friends or relatives" (e.g., learning that a close friend or relative was seriously physically attacked) was added as a qualifying traumatic event in the DSM-IV (135), and is distinguished from events that were experienced directly by participants; and (4) the "sudden, unexpected death of a close friend or relative", which is often considered

separately from other traumatic events because of its high period prevalence in the population (106, 121). The total number of traumatic events participants reported to have occurred in their lifetime prior to the Wave 1 interview was grouped into four categories for analyses: 0, 1-3, 4-6, and 7 or more events.

During the Wave 2 interview, respondents were asked whether any of these nineteen traumatic events had occurred since the last interview. Three measures of interest were created from the number of traumatic events reported to have occurred between Waves 1 and 2. First, we created a dichotomous variable indicating whether any of the nineteen traumatic events had occurred. Second, a 5-category nominal variable identifying the type of most severe traumatic event that occurred was created, using the four broad categories listed above and a fifth category for those who did not experience a traumatic event during the follow-up period. Individuals who reported events of more than one type during this period (e.g., assaultive violence and sudden death of a loved one) were assigned to the category deemed to be most severe, with severity in descending order as follows: assaultive violence, other injuries or shocking experiences, learning of traumatic events to others, and sudden death of someone close. This procedure was similar to categorization methods used in other studies, which generally distinguish between those who have experienced traumatic loss only, non-interpersonal events only, and interpersonal violence (50, 51, 117, 136). Third, a count of the number of distinct traumatic events reported (e.g., rape, motor vehicle accident, natural disaster), regardless of type, was created.

Non-traumatic stressors

During the Wave 1 interview, participants were asked to report the occurrence of nine non-traumatic stressors in their lifetime; these stressors were modified from lists used in previous studies (85, 137). Stressors included the serious drug or alcohol problem of a parent or other family member, a divorce or “break up” with a significant other, losing one’s job, being unemployed and looking for work for three months or longer, emotional mistreatment, stressful legal problems, serious financial problems, and problems getting access to adequate healthcare. The number of lifetime stressors was categorized as 0, 1-2, 3-5, and 6 or more.

Social support

Social support in the twelve months prior to the Wave 1 interview was assessed with three items from the Postdeployment Social Support Scale (138), assessing respondent agreement with the following statements: “Among my friends or relatives, there is someone who makes me feel better when I am feeling down”; “Among my friends or relatives, there is someone I go to when I need good advice”; and “My friends or relatives would lend me money if I needed it”. Response choices were “strongly agree”, “somewhat agree”, “somewhat disagree”, and “strongly disagree”. Cronbach’s alpha for the social support scale was 0.64 in the study sample. DNHS participants with total social support scores in the bottom third of the sample were categorized as having low levels of social support.

Socio-demographic characteristics

The DNHS Wave 1 interview also collected information on the demographic characteristics of study participants, including gender, age, marital status, and

race/ethnicity. Socioeconomic characteristics of participants were also assessed, including educational attainment and household income.

Statistical analyses

First, we calculated descriptive statistics for the individual-level characteristics of interest in the analysis sample (i.e., 1,037 residents who participated in both Waves 1 and 2 and who had been living in their neighborhood for at least one year at Wave 1), as well as the neighborhood characteristics of interest in the 54 Detroit Master Planning neighborhoods. Second, we divided neighborhood-level variables into quartiles to examine the bivariable (unadjusted) associations between each of our three measures of traumatic event exposure during follow-up (any traumatic event, type of traumatic event, and number of traumatic events) and each neighborhood characteristic, as well as mean depression severity (PHQ-9 score) across levels of each neighborhood characteristic, using chi-square tests for categorical covariates (any traumatic event, types of traumatic events) and one-way analysis of variance (ANOVA) tests for continuous covariates (number of traumatic events, PHQ-9 scores).

Third, we investigated the potential of traumatic event exposure to serve as a mediator of the relation between neighborhood conditions and depressive symptoms. For traumatic event exposure to be a mediator of the effect of neighborhood conditions on depression, traumatic events must be on the causal pathway between neighborhood conditions and depression severity. Therefore, we first need to establish that neighborhood conditions precede and are associated with traumatic event exposure, adjusting for potential confounders. Since neighborhood conditions were measured for the year prior to the Wave 1 interview, we assumed that neighborhood conditions

preceded experiences of traumatic events occurring between the Waves 1 and 2 interviews. To estimate the effects of neighborhood conditions on exposure to traumatic events, we used generalized estimating equations (GEE) to fit multilevel logistic regression models assessing the relation between each neighborhood characteristic and exposure to any traumatic event and each type of traumatic event between Waves 1 and 2. We used multilevel negative binomial GEE models to assess the relation between each neighborhood characteristic and the number of traumatic events experienced between Waves 1 and 2, since the number of traumatic events was a count outcome best modeled with a negative binomial distribution (142). In keeping with previous work on neighborhood conditions and depression (90, 224), separate models were fit for each of the four neighborhood conditions of interest and neighborhood-level variables were transformed to z-scores with mean 0 and standard deviation 1. Exponentiated regression coefficients from these models thus indicate the odds ratio (OR, for logistic regression models) or incidence rate ratio (IRR, for negative binomial models) associated with a one standard deviation increase in the neighborhood-level predictor. For each outcome and each neighborhood covariate, a model was first fit including only the neighborhood-level covariate of interest, followed by a second model additionally adjusting for all individual-level potential confounders (gender, race, age, marital status, education, household income, number of traumatic events and stressors in lifetime, social support at baseline, and duration of residence in the neighborhood).

GEE models provide population-averaged parameter estimates with robust standard errors, accounting for clustering by neighborhood (225). When interest lies in estimating the average change in the outcome associated with a one-unit change in the

neighborhood predictor, GEE models have some advantages over random effects, or mixed, models, including robustness to misspecification of the model (226). Estimates for fixed effects are similar in GEE and random effects models (226, 227), but GEE models do not allow for examination of variation at the group and individual levels. However, partitioning variance for dichotomous or count outcomes is not straightforward, particularly when models are adjusted for predictors (228-230), limiting our ability to examine the degree to which variability is explained by individual- and neighborhood-level factors in the logistic and negative binomial models used here. In order to determine whether there was substantial variation in trauma exposure at the neighborhood level, we fit a null random intercept logistic regression model for each type of traumatic event exposure during follow-up and calculated the intraclass correlation coefficient (ICC)⁴, which indicates the proportion of the total variance in the outcome that is between neighborhoods (231), but remaining multilevel analyses were conducted using GEE models.

Fourth, we used multilevel negative binomial GEE models to assess associations between neighborhood conditions at Wave 1 and depression severity at Wave 2. The outcome of these models was the total PHQ-9 score in the past month at Wave 2. A series of models were fit for each of the four neighborhood-level covariates separately: (1) Model 1 included only the neighborhood-level covariate; (2) Model 2 also included individual-level covariates (PHQ-9 score at Wave 1, gender, race, age, marital status,

⁴ The ICC can be calculated for multilevel logistic regression models using the following formula: $r_0^2 / (r_0^2 + \pi^2/3)$, where r_0^2 represents random variance at level 2 (i.e., the neighborhood level). In this equation, the standard logistic variance ($\pi^2/3$) is assumed for level 1 (i.e., the individual level); however, this assumes that the level 1 variance is fixed and does not change when adding predictor variables (229, 230, 266), which is a limitation of this method.

education, household income, lifetime traumatic events and stressors, social support at baseline, and number of years in neighborhood); (3) Model 3 added a dummy variable for any traumatic event exposure during follow-up; (4) Model 4 built off Model 2 to add a categorical variable for the type of traumatic events experienced during follow-up; and (5) Model 5 built off Model 2, adding a count of the number of traumatic events experienced during follow-up. In this way, we examined relations between neighborhood characteristics and depression severity at Wave 2 when adjusting for individual-level covariates as well as alternate measures of traumatic event exposure during follow-up. The exponentiated regression coefficients ($e^{\hat{\beta}}$) from the fitted negative binomial models can be interpreted as the ratio of the average PHQ-9 score among those separated by one standard deviation of the neighborhood variable. We will use the term “mean ratio” to refer to these estimates hereafter. We note that, given the challenges of assessing direct and indirect effects when using non-linear models including an exposure and mediator that may interact (209, 232, 233), we are not attempting to formally decompose effects of neighborhood conditions into direct and indirect effects. However, we were careful to adjust for potential confounders of the relation between traumatic event exposure and depression severity in order to avoid introducing confounding of the relation between neighborhood characteristics and depression severity by adjusting for an intermediate variable (209, 234).

Fifth, we investigated the potential of neighborhood conditions to serve as effect measure modifiers of the relation between traumatic event exposure and depressive symptoms. Effect measure modification was considered by including product terms for the statistical interaction between traumatic events during follow-up and each

neighborhood characteristic in multilevel negative binomial GEE models predicting depression severity. Separate models were fitted to assess statistical interactions between each of the four potential neighborhood-level modifiers with each of the three measures of traumatic events between Waves 1 and 2, for a total of twelve models. These models also included adjustment for Wave 1 PHQ-9 score, baseline demographics and SES, lifetime traumatic events and stressors prior to Wave 1, social support in the year prior to Wave 1, and duration of residence in the neighborhood. Departure from homogeneity of the ratio of the mean PHQ-9 scores for each traumatic-event measure across levels of each potential modifier was assessed using an adjusted Wald F test with the null hypothesis that all product terms in the model had coefficients of 0; this test approximates the likelihood ratio test comparing models with and without the product terms, but it is more appropriate than the likelihood ratio test when using complex survey data (154).

All analyses were weighted to account for differential probabilities of selection into the study across participants, by number and types of telephone numbers and number of adults in households. Post-stratification weights were also incorporated to ensure comparability between the study sample and the population of the city of Detroit on socio-demographic characteristics (gender, age, race/ethnicity, marital status, educational attainment, and household size), housing tenure, and type of telephone service, using data from the 2005-2007 American Community Survey (155). Finally, attrition weights were developed using the inverse probability of censoring method (156) to account for differences between respondents who participated in the Wave 2 interview and the full baseline sample. Weighted percentages, means, and associations are thus approximately unbiased estimates of the percentages, means, and associations in the underlying source

population or sampling frame (i.e., all adult residents in the city of Detroit at the time of the baseline interview). All analyses were conducted in SAS (Version 9.2, SAS Institute, Cary, NC), appropriately accounting for the weights and the complex sampling design.

Results

Table 4.1 shows the weighted percentages of demographic characteristics, socioeconomic status indicators, lifetime traumatic events and stressors, and social support in the sample, corresponding to distributions in the source population. About 30% of the source population had experienced seven or more traumatic events prior to the Wave 1 interview, with 25% experiencing six or more lifetime stressors. About one quarter had lived in their current neighborhood for thirty years or longer, although about 36% had lived in their neighborhood for less than ten years.

Detroit neighborhoods were characterized by high levels of poverty, unemployment, female-headed families, and low household income and education (Table 4.2). The average homicide rate across Detroit neighborhoods was 40.5 per 100,000 per year. Neighborhood disadvantage was highly correlated with the other neighborhood measures (Table 4.3). Neighborhood homicide rate was highly correlated with neighborhood social cohesion ($r = -0.55$), but neighborhood physical disorder was only weakly correlated with these two constructs ($r = 0.22$ for homicide rate and $r = -0.25$ for social cohesion).

Table 4.4 presents the percentage of the population who experienced traumatic events during the one-year follow-up period between Waves 1 and 2 (as well as mean numbers of traumatic events experienced and mean depression severity score), by quartile

of neighborhood disadvantage, homicide, physical disorder, and social cohesion.

Neighborhood conditions appeared to be only minimally associated with exposure to traumatic events; this was confirmed in unadjusted and adjusted multilevel models predicting exposure to traumatic events (Table 4.5). However, substantial between-neighborhood variability in trauma exposure was observed, with intraclass correlations of 19.5%, 31.5%, 11.4%, 14.8%, and 22.8% for any traumatic event, assaultive violence, other injuries or shocking events, learning of trauma to others, and sudden death of a loved one, respectively.

Unadjusted associations between neighborhood conditions and depression severity were observed, such that depression severity was higher in neighborhoods characterized by higher levels of disadvantage and disorder and lower levels of social cohesion (Table 4.4). In multilevel GEE models (Table 4.6), neighborhood disadvantage was positively associated with past month PHQ-9 score at Wave 2 (unadjusted mean ratio = 1.22 per 1 standard deviation increase in neighborhood disadvantage, 95% CI 1.01-1.49; Model 1), and when adjusting for individual-level characteristics, including PHQ-9 score at Wave 1 and traumatic event experiences between Waves 1 and 2 (adjusted mean ratio = 1.25, 95% CI 1.08-1.45; Model 4). Similarly, neighborhood social cohesion was inversely associated with depression severity in multilevel models (unadjusted mean ratio = 0.67, 95% CI 0.54-0.83; Model 1), and when adjusting for individual-level covariates (adjusted mean ratio = 0.72, 95% CI 0.59-0.89; Model 4).

No evidence for statistical interactions on the multiplicative mean scale was found when including product terms for each neighborhood characteristic with any traumatic event exposure or with number of traumatic events experienced between Waves 1 and 2.

However, there was some evidence for departure from multiplicativity (heterogeneity of the mean ratio) when assessing the statistical interaction between each neighborhood condition and the type of traumatic event experienced during follow-up. Figure 1 displays the ratio of the mean Wave 2 PHQ-9 score among individuals reporting each type of traumatic event to the mean score among those with no trauma exposure during follow-up, contrasting those living in neighborhoods characterized by high levels of disadvantage (one standard deviation above the mean) and low levels of disadvantage (one standard deviation below the mean) ($F[4,1009] = 22.31, p < 0.001$). The association between assaultive violence and depression severity was stronger for those living in highly disadvantaged neighborhoods, whereas the association between other injuries and shocking experiences and depression severity was stronger for those living in less disadvantaged neighborhoods (adjusted mean ratios and 95% CI for main effects and product terms were as follows: neighborhood disadvantage [per SD] = 1.21 [1.03-1.42]; assaultive violence (vs. no trauma) = 2.43 [1.14-5.22]; other injury or shocking event (vs. no trauma) = 3.05 [2.14-4.35]; neighborhood disadvantage \times assaultive violence = 1.57 [0.74-3.32]; neighborhood disadvantage \times other injury or shocking event = 0.49 [0.34-0.70]). Generally similar results were observed for the interaction between type of traumatic event and neighborhood homicide rate (Figure 2; $F[4,1009] = 12.14, p = 0.016$) and neighborhood social cohesion (Figure 3; $F[4,1009] = 44.88, p < 0.001$).

Discussion

In this study of adult residents of the city of Detroit, living in a neighborhood characterized by higher levels of disadvantage, crime, physical disorder, and lower levels

of social cohesion for at least one year at baseline was only minimally associated with exposure to traumatic events during a one-year follow-up period. Living in highly disadvantaged neighborhoods and neighborhoods with lower levels of social cohesion was positively associated with depression severity at follow-up, adjusting for depression severity at baseline as well as other potential individual-level confounders. Exposure to traumatic events during follow-up did not appear to mediate the hypothesized effect of neighborhood conditions on depression severity. However, we found some evidence that neighborhood characteristics modify the mean ratio for the effect of exposure to traumatic events on depression severity. In particular, relations between assaultive violence and depression severity were stronger among those living with more adverse neighborhood conditions, whereas estimated effects of other injuries or shocking events on depression severity were stronger among those living in more favorable neighborhood environments.

A small number of prior studies have investigated the mediating influence of exposure to traumatic events, particularly experiences of violence, on the relation between neighborhood conditions and mental health. Curry and colleagues (86) found that neighborhood violent crime influenced depression through increased exposure to violence and negative perceptions of the neighborhood environment. Boardman and colleagues (85) observed an association between neighborhood disadvantage and greater exposure to stressors, including experiences of violence, injuries, and the death of someone close; these stressors were in turn associated with drug use. Other studies have found correlations between neighborhood characteristics, including levels of crime and collective efficacy, and actual experiences of violence among adolescents and young

adults (83, 235). In contrast, our study results indicate that neighborhood characteristics, including neighborhood homicide rate, were only minimally associated with traumatic event experiences, including assaultive violence; thus, traumatic events (although themselves strongly associated with depression severity) do not appear to serve as mediators between neighborhood conditions and depression severity in this population.

Several explanations are possible for the observed lack of association between neighborhood conditions and traumatic event experiences. Neighborhood conditions may influence daily and chronic stressors and strains, including harassment and experiences of discrimination as well as fear of and experiences of property crime, rather than experiences of traumatic events of a life-threatening nature (to oneself or a loved one) (85), which, although patterned by individual risk factors (32) are still somewhat unpredictable in nature. However, the lack of association between an objective measure of neighborhood crime (homicide rate) and actual experiences of violent victimization was particularly surprising. It is possible that the neighborhood homicide rate does not adequately distinguish neighborhoods with high levels of the type of violence most relevant to risk of individual victimization (e.g., drug activity) (86). Several studies have found strong relations between neighborhood conditions and fear of crime, which may also be an important mediator of relations between neighborhood characteristics and depression (88, 236), but which is often uncorrelated with actual experiences of violent victimization (237-239). Finally, the influence of neighborhood conditions may not be adequately captured by focusing on levels of disadvantage and other characteristics in the Detroit Master Planning neighborhood in which an individual resides. In particular, incorporating information on other areas where individuals work, go to school, or spend

time with family or friends (240) may provide a more complete picture of neighborhood-level influences on trauma exposure, since such exposure may occur in areas other than near the individual's residence. Furthermore, smaller areas may be more relevant for consideration of area-level influences on exposure to traumatic events. For example, prior research has suggested that the census block group level may be most appropriate for analyses of violent crime (86).

We documented evidence for a modifying role of neighborhood disadvantage, crime, and social cohesion on relations between type of traumatic event exposure and depression severity in our study. Consistent with previous work investigating interactions between neighborhood conditions and negative life events (20, 208), we found that exposure to the most severe type of traumatic event (assaultive violence) had a stronger association with depression severity among those living in more disadvantaged, more dangerous, and less cohesive neighborhoods. Chronic exposure to adverse neighborhood conditions may erode one's sense of optimism for the future and mastery over one's life and environment, which decline even further when faced with an uncontrollable and terrifying event like assaultive violence; such an event may not produce such a dramatic descent into hopelessness among those living in more favorable circumstances (19, 20). Alternatively, fear of crime, already high among residents of disadvantaged neighborhoods (241), may become heightened after direct exposure to violence, with negative psychological consequences beyond those associated with exposure to violence under typical circumstances. One surprising caveat to our results was our observation that other injures or shocking experiences like car accidents were actually more strongly associated with depression severity in neighborhoods with more

favorable conditions (in contrast to the results for assaultive violence). It is possible that individuals chronically faced with detrimental neighborhood conditions are less distressed by these types of traumatic events because they have become accustomed to facing stressful situations, whereas such events come as a substantial shock to individuals accustomed to more favorable circumstances (91).

In addition to the modifying role of neighborhood conditions, we found associations between neighborhood disadvantage and neighborhood social cohesion and depression severity that persisted when adjusting for individual-level variables including baseline depression severity. These results contribute to a growing body of literature demonstrating associations between neighborhood characteristics and depression using longitudinal data (88-90, 242). Our failure to confirm more than trivial associations between neighborhood violent crime and neighborhood physical disorder with depression severity (20, 88, 90, 95, 242, 243) may reflect differences in the way these neighborhood conditions were operationalized (most previous studies have used participant-reported measures of neighborhood disorder or perceived violence); the longitudinal nature of our study (most previous studies have been cross-sectional); or differences in the neighborhood conditions that are most salient to mental health in different contexts and populations. For example, elements of physical disorder like vacant and boarded-up buildings have become very common across Detroit neighborhoods (244), perhaps leading residents to become accustomed to their presence; habituation to these conditions may lessen or eliminate their influence on depressive symptoms. Similar arguments have been made in areas with very high levels of crime (88). Further work could investigate whether the inconsistencies that have been observed in relations between different

neighborhood characteristics and depression (80, 81) could be at least partly attributed to differences in the absolute levels of these characteristics across studies.

Several limitations of this study should be considered when interpreting the results. First, about 30% of the Wave 1 DNHS participants did not complete the Wave 2 interview. Baseline participants lost to follow-up were younger, less educated, more likely to be unemployed, and unmarried (178). Inverse probability of censoring weights (156) were calculated to address these differences between the participants at follow-up and the full baseline sample, but this method may not fully control for the bias due to selective attrition. Second, the study questionnaire did not assess the exact timing of traumatic events or onset of depressive symptoms during the follow-up period; therefore, some temporal ambiguity exists, with the possibility that some traumatic events reported to have occurred between Waves 1 and 2 were actually experienced after the onset of depressive symptoms during follow-up. Using a measure of depressive symptoms that is focused on the 30 days prior to the Wave 2 interview ensured that the vast majority of traumatic events experienced by the study population during the one-year follow-up period would likely have occurred prior to the time for which depression was assessed, yet changes in depressive symptoms may still have preceded traumatic events. Third, the recall and reporting of traumatic events prior to the Wave 1 interview and since the Wave 1 interview may have been influenced by the participant's level of depressive symptoms at Wave 1 and Wave 2, respectively (179). However, the traumatic events assessed in this study are objective events of serious magnitude; therefore, reporting of such events is less likely to be influenced by changing perceptions of past experiences influenced by current depressive symptoms (180). Similarly, depressive symptoms at the time of the

Wave 1 interview may have influenced individual social cohesion ratings, leading to bias in the estimated effect of neighborhood social cohesion on depression. However, similar relations between area-level social cohesion and depression have been found when using study participant ratings of neighborhood cohesion versus ratings made by an independent sample from the same neighborhoods (90, 93). In our study, about 30% of the participants providing the social cohesion ratings were not in our analysis sample because of attrition at Wave 2, so same-source bias should be somewhat attenuated. Similar to another recent study of neighborhood collective efficacy and depression (245), we re-ran analyses using a neighborhood social cohesion score for each participant that was obtained by averaging ratings from all residents in the neighborhood except the participant, and adjusting for each individual's own social cohesion rating in the models, and results did not differ from those reported above. Fourth, the study had low power to detect statistical interactions, and considering twelve possible statistical interactions increased the probability of a Type I error, i.e., rejection of the null hypothesis when it is, in fact, true.

Fifth, we used Detroit Master Planning neighborhoods as our area-level unit of analysis. Although these areas represent meaningful neighborhoods and reflect distributions of resources in Detroit (210, 211), it is possible that the processes studied here (i.e., the influence of neighborhood conditions on exposure to traumatic events and on depression) may operate at a smaller area level. Sixth, we looked solely at the influence of individuals' residential environment; incorporating information on other areas where individuals spend time at work, school, or with friends may have provided a better test of the influence of neighborhood conditions on trauma exposure and

depression (240). Although we asked DNHS participants whether there was another neighborhood in Detroit where they spend substantial amounts of time, only about 15% of participants provided an alternate address so we were not able to look at the influence of other locations on traumatic event exposure or depression severity in this study. Seventh, a history of depression may influence or limit an individual's "choice" of neighborhood location, so that some of the observed associations may reflect selection into certain types of neighborhoods by depressed individuals, rather than the influence of the neighborhood environment on depression. Finally, this study was conducted in a particular urban area with very high levels of disadvantage, crime, and physical disorder; results may not be generalizable to other settings with lower levels of neighborhood problems.

Notwithstanding these limitations, our findings indicate that traumatic events probably do not mediate the effects of neighborhood conditions on depression severity, but that neighborhood conditions modify the effects of specific types of traumatic events on depression severity among adult residents of Detroit. Understanding how these two factors work together to influence depression can inform interventions to reduce depressive symptoms after exposure to traumatic events (targeting those who live in unfavorable neighborhoods) and highlight the need to improve neighborhood conditions in order to improve mental health among residents.

Table 4.1. Descriptive statistics for Detroit Neighborhood Health Study participants who had been living in their current neighborhood for at least one year at baseline (n = 1,037)

	n	Weighted %
Demographic characteristics		
Sex		
Male	420	47.6
Female	617	52.4
Race		
White and other races	159	12.9
African American	872	87.1
Age		
18-24 years	56	19.7
25-34 years	72	12.4
35-44 years	161	15.0
45-54 years	241	24.1
55-64 years	258	15.4
≥ 65 years	242	13.5
Marital status		
Married	277	29.0
Divorced, separated, or widowed	408	26.4
Never been married	352	44.6
Socioeconomic status		
Education		
< High school	131	15.3
High school or equivalent	297	42.8
Some college	364	27.0
College degree or graduate work	245	14.9
Household income in past year		
< \$15,000	292	29.1
\$15,000 - \$34,999	254	23.2
\$35,000 - \$49,999	140	15.7
≥ \$50,000	234	19.3
Missing	117	12.7
Lifetime traumatic events and stressors		
Number of lifetime traumatic events		
0	105	12.4
1-3	357	31.7
4-6	265	25.3
7 or more	310	30.6
Number of lifetime stressors		
0	166	17.5
1-2	268	24.1
3-5	349	33.5
6 or more	254	25.0
Social support at Wave 1		
Low social support in past 12 months		
No	738	72.4
Yes	298	27.6
Number of years in neighborhood at Wave 1		
1-9	337	35.9
10-19	217	23.9
20-29	178	15.2
30 or more	305	25.0

Table 4.2. Descriptive statistics for neighborhood conditions in the city of Detroit (n = 54 Master Planning neighborhoods)

	Mean	SD	Median	Range
Neighborhood disadvantage	1.42	0.38	1.42	0.6-2.2
Percent below the poverty level	27.63	9.50	30.17	9.3-44.1
Percent receiving public assistance	11.67	4.75	11.89	2.1-22.1
Percent households with <\$30,000 annual income	52.46	12.18	53.64	20.5-74.5
Percent unemployed	14.43	5.30	14.09	2.8-28.7
Percent with less than high school degree	32.28	11.41	31.47	7.4-56.8
Percent female-headed families with children	28.05	7.63	28.50	7.6-41.3
Neighborhood homicide rate (per 100,000 per year)	40.48	26.59	36.95	0-123.8
Neighborhood physical disorder	-0.03	0.72	0.00	-1.5-1.2
Percent street segments that had buildings with broken or boarded-up windows	35.43	14.23	37.04	4.4-60.3
Percent street segments that had buildings with outside damage requiring major repairs	32.25	15.90	31.80	3.3-75.0
Percent street segments that had entirely vacant buildings	33.73	12.89	34.73	4.2-58.8
Percent street segments that had vacant lots	39.22	24.76	36.36	0-92.6
Neighborhood social cohesion	3.24	0.45	3.26	1.3-4.3

Table 4.3. Pearson correlation coefficients for neighborhood conditions in the city of Detroit (n = 54 Master Planning neighborhoods)^a

	Neighborhood disadvantage	Neighborhood homicide rate	Neighborhood physical disorder
Neighborhood homicide rate	0.56 <i><0.001</i>		
Neighborhood physical disorder	0.61 <i><0.001</i>	0.22 <i>0.12</i>	
Neighborhood social cohesion	-0.43 <i>0.001</i>	-0.55 <i><0.001</i>	-0.25 <i>0.07</i>

^a p-values associated with Pearson correlation coefficients are listed in italics

Table 4.4. Bivariable associations between neighborhood conditions, exposure to traumatic events between Waves 1 and 2, and depression severity (PHQ-9 score) at Waves 1 and 2 (n = 1,037)^a

	Traumatic events between Waves 1 and 2					PHQ-9 score for past month		
	Any traumatic event Weighted %	Sudden death of someone close Weighted %	Learned of trauma to someone close Weighted %	Other injury or shocking event Weighted %	Assaultive violence Weighted %	Number of traumatic events Mean (SE)	Wave 1 Mean (SE)	Wave 2 Mean (SE)
Total	54.4	37.9	19.6	17.9	7.3	0.97 (0.07)	2.71 (0.27)	3.39 (0.27)
Neighborhood disadvantage								
1 st	56.3	42.3	23.4	15.4	6.8	0.95 (0.10)	2.04 (0.32)	2.26 (0.36)
2 nd	62.5	43.6	18.5	18.1	9.6	1.04 (0.12)	2.89 (0.67)	4.20 (0.62)
3 rd	45.6	27.4	19.4	20.1	3.2	0.93 (0.18)	2.95 (0.52)	3.44 (0.55)
4 th (least favorable)	47.9	32.5	14.0	20.0	9.6	0.95 (0.16)	3.47 (0.59)	4.33 (0.67)
<i>p-value</i> ^b	0.077	0.070	0.432	0.789	0.384	0.940	0.028	0.008
Neighborhood homicide rate								
1 st	64.0	47.5	23.0	18.2	8.1	1.03 (0.11)	2.04 (0.38)	2.29 (0.37)
2 nd	59.2	43.5	21.7	18.6	10.0	1.12 (0.14)	2.76 (0.60)	3.77 (0.57)
3 rd	46.3	32.0	12.5	17.0	4.5	0.82 (0.13)	3.52 (0.56)	4.46 (0.61)
4 th (least favorable)	43.0	21.6	22.1	17.5	6.2	0.84 (0.15)	2.39 (0.44)	2.85 (0.45)
<i>p-value</i> ^b	0.008	0.002	0.193	0.992	0.456	0.113	0.164	0.062
Neighborhood physical disorder								
1 st	64.2	49.6	18.7	13.4	9.7	0.97 (0.11)	2.13 (0.42)	2.68 (0.50)
2 nd	43.6	30.1	20.5	15.0	2.2	0.75 (0.11)	1.97 (0.32)	3.03 (0.44)
3 rd	54.1	34.2	20.1	22.2	9.3	1.02 (0.13)	2.92 (0.63)	3.60 (0.54)
4 th (least favorable)	55.2	38.2	18.8	20.2	7.7	1.15 (0.17)	3.93 (0.61)	4.35 (0.66)
<i>p-value</i> ^b	0.034	0.031	0.987	0.328	0.164	0.231	0.007	0.033
Neighborhood social cohesion								
1 st (least favorable)	47.7	32.5	11.1	17.9	8.2	0.83 (0.15)	2.94 (0.59)	4.33 (0.71)
2 nd	62.1	41.2	20.6	20.9	9.2	1.08 (0.12)	3.40 (0.67)	4.31 (0.58)
3 rd	49.3	33.7	24.3	18.5	6.8	0.95 (0.13)	2.36 (0.34)	2.82 (0.42)
4 th	56.8	44.2	15.8	12.7	5.0	0.94 (0.12)	2.22 (0.45)	2.47 (0.45)
<i>p-value</i> ^b	0.140	0.332	0.112	0.451	0.755	0.978	0.116	0.003

^a Each neighborhood condition was divided into quartiles.

^b p-values from chi-squared tests (comparing percentages with and without each type of traumatic event across neighborhood quartiles) and ANOVA tests (comparing mean numbers of traumatic events and depression severity across neighborhood quartiles).

Table 4.5. Estimated odds ratio or incidence rate ratio for traumatic event exposure, per one standard deviation increase in each neighborhood condition: Results of multilevel logistic and negative binomial regression models predicting exposure to traumatic events between Waves 1 and 2 (n = 1,037)^a

	Traumatic events between Waves 1 and 2					
	Any traumatic event OR (95% CI)	Sudden death of someone close OR (95% CI)	Learned of trauma to someone close OR (95% CI)	Other injury or shocking event OR (95% CI)	Assaultive violence OR (95% CI)	Number of traumatic events IRR (95% CI)
Neighborhood disadvantage						
Unadjusted	0.91 (0.71-1.17)	0.84 (0.65-1.10)	0.92 (0.72-1.17)	1.31 (1.07-1.60)	1.07 (0.72-1.60)	1.05 (0.95-1.17)
Adjusted ^b	0.83 (0.66-1.06)	0.76 (0.58-1.01)	0.89 (0.68-1.18)	1.27 (0.99-1.63)	0.92 (0.61-1.38)	0.99 (0.89-1.11)
Neighborhood homicide rate						
Unadjusted	0.77 (0.58-1.02)	0.64 (0.50-0.81)	0.92 (0.67-1.25)	1.10 (0.88-1.38)	0.89 (0.51-1.53)	0.92 (0.80-1.07)
Adjusted ^b	0.70 (0.54-0.92)	0.59 (0.47-0.75)	0.84 (0.64-1.10)	0.95 (0.76-1.20)	0.76 (0.48-1.23)	0.84 (0.75-0.94)
Neighborhood physical disorder						
Unadjusted	0.84 (0.66-1.07)	0.75 (0.59-0.97)	1.02 (0.81-1.28)	1.26 (1.05-1.53)	1.05 (0.67-1.63)	1.06 (0.94-1.19)
Adjusted ^b	0.77 (0.60-0.99)	0.71 (0.54-0.93)	0.99 (0.76-1.29)	1.22 (0.97-1.52)	0.94 (0.68-1.31)	1.00 (0.89-1.13)
Neighborhood social cohesion						
Unadjusted	1.04 (0.83-1.29)	1.16 (0.91-1.47)	1.05 (0.85-1.30)	0.81 (0.66-1.01)	0.81 (0.56-1.18)	0.97 (0.87-1.09)
Adjusted ^b	1.19 (0.96-1.47)	1.29 (0.99-1.68)	1.18 (0.92-1.50)	0.85 (0.64-1.12)	1.07 (0.74-1.54)	1.08 (0.97-1.20)

^a Multilevel logistic regression models were used for the outcomes of any traumatic event and each type of traumatic event, whereas multilevel negative binomial models were used for number of traumatic events between Waves 1 and 2. Each neighborhood condition was included in a separate model.

^b Adjusted for gender, race, age, marital status, education level, household income, number of lifetime traumatic events prior to Wave 1, number of lifetime non-traumatic stressors prior to Wave 1, low social support in the year prior to Wave 1, and number of years lived in current neighborhood at Wave 1.

Table 4.6. Estimated ratio of average past month PHQ-9 score at Wave 2, per one standard deviation increase in each neighborhood condition: Results of multilevel negative binomial regression analyses (n = 1,037)^a

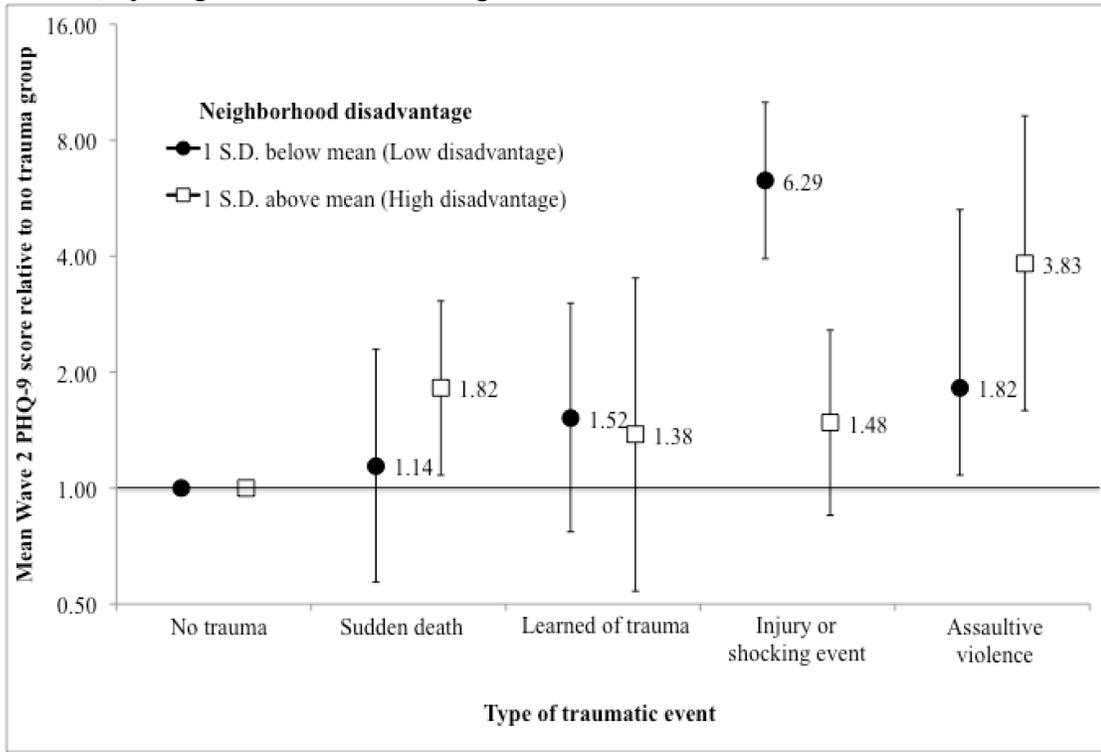
	Model 1	Model 2	Model 3	Model 4	Model 5
	Including neighborhood variable only	Model 1 + potential individual-level confounders ^b	Model 2 + any traumatic event between Waves 1 and 2	Model 2 + type of traumatic event between Waves 1 and 2	Model 2 + number of traumatic events between Waves 1 and 2
	Mean Ratio (95% CI)	Mean Ratio (95% CI)	Mean Ratio (95% CI)	Mean Ratio (95% CI)	Mean Ratio (95% CI)
Neighborhood disadvantage	1.22 (1.01-1.49)	1.21 (1.07-1.38)	1.25 (1.10-1.43)	1.25 (1.08-1.45)	1.22 (1.06-1.41)
Neighborhood homicide rate	0.99 (0.78-1.25)	1.02 (0.87-1.20)	1.10 (0.94-1.29)	1.10 (0.90-1.34)	1.11 (0.94-1.31)
Neighborhood physical disorder	1.11 (0.83-1.49)	0.98 (0.81-1.18)	1.02 (0.86-1.20)	0.98 (0.81-1.19)	0.97 (0.79-1.19)
Neighborhood social cohesion ^c	0.67 (0.54-0.83)	0.76 (0.62-0.92)	0.74 (0.62-0.89)	0.72 (0.59-0.89)	0.72 (0.58-0.88)

^a Each neighborhood condition was included in a separate model.

^b Potential individual-level confounders were gender, race, age, marital status, education level, household income, number of lifetime traumatic events prior to Wave 1, number of lifetime non-traumatic stressors prior to Wave 1, low social support in the year prior to Wave 1, and number of years lived in current neighborhood at Wave 1.

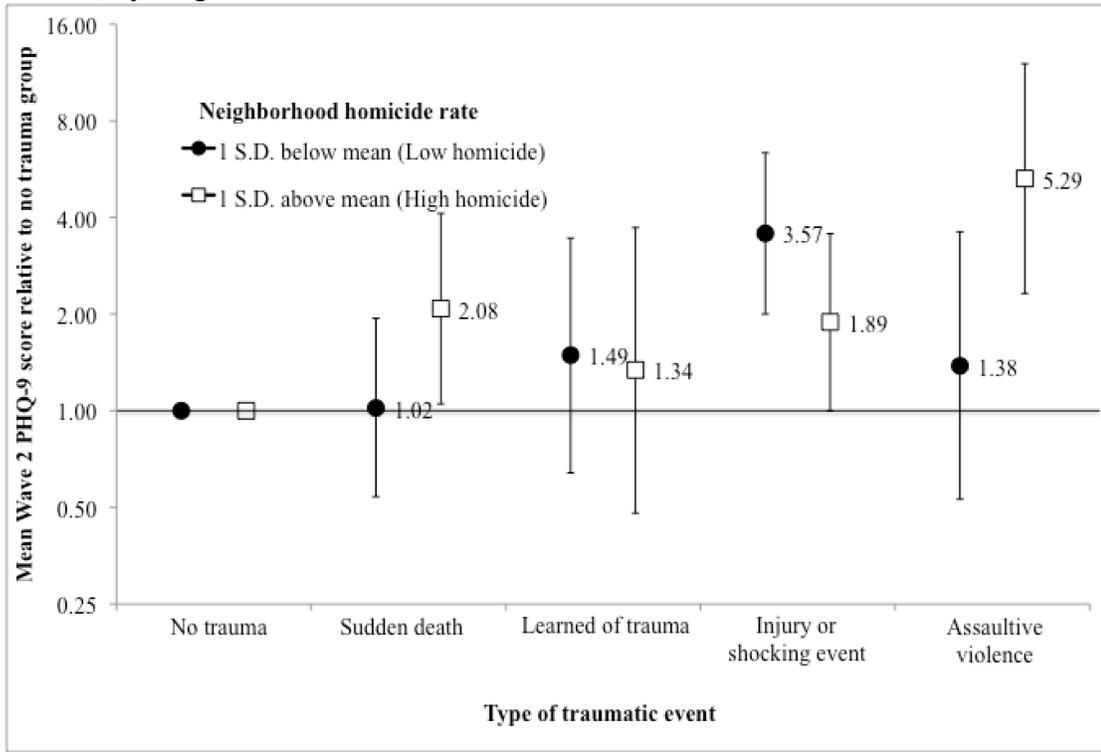
^c Higher levels of this variable are more favorable, indicating higher levels of neighborhood social cohesion.

Figure 4.1. Ratio of mean past month depression severity at Wave 2 among those with each type of traumatic event compared to those with no traumatic events between Waves 1 and 2, by neighborhood disadvantage at Wave 1^a



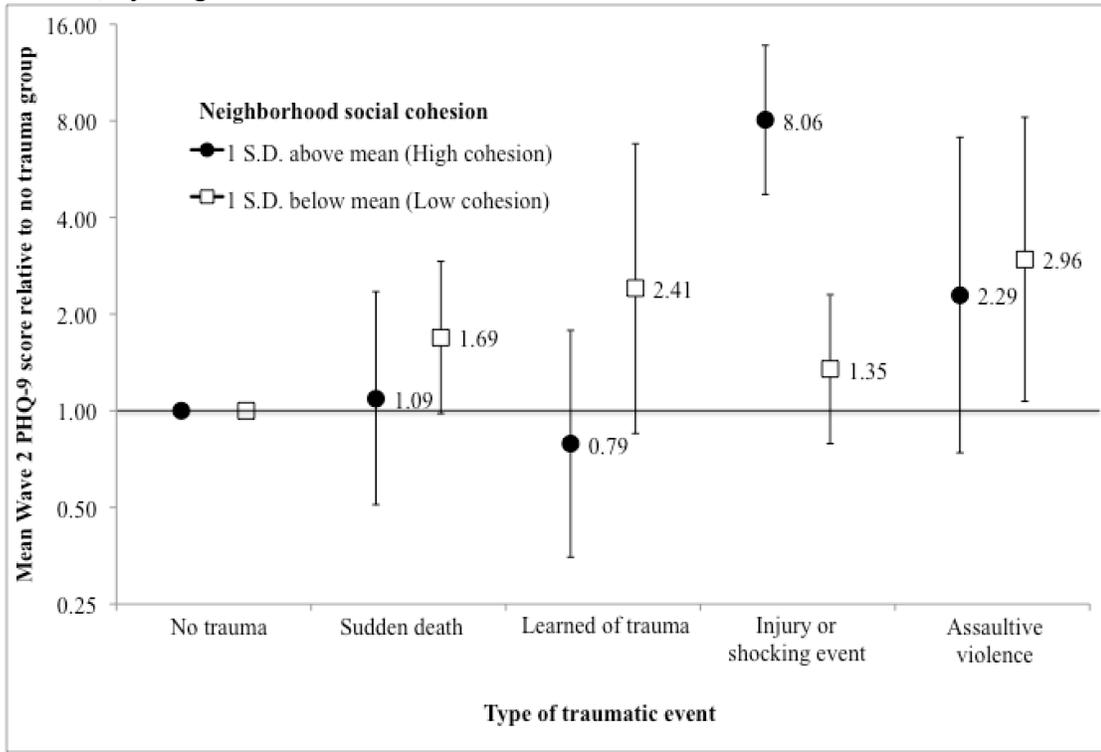
^a Mean ratios were calculated from models adjusted for Wave 1 PHQ-9 score, gender, race, marital status, education level, household income, number of lifetime traumatic events prior to Wave 1, number of non-traumatic stressors prior to Wave 1, and low social support at Wave 1

Figure 4.2. Ratio of mean past month depression severity at Wave 2 among those with each type of traumatic event compared to those with no traumatic events between Waves 1 and 2, by neighborhood homicide rate at Wave 1^a



^a Mean ratios were calculated from models adjusted for Wave 1 PHQ-9 score, gender, race, marital status, education level, household income, number of lifetime traumatic events prior to Wave 1, number of non-traumatic stressors prior to Wave 1, and low social support at Wave 1

Figure 4.3. Ratio of mean past month depression severity at Wave 2 among those with each type of traumatic event compared to those with no traumatic events between Waves 1 and 2, by neighborhood social cohesion at Wave 1^a



^a Mean ratios were calculated from models adjusted for Wave 1 PHQ-9 score, gender, race, marital status, education level, household income, number of lifetime traumatic events prior to Wave 1, number of non-traumatic stressors prior to Wave 1, and low social support at Wave 1

Chapter 5

Conclusions and future directions

This dissertation examined relations between neighborhood conditions, traumatic event exposure and depression severity in the Detroit Neighborhood Health Study (DNHS), a community-based cohort study of a representative sample of adult, primarily African American, residents of the city of Detroit. Two waves of data were included in our analyses, allowing prospective assessment of traumatic events and adjustment for pre-trauma measures of depression severity. This work fills important gaps in our understanding of the associations between different types and number of traumatic events and changes in depression severity, and identifies particular sub-groups of the population who may be most at risk for increases in depression severity following traumatic event exposure. Consideration of the context in which traumatic events occur, in terms of the individual's prior history of depression, prior exposure to traumatic events, and neighborhood environment, proved vitally important in determining psychological responses to these events.

Our findings, summarized below, have several implications for approaches to depression treatment and interventions after traumatic event exposure, and suggest a number of avenues for future research. Although this study has limitations, its many strengths, including the use of a representative sample of an urban population, the

longitudinal study design, and the consideration of a broad range of traumatic events and neighborhood conditions, lend credence to our findings and support our conclusions that traumatic event exposure poses a grave and potentially long-lasting threat to mental health.

Summary of findings

In Chapter 2, we reported the findings of analyses assessing relations between traumatic event exposure between Waves 1 and 2 of the DNHS and changes in depression severity during that period. We found strong evidence for an association between traumatic event exposure and depression severity at Wave 2, adjusting for baseline depression severity and other potential confounders including demographic and socioeconomic characteristics. The greatest increases in depression severity were associated with exposure to assaultive violence and directly experienced injuries and shocking experiences (e.g., being injured in a car accident or experiencing a natural disaster). This suggests that a focus on assaultive versus non-assaultive traumatic events (117, 136) may obscure the effects of directly-experienced events other than interpersonal violence; traumatic events may be more usefully categorized as direct (personal) experiences versus learning about a traumatic experience or the sudden death of a loved one. We also found greater increases in depression severity associated with multiple traumatic event exposure, which was common in the study population. Finally, we observed stronger associations of more severe traumatic events and greater numbers of traumatic events with depression severity among individuals with lower depression severity at baseline, consistent with some prior evidence that individuals without a

history of depression may be more psychologically affected when exposed to severe, potentially life-threatening events like those assessed in our study, whereas such events may have a less dramatic effect on the mental health of individuals who have already experienced depression (70, 71, 120).

Chapter 3 extended this work to consider in more depth the influence of lifetime traumatic events on later depression severity as well as on responses to subsequent traumatic experiences. We found that the number of lifetime traumatic events prior to the Wave 1 interview was positively associated with depression severity at Wave 2 when adjusting for baseline depression severity and other potential confounders. When simultaneously considering the numbers of different types of prior traumatic events, childhood abuse was associated with greater depression severity. We also found evidence for a stress sensitization effect of total prior traumatic events, childhood abuse, and prior assaultive violence on responses to subsequent traumatic event exposure between Waves 1 and 2. The stress sensitization hypothesis posits that prior exposure to adversity lowers the amount of future stress required to produce an adverse psychological reaction, and indeed we found that individuals with several prior traumatic event experiences exhibited greater depression severity than those with no prior trauma exposure when exposed to low numbers of traumatic events during follow-up. Associations between prior traumatic events and depression severity, and the sensitization effect of prior traumatic events on relations between recent traumas and depression severity, did not appear to be accounted for by prior history of psychopathology. These findings confirmed previous work on the long-lasting effects of childhood abuse on adult depression (39, 145, 147, 183, 184), and suggested that stress

sensitization may not be associated only with childhood traumatic events but may occur after exposure to severe, life-threatening events throughout the lifecourse.

Chapter 4 incorporated information on study participants' neighborhood of residence at the time of the Wave 1 interview to assess relations between neighborhood disadvantage, neighborhood violent crime, neighborhood physical disorder, and neighborhood social cohesion on traumatic event exposure during follow-up and changes in depression severity during that period. In contrast to other studies examining relations between neighborhood characteristics and likelihood of experiencing violent victimization (83, 85, 86, 235), we found no clear evidence of associations between neighborhood conditions and traumatic event exposure during follow-up, whether considering any traumatic event exposure, different types of traumatic events, or number of traumatic events. However, neighborhood disadvantage was positively associated with depression severity, and neighborhood social cohesion was inversely associated with depression severity, adjusting for baseline depression severity and other potential confounders. Furthermore, differential associations between type of traumatic event exposure and depression severity by neighborhood conditions were observed, such that individuals living in neighborhoods characterized by high levels of disadvantage and homicide, and low levels of social cohesion, were more vulnerable to increased depression severity after assaultive violence events, whereas individuals living in "better" neighborhoods were more vulnerable to increased depression severity after other injuries or shocking experiences.

Taken together, these findings confirm the influence of a variety of traumatic event experiences on changes in depression severity. Prior exposure to traumatic events

not only influences depression severity later in life, but affects subsequent exposure to traumatic events and psychological responses to those events. Individuals without a history of depression and those living in more disadvantaged neighborhoods may be at heightened risk for depressive responses when faced with assaultive violence. Responses to a traumatic event are thus shaped by individual experiences leading up to that event, including the physical and social environment in which that individual resides.

In our study, nearly all participants had experienced at least one lifetime traumatic event (with the majority experiencing more than one such event) and over half of the study population reported experiencing at least one traumatic event during the one-year follow-up period. This corroborates previous work finding traumatic events to be relatively common despite their extreme nature, particularly in urban areas with a history of violence and economic problems, like Detroit (30, 103-106). Although most individuals will not develop psychopathology after exposure to traumatic events, such a high frequency of these events is likely associated with a high burden of depression and other disorders in this population.

Study limitations

There are a number of important limitations of this work that should be considered when interpreting findings and comparing results to other studies.

Loss to follow-up

About 30% of the Wave 1 DNHS participants did not complete the Wave 2 interview and were thus excluded from our analyses. Bias may have occurred if this loss

to follow-up was associated with the exposures of interest and depression severity. Although this bias cannot be directly assessed, we compared those who participated in the follow-up wave to those who did not on baseline characteristics. Wave 1 participants who were lost to follow-up were younger, less educated, more likely to be unemployed, and unmarried, compared to participants who completed both Wave 1 and Wave 2 interviews (178). Inverse probability of censoring weights (156) were calculated to address these differences between the participants at follow-up and the full baseline sample, but this method may not fully control for bias due to selective attrition.

Generalizability

This work was conducted with adult residents of Detroit, who were primarily African American, of relatively low socioeconomic status, and whose neighborhoods were characterized by high levels of disadvantage, crime, and disorder compared to national averages. This population also reported higher levels of traumatic event exposure, including experiences of assaultive violence, than previously reported in other studies. Results of this study may not be generalizable to other populations with lower traumatic event exposure or a different composition of traumatic event exposure, or to populations with different backgrounds and different residential environments.

Assessment of depression

Depression severity was assessed with the Patient Health Questionnaire-9 (PHQ-9). Despite its wide use and favorable validation, this scale relies on self-reports of depressive symptoms and cannot be used to diagnose depression. We used a slightly nontraditional administration of the PHQ-9, asking about symptoms in the respondent's

lifetime and whether each symptom occurred in the past month, rather than referring only to the past two weeks.

Assessment of traumatic event exposure

Information on the number of times a specific traumatic event occurred in the participant's lifetime or during the follow-up period was not collected, potentially leading to misclassification of the number of traumatic events experienced by study participants. In particular, we did not distinguish between ongoing and single-occurrence childhood abuse events and we counted each type of traumatic event (e.g., rape) only once although it may have occurred multiple times in the participant's lifetime. We also did not assess the exact timing of traumatic events, limiting our ability to determine whether events occurring at specific times in the lifecourse have a greater influence on depression severity. Since we relied on self-reports of traumatic event experiences, we cannot rule out the possibility that exposure to childhood abuse and other traumatic events like sexual assault were underreported (23, 78, 246).

Depressive symptoms at the time of the Wave 1 interview may have influenced reports of lifetime traumatic events prior to Wave 1, and depressive symptoms at the time of the Wave 2 interview may have influenced reports of traumatic events that occurred between Waves 1 and 2 (179). However, the traumatic events assessed in this study are objective events of serious magnitude; therefore, reporting of such events is less likely to be influenced by changing perceptions of past experiences influenced by current depressive symptoms (180).

Assessment of neighborhood conditions

In our study, each participant's residential address was located within one of the 54 Detroit Master Planning neighborhoods. Census data reflecting socioeconomic conditions, crime data reflecting numbers of homicides, and physical disorder data reflecting results of a systematic neighborhood observation for each neighborhood were then linked to participant's survey responses. However, we cannot rule out the possibility that smaller areas (e.g., census tracts or block groups, or a more individualized measure of neighborhood within a certain radius of the participant's residence (247)) would be more meaningful to the processes studied here. Furthermore, neighborhood social cohesion was assessed by averaging responses from participants residing in the neighborhood, rather than using an independent sample to create this measure (90). If depression influences social cohesion ratings, our estimates of the association between neighborhood social cohesion and depression severity may be biased. Finally, as in all studies of neighborhood conditions, we cannot fully rule out the possibility that "social selection," whereby individuals with poorer health or other characteristics like low SES locate in more disadvantaged neighborhoods (248), influenced our findings of associations between neighborhood conditions and depression severity.

Temporal ambiguity

As noted above, the study questionnaire did not assess the exact timing of traumatic events; it also did not assess the exact timing of onset of depressive symptoms during the follow-up period. Therefore, some temporal ambiguity exists, with the possibility that some traumatic events reported to have occurred between Waves 1 and 2 were actually experienced after the onset of depressive symptoms during follow-up. Using a measure of depressive symptoms that is focused on the 30 days prior to the Wave

2 interview ensured that the vast majority of traumatic events experienced by the study population during the one-year follow-up period would likely have occurred prior to the time for which depression was assessed, yet changes in depressive symptoms may still have preceded traumatic events.

Residual confounding

We collected information on a range of potential confounders of associations between traumatic event exposure and depression severity, including demographic and socioeconomic characteristics, history of non-traumatic stressors, and level of social support. However, there may be residual confounding of the relations studied, for example by other childhood characteristics (e.g., family SES, family disruption, parental psychopathology) that may predispose individuals both to traumatic events and depressive symptoms later in life.

Low power to detect interactions

This study had low power to detect statistical interactions, particularly when using multilevel models including cross-level interactions (i.e., interactions between measures at the individual- and group-level). Thus, our failure to find evidence of departure from multiplicativity on the mean-ratio scale when assessing some hypothesized interactions should not be taken as definitive evidence that the factors in question do not interact in producing changes in depression severity.

Use of negative binomial regression models

The outcome of interest in these studies, the PHQ-9 score measuring depression severity in the past month at Wave 2, was highly skewed in our study sample, with about half of participants reporting no trouble from any of the depressive symptoms (and thus

having a PHQ-9 score of 0). Negative binomial models provided the best fit to the data and were used to calculate the ratio of mean PHQ-9 score across categories of predictors of interest. The use of these models, although entirely appropriate (139) somewhat limits our ability to compare our results with previous studies of these questions, which often model depressive symptoms using a linear model (88, 90). Statistical interactions in linear models are on the additive scale, whereas interactions in our analyses were considered on the multiplicative scale; this may partly explain some differences in our findings regarding interactions compared to previous work. The use of negative binomial models also limited our ability to assess the proportion of variance in depression severity that was between neighborhoods because of difficulties in partitioning variance when using count outcomes and nonlinear models (229, 230). However, multilevel negative binomial GEE models provided adequate estimates of the fixed effects of interest in our analyses of the influence of neighborhood conditions on changes in depression severity.

Public health implications

Despite these limitations, our findings have a number of practical implications for population mental health amid fairly widespread traumatic event exposure. First, attention should be focused on victims of violent trauma, individuals experiencing other traumatic events directly rather than second-hand (e.g., serious physical injuries), and those experiencing more than one traumatic event in a relatively short time, as these groups are at greatest risk of increased depression severity following trauma. Our findings for increased risk of depression severity associated with injuries and other shocking experiences should be particularly noted, as previous studies have indicated that

survivors of traumatic physical injuries are not always reached by psychological interventions (249, 250).

Second, early interventions with childhood abuse victims and others exposed to traumatic events early in life may be critical to reducing the negative consequences of these events, which include a very high potential for later exposure to other traumatic events as well as depression in adulthood. Early intervention may also decrease the potential of these events to sensitize individuals to the effects of future stress. As such, further efforts to increase utilization of clinically proven trauma-focused interventions like trauma-focused cognitive behavioral therapy for maltreated children are warranted (251). Interventions also need to address behaviors and characteristics that may predispose victims of childhood abuse to revictimization (34, 252). For example, “contextual therapy,” which considers the context in which trauma occurred and focuses on skills acquisition and reframing self-perceptions rather than trauma processing, may be beneficial in developing improved daily functioning and coping strategies that may have been circumscribed by abuse and a poor family environment during key developmental periods (253).

Third, one of our main findings was that depressive responses to traumatic event experiences were modified by individuals’ prior history of depression and traumatic event exposure, and neighborhood conditions. This suggests that consideration of these factors may help practitioners assess risk of psychopathology among trauma victims. Recent work has focused on developing a risk algorithm to predict onset of major depression among patients seen by general practitioners (254), akin to risk algorithms widely used in the prediction of coronary heart disease (255). A similar approach could

be taken to develop a risk algorithm to predict onset of psychopathology among trauma victims, including past trauma exposure and psychopathology, and socioeconomic and neighborhood conditions; such an algorithm could be used by clinicians seeing trauma survivors in emergency rooms or rape crisis centers. Consideration of the factors identified in our study as modifiers of relations between trauma exposure and depression may also be important to decisions about the best course of treatment, as some studies suggest that the effectiveness of different treatments for depression may vary according to history of trauma exposure, including early adversity (75, 252).

Fourth, characteristics of an individual's neighborhood environment may not directly increase exposure to traumatic events, but they do seem to alter the individual's psychological responses when exposed to trauma, and to influence depression severity regardless of trauma exposure. Detroit is a particularly salient example of an urban area facing extraordinary amounts of blight, unemployment, and violence. A number of recent initiatives in Detroit aim to improve neighborhood conditions. For example, the Skillman Foundation's "Good Neighborhoods Initiative" focuses on involving community residents in efforts to improve services especially for children and families in six Detroit neighborhoods, thereby increasing community social cohesion (256), while the Next Detroit Neighborhood Initiative's "Clean Neighborhoods" program aims to improve physical neighborhood conditions through trash and graffiti removal as well as engagement and empowerment of community residents (257). Such improvements are critical to improved population mental health in this area.

Future research directions

In addition to the implications of our findings for public health interventions, this work suggests a number of avenues for further research. In particular, a more detailed consideration of both non-traumatic stressors and traumatic events, including their interrelations and joint effects on depression severity, may provide greater insight into the pathways between traumatic event exposure and depression over time. For example, several recent studies of natural disasters have suggested that, in the longer term, stressors like financial problems and relocation are more predictive of persistent mental health problems than actual traumatic exposures (258, 259), and these stressors may increase risk for future traumatic events (151). Longitudinal studies with more than two waves of data could consider trajectories of trauma and stress and their influence on trajectories of depression over time (260, 261).

Complex systems models have great potential to further our understanding of dynamic relations between traumatic events, subsequent stressors, and depression over time, also incorporating the influence of social networks and neighborhood conditions. Complex systems models (e.g., agent based models) use computer-based algorithms to model dynamic interactions between individuals and between individuals and their environment (151, 262). Advantages of these models include their ability to incorporate “feedback” and bidirectional relations (e.g., prior depression influencing later depression; traumatic events influencing depression and vice versa); their explicit inclusion of interactions between individuals, allowing consideration of social support as well as transmission of risk behaviors and outcomes through social networks; their explicit inclusion of interactions between individuals and their environment, allowing individuals to change and be changed by their neighborhood surroundings and to move in response to

changing neighborhood conditions; and their ability to simulate counterfactual conditions by running experiments to compare population patterns of disease under different conditions (262-265). These models have already provided useful insights into the mental health consequences of mass trauma exposure (151), and may be particularly useful for comparing the effects of different neighborhood interventions on population mental health.

Given the potentially devastating effects of depression on functioning, productivity, quality of life, physical health, and social relationships, efforts to further our understanding of the role of traumatic events and neighborhood conditions on changes in depression severity may be a great benefit to population health. This work successfully extended previous work assessing the relations between traumatic event exposure and depression severity and identified sub-groups of the population who may be most at risk of increased depression severity when exposed to traumatic events, with concrete implications for public health interventions and future research.

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