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Identifying resilience and the role of neighborhood environments following exposure to a natural disaster: a mental health trajectory analysis among survivors of Hurricane Katrina

By

Angela Maithy N. Nguyen

A dissertation submitted in partial satisfaction of the

requirements for the degree of

Doctor of Public Health

in the

Graduate Division

of the

University of California, Berkeley

Committee in charge:

Professor Emily Ozer, Co-chair
Professor Ralph Catalano, Co-chair
Professor Sophia Rabe-Hesketh

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Abstract

Identifying resilience and the role of neighborhood environments following exposure to a natural disaster: a mental health trajectory analysis among survivors of Hurricane Katrina

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Angela-Maithy Nguyen

Doctor of Public Health

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Professor Emily Ozer, Co-chair

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Disasters affect millions of people every year and the frequency of natural disasters, in particular, are increasing due to climate change. Exposure to natural disasters is associated with a variety of mental health consequences, and some of the most studied outcomes are post-traumatic stress disorder, major depressive disorder, and physical and mental health comorbidities. The burden of these outcomes have been well documented. There is limited literature on those who experience positive adjustment in the aftermath of a traumatic event. Only recently did we really begin to understand the long-term mental health impacts among those who experience disasters. Evidence from the small pool of longitudinal studies have found that symptoms of distress peak among survivors in the year following the disaster and then improve for some. For others, symptoms persist for months and even years. Because of this, there are several proposed response pathways. These pathways include chronic low well-being, resistant, and resilience. However, the literature on what contributes to these different pathways, especially those who experienced resilience in the long term, is limited.

Psychological resilience is generally defined as the process of how individuals remain relatively stable levels of psychological and physical functioning after exposure to trauma. One of the main methodological barriers in addressing this gap is due to lack of longitudinal data among survivors. Understanding the impacts of long-term mental health and the contributing factors which bolster resilience may provide new and enhanced prevention and treatment strategies for communities exposed to emergencies and disasters, in addition to informing upstream disaster management and crisis response efforts among those who are most vulnerable.

Another important aspect of post-disaster mental health is how place matters, particularly for those who experienced severe displacement. The Hurricane Katrina disaster in 2005 resulted in the largest internal displacement in the country since the Dust Bowl. The general literature on place and health is substantial, though more limited in the context of post-disaster mental health. Due to displacement, both forced and voluntary, survivors are forced to adapt in new neighborhoods. These neighborhoods themselves undergo changes and it is likely that these changes impact mental health both in the short- and long-term.

This dissertation is composed of three research studies that explore psychological resilience, post-disaster mental health trajectories, and the mental health impacts of neighborhood social and economic conditions among natural disaster survivors. The first paper is a systematic and qualitative synthesis of how psychological resilience has been conceptualized and measured in longitudinal studies conducted among natural disaster survivors. The literature search was conducted through four databases and guided by the Population, Intervention, Comparator, Outcome, and Study Design framework. Twelve studies were included in the synthesis which examined resilience following a range of natural disasters. Findings from the review were that most of the studies had clear conceptualizations of resilience and used data-driven methods to measure resilience. However, conceptualizations of resilience were not consistent across studies and limitations of methodological approaches were not addressed.

The second paper is a quantitative analysis to identify which mental health trajectories emerged among a cohort of adult Hurricane Katrina survivors across 10 years of survey data. Using latent growth mixture modeling, we found three distinct trajectories which we characterized as recovery, resilience, and chronic. We also found that baseline predictors associated with trajectory membership were employment change, residential mobility, and having received financial resources. These results warrant future examination of contextual factors, specifically at the community-level.

The third paper is a quantitative analysis which examines the association between neighborhood-level socioeconomic status and mental health among women survivors of Hurricane Katrina, a particularly vulnerable population. Findings from this study were that while increased neighborhood socioeconomic status was associated with increased mental health, this relationship differed by move status. Women who did not move or were able to return to their pre-disaster neighborhoods were predicted to have better mental health compared to women who relocated and did not return. This study's findings revealed the importance of displacement patterns and how changing neighborhood social and economic conditions may be important for mental health among survivors over time.

To my dad, who has never doubted my ability to accomplish hard things

To Andrew, my pillar of support in helping me find my confidence and voice

And, finally, in loving memory of my mom, whose extraordinary strength, wisdom, and selfless
love continues to inspire me every day

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Chapter 1: Introduction

We have to appreciate that there is quite a lot of variability and diversity in the way that we respond [to trauma]. And some have argued that the diagnosis of PTSD is too limiting, and some have argued that it's too expansive, but one thing is for certain — PTSD is one kind of response to trauma, and there are probably many others, including resilience.

- Rachel Yehuda (2017)

Overview of disaster mental health

The mental health impacts of large-scale disasters are well documented. Most of the existing literature, particularly in the aftermath of the September 11, 2001 terrorist attacks, have focused on post-traumatic stress disorder (PTSD) as one of the main adverse mental health outcomes following exposure. Studies show that approximately 30-40% of survivors report probable PTSD following exposure to traumatic events (Goldmann & Galea, 2014). While PTSD is the most prevalent outcome among disaster-exposed populations, the course of PTSD symptomology is not a linear process (Ozer et al., 2003). Survivors of mass trauma may exhibit initial heightened levels of psychological distress that will decline over time, or they may experience patterns of remitted, chronic, or delayed psychological distress (Norris et al., 2009). The literature shows that the psychological response to trauma is heterogeneous and can change over time. In addition, trajectories of post-traumatic stress may vary across different survivor cohorts. Loss of social and emotional support, social isolation, and low levels of social cohesion are all strongly associated with chronic or worsening PTSD among disaster survivors (Butler et al., 2009; Welch et al., 2016). At the same time, changes in social support and cohesion are common following trauma exposure due to forced migration, residential mobility, damage to infrastructure, and disruption in social services delivery (Galea et al., 2002). These findings collectively emphasize how social support and social cohesion are central to the lived experiences among disaster survivors and that the loss or disruption of these resources can negatively impact mental health. As the world continues to face social, environmental, and political instabilities and catastrophes, understanding the long-term psychological outcomes of trauma survivors and the driving contextual and social factors is critical for intervention design. While the disaster mental health literature is substantial, few studies have documented the long-term mental health impacts among survivors more than a few years following the event.

Mental health impacts among Hurricane Katrina survivors

Hurricane Katrina, a tropical cyclone, made landfall along the U.S. Gulf Coast on August 29, 2005. The hurricane led to nearly 2,000 fatalities, displaced over one million individuals in the Gulf Coast region, and destroyed nearly 900,00 homes. The physical and societal impacts of the catastrophe resulted in a staggering economic toll of 125 billion dollars, making Katrina the costliest disaster in U.S. history (Britannica, 2020). The devastating effects of Katrina revealed a long history of environmental racism and injustices in New Orleans. The majority of those

directly impacted by the disaster were low income and Black communities living in structurally vulnerable environments (Solnit, 2010). Not only were Black and low-income residents living in neighborhoods that suffered severe housing damage and greater flooding, but they also experienced higher rates of post-disaster-related stressors, such as job loss, delayed evacuation, and delayed return, compared to White and higher income communities (Fussell et al., 2010).

Several studies demonstrated elevated psychological stress and adverse mental health outcomes in the immediate aftermath of Katrina (Galea et al., 2007; Kessler, 2000; Sastry & VanLandingham, 2009). Findings from these early studies also showed significant disparities in mental health by race, employment status, and hurricane-related stressors (i.e., job loss, physical adversity). Galea et al. assessed the prevalence of probable anxiety-mood disorders and PTSD among a probability sample of over 1,000 pre-hurricane residents several months after Katrina. They found that nearly half of residents had self-reported probable anxiety-mood disorder and over a third had probable PTSD (Galea et al., 2007).

Despite these short-term findings, few studies have been able to examine the long-term mental health impacts among Katrina survivors. To our knowledge, only one study has examined post-traumatic stress symptoms more than a decade following Katrina (Raker et al., 2019). In this study, the investigators utilized long-term trajectories of mental health (post-traumatic stress symptoms (PTSS) and non-specific psychological stress (PD), assessed across three time points 12 years after Katrina. Compared to the general population, rates of PD remained relatively high across all time points. Overall rates of PTSS declined across time, though nearly 20% of the sample remained having probable self-reported PTSD at the third follow-up. The study also examined predictors of changes in mental health, categorizing individuals into PTSS trajectories as persistent, recovered, incident, and never PTSS. Compared to never having experienced PTSS, older participants were more likely to recover from PTSS. Black participants, compared to non-Black respondents, were also more likely to recover from PTSS. However, Black participants were also more likely to experience persistent PTSS compared to never having PTSS. Hurricane-related experiences were also associated with changes in PTSS over time. Respondents were asked questions about their post-disaster experiences related to lacking food, water and/or medicine, safety, access to medical care, and more. Each additional post-disaster experience was associated with a 17 percent increase in risk of persistent PTSS rather than recovering from PTSS. Findings from this novel study underscore the need to better understand factors related to changes in PTSS over time, particularly the role of social and environmental determinants among those who experienced resilience and recovery in the long-term.

Research aims

My dissertation presents an opportunity to use three different methodological approaches in understanding several key aspects of post-disaster mental health among adult survivors of natural disasters. The methodological approaches are guided by three main research questions which generated three related studies.

The first paper is a systematic and qualitative synthesis of longitudinal studies on psychological resilience in the context of natural disasters. The primary aims of this study were to 1.) synthesize how ‘psychological resilience’ is conceptualized and measured in disaster research as

a latent construct and 2.) compare and contrast differences in study design, methodologies, and measurements, and 3.) summarize the range of predictors examined in relationship to resilience. This paper poses the research question:

How is psychological resilience conceptualized and measured in longitudinal studies conducted among adults survivors of natural disasters?

The second paper is a quantitative analysis to identify the distinct trajectories of post-disaster mental health among a cohort of adult Hurricane Katrina survivors across five Waves of survey data. This analysis was conducted using an exploratory approach known as latent growth mixture modeling followed by a multivariate analysis to better understand the predictors associated with each trajectory. The primary aims of this study were to: 1.) identify the post-traumatic mental health trajectories among Hurricane Katrina survivors, and 2.) assess individual-level predictors associated with each identified post-traumatic mental health trajectory among Hurricane Katrina survivors. This paper poses the main research question:

- 1.) How do the longitudinal trajectories of post-traumatic mental health differ among adult survivors of Hurricane Katrina 10 years following the disaster?

Sub-research question:

- 2.) What are the baseline predictors associated with the identified trajectories among adult survivors of Hurricane Katrina?

The third paper is quantitative analysis to examine the association between neighborhood socioeconomic status and post-disaster mental health among adult women survivors of Hurricane Katrina. This analysis utilized a three-level hierarchical modeling approach to examine the effects of neighborhood-level social and economic factors on mental health across 10 years of survey data. An interaction analysis was also conducted to better understand how this relationship differed between individuals who stayed or returned to their pre-disaster communities and those who permanently relocated. The primary aims of this study were to: 1.) evaluate how neighborhood-level socioeconomic status is associated with post-disaster mental health among women survivors, and 2.) estimate the predicted effects of moving status on the association between neighborhood-level socioeconomic status and mental health among women survivors. This paper poses the main research question:

- 1.) How does neighborhood socioeconomic status affect self-rated mental health among Hurricane Katrina women survivors?

Sub-research question:

- 2.) Is the association between neighborhood socioeconomic status and mental health modified by moving patterns among Hurricane Katrina women survivors?

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Chapter 2: Measuring psychological resilience of adult survivors of natural disasters: a systematic review & qualitative synthesis (2009 – 2020)

Introduction

The contemporary and broad perspective of psychological resilience is that it is a form of mental health protection, described as “the phenomenon or process reflecting relatively positive adaptation despite experiences of significant adversity or trauma” (Luthar et al., 2014). While there is no unified definition across disciplines, there are two central constructs in nearly every definition of resilience: adversity and positive adaptation (Luthar & Cushing, 2002). The literature on psychological resilience is longstanding, and the definition of resilience has evolved throughout distinct phases of the research. The literature suggests that there is no widely agreed upon definition or measurement of resilience because it is not an observable condition; thus, the conceptualization and metrics of resilience are arguably ambiguous (Almedom & Glandon, 2007).

Early research in the 1960s and 1970s focused on resilience in the context of developmental psychology and trauma among ‘high-risk children’ who had endured chronic adverse life events, such as poverty, abuse, and/or loss of a family member (Garmezy, 1993; Masten & Powell, 2003). In these studies, children were observed across the lifespan. Despite enduring trauma, these children developed into adaptive and functional adults later in life. Findings from these studies showed that individual-level temperament, intelligence, and cognitive skills were associated with resilience (Garmezy, 1993; Hoge et al., 2007; Masten, 2001). Research on resilience further expanded in the 1980s and 1990s where the perspective shifted from examining personal qualities to external factors among children (Luthar et al., 2014). These factors were related to children’s family dynamics and aspects of their social environment. The conceptualization also shifted, in that, resilience was seen as something that fluctuated over time rather than being fixed. More specifically, Luthar et al. emphasizes that “...positive adaptation despite adversity is never permanent; rather, it is a developmental progression with new vulnerabilities and strengths emerging with changing life circumstances” (Luthar et al., 2014). By the early 2000s, the research area of resilience again shifted and expanded towards examining its relationship to post-traumatic stress disorder (PTSD) among adults in the context of an acute or single incident trauma (Bonanno, 2004). Research at the intersection of PTSD and psychological resilience increased in the context of natural disasters and events such as 9/11 (Goldmann & Galea, 2014). PTSD was established as one of the primary mental health outcomes following acute trauma, but few studies had examined survivors who were seemingly less vulnerable to mental health impairment. Given the longstanding research on resilience, a new label for resilience referred to as “minimal-impact resilience” emerged (Bonanno & Diminich, 2013). This approach focuses on isolated and/or unexpected stressors experienced by groups of people in an otherwise stable environment, particularly war veterans and adult survivors of large-scale catastrophes.

Some risk factors associated with PTSD, among trauma-exposed adults, are low levels of perceived social support, lower educational attainment, and subsequent life stress (Hoge et al., 2007; Kessler et al., 1999). Though it might seem that these factors are inversely associated with resilience, the conceptualization of resilience cannot simply be depicted as the absence of PTSD. Rather, there are some risk factors of PTSD that share similar domains as factors associated with resilience. It is hypothesized that resilience represents “qualities encompassing process and mechanisms that confer protection” and that these qualities operate both directly and indirectly over time (Hoge et al., 2007; Rutter, 1985). There are challenges in understanding the role of history of prior trauma or cumulative life events and post-traumatic resilience among adults. This impact of previous life stressors or prior trauma is more consistent for PTSD. Findings from a meta-analysis showed that history of prior trauma was an important predictor of PTSD, in that survivors who reported experiencing a traumatic event prior to the target stressor had higher levels of post-traumatic symptoms. However, this association varied by the type of traumatic experience (Ozer et al., 2003). In contrast, findings from a study among firefighters showed that previous exposure to trauma increased participants’ sense of locus of control and self-efficacy (Regehr et al., 2000). Hoge et al. postulated that prior exposure to trauma may be a protective factor “if it is associated with an increased sense of mastery or growth”, though this relationship remains understudied (Hoge et al., 2007). Furthermore, measures of resilience have since moved away from using factors related to the internal locus of control in the current phase of adult resilience research.

Some of the limitations and challenges in the current phase of resilience research is due to study design, conceptualization, and measurement. Most of the existing research on the relationship between life stressors and psychological resilience is cross-sectional, which undermines the conceptualization of resilience as a process. While there are increasing number of prospective studies, few have examined resilience in the context of disasters. The existing literature does illuminate that there are varying lag periods of delayed resilience. In other words, the duration of follow-up is an essential element of prospective studies to fully capture the life course of psychopathology among adult survivors. Several studies have also examined recovery as an additional distinct response following trauma, in that those who exhibited post-traumatic stress symptoms (moderate to severe) in the immediate aftermath of trauma later experienced a decline in symptomology, while others have presented resiliency and recovery as similar types of post-traumatic responses. These findings have supported the argument that resilience cannot be measured as a binary outcome, but in relation to other types of post-traumatic responses. There also does not appear to be a gold standard in measuring resilience.

Previous theoretical reviews of the resilience literature in general have all concluded that while resilience has been examined for decades, the research on resilience needs to be more explicit in their conceptualization (Fletcher & Sarkar, 2013; Hoge et al., 2007; Vella & Pai, 2019). Theoretical reviews have provided an informative historical review of definitions of resilience and have highlighted the major paradigm shifts in research, but reviews have not summarized theory-informed methodological approaches. Furthermore, these reviews were not specifically focused on the context of natural disasters, which is an important gap to address. Defining resilience should be domain or context specific. Ambiguous definitions of resilience have arguably contributed to inconsistent measurement and application in research (Infurna & Luthar, 2018). Considering the growing disaster resilience research, a systematic review focused on this field is critical to generate recommendations and strengthen future studies. A recent systematic

review of operationalizing resilience in longitudinal studies on ageing found that most studies were using data-driven methods to identify resilience using statistical procedures (Cosco et al., 2017). It is unclear if this is the case for longitudinal studies on natural disasters. Furthermore, it is critical to uncover how aligned the methods are to the conceptualizations across these studies. To our knowledge, there are no systematic reviews systematic reviews exist, which centers on the conceptualization and measurement of resilience in the context of natural disasters.

The purpose of this review is to understand how psychological resilience is studied, to date, following exposure to a natural disaster(s). This systematic review aims to summarize 1.) themes of resilience conceptualization and operationalization across different natural disaster survivor cohort studies, 2.) differences in study design, methodologies, and measurements, and 3.) the range of predictors examined in relationship to resilience. The impacts of this review are to provide greater insight on how adult resilience has been examined in the context of natural disasters and to inform future research investigating the association between exposure to a disaster and psychological resilience, specifically to identify methods to characterize resilience in a longitudinal analysis. A critical review of studies to date will inform researchers on how to approach disaster resilience research that will inform emergency preparedness and resource mobilization efforts.

Methods

Search Strategy

The systematic review was conducted using the Preferred Reporting items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines (Page et al., 2021). The Population, Intervention, Comparator, Outcome, and Study Design (PICOS) framework (Table 1) guided the research question which was, “In longitudinal mental health studies conducted among adult survivors of natural disasters, how is psychological resilience conceptualized and measured?”. The literature search was conducted through four databases: PubMed, Web of Science (WoS), ProQuest (PsycInfo) and Scopus in January 2022. To determine the appropriate keywords to use, a range of relevant terms were collected using the National Library of Medicine’s (NLM) curated medical vocabulary resource, Medical Subject Headings (MeSH). The MeSH entry terms, “Resilience, Psychological” (a sub-heading of “Psychological Phenomena”) was introduced in 2009 and is defined as “the human ability to adapt in the face of tragedy, trauma, adversity, hardship, and ongoing significant life stressors”. It was previously indexed as “Adaptation, Psychological” (2004-2018), defined as “a state of harmony between internal needs and external demands and the processes used in achieving this condition” (From APA Thesaurus of Psychological Index Terms, 8th ed). To widen the search, both sub-headings were included as entry terms in the literature search. The MeSH entry terms “Natural Disasters” was not introduced until 2019, In order to retrieve articles related to natural disasters, “Natural disaster” was also added based to the terms after developing a brief literature matrix. In order to narrow down the search results to prospective studies, three keywords related to studies over time were added. Neither Scopus or WoS uses MeSH terms and approximately 35% of PsycInfo records include MeSH terms. Each database search was limited to peer-reviewed publications. The final combination of keywords used were as follows:

1. PubMed: ("Adaptation, Psychological"[Mesh] OR "Resilience, Psychological"[Mesh]) AND ("Natural Disasters"[Mesh] OR "natural disaster") AND "Cohort Studies"[Mesh].
2. WoS and PsycInfo: ("Resilienc*" AND "Natural Disaster*" AND ("Cohort" or "Longitudinal")). Search terms could be present in any available fields.
3. Scopus: ("Resilienc*" AND "Natural Disaster*" AND ("Cohort" OR "Longitudinal")). Search terms had to be present in the title, abstract, or keywords.

Reference lists of eligible articles were further examined to identify additional relevant studies for the qualitative synthesis.

Eligibility Criteria

The following types of papers were removed: 1.) any systematic or narrative reviews, 2.) qualitative studies, 3.) animal studies, 4.) cross-sectional studies, 4.) studies in which the outcome(s) did not include or mention resilience, 5.) if the population of interest did not include adults, and 6.) if the exposure of traumatic events that did not fall into the definition of a natural disaster. With respect to the study sample inclusion criteria, papers which focused solely on adolescents, war veterans, law enforcement officials, paramedics, or healthcare professionals were removed during this screening process. The rationale in doing this is because the population of interest for this review are adult survivors of disasters. War veterans, law enforcement officials, healthcare professionals may be exposed to repeated events of trauma in their work environments, and they may also have had resilience trainings in their fields of employment.

The full text of the remaining 27 articles were carefully examined to assess their study designs, study samples, research questions, and variables of interest. Citations of these articles were also examined to include any possible literature which did not come up during the initial search.

Data Extraction and Quality Assessment

Of the final papers selected, the data extracted for the results and analyses were the type of disaster examined, year at baseline data collection, baseline population size and attrition rates, region, study duration and number of follow-ups for data collection, predictor and outcome variables, types of analytical models employed, and results. Some of the key data extracted from all studies are summarized in the matrix (Table 2).

Each study was assessed using the National Heart, Lung, and Blood Institute's Quality Assessment Tool for Observation Cohort and Cross-Sectional Studies (NHLBI) (National Heart, Lung, and Blood Institute, 2021). The NHLBI tool was developed in 2013 to support reviews in assessing a study's internal validity. For each study, the sum of positive responses (= 1) across 14 indicators were calculated to obtain a potential total score ranging from 0 to 14. The results of the quality assessment are shown in Table 2.

Results

Literature retrieval and study characteristics

A summary of the literature retrieval is shown in the PRISMA flow diagram in Figure 1. The first round of results was limited to English-language and peer-reviewed articles published in any

given year. During this round, 288 articles across the four databases were retrieved. Before papers were examined for relevance, 77 duplicates were manually removed. The titles and abstracts for all remaining papers (N=211) were then closely examined referencing the PICOS criteria. After excluding ineligible studies, 27 studies were eligible for full text downloading and further screening. Twelve studies met the final inclusion criteria for the qualitative synthesis. The studies include 11 distinct survivor cohorts who were exposed to a range of natural disasters: earthquakes in Thailand, Japan, and New Zealand, bushfires in Australia, the Indian Ocean tsunami, Hurricane Katrina, Hurricane Ike, Hurricane Rita, and floods in Mexico. Two of these studies, conducted by Johannesson et al., reported findings among the same cohort three and six years following the Indian Ocean tsunami disaster (Johannesson et al., 2011; Johannesson et al., 2015). The majority of the studies included two timepoints of analysis (N=6), followed by three timepoints (N=4), and four timepoints (N=2). Only one study included pre-disaster data. The studies were published between 2009 and 2020. Table 2 presents the details of the studies.

Results of the study quality assessment are presented in Table 2. The studies yielded scores ranging from 9-12, with an average score of 9.83. Some of the strengths observed across the majority of the studies were that the study population, exposure, and outcome measures were clearly defined. Measures were also valid, reliable, and implemented consistently across all study participants. The studies also had appropriate follow-up periods to measure resilience in the aftermath of the disaster. The primary weakness was loss to follow-up rates of over 20 percent during the second or third wave of data collection.

Conceptualizing and operationalizing resilience

The term “resilience” was defined and conceptualized in all but one of the studies. Findings from the data extraction yielded several broad themes: 1.) the absence or “stably” low levels of psychological distress following the event and 2.) the ability to “bounce back” or the process of positive psychological adaptation over time. Under the “bounce back” theme, Lowe et al. further describe resilience as those who experience “initial post-disaster elevation in distress” in the immediate aftermath (Lowe & Rhodes, 2013). In their later study, Lowe et al.’s definition of resilience, “a trajectory of low levels of symptoms or problems in a given outcome over time”, is more aligned with the first “stably low” theme (Lowe et al., 2015). While all the studies limited to this systematic review were longitudinal in nature, resilience was explicitly defined as a process that occurs over time in only eight of the studies. Osborne & Sibley conceptualized resilience as a personal trait and their definition did not fall under either of the aforementioned themes (Osborne & Sibley, 2013). Lowe et al. and Norris et al. both discuss how resilience has been used heterogeneously in empirical research (Lowe et al., 2015; Lowe & Rhodes, 2013; Norris et al., 2009). Norris et al., the earliest published study in this review, states that resilience is beyond the state of an absence of psychopathology but that it is “one of multiple routes to good mental health” (Norris et al., 2009). Lowe et al. emphasizes how the growth in this body of literature has shown that resilience is a multidimensional construct and that its definition is context specific (Lowe et al., 2015).

There were two main categories for how resilience was operationalized. The first being below the cut-off points of psychological distress or mental health disorder across time points. Fernandez et al, Johannesson et al., Tang et al, and Wadsworth et al. operationalized resilience as having not met the criteria for mental health disorders such as PTSD, manic depressive disorder, and acute stress disorder at both time points (Fernandez et al., 2020; Johannesson et al., 2011;

Tang, 2007; Wadsworth et al., 2009). Bryant et al. examined symptoms of psychological distress at both time points and classified “no to minimal psychological programs” reported in the past 30 days as psychological resilience at either time point (Bryant et al., 2018). Osborne et al. characterized resilience as a personality trait related to Emotional Stability, one of the dimensions of the Big-Five personality theory (Osborne & Sibley, 2013). The authors hypothesized that Emotional Stability “reflects individual differences in people’s resilience” in response to potentially stressful circumstances and is “most relevant for predicting people’s changes in mental health” (Osborne & Sibley, 2013). The remaining six studies operationalized resilience as one member of a set of potential symptom trajectories following exposure to trauma. There were differences between the studies on characterizing the shape of the trajectory looked line and what other symptom trajectories were identified. In Johannesson’s second study, those in the resilient class had low levels of posttraumatic stress at each time point. Similarly, Lowe et al. and Sakuma et al. identified a resilience as a trajectory which resembled minimal to mild symptoms throughout the study period (Lowe et al., 2015; Sakuma et al., 2020). In contrast to a consistent stable shape, Norris et al. and Pietrzak et al. described a resilience trajectory as a group of people who with moderate or increased symptoms at the first post-disaster time point followed by a reduction to minimal or no symptoms over time (Norris et al., 2009; Pietrzak et al., 2013). Lowe & Rhodes 2013 study among Hurricane Katrina women survivors was the only study with pre-disaster data, and they described a pattern of resilience as “an increase in psychological distress from pre- to post-hurricane, followed by a decrease in distress between two post-disaster time points” (Lowe & Rhodes, 2013). These six studies identified a range of three to six trajectories which were referred to as resilient, remitted, recovered, chronic, moderate chronic, delayed onset, and resistant. Only one study classified a trajectory as resilient in which the baseline trajectory was above the cut-off point. The majority of study participants in each of these studies were characterized as resilient.

Measures and statistical methodologies

Six of the studies employed group-based or trajectory models to identify distinct patterns of psychopathology (Johannesson et al., 2011; Lowe, Joshi, et al., 2015; Lowe & Rhodes, 2013; Norris et al., 2009; Pietrzak et al., 2013; Sakuma et al., 2020). Unlike regression, which is a conventional variable-centered approach, trajectory modeling is a person-centered approach which focuses on the response patterns of individuals (Jung & Wickrama, 2008). The purpose of a person-centered approach framework is to assess whether the population of interest is comprised of subpopulations which present distinct trajectories of change or stability over time (Feldman et al., 2009). This domain of statistical methodology has become increasingly utilized in understanding long-term psychological outcomes among individuals exposed to stressful life events. There are different types of latent class analyses, all of which employ distributional assumptions of the data (Feldman et al., 2009). These approaches are useful in identifying latent and meaningful subpopulations or classes of individuals, in that, these groups are not directly observed but are rather inferred (Jung & Wickrama, 2008). The main methodological approaches used in the six studies were latent growth mixture modeling (LGMM) (N=4), latent class growth analysis (LCGA) (N=1), and semi-parametric group-based modeling (N=1). LCGA is a type of LGMM in which the intercept and slope terms (i.e., variance terms) are fixed to be the same for each class. Lowe & Rhodes employed this method in their analysis because models are “more easily specified and have faster convergence” (Lowe & Rhodes, 2013). Norris et al. applied semi-parametric group-based modeling approach, but they did not state justifications for this

particular methodology (Norris et al., 2009). Semi-parametric group-based modeling, also referred to as group-based trajectory modeling (GBTM), are conceptually similar to LGMM and LCGA, but its application and specifications are fundamentally different (Nagin & Odgers, 2010). The main differences are that GMM establishes assumptions about the population distribution trajectories and allows for more within-group variability at the individual-level, whereas GBTM does not (Nagin, 1999; Nagin & Odgers, 2010).

The measures used in identifying psychological resilience were not consistent. In estimating trajectories of post traumatic response patterns, the outcome trajectories are based on a selected indicator(s) in the model. Seven different diagnostic criteria were used in the six group-based trajectory studies: Kessler-6 (K6), Patient Health Questionnaire (PHQ-9), Short Post-Traumatic Stress Disorder Rating Interview-Expanded version (SPRINT-E), Center for Disease Control and Prevention's Health-Related Quality of Life-4 (CDC HRQOL-4), DSM-IV PTSD Checklist-Stressor Specific (PCL-S), Impact of Event Scale Revised (IES-R), and Composite International Diagnostic Interview (CIDI) Version 2.1 (Blanchard et al., 1996; Kessler et al., 2003; Kimerling et al., 2014; Motlagh, 2010; Ruggiero et al., 2003). The non-trajectory analysis studies also used K6, PCL-S, and CIDI, in addition to the Mini-International Personality Item Pool (Mini-IPIP), DSM-IV Acute Stress Disorder Scale (ASD), DSM-IV PTSD Checklist (PCL), the UCLA PTSD Index for DSM IV, and Adult Self-Report (ASR) scale for Affective Disorders (Achenbach, 1997, 1997; Bryant et al., 2000; Donnellan et al., 2006; Steinberg et al., 2013). The studies and their corresponding measures are presented in Table 2. These tools are validated and have demonstrated reliability and internal consistency. The measures IES-R, CIDI, PCL, PCL-S, SPRINT-E, and UCLA PTSD Index all serve as self-report questionnaires/checklists to assess participants' posttraumatic stress symptoms and references the DSM-IV criteria for PTSD. The K6 tool is a 6-item scale for nonspecific psychological distress which screens individuals for potential severe mental health conditions (Kessler et al., 2002). The ASR scale is a 126-item self-report questionnaire which assesses a range of adaptive functioning, behavioral, emotional, and social problems consistent with the DSM-IV oriented scales (Ivanova et al., 2015). The PHQ-9 and CDC HRQOL-4 are measures to assess depressive symptoms and days of poor health, respectively, and they were used as two of four total independent measures of resilience in Lowe et al.'s study (Lowe et al., 2015). Lastly, the Mini-IPIP is a 20-item short form measure of five broad personality traits. While its utility is rooted in trait psychology, this measure has been used to better understand the associations between personality characteristics (e.g., optimism) and physical health outcomes (e.g., cardiovascular disease) (Baldasaro et al., 2013; Smith & MacKenzie, 2006).

Protective factors associated with resilience

Six of the twelve studies examined a range of predictors associated with resilience. In addition to demographic characteristics (e.g., age, gender, race/ethnicity, education, household composition), several of the studies examined factors related to exposure severity, bereavement, history of trauma and stressors (pre-disaster and/or post-disaster), disaster-related financial and property loss, substance use behavior, history of mental health conditions, perceived social support, healthcare utilization, and collective efficacy. Bryant et al. found that education was a significant predictor for resilience among a cohort of Australian adult survivors of the 'Black Saturday' bushfires. Fernandez et al. hypothesized that history of stressful life events (with no prior history of PTSD and/or MDD) was a protective factor for resilience among a Chilean disaster survivor cohort, but their results yielded the opposite findings (Fernandez et al., 2020).

Johannesson et al. conducted two separate studies, several years apart, among the same civilian Swedish cohort exposed to the Indian Ocean Tsunami (Johannesson et al., 2015; Johannesson et al., 2011). They found similar findings related to resilience in both analyses. Higher education, middle age, being male, being partnered, social support and having received disaster-related treatment were protective factors for resilience. In Lowe & Rhodes' study among low-income women exposed to Hurricanes Katrina and Rita, they found that those who fell in the resilience trajectory had lower degrees of exposure severity, were less likely to experience pet bereavement, and had higher levels of perceived social support (Lowe & Rhodes, 2013). In a later study among a different cohort of adults exposed to Hurricane Ike, Lowe et al. found that lower peri-event emotional reactions, higher community-level collective efficacy, disaster-related financial loss and loss of personal property were significant predictors for resilience (Lowe et al., 2015).

Discussion

This systematic review included twelve peer-reviewed prospective studies published between 2009 and 2020 which represent empirical research on psychological resilience following exposure to a natural disaster. The purpose of this synthesis was to examine how psychological resilience is conceptualized and measured among the context of adult survivors exposed to natural disasters, specifically in longitudinal research. The majority of these studies represent the more accepted definition of resilience, in that, its characterization extends beyond the absence of PTSD. The psychological construct of resilience has evolved in the last few decades and will continue to do so in future empirical research.

Norris et al. proposed that resilience is “best understood and measured as a trajectory” given the increasing consensus that resilience is a process of adaptability over time, rather than a personality trait or immunity from harm (Norris et al., 2009). Recent annual and conceptual reviews since then have also proposed trajectory analysis as the emerging statistical direction in identifying resilient groups alongside other latent symptomatic groups (Bonanno & Mancini, 2012; Southwick et al., 2014). While Infurna and Jayawickreme state that the adult resilience literature has “exclusively been studied” via trajectory analyses, this was only observed in half of the studies included in this review (Infurna & Jayawickreme, 2019). However, this methodological approach may be disproportionately represented across different types of potentially traumatic events (PTEs). In addition to natural disasters, prospective and longitudinal studies on adult resilience include survivors of mass violence and terrorism, technological disasters, traumatic injuries, deployment in military duties, and life-threatening medical procedures (Bonanno & Diminich, 2013). Among the studies in this review which measured resilience as a trajectory, the results indicated high rates of resilience. Bonanno & Diminich synthesized the existing empirical literature at the time of their review and found that resilience was the most common observed pattern following exposure to disaster in all of the studies (Bonanno & Diminich, 2013). They describe this trajectory as one that is characterized as “consistently low levels of symptoms and distress...both before and after the occurrence of a PTE”, which is a similar characterization across the studies included in this review. What is important to note here is that this definition describes the presence of pre-disaster data which is a major data limitation in this research area. Only one study in our review had access to pre-disaster data, and this is typically uncommon across disaster cohort studies (Lowe & Rhodes, 2013).

The “resilience is commonplace” perspective is cited and referenced in the majority of the studies in this review. Recently, this perspective has received some criticism, as the utility of group-based modeling (i.e., growth mixture modeling (GMM)) has become increasingly adopted in adult resilience research. As observed in a systematic review on ageing and resilience, we found that group-based modeling was the most common methodological approach in measuring resilience in natural disaster survivors (Cosco et al., 2017). The authors present the prevalence of resilience across studies and limitations using GMM in their systematic review, but they did not discuss whether resilience was a common response or critique this perspective as it relates to the methods being used. The objective GMM is to produce an appropriate and probable representation of latent group differences within a study sample of interest. The information obtained include “the mean change, extent of interindividual differences in change, and pattern of changes for the unobserved groups, and for each individual, the probability that they belong to each of these groups (Ram & Grimm, 2009). Groups are determined in a post hoc manner (i.e., testing for a hypothesis after the data has been observed) and overall findings are dependent on how models are specified.

Considering the exploratory nature of GMM, Infurna and Luthar support the claims that subgroups identified from GMM must be carefully interpreted (Infurna & Luthar, 2016). In their replication GMM analyses on prior research by the German Socioeconomic Panel (SOEP) study, Infurna and Luthar hypothesized that adjustments to central data analytical assumptions would yield different results in the number of trajectories identified and/or the distribution of individuals across the trajectories. There were three changes in their model specifications procedure as conducted in the previous study, which utilized life satisfaction scale as their measure for resilience for the life stressors spousal loss, divorce, and unemployment (Infurna & Luthar, 2016). First, Infurna and Luthar specified for the slope of each trajectory to differ from another, opposed to having it fixed. Second, the variation around the mean of life satisfaction also varied, opposed to having it fixed. And lastly, they allowed for the rate of change in life satisfaction to vary within trajectory. These adjustments to the amount of variance and slope are aligned with the definition of resilience, in that, non-resilience trajectories would have more “ups and downs” (i.e., not stable;) compared to a resilience trajectory that would exhibit a more stable pattern. The results from Infurna and Luthar’s adjusted analyses showed that resilience was the least common outcome, in contrast to the original study’s findings. These results lend to findings from a study among sexual assault survivors, in which a resilience trajectory was not observed at all (Steenkamp et al., 2012). While these results novel and counter the status quo of adult resilience, they may not be generalizable to other stressful events, particularly disasters. In our systematic review, Pietrzak et al did not identify a resilience trajectory in their study (Pietrzak et al., 2013). The results yield three groups: resistant, chronic, and delayed onset. It is important to note that there are a range of fit indices and statistics used for model selection. Pietrzak et al.’s results indicate that AIC and BIC fit statistics suggested “relative improvements with an increasing number of classes”, the entropy values indicated that a 3-class model was the best fit.

In previous theoretical reviews, the authors argued that while the conceptualization of resilience has shifted away from absence of PTSD, there is still a lack of distinction between the characterization of resilience and resistance, which adds further complexity in adult resilience research (Fletcher & Sarkar, 2013; Hoge et al., 2007; Vella & Pai, 2019). These constructs represent a form of positive adjustment after trauma, but their pathways may be distinct from one another, thus they should be recognized as different potential responses to life stressors

(Southwick et al., 2014). Our systematic review also found ambiguous characterization of these terms in several studies. In the studies included in this review, resistance and resilience were classified as distinct trajectories ($N = 2$) or were terms used interchangeably and/or conflated in their definitions ($N = 2$). There was no mention of resistance in two of the studies. Norris et al. and Pietrzak et al. explicitly defined resistance as minimal to no symptoms over time and emphasized that a resilience trajectory is identified by its initial peak followed by minimal to no symptoms over time (Norris et al., 2009; Pietrzak et al., 2013). While Norris et al. observed both response patterns in their Mexico study, Pietrzak et al. observed a pattern which aligned with resistance. While Bonanno's early definition of resilience centered on one's "ability to maintain a stable equilibrium", findings from Norris et al. and Pietrzak et al. further support the re-conceptualization of resilience to be seen as an adaptability process, rather than stability (Bonanno, 2004). Thus, future studies should recognize the distinction between both resilience and resistance, and how the determinants of these trajectories may differ if they are identified.

Post-disaster baseline assessment and follow-up period varied across the twelve studies. Data collected after the occurrence of the aversive event ranged between 3 months to 3 years, which may be problematic for several reasons. For example, studies which identify resilience based on baseline data assessed a year or longer after the onset of trauma does not capture the post-traumatic symptoms experienced in the immediate aftermath of the event. Resilience is defined as having experience and initial heightened levels of posttraumatic symptoms or distress, but it is unclear what is an appropriate timeframe to assess the existence of these experiences. In addition, individuals may have moved or were displaced soon after the events, due to severe trauma, property loss/damage, and other life events [30]. Studies may miss collecting baseline data from these individuals if survivor registries are not established early on. While the frequency of data collection was similar across the twelve studies (two to three assessments), the follow-up period ranged between 15 months to 10 years. The recent literature has suggested that mapping out trajectories over several years may be useful in capturing the changes and heterogeneity in mental health symptomology (Bonanno & Mancini, 2012; deRoos-Cassini et al., 2010; Orcutt et al., 2014). One or two years of total follow-up may not be sufficient, particularly in identifying gradual recovery, improved positive adjustment, and delayed reactions (Bonanno & Diminich, 2013; Southwick et al., 2014). These limitations underscore the importance in establishing a survivor registry in the immediate aftermath of a potentially traumatic event and in collecting repeated assessments over an extended period of time.

Strengths and Limitations

The strengths of this study include the review of ten distinct cohorts of adult survivors exposed to natural disasters in different settings. While it is important to note that this type of research has and continues to be done among a range of potentially traumatic events, it also presents a limitation in this review since findings may not be comparable due to differences in data collection periods, measures used, and lack of generalizability among study populations. Longitudinal studies are vulnerable to loss-to-follow up, and sample size may impact the yield of trajectories and other outcome measurements. Most of the studies were vulnerable to high attrition rates, particularly studies with longer observation periods, as noted during the quality assessments. One of the major limitations of this review process is the specific inclusion criteria which is subject to bias during article selection and filtering. In addition, this review was only limited to research articles published in English. Research studies published in other languages may provide further insight on measurement of psychological resilience.

One of the strengths in this review is that all studies included data on a range of potential protective factors associated with psychological resilience, particularly factors at the household level, types of life stressors, and post-disaster resource losses. While the results of the studies are not discussed in-depth in this review, this review sheds further light on the methodologies used and important factors relevant to better understanding what predicts psychological resilience among disaster survivors. The studies in this review have mainly focused on economic and social resources at the individual level. A conceptual framework, put forward by Abramson et al., proposes that resilience should be expanded and measured via access to, or availability of, four sources of capital (social, human, economic, and political), both at the individual and community level (Abramson et al., 2015). There are also still gaps of knowledge surrounding the intersection of community and individual resilience, thus emphasizing the importance of a multidisciplinary approach in examining this phenomenon.

Conclusion

Findings from this review provide an increased understanding of the conceptualization and adopted statistical approaches in assessing psychological resilience. Many of the studies sought to examine the course and changes of psychopathology, underscoring the importance in capturing the heterogeneity of mental health outcomes. As the world continues to face natural disasters and other potentially traumatic events, it is crucial to examine the psychological aftermath among survivors, particularly the processes in resilience to inform a framework that is accessible to both researchers and policymakers.

**Table 1. Population, Intervention, Comparator, Outcome, and Study Design (PICOS)
Inclusion and Exclusion Criteria**

Parameter	Inclusion	Exclusion
Population	Adult survivors	• Adolescents • War veterans • Rescue/recovery workers
Intervention (Exposure)	Natural disaster	Other life stressors related to terrorism, mass violence, war or conflict, injury
Comparison	N/A	
Outcome	Individual-level or psychological resilience	Outcomes which were not explicitly stated or related to individual-level or psychological resilience
Study Types	Observational cohort or longitudinal with >1 time point of follow-up	• Cross-sectional • Not population-based or observational (animal, toxicological, experimental) • Systematic, meta-analysis, and/or narrative review • Not a peer-reviewed publication

Figure 1: Preferred Reporting Items for Systematic Reviews & Meta-Analyses (PRISMA)

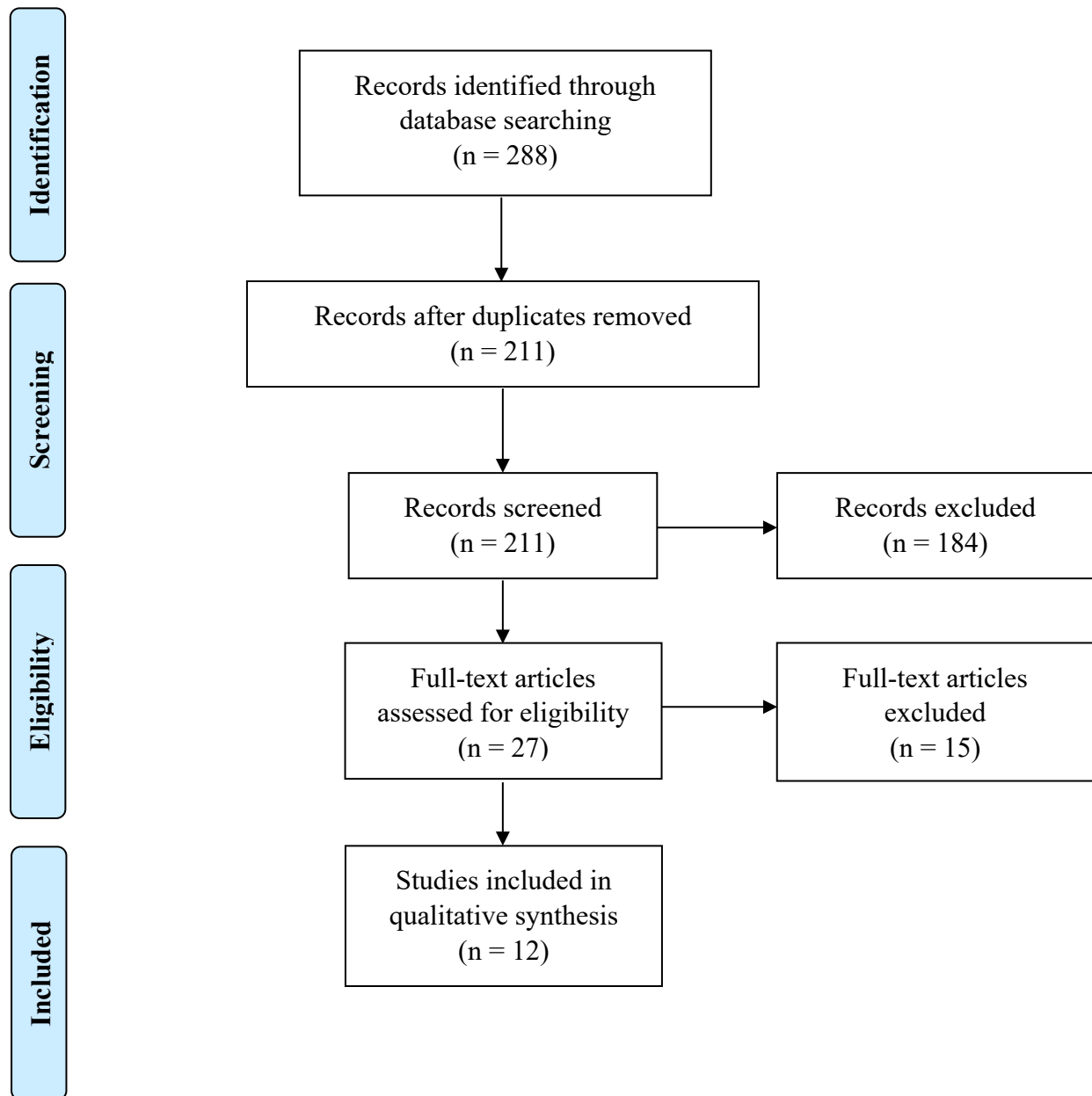


Table 2. Summary of studies included in qualitative synthesis (N = 12)

Author & Year	Study Location/Disaster	Study Sample Description	Number of Timepoints	Predictors examined	Statistical Method(s)	Measures Related to Resilience	Resilience operationalized	Resilience conceptualized
Bryant et al., 2018	Victoria, Australia 2009 'Black Saturday' bushfires	Adults living in 25 communities in 10 locations in Victoria that were variably affected by the disaster (N=707)	Two (2011-2013; 2014)	sex, age at event, education, exposure severity, major life stressors	Multivariable regression	Generic Psychological Distress (K6)	K6 scores of 0-7 (none to low)	"...the absence of persistent psychological distress (as distinct from the absence of mental disorder)" (Bonanno et al., 2004)
Fernandez et al., 2020	Chile Earthquake on the coast of central Chile (February 2010)	Adult Chilean primary care attendees (PREDICT study) (N=1160)	Two (2003; 2011)	age, gender, education	Multivariable regression	Composite International Diagnostic Interview (CIDI)	Absence of PTSD and MDD	"...positive psychological adaptation to adversity" (Southwick 2011)
Johannesson et al., 2011	Stockholm, Sweden Indian Ocean tsunami (2004)	Civilian Swedish population who were travelling in Southeast Asia at the time of disaster (N=3457)	Two (14 months post disaster; 2007)	gender, age, family situation, education, previous mental problems, previous trauma experiences, social support	Negative binomial regression; Generalized estimating equations	Impact of Event Scale-Revised (IES-R)	Below cut off at time points	"...adaptability rather than stability and more about "bouncing back" from harm rather than immunity from harm." (Layne et al., 2007; Norris et al., 2009)

Johannesson et al., 2015	Stockholm, Sweden Indian Ocean tsunami (2004)	Civilian Swedish population who were travelling in Southeast Asia at the time of disaster (N=2268)	Three (2004; 2007; 2010)	age, gender, education, family status, previous adverse life events, and previous psychiatric problems	Latent growth mixture model; multinomial regression analysis	Impact of Event Scale-Revised (IES-R)	Low levels of posttraumatic stress at each time point	"...minimal to no symptoms at any time after the event..."
Lowe et al., 2013	New Orleans Hurricanes Katrina and Rita (2005)	African American women who survived Hurricane Katrina (N=386)	Three (12 months pre-disaster in 2004, 2006-2007; 2009-2010)	age, race, ethnicity, number of children, pre-disaster social and material resources	Latent class growth analysis; multinomial regression analysis	K6; IES-R	Below the cutoff for probable mild or moderate psychological distress, increased from pre- to post disaster, then decreased to below pre-disaster levels	"...the return to pre-disaster levels of functioning after an initial postdisaster elevation in distress..." (Bonanno, 2004)

Lowe et al., 2015	Galveston County, Texas; Chambers County, Texas Hurricane Ike (2008)	Adults living in either county for >1 month prior to disasters (N=508)	Three (2-5 months post-disaster; 5-9 months; 14-19 months)	age, sex, race, ethnicity, education, marital status, pre-disaster trauma exposure and psychopathology	Latent growth mixture model; multinomial regression analysis	PTSD Checklist (PCL-S); Patient Health Questionnaire (PHQ-9); Short PTSD Rating Interview-Expanded (SPRINT-E), Center for Disease Control and Prevention's Health-Related Quality of Life-4 (CDC HRQOL-4)	Stable low levels over time	"...a trajectory of low levels of symptoms or problems in a given outcome over time, with minimal elevations that are limited to the time period during the disaster and its immediate aftermath" (Bonanno, 2004; Bonanno and Diminich, 2013)
Norris et al., 2009	Villahermosa, Mexico; Teziutlan, Mexico Flooding in Mexico (1999)	Households affected by the flood damage (N=561)	Four (6 months, 12, 18, and 24 months postdisaster)	N/A	Semi-parametric group-based modeling	CIDI	Moderate or severe symptoms at the first post event interview followed by a sharp decrease	"...characterized adaptability...a process of 'bouncing back'...and may be best understood and measured as a trajectory of a set of possible trajectories" (Layne et al., 2007; Garnezy, 1993; Adger, 2000, Klein, Nicholls, & Thomalla, 2003).

Osborne et al., 2013	Canterbury region of New Zealand Christchurch earthquake (2011)	Adult survivors living in the Canterbury region before the disaster (N=325)	Two (2011; 2011)	N/A	Multivariable regression	Mini-International Personality Item Pool (Mini-IPIP)	Operationalized as a personality trait, Emotional Stability, which is one of the five distinct dimensions of personality.	"Emotional Stability (ability to cope with stressors) reflects individual differences in people's resilience to situational stressors...high levels of Emotional Stability should provide people with psychological resources needed to buffer themselves from increases in psychological distress likely to occur following a natural disaster" (Weems et al., 2007)
Pietrzak et al., 2013	Galveston County; Chambers County, Texas Hurricane Ike (2008)	Adults who had been living in Galveston County or Chambers County, Texas for at least one month before disaster occurred (N=206)	Three (12/21/2008; 04/05/2009; 12/28/2009)	N/A	Latent growth mixture model; stepwise multinomial logistic regression analysis	PTSD Checklist-Specific Stressor Version (PCL-S)	Initial mild-to-moderate symptoms followed by a reduction to minimal/no symptoms over time	None

Sakuma et al., 2020	Northeastern Japan Great East Japan Earthquake (2011)	Municipality and medical workers involved in disaster recovery (N=745)	Four (14 months, 30 months, 43 months, 54 months)	N/A	Latent growth mixture model	PTSD Checklist-Specific Stressor Version (PCL-S)	Trajectory which resembled minimal to mild symptoms and remained stable throughout the study period	"...never showing more than mild distress" (Galatzer-Levy et al., 2018)
Tang et al., 2007	Phuket, Thailand Southeast Asian earthquake-tsunami (2004)	Adult Thai survivors who worked in the western coastal regions of Phuket, Thailand at the time of study (N=265)	Two (2 weeks, 6 months postdisaster)	N/A	Descriptive; Bivariate analyses	Self-report Symptom checklists for Acute Stress Disorder (ASD) and PTSD based on the DSM-IV	Did not meet the criteria for PTSD or ASD at either time point	"...the capacity to maintain a stable emotional equilibrium and to grow in the face of trauma" (Agaibi & Wilson, 2005; Bonanno, 2004; Ozer et al., 2003)
Wadsworth et al., 2009	Lowry, Colorado; Denver, Colorado; Hurricane Katrina (2005)	Adult survivors of disaster who were displaced and relocated to Colorado (N=93)	Two (3-6 months; 9-12 months)	N/A	Descriptive; Bivariate analyses	UCLA PTSD Index; Adult Self-Report (ASR) raw Affective Disorders scale	Participants without clinical elevations of PTSD or depression at either time point	"...do not have clinical levels of symptoms initially or later on [in the face of disaster]" (Adams & Boscarino, 2006; Sungur & Kaya, 2001)

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Chapter 3: Predictors of mental health trajectories among adult survivors ten years after Hurricane Katrina, 2005-2015

Introduction

There are long-term mental health impacts among individuals who experience disasters, in addition to effects on communities at large. Post-traumatic stress disorder (PTSD) is intrinsically linked to exposure to trauma and while the incidence and prevalence rates of PTSD have been well-documented across different survivor cohorts, only recently did we really begin to understand the spectrum of long-term mental health responses among survivors. The current literature recognizes the heterogeneity of responses to trauma and evidence from the small pool of longitudinal studies shows that symptoms of distress may persist for months and even years for some (Galatzer-Levy et al., 2018). For others, symptoms peak within the year following the disaster and then improve. This type of response following exposure to trauma has been generally defined as psychological resilience (Galatzer-Levy et al., 2018).

In the context of natural disasters and other large scale catastrophes, one definition of psychological resilience is that it is the process of how individuals maintain relatively stable levels of psychological and physical functioning after exposure to an isolated and potentially traumatic event (Southwick et al., 2014a). The literature on psychological resilience is longstanding, and the definition of resilience has always been broad, evolving through different phases of research. The literature suggests that there is no agreed upon definition or measurement of resilience because it is not a condition that can be observed, and thus conceptualization and metrics of resilience have been largely ambiguous. There is also a significant knowledge gap in what contributes to different response pathways. Alongside resilience, there are several proposed response pathways which include but are not limited to recovery, delayed onset (initial minimal symptoms followed by a decrease in well-being over time), chronic distress (consistent high level of symptoms over time), and resistance (minimal or no symptoms over time) (Bonanno, 2005; deRoos-Cassini et al., 2010; Norris et al., 2009b). Little is known about pathways to resilience and how these pathways differ from other types of responses. The critical barriers in addressing this gap are mainly due to lack of longitudinal data of trauma survivors.

While the previous adult resilience research supports identifying resilience as one of several potential latent response patterns following a disaster, the measures used in existing studies are inconsistent. The majority of studies have used measures related to mental health outcomes to identify patterns of resilience (Johannesson et al., 2015; Lowe, Rhodes, et al., 2015; Norris et al., 2009a; Pietrzak et al., 2013; Sakuma et al., 2020). The most common measures are related to Diagnostic and Statistical Manual of Mental Disorders (DSM) criteria for posttraumatic symptoms such as versions of the PTSD Checklist (PCL) or measures related to severe mental health psychological distress such as the Kessler-6 (Blanchard et al., 1996; Kessler et al., 2003). While studies have shifted away from conceptualizing resilience as the absence of psychopathology, much of the focus still remains on mental health outcomes. To our knowledge, only one study has sought to examine other domains related to resilience (Lowe, Joshi, et al., 2015). A study conducted among a survivor cohort of Hurricane Ike examined broader domains of health and wellness, such as role functioning and days of poor health, to measure resilience.

These domains, in addition to depression and post-traumatic stress symptoms, were all examined independently to measure resilience. They found that more than half of the study sample exhibited resilience across all indicators except for functional impairment. The highest prevalence of resilience (74.9%) was found using the PTSD PCL-Specific measure compared to using indicators related functional impairment and days of poor health (45.1% and 52.6%, respectively) (Lowe, Joshi, et al., 2015). Resilience is thought to be the most common response following disaster, but this is likely attributable to the consistent focus on the domain of PTSD, which may lead to overestimates. Considering the evolving definitions of resilience, the process of adversity and adaptation may still be present among individuals who experience posttraumatic symptoms (Southwick et al., 2014a). There is no gold standard in measuring resilience, and as it stands, resilience is a multidimensional construct and requires careful consideration in the type of outcomes and domains used in quantitative research.

The perspective of resilience being a common response to disaster has received further scrutiny due to methodological processes and assumptions (Infurna & Grimm, 2018). The growing interest in resilience research has led to increased utilization of longitudinal research methodologies, specifically the use of latent growth mixture modeling (LGMM). LGMM is used to identify discrete trajectories, or classes, from a given study population. Commonly applied assumptions in conducting LGMM may result in incorrect number of trajectory classes (i.e., how many distinct subpopulations characterized by different trajectories) and size of each trajectory (i.e., the proportion of people who fall within each trajectory class) (Infurna & Grimm, 2018). One of the main assumptions revolves around homogeneity of variance across trajectories, which assumes that the individuals within the same trajectory have the same rate of change. In a study examining resilience to major life stressors, they found that relaxing this constraint resulted in fewer distinct classes in addition to improved model fit (Infurna & Jayawickreme, 2019). Furthermore, determining the number of classes or types of class-specific trajectories in resilience research should come from theoretical justification, plausibility, and interpretability (Bauer & Curran, 2003). Results from methodological assumptions and model constraints have potentially harmful impacts on how resilience is communicated, the narrative of what survivors experience after a disaster, and future directions and investments for disaster mitigation.

In addition to understanding what long-term mental health trajectories emerge among disaster survivors, it is equally important to understand what predicts trajectory class membership, particularly factors related to resilience. The current study's research questions and hypotheses are influenced by the Conservation of Resources (COR) (Hobfoll & Ford, 2007). Characteristics related to the exposure are all interrelated and influence mental health outcomes. The main driver, exposure severity, is rooted in the COR theory, which is central to the broader stress theory, in that people work hard to obtain, retain, protect, and foster the things that they value (Hobfoll, 2011). Exposure severity can include resource loss, damage to home, personal harm, and witnessing potentially traumatizing events. Stress occurs when valued resources are threatened and when individuals are unable to 'gain' new resources which in turn leads to psychological distress. Peri- and post-disaster risk factors such as exposure severity, proximity, and loss have all been shown as important predictors of resilience and trauma response in general (Bonanno et al., 2006; Goldmann & Galea, 2014; Raker et al., 2019). These factors are typically captured early on within a few months of exposure.

While the pool of studies is small, the range of predictors explored in previous studies have included demographic characteristics, bereavement, history of life stressors, disaster-related financial and property loss, history of mental health conditions, social support, healthcare utilization, and collective efficacy (Bryant et al., 2018; Johannesson et al., 2015; Lowe, Rhodes, et al., 2015; Lowe & Rhodes, 2013; Pietrzak et al., 2013; Sakuma et al., 2020; Tang, 2007). Some findings suggest that demographic characteristics related to educational attainment, age, being male, being partnered were protective factors for resilience. In addition, factors related to low social support, increased exposure severity, bereavement, and unmet healthcare needs were associated with chronic or consistently symptomatic trajectories compared to resilience. However, these findings are not consistent across the limited pool of studies. Conflicting findings are likely due to several main limitations. First, the timing of assessments remains a challenge in disaster cohort studies. The spacing and frequency of assessments are important to classify changes in mental health more accurately. Second, as highlighted earlier, most studies have measured resilience and other trajectories through indicators of PTSD, depression, and other mental health outcomes.

The existing literature has examined resilience among adult survivors in the context of various global natural and environmental disasters. This current study focused on adult survivors of Hurricane Katrina, a tropical cyclone that made landfall along the United States Gulf Coast on August 29, 2005. The disaster led to thousands of fatalities, severe displacement, and destroyed homes. It was the costliest disaster in U.S. history resulting in \$125 billion dollars in damage (Britannica, 2020). The primary aim of the study is to identify the post-disaster mental health trajectories 10 years following Hurricane Katrina among a cohort of adult survivors who were directly impacted by the disaster. We will do this using a composite measure that is comprised of different mental health domains related to role functioning, vitality, and general mental health wellness. The second aim of the study is to determine whether resilience will emerge as one of the latent trajectory classes in our study population. Lastly, we aim to assess a range of baseline predictors associated with each identified trajectory class. Based on the limited literature on adult resilience among disaster survivors, we hypothesize that at least four trajectory classes will emerge, one of which will resemble resilience. Given the limitations of the data, we further hypothesize that factors related to social support, residential stability, having received post-disaster financial assistance and access to mental health services in the early aftermath of the disaster will be important determinants of resilience compared to other trajectory classes.

Methods

Participants and Procedure

The GCAFH study is a longitudinal cohort of Louisiana and Mississippi households (N = 555 and 524, respectively) that had been displaced or severely impacted by Hurricane Katrina (Katrina). The cohort includes 1,079 households which were randomly sampled from the Federal Emergency Management Agency trailer parks, commercial trailer parks, and hotels. The study began six months following Katrina, first in Louisiana and then replicated in Mississippi. The detailed description and recruitment processes of the GCAFH cohort have been previously described elsewhere (D. Abramson et al., 2008). At baseline (Wave 1), data was collected on demographic characteristics, household composition, child health, chronic diagnosed medical conditions, access to health care and services, having received financial resources prior to and

after the disaster, history of displacement, domains of physical and mental health, and future plans. Four follow-up surveys were conducted in 2007 (Wave 2), 2008 (Wave 3), 2009 (Wave 4), and 2015 (Wave 5). Waves 2-5 included additional measures and indicators related to social support, sense of community, life events, post-traumatic growth, and self-efficacy. Participants in this study included 1,075 participants who were 18 years or older at Wave 1. Participants with incomplete data on mental health at baseline were excluded (N = 4).

Measure

Domains of mental health were assessed at each Wave using the Short-Form 12 Health Survey, Version 2 (SF-12v2). The SF-12v2 is a generic health-related quality-of-life instrument and an abbreviated version of the Short-Form 36-Item (SF-36) health survey (Vilagut et al., 2013). Six items from the SF-12v2 make up the Mental Health Inventory. These questions are related to vitality, social functioning, role-emotional, and general mental health (e.g., “How much over the past four weeks have you felt downhearted and depressed?”). Items are rated from 1 (“All of the time”) to 5 (“None of the time”). The remaining six items of the SF-12v2 make up the Physical Health Inventory which are related to physical functioning, role-physical, bodily pain, and general health. The SF-12v2 is a validated and reliable instrument which produces two summary scores: 1.) Mental Health Component Summary (MCS) score and 2.) Physical Health Component Summary (PCS) score (Vilagut et al., 2013; Ware et al., 1996). The scales range from 0-100; higher scores indicating higher mental or physical health. The SF-12 was administered at each survey wave and summary scores were calculated in a proprietary software, QualityMetric, purchased from Optum, Inc using norm-based scoring (QualityMetric, n.d.).

Predictors

We examined baseline demographic and household characteristics, physical and general health status, religiosity, having received financial resources within the first six months following the disaster, met mental health care needs, and number of times moved within the first six months following the disaster as potential predictors for belonging to the different mental health trajectory classes. All of these predictors were self-reported at Wave 1. Demographic and household characteristics were age, sex (male/female), race/ethnicity, marital status, whether there was a minor living in the household (yes/no), household income, and employment status. We recoded marital status as a binary variable to reflect being partnered or non-partnered. Participants were also asked to report their total household income from “all sources last year”, thus reflecting their pre-Katrina household income for the year 2004. For employment status, participants were asked about their employment status the week prior to the hurricane and their employment status at time of survey completion. The variable was recoded as: employed, unemployed after hurricane, unemployed before and after hurricane.

We also included two indicators related to general health and physical health: self-reported health status (Excellent/Very good/Good/Fair/Poor) and PCS score via the SF-12v2. We included religiosity as a proxy for post-disaster social capital. Participants were asked “*Since the hurricane, how often have you attended church or any religious service?*” which was coded as never, infrequently, and often. Receiving financial support after the hurricane was included as a proxy for post-disaster economic capital. Participants were asked if they had received income or financial assistance from their job, occasional work, emergency assistance (e.g., FEMA or Red Cross), public assistance (e.g., WIC, TANF), alimony or child support, or social security. Total number of resources were calculated for each participant and the sum of resources received was

included in the analysis. We also examined a variable to assess the needs and receipt of post-disaster mental health services. Participants were asked two questions, whether they or anyone in their household needed help or assistance with “emotional or psychological difficulties, including relationship problems” and whether they received services related to this in the last 3 months. In theory, these questions assess mental health care needs at the three-month mark following Katrina. From these two questions we created a three-categorical variable which we coded as did not have any needs (reference group), needed and received mental health services (“met”), and needed and did not receive mental health services (“unmet”). Lastly, participants were asked “*How many times have you moved since the hurricane?*”, which we used as an indicator for residential mobility. This continuous variable was examined as the number of times participants reported having moved since the hurricane.

Data Analysis

We used five Waves of data collected between six months to 10 years following Hurricane Katrina among adult survivors. To identify trajectory classes of mental health, we conducted latent growth mixture modeling using maximum likelihood estimation to model MCS scores as a function of time. Based on the frequency of assessments, we coded time as months since Hurricane Katrina. All linear GMM (LGMM) analyses were conducted within the R package ‘lmm’ (Proust-Lima et al., 2017). Latent class modeling procedures, such as LGMM, are commonly used to identify latent classes or clusters of individuals within a study population (Nagin, 2014). The objective in this approach is employing LGMM’s unique technique to classify individuals into subgroups based on their mental health component scores. LGMM is an extension of conventional growth curve modeling (GCM) in which changes over time are modeled to describe interindividual differences and to obtain the average growth in the population. While there are types of GCM to examine changes among multiple groups of individuals, LGMM is used to describe what those observed patterns or trajectories of change are, the probability of a participant being assigned to give trajectory, and to examine the changes and differences between and within trajectories (Nagin, 2014).

Given that LGMM is exploratory in nature, we incorporated recommendations and step-by-step procedures for fitting and selecting from multiple GMMs. The analysis was conducted using a validated four-step framework: 1.) problem definition, 2.) model specification, 3.) model estimation, and 4.) model selection and interpretation (Ram & Grimm, 2009). Based on length of follow up, previous empirical findings and longitudinal plots of raw data (random drawn sample of $N = 25$), we hypothesized that we would observe up to four distinct classes of mental health trajectories. As a starting point, we began with a baseline single growth curve model with a fixed intercept and slope. We then refined the baseline model to determine the optimal number of classes by conducting latent class growth analysis (LCGA) models for 2-4 latent classes. In our next procedure, we estimated GMMs that added intercepts to the LCGA so that trajectories could vary in their intercepts within a given class. In doing this, we allowed for within class variances to be freely estimated compared to LCGA which fixes the within-class variance to zero. In other words, the initial status of each latent trajectory is allowed to vary within each latent class. We expanded the LGMMs by refining three additional model specifications: 1.) including a random intercept and random slope, 2.) including a random slope keeping the variance-covariance matrix common over latent classes, and 3.) including a random quadratic keeping the variance-covariance matrix common over latent classes. Including a random slope allows for change over time to occur at different rates with each trajectory. By including a random quadratic term, we

allow trajectories for individuals to vary in shape or curvature, however each class is assumed to have same variability. For our model selection procedure, we first assessed for convergence satisfaction and compared the Bayesian Information Criterion, Akaike Information Criterion, and entropy values across all models. We selected models based on smaller BIC and AIC values and higher entropy values. We also determined the final model based on posterior probabilities and ensured that the smallest class size included more than 5 percent of the total sample. Lastly, for model interpretation, we plotted mean trajectories across time for each class to further interpret the plausibility and distinctiveness of the trajectory classes.

In the second stage of analysis, we examined predictors associated with each trajectory membership using baseline GCAFH data. We conducted a multinomial logistic regression analysis to identify predictors of latent trajectory class membership. Trajectory class membership was treated as three-level categorical outcome variable in our analytical model, with the lowest mental health trajectory set as the reference group. We incorporated the COR theory and prior relevant research to select predictors of interest that were accessible in baseline data. Prior to building our statistical model, we calculated chi-square and t-test statistics our bivariate analyses to assess the independent associations between predictors of interest and trajectory class membership. Statistical significance was determined at the 5 percent level. All statistical analyses were conducted using R version 4.1.1. (RStudio Team, 2018).

We acknowledge that there are various ways of using GMM to obtain and interpret the appropriate number of latent classes to represent a complex phenomenon such as resilience (Huang et al., 2010). In our study, we employed the more conventional two-stage approach to examine the differences in latent group classification, in which the first stage involves estimating the number of trajectories using a GMM with no covariates (“unconditional model”). Alternatively, we considered extending the growth mixture model to conduct a joint estimation of the impact of selected covariates on latent class membership (“conditional model”). In doing this, the number of trajectory classes and the estimates for each included covariates are produced in one step. However, conditional models add more complexity to model specification and often result in convergence failure (Huang et al., 2010). Due to lack of robust guidelines for developing an appropriate conditional GMM and the limited empirical research in the context of post-disaster resilience, we chose to employ the two-stage process in our study. Furthermore, a two-stage process is generally recommended to explore possible predictors associated with trajectory to inform future research, which is the center of our third research aim.

Results

Trajectories of mental health scores

Table 1 shows fit statistics for models with 1-4 classes of mental health score trajectories for more than three types of model specifications. Based on the AIC and BIC fit statistics, we selected the random intercept 3-class model as the most optimal. While the entropy decreased from a 2-class to a 3-class model, the difference of more than 10 BIC points with the additional class indicates a better model fit (Frankfurt et al., 2016; Raftery, AE., 1995). While the 2-class random slope model had a difference of 3 BIC points compared to the 3-class random intercept model, the AIC of the 3-class model was more than 10 points lower compared to the 2-class model. In the selected 3-class random intercept model, over half of participants (52.4%, N = 564)

were classified in a trajectory that showed a relatively sharper increase in mental health between Waves 1 and 2 followed by a stable and near flat line in its trajectory. This trajectory was labelled as “resilience”. Over a quarter (27.3%, N = 294) of participants fell in a trajectory with the initial low mental health which steadily increased over time which we labelled as “recovery” trajectory. At Wave 5, the mean mental health score among participants in the recovery trajectory is similar to those in the resilience trajectory. Lastly, 20.2 percent (N = 217) of participants were classified in a trajectory that had a low mental health at baseline which does not increase or exceed the initial mean mental health score at any of the following time points. We classified this trajectory as “chronic” due to its low mental health scores at each time assessment. Figure 1 shows the mean mental health scores over time for each of the three classified trajectories.

Descriptive findings

Table 2 shows the distribution of characteristics among study participants by predicted trajectory class membership (predictor based on highest posterior probability). At baseline, more than half of participants were female (59.3%), non-partnered (64.7%), had at least one child in the household (60.7%), and moved three times or more since the disaster. There were differences in characteristics between the Chronic, Recovery, and Resilience groups. With the exception of marital status, all of the demographic and household characteristics were significantly related to class membership. Self-reported general health status, physical component score, and number of times moved post-disaster were also related to class membership. Age distributions were relatively similar across three groups, except for the oldest age group, those 66 years and older at Wave 1. Compared to the Chronic group (6.9%), the Resilience group had more than double the proportion of those in the oldest age group 16.3%). Those in the Chronic group had a higher proportion of women (67.3%) relative to the Recovery (63.9%) and Resilience (53.9) groups. The Chronic group had lower mean pre-Katrina household incomes and had a higher proportion of those below the poverty line in 2005 (54.4%) relative to the other groups. More than half of those in the Recovery and Resilience group were non-Hispanic Black (50.3% and 50.7%, respectively), whereas more than half of those in the Chronic group were non-Hispanic White (54.4%). In terms of health status, individuals in the Recovery and Resilience group had higher mean physical component scores at baseline compared to the Chronic group. As for self-reported general health, nearly a third of those in the Resilience group (31.9%) reported their health status as “Excellent/Very Good”, which was higher than that of the Recovery group (21.4%) and Chronic group (18%). While the majority of each trajectory group reported their health as “Fair/Poor”. Compared to the Resilience (37.8%) and Recovery (47.6%) groups reported more than half (59.9%) of the participants in Chronic group were in “Fair/Poor” category. Participants in the Chronic group had a higher average number of times moved compared to the other groups (mean: 3.61, standard deviation (SD): 2.59). On average, those in the Resilience group received a higher number of post-disaster financial resources (mean: 1.95, SD: 0.95) compared to the other groups. Finally, over 70 percent of the Resilience group did not report having or using any mental health services within the last three months. Over two thirds of the Chronic and Recovery group had unmet mental health care needs. A higher proportion of the Recovery group (15.3%), relative to the other groups, reported needing and receiving mental health care services.

Predictors of mental health trajectories

Results from the multinomial logistic regression are presented in Table 3, which shows the adjusted odds ratios (aORs) and 95 percent confidence intervals (95% CIs) for baseline predictors of interest. Among demographic characteristics, age, sex, race/ethnicity, and pre-disaster household income were significant predictors of trajectory class membership. Older age groups were more likely to be in the Recovery and Resilience groups than in the Chronic group. Compared to the 18–34-year-old group, those 66 years and older were estimated to have more than twice the odds of being in the Resilience group compared to the Chronic Group (aOR: 2.69, 95%CI: 1.25, 5.79). Age group 50-65 years, compared to the youngest age group, were also estimated to have more than twice the odds of being in the Recovery group compared to the Chronic group. Both Recovery and Resilience groups were associated with higher pre-disaster household incomes and being non-Hispanic White. Marital status and having a minor in the household were not significant predictors of either trajectory membership. Sex and employment status were important predictors for Resilience group, but not for Recovery. Compared to females, males were significantly more likely to be in the Resilience group than in the Chronic group (aOR: 1.66, 95% CI: 1.11, 2.49). Those who became unemployed after Hurricane Katrina were less likely to be in the Resilience group compared to Chronic (aOR: 0.56, 95% CI: 0.32, 0.98).

In addition to demographic and household characteristics, those who reported Excellent/Very Good compared to Fair/Poor health status at baseline were more likely to be in the Resilience group compared to Chronic (aOR: 3.62, 95% CI: 1.81, 7.23). Findings were also statistically similar among those who reported health status compared to Fair/Poor status (aOR: 3.34, 95% CI: 1.88, 5.93). As for physical health across multiple domains, PCS score was associated with the Recovery group, but not the Resilience group. Residential mobility, or number times moved reported at the time of Wave 1, was also a significant predictor for Recovery, but not for Resilience. Those who moved 2 times or more compared to 0-1 time after Hurricane Katrina had lower estimated odds of being in the Recovery group compared to the Chronic group (aOR: 0.52, 95% CI: 0.29, 0.93). Religiosity, our indicator for social participation, was not a significant predictor for either Resilience or Recovery group. Lastly, having received post-disaster financial resources and mental health services at the time of Wave 1 survey completion were significant predictors for the Resilience group, but not for the Recovery group. For every additional financial resource assistance received, the odds of being in the Resilience group as compared to the Chronic group was estimated to increase 24% (aOR: 1.42, 95% CI: 1.00, 1.53). Those who did not have any mental health needs within the first few months following the disaster compared to those with unmet needs were estimated to have greater odds of being in the Resilience group versus the Chronic group (aOR: 4.4, 95% CI: 2.81, 6.90). However, receiving mental health-related services compared to having unmet needs was not associated with being in the Resilience Group.

Discussion

The study examined the long-term course of mental health wellness among a cohort of adults who were directly impacted by Hurricane Katrina. Our study population exhibited three distinct trajectory classes of mental health wellness, which we interpreted as resilience, recovery, and chronic low mental health. Furthermore, the majority of participants showed patterns of

resilience 10 years following the disaster, which is in line with previous findings, though at a relatively more conservative estimate. We also identified demographic and health characteristics and post-disaster resources within the first few months following the disaster as significant predictors of trajectory membership. Our results extend the findings of previous studies. Our study also utilized data from five time points, which is a higher number of assessments compared to the majority of previous studies. More time points is generally preferred for LGMM to increase the reliability of trajectory identification (Jung & Wickrama, 2008).

The estimated probability of being in the resilience class in our study is relatively lower than in other studies in which resilience was measured using posttraumatic stress, depression, and/or psychological distress screening instruments. Our estimated probability is similar to a previous study which examined resilience within the domains of functional impairment and days of poor health (Lowe et al., 2015). In their study, resilience was measured and compared separately for each domain. Our study's measure builds upon this previous study by examining resilience through a multidimensional general health measure. In our study we used the mental health components of a health-related quality of life scale, the SF-12v2, which covers the domains of vitality, social functioning, role-emotional, and general mental health. This measure has been infrequently used to assess the mental health impacts of natural disasters, despite its practical use (due to its length), validity, and reliability. To our knowledge, our study is the first to quantify resilience using the SF-12v2. The advantage in using the SF-12v2 is that it is a composite score which encompasses multiple domains related to resilience.

While resilience research in the context of traumatic events has moved away from operationalizing resilience as a personality trait or as the absence of mental health outcomes, most studies focus on single outcomes which inflate the prevalence of resilience (Infurna & Jayawickreme, 2019). A recent review of the general adult resilience literature found that more than 80 percent of LGMM-based quantified resilience on the basis of single outcomes, which implies that the process of resilience itself is unidimensional. This commonality across studies has enabled the "resilience is commonplace" assumption (Infurna & Luthar, 2018). In the context of disasters and environmental exposures, mental health screening tools, such as the PTSD PCL, are most often used. In these studies, resilience is generally conceptualized as stably low posttraumatic stress symptoms over time. This conceptualization implies that the process of resilience is a process in which PTSD or other mental health conditions do not co-exist. One of the more contemporary and holistic definitions of resilience is the ability to "move forward in an insightful integrated positive manner from an adverse experience" and that individuals who experience resilience may also experience PTSD (Southwick et al., 2014b; Yehuda et al., 2013). Those who experience stably low or no symptoms over time are more accurately described as experiencing resistance, rather than resilience. Some studies have described the distinction between these two types, while others have conflated these two processes. Our study did not observe a trajectory class which resembled resistance. The trajectory class we interpreted as resilience exhibited a low mental health score (below the median 50) at baseline which increased at Waves 2 and 3 then became stable at Waves 4 and 5. We determined this trajectory as closely resembling our preferred definition of resilience.

The third aim of our study was to investigate differences among the three trajectory groups with respect to demographic characteristics, post-disaster stressors, social support, access to mental health care needs and financial assistance services. We found that several post-disaster stressors were significant predictors for trajectory membership. Specifically, those who became

unemployed after Hurricane Katrina had significantly decreased likelihood of resilience compared to chronic low mental health. This finding aligns with established findings related to the mental health impacts of financial loss or distress (Galea et al., 2007). Income loss is one of the significant hurricane-related stressors and employment is critical for recovery among residents. In the case of Hurricane Katrina, high rates of job loss occurred due to forced evacuations and migrations out of the impacted area. Furthermore, low-income and Black Residents were more likely to experience post-disaster job loss compared to high-income and White residents (Elliott & Pais, 2006; Fussell et al., 2010). Our study's finding indicate that post-disaster job loss has potential long-term impacts on mental health, however, we were not able to assess employment status change in more detail. Other important factors would be to examine length of post-disaster unemployment loss or re-employment as predictors of resilience or recovery. The broader sociological literature at large indicates that temporary job loss has long-term consequences on health and social behavior. While it is established that socioeconomic status and positioning are important factors in how people cope and recover after a disaster, the specific aspects of employment recovery or changes in employment status have not been closely examined in the context of disasters. However, there are findings indicating what factors are related to employment recovery among Katrina survivors. In terms of temporary job loss, a previous study examined predictors of short- and medium-term employment recovery approximately one month and one year after Hurricane Katrina. Home ownership and higher incomes were protective factors for employment recovery in the short-term aftermath (Zottarelli, 2008). At the one-year mark, women had significantly greater odds of being in a worse employment situation or having no job compared to men. Having moved, race, and residency in New Orleans were also significantly associated with lack of employment recovery at both time points. Our study's findings highlight the significance of employment status change as a social determinant of health. Those who experienced post-disaster employment loss were less likely to experience resilience, but it is critical to better understand whether employment recovery at any time point after Wave 1 influences trajectory membership in either recovery or resilience.

We also found that those who moved multiple times compared to those who did not move or only moved once were less likely to experience recovery. We did not find a statistically significant association between moving status and resilience; however, the magnitude of the estimate was similar to the estimate for recovery. Nonetheless, our finding with respect to the recovery group is in line with prior work on the mental health impacts of displacement among disaster survivors (Fussell & Lowe, 2014). Displacement itself has at least four different dimensions: 1. the geographic distance from where one lived before the disaster occurred, 2. type of housing one was displaced to, 3. time spent in displacement, and 4. number of times moved following disaster (Fussell & Lowe, 2014). One of the pathways in which displacement impacts the trajectory of mental health is by disrupting the existing social support systems which typically function to buffer the potentially traumatic experiences and/or losses during and after a disaster (Morris & Deterding, 2016). In addition to changes in social capital, displacement can result in additional stressors in new living environments. As mentioned earlier, unemployment or ending up in a worse employment situation may operate as a mediator between having to move and mental health outcomes. These stressors may be further exacerbated particularly among those who are unable to return to their pre-disaster communities. A study among low-income parents after Hurricane Katrina found that the four different dimensions of displacement was consistently linked to worse post-disaster mental health (Fussell & Lowe, 2014). Alternatively, findings from a mixed-methods study indicated that some survivors viewed their displacement

from a more positive perspective that contributed to growth through new opportunities (Manove et al., 2019). While there are prior studies on post-disaster displacement and mental health outcomes (e.g., depression, posttraumatic stress, and psychological distress), there are very few studies that have directly examined the association between displacement and resilience (alongside other trajectories). In our study, we only examined the number of times moved, which we do not directly refer to as displacement due to lack of sufficient information on type and distance of moves. Future studies should incorporate, if possible, more granular information related to displacement to better understand its impact on mental health trajectories.

Our study also had two other main findings related to post-disaster financial resources and utilization of mental health services. First, we found that the number of sources of financial support received after hurricane for one's household was significantly associated with resilience, which was in line with our hypothesis. There was no association observed for the recovery trajectory. In our study, the importance of financial resources (public assistance, SSI, child support, emergency assistance) received after a disaster further emphasize how financial loss and socioeconomic positioning operate as specific stressors, and possibly access to social capital, in the immediate aftermath of a disaster. While the average number of financial resources received was higher the resilience group relative to chronic and recovery, the difference was not statistically significant. Number of financial resources were not significantly different across groups. A previous study also examined similar financial resources (unemployment, social security income, welfare, or food stamps) (Lowe & Rhodes, 2013). They found that those in the identified "decreased distress" trajectory had significantly higher access to social benefits ("in the past month") relative to resilience and four other identified trajectories (coping, delayed distress, and improved) (Lowe & Rhodes, 2013). Study investigators hypothesized that this group may have had lower levels of social capital. In their study, decreased distress was identified as severe psychological distress which later decreased to the mild to moderate range over time. It is important to note here that only less than 5 percent of their study sample was in their decreased distress trajectory, thus there were limitations to detect any meaningful differences across groups.

We were interested to examine whether met mental health needs was associated with resilience. The two survey questions related to mental health needs and utilization were retrospectively assessed within the first three months following Katrina, thus we saw this as an opportunity to better understand how mental health needs in the early aftermath of the disaster may impact resilience in the long-term relative to other trajectories. In addition to lack of pre-disaster data, majority of disaster cohort studies have not been able to examine mental health needs during the first few months following exposure to trauma. We hypothesized that those who needed and received services during this timeframe would have higher odds of experiencing resilience, but we did not observe this for either resilience or recovery. Though, we did find that those who reported not having any mental health needs were more than four times likely to experience resilience compared to those with unmet needs. This finding could be interpreted in several ways; one being that individuals may have received services during the immediate aftermath of Katrina (0-3 months post-disaster). We also did not have baseline information related to history of mental health illness; thus, we hesitate to make any conclusions based on this particular finding. While previous studies have assessed post-disaster utilization of mental health services, there are limited findings on proportion of people who did or did not have their needs met in the

immediate aftermath and how this might influence long-term mental health outcomes (Johannesson et al., 2015; Sakuma et al., 2020) .

Strengths and Limitations

Our study has several major strengths and limitations worth noting. Resilience is a complex phenomenon; thus, our study's findings should be interpreted with caution. First, as is common with the majority of disaster cohort studies, we do not have pre-disaster data. We also do not have data in the immediate aftermath of Katrina since baseline data collection did not start until six months following the disaster. There is little known about the timing at which resilience manifests. While resilience is now understood as a process that occurs over time, the existing research is tethered to the frequency and spacing of survey assessments which has its limitations. Without frequent assessments, we are not able to fully capture the course of adaptation following disaster. The timing of resilience has important implications for ideal "windows of opportunity" for prevention and intervention. To our knowledge, most prospective disaster studies have examined two to three time points of assessment. Person-centered techniques, such as LCGA and LGMM, require a minimum of three time points to produce trajectory classes (Cosco et al., 2017). In our study, we had five time points (Waves 1-5) of assessment which allowed us to better examine the complex patterns of change up to 10 years following Hurricane Katrina. Second, we lacked comprehensive information related to different dimensions of social capital, which was of particular interest and central to the stress-buffering model (Kawachi & Berkman, 2001). We were not able to directly examine baseline levels of social support, but we attempted to capture some aspects of social participation using religious attendance. Religiosity, in the post-disaster contexts, is an important coping mechanism for survivors, and potentially a significant predictor for resilience. This relationship has not been frequently examined, though the broader literature has shown significant associations between religion/spirituality and mental health (Cherry et al., 2015; Ellison, 1991; Pargament et al., 2001). Third, our study did not assess any contextual or community-level predictors. A proposed "Resilience Activation Framework" was recently developed as a framework to understand the mechanisms of resilience (Abramson et al., 2015). The main hypothesis behind this framework is that that psychological resilience is initiated via access to, or availability of, four sources of capital – social, human, economic, and political – and that these resources differ at both the individual and community level. However, understanding resilience from a multilevel perspective is challenging due to data limitations. One recent study's findings indicated that community-level social support and collective efficacy were significant predictors of mental health wellness, which supports the multidimensional nature of resilience (Lowe et al., 2015). Lastly, there are advantages and disadvantages in using latent variable modeling. The strength in employing LGMM is the ability to determine whether an unobservable construct, such as resilience, exists more objectively compared to using definition-driven methods. However, some biases may be introduced during model selection and interpreting the trajectories. In our study, we strived to adhere to the guidance and recommendations from several highly cited sources and we carefully considered the conceptual plausibility for the trajectories we obtained (Infurna & Grimm, 2018; Jung & Wickrama, 2008; Ram & Grimm, 2009). While our study's findings may lack generalizability to other disaster survivor cohorts, our findings further demonstrate that mental health patterns are not linear and resilience may, in fact, emerge alongside other types of response patterns. Our findings emphasize the need for continued assessment and exploration of the long-term mental health impacts among disaster survivors.

Conclusion

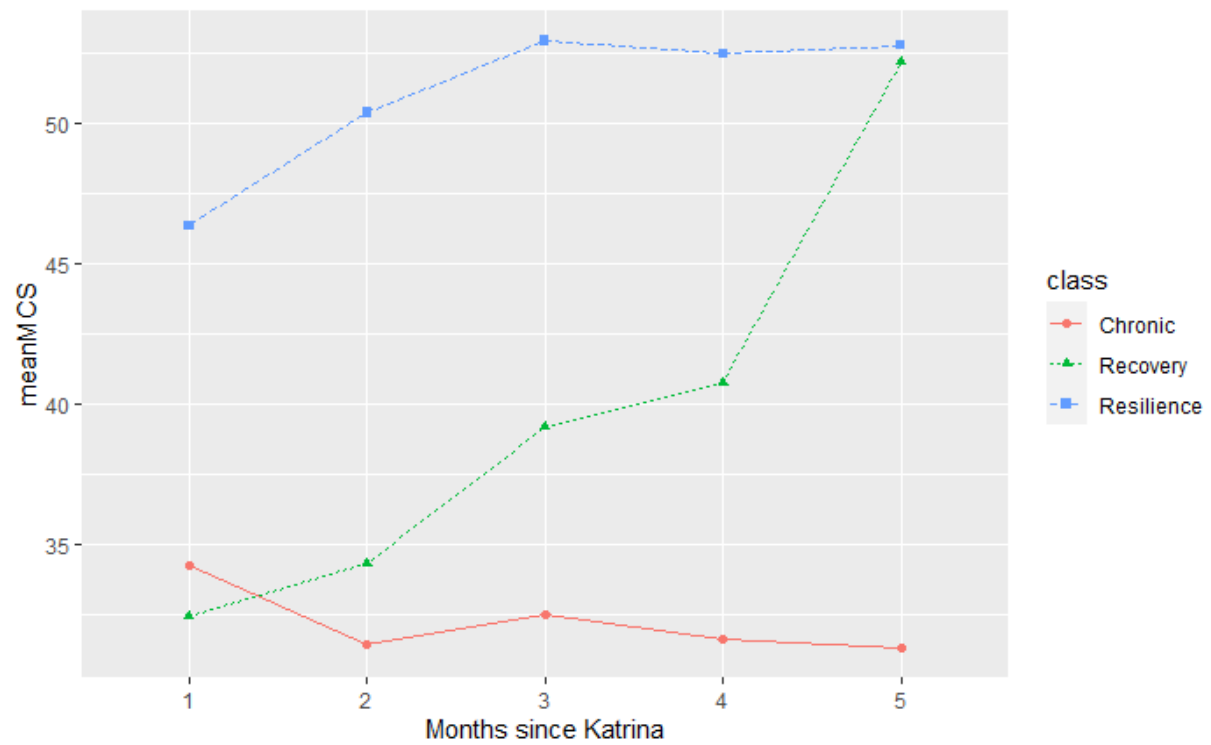
Our study adds to the growing literature on adult resilience in the aftermath of a natural disaster. While resilience research has expanded, our study is one of the few to capture the complex construct of resilience using a multidimensional quality of life measure. We found that resilience was the dominant response pattern in our study sample, though the estimated probability was lower compared than in previous studies. Employment change, residential mobility, and receiving financial resources were some of the important predictors of trajectory membership. Future research should focus on further elucidating the mechanisms of resilience and examining what predicts resilience, in addition to other responses to disasters, from a multilevel approach.

Table 1. Fit statistics for tested models

Number of classes	Log likelihood	AIC	BIC	Entropy	Mean posterior probability (range)
Fixed (LCGA)					
1					
2	-15898.67	31809.3	31839.2	0.64	0.88-0.89
3	-15856.36	31730.7	31775.5	0.55	0.79-0.83
4	-15848.92	31721.8	31781.6	0.60	0.71-0.83
Random intercept					
2	-15866.12	31748.2	31788.1	0.60	0.67-0.86
3 [†]	-15844.47	31713.0	31772.7	0.45	0.69-0.80
4	-15843.42	31718.9	31798.5	0.39	0.50-0.73
Random intercept & slope					
2	-15854.1	31728.2	31778	0.49	0.77-0.87
3	-15843.22	31714.4	31784.2	0.46	0.63-0.80
4	-15842.51	31721	31810.7	0.40	0.52-0.74
Random slope					
2	-15853.18	31724.4	31769.2	0.54	0.77-0.88
3	-15845.78	31715.6	31775.3	0.45	0.59-0.73
4	-15843.26	31716.5	31791.2	0.55	0.64-0.80
Random quadratic intercept					
2	-15866.02	31750.0	31794.9	0.47	0.79-0.85
3	-15846.87	31719.7	31784.5	0.47	0.60-0.72
4	-15843.52	31721.0	31805.7	0.55	0.65-0.80

[†] Lowest information criterion across models

Figure 1. Trajectories of mental health components over time among Hurricane Katrina survivors



MCS: Mental Component Summary Score

Table 2. Characteristics of study participants by predicted trajectory membership among Gulf Coast Child and Family Health study sample

Characteristic	Total N = 1075	Chronic N = 217	Recovery N = 294	Resilience N = 564	<i>p</i>
Age, years					
18-34	248 (23.1)	61 (28.1)	67 (22.8)	120 (21.3)	<i>0.001</i>
35-49	362 (33.7)	86 (39.6)	98 (33.3)	178 (31.6)	
50-65	323 (30.0)	54 (24.9)	101 (34.4)	168 (29.8)	
66+	132 (12.3)	15 (6.9)	25 (8.5)	92 (16.3)	
Missing	10 (0.9)	1 (0.5)	3 (1.0)	6 (1.1)	
Sex					
Female	638 (59.3)	146 (67.3)	188 (63.9)	304 (53.9)	<i>0.001</i>
Male	437 (40.7)	71 (32.7)	106 (36.1)	260 (46.1)	
Pre-Katrina Household Income					
<10k	316 (29.4)	80 (36.9)	90 (30.6)	146 (25.9)	<i>0.005</i>
10-20k	344 (32.0)	75 (34.6)	95 (32.3)	174 (30.9)	
20-35k	182 (16.9)	34 (15.7)	39 (13.3)	109 (19.3)	
>35k	173 (16.1)	21 (9.7)	50 (17.0)	102 (18.1)	
Missing	60 (5.6)	7 (3.2)	20 (6.8)	33 (5.9)	
44.97		41.83	46.19	45.52	
PCS (mean (SD))	(15.26)	(16.18)	(15.15)	(14.81)	<i>0.003</i>
Marital Status					
Non-Partnered	695 (64.7)	139 (64.1)	199 (67.7)	357 (63.3)	<i>0.475</i>
Partnered	357 (33.2)	72 (33.2)	92 (31.3)	193 (34.2)	
Missing	23 (2.1)	6 (2.8)	3 (1.0)	14 (2.5)	
Below the poverty line					
No	552 (51.3)	92 (42.4)	144 (49.0)	316 (56.0)	<i>0.001</i>
Yes	463 (43.1)	118 (54.4)	130 (44.2)	215 (38.1)	
Missing	60 (5.6)	7 (3.2)	20 (6.8)	33 (5.9)	
Child <18 years in household					
No	652 (60.7)	114 (52.5)	170 (57.8)	368 (65.2)	<i>0.011</i>
Yes	422 (39.3)	103 (47.5)	124 (42.2)	195 (34.6)	
Missing	1 (0.1)	0 (0.0)	0 (0.0)	1 (0.2)	
Race and Ethnicity					
NH Black	515 (47.9)	81 (37.3)	148 (50.3)	286 (50.7)	<i>0.038</i>
NH White	458 (42.6)	110 (50.7)	120 (40.8)	228 (40.4)	
Other	70 (6.5)	19 (8.8)	19 (6.5)	32 (5.7)	
Missing	32 (3.0)	7 (3.2)	7 (2.4)	18 (3.2)	
Employment Status					
Employed	191 (17.8)	25 (11.5)	43 (14.6)	123 (21.8)	<i>0.004</i>
Unemployed After HK	431 (40.1)	93 (42.9)	135 (45.9)	203 (36.0)	

Unemployed Before and						
After HK	429 (39.9)	93 (42.9)	108 (36.7)	228 (40.4)		
Missing	24 (2.2)	6 (2.8)	8 (2.7)	10 (1.8)		
General Health Status						
Excellent/Very Good	282 (26.2)	39 (18.0)	63 (21.4)	180 (31.9)	<0.01	
Good	302 (28.1)	45 (20.7)	89 (30.3)	168 (29.8)		
Fair/Poor	483 (44.9)	130 (59.9)	140 (47.6)	213 (37.8)		
Missing	8 (0.7)	3 (1.4)	2 (0.7)	3 (0.5)		
Religious Attendance						
Never	295 (27.4)	67 (30.9)	87 (29.6)	141 (25.0)	0.38	
Infrequent	403 (37.5)	79 (36.4)	109 (37.1)	215 (38.1)		
Often	359 (33.4)	65 (30.0)	94 (32.0)	200 (35.5)		
Missing	18 (1.7)	6 (2.8)	4 (1.4)	8 (1.4)		
Number times moved (mean (SD))	3.21 (2.28)	3.61 (2.59)	3.25 (2.08)	3.03 (2.24)	0.006	
Number times moved						
0 – 1 time	155 (14.4)	23 (10.6)	46 (15.6)	86 (15.2)	0.49	
2 times or more	913 (84.9)	193 (88.9)	246 (83.7)	474 (84.0)		
Missing	7 (0.7)	1 (0.5)	2 (0.7)	4 (0.7)		
Number of post-disaster financial resources received (mean (SD))	1.91 (0.96)	1.87 (0.96)	1.87 (0.97)	1.95 (0.95)	0.377	
Needed and received mental health services within 3 months following disaster						
Unmet needs	271 (25.2)	84 (38.7)	110 (37.4)	77 (13.7)	<0.01	
Did not have any needs	608 (56.6)	80 (36.9)	127 (43.2)	401 (71.1)		
Needs met	143 (13.3)	43 (4.6)	45 (15.3)	55 (9.8)		
Missing	53 (4.9)	10 (4.6)	12 (4.1)	31 (5.5)		

Table 3. Multinomial logistic regression results for the association between Wave 1 predictors and mental health trajectory membership among Gulf Coast Child and Family Health study sample (N=1075)

Characteristic	Recovery versus Chronic Trajectory		Resilience versus Chronic Trajectory	
	aOR ¹ (95% CI)	<i>p</i>	aOR (95% CI)	<i>p</i>
(Intercept)	0.64 (0.15, 2.62)	0.530	1.47 (0.38, 5.64)	0.573
Age, years				
18-34	Reference		Reference	
35-49	1.17 (0.67, 2.02)	0.579	0.82 (0.48, 1.38)	0.456
50-65	2.16 (1.13, 4.12)	0.020	1.25 (0.67, 2.31)	0.486
66+	1.93 (0.79, 4.73)	0.149	2.48 (1.1, 5.6)	0.029
Sex				
Female	Reference		Reference	
Male	1.18 (0.75, 1.86)	0.476	1.65 (1.07, 2.54)	0.022
Marital Status				
Non-Partnered	Reference		Reference	
Partnered	0.97 (0.62, 1.52)	0.896	1.1 (0.71, 1.69)	0.674
Pre-Katrina Household Income				
<10k	Reference		Reference	
10-20k	1.05 (0.64, 1.73)	0.832	1.11 (0.69, 1.8)	0.667
20-35k	0.99 (0.53, 1.88)	0.984	1.73 (0.96, 3.14)	0.070
>35k	2.38 (1.12, 5.05)	0.024	2.41 (1.16, 5)	0.018
Child <18 years in household				
No	Reference		Reference	
Yes	1.06 (0.65, 1.74)	0.821	0.63 (0.4, 1.02)	0.059
Race and Ethnicity				
NH Black	Reference		Reference	
NH White	0.6 (0.38, 0.93)	0.024	0.52 (0.34, 0.8)	0.003
Other	0.61 (0.27, 1.39)	0.241	0.56 (0.25, 1.24)	0.152

Employment Status

	Employed	Reference		Reference	
Unemployed After HK	1.37 (0.71, 2.61)	<i>0.345</i>	0.5 (0.28, 0.89)	<i>0.020</i>	
Unemployed Before and After HK	1.39 (0.69, 2.82)	<i>0.362</i>	0.64 (0.34, 1.22)	<i>0.175</i>	

General Health Status

	Fair/Poor	Reference		Reference	
Good	1.56 (0.87, 2.8)	<i>0.137</i>	3.34 (1.88, 5.93)	<i><0.01</i>	
Excellent/Very Good	0.87 (0.42, 1.8)	<i>0.716</i>	3.62 (1.81, 7.23)	<i><0.01</i>	
Physical Health Component Score	1.02 (1, 1.04)	<i>0.038</i>	0.99 (0.97, 1.01)	<i>0.152</i>	

Religious Attendance

	Never	Reference		Reference	
Infrequent	0.77 (0.47, 1.27)	<i>0.311</i>	1.08 (0.67, 1.76)	<i>0.741</i>	
Often	0.75 (0.45, 1.27)	<i>0.287</i>	1.1 (0.66, 1.82)	<i>0.718</i>	

Number times moved

	Reference		Reference	
	0.52 (0.29, 0.93)	<i>0.028</i>	0.63 (0.35, 1.11)	<i>0.110</i>

Number of post-disaster financial resources received	1.02 (0.82, 1.28)	<i>0.831</i>	1.24 (1, 1.53)	<i>0.049</i>
Needed and received mental health services within 3 months following disaster				

	Unmet needs	<i>Ref</i>		<i>Ref</i>	
Did not have any needs	0.96 (0.61, 1.51)	<i>0.866</i>	4.4 (2.81, 6.9)	<i><0.01</i>	
Needs met	0.72 (0.41, 1.26)	<i>0.247</i>	1.03 (0.57, 1.85)	<i>0.920</i>	

1: Adjusted Odds Ratio

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Chapter 3: Neighborhood socioeconomic status and women's mental health: A longitudinal study of Hurricane Katrina survivors, 2005-2015

Introduction

Existing research has established links between place and health, in that the neighborhood context plays a pivotal role in influencing health outcomes. Among the conceptual underpinnings of this association between place and well-being are: (a) social determinants of health, (b) fundamental cause (access to power, resources, status), (c) economic and social opportunity, (d) social and cultural norms, (e) environmental hazards and toxins, and (f) structural and instrumental assets or liabilities, among others, in addition to a broad range of individual-level characteristics (Arcaya et al., 2016; Browning & Cagney, 2003; Keizer et al., 2008). While the majority of previous studies have focused on physical health outcomes, there is some evidence to suggest that the neighborhood factors may impact mental health outcomes both in the short- and long-term, including outcomes related to overall self-rated mental health, depression, psychological distress, and anxiety (Arcaya et al., 2016; Gong et al., 2016). The broader literature on neighborhood and health outcomes is indeed vast, however, the impacts of neighborhood environment among vulnerable and displaced populations remain underexplored. This study seeks to bridge this gap by examining the association between neighborhood socioeconomic status and mental health over time among women survivors of a natural disaster.

Some of the earliest research on neighborhood factors and mental health among women came from the Stirling County Study, a prospective epidemiological study conducted in Atlantic Canada in the 1950s following the Second World War (Leighton et al., 1963; Murphy et al., 2000). The incidence of depression among women were double of that of men. These findings generated the hypothesis that changes in the post-war social environment related to educational opportunities, family ties, racial tensions, employment, and poverty led to disintegration were associated with poor mental health. Furthermore, these findings garnered interest to better understand how environmental conditions, in addition to individual-level socioeconomic positioning and life experiences, were important for women's mental health. A more recent study found that the residential environment was likely to be more important for women's self-rated health than it was for men, specifically characteristics related to the physical environment and economic opportunities (Stafford et al., 2005). In addition, a qualitative study was conducted among African American women who participated in the Moving to Opportunity experimental study to better understand the processes of how moving to a low-poverty neighborhood impacted their mental health (Turney et al., 2013). The study's findings were that social environmental factors related to collective efficacy, physical environmental factors related to improved neighborhood, and home aesthetics were important for mental health. While gender differences may arguably be context or population specific, these limited findings suggest that the neighborhood environment potentially has significant impacts on women. However, most studies have either treated gender as a confounder in analytic models and/or have been cross-sectional in nature, warranting further investigation.

There is also limited literature on the relationship between neighborhood effects and health outcomes among women who have experienced natural disasters. The relationship between place

and health is crucial in the context of post-disaster mental health for several reasons. First, in the event of a natural disaster, forced migration or displacement is likely to occur. In the case of Hurricane Katrina, the disaster resulted in the displacement of over 400,000 residents in New Orleans, either temporarily or permanently. Hurricane Katrina also directly affected structurally vulnerable regions of the United States. In New Orleans, approximately one-third of the population was living below the poverty line at the time of Hurricane Katrina (*Census 2000 Summary File 1 [Louisiana]*, 2001). Due to the significant displacement, residents were forced to resettle in new communities. Second, neighborhoods themselves experience significant changes post-disaster due to disruption, rebuilding, and recovery processes (Lee, 2020; Pais & Elliott, 2008). Geographic mobility, neighborhood changes, and social ties are all important factors related to disaster recovery.

This research is guided by Fundamental Cause Theory and the Spatial Opportunity Structure Framework (Link & Phelan, 1995). Link and Phelan developed Fundamental Cause Theory to better understand how to contextualize risk factors as a process and to determine the social conditions under which people “at risk of risk”. Fundamental causes, such as socioeconomic status (both at the individual or community level), are associated with access to flexible resources which allow people to minimize their risk or maximize their protection. These flexible resources include power, prestige, money, as well as interpersonal resources, such as social capital and these flexible resources are embedded in neighborhoods. People’s access to flexible resources are bound to change when their neighborhood environments are changing.

The mechanisms in how neighborhood social and economic conditions influence health may also be best understood through a proposed “Spatial Opportunity Structure” framework (Galster & Sharkey, 2017). The spatial opportunity structure is thought of as variations in natural or intentional spatial inequalities in socioeconomic, environmental, institutional, and political domains. This conceptual framework is modeled as several pathways between individual’s life decisions, individual’s attributes, spatial opportunity structure, and individual’s achieved status. An individual’s attributes include both fixed and malleable characteristics over a lifetime. First, spatial opportunity structures are thought to act as a mediator between individual’s current characteristics and desired outcomes. One’s access to opportunities and ability to “convert their most productive personality attributes” will always be influenced by where they live, work, and socialize. Second, spatial opportunity structures may also act as modifiers through environmental exposure. Physical and/or social environmental factors may unconsciously shape or change individual-level attributes, behaviors, or preferences. Some examples include exposure to neighborhood violence or collective socialization. Spatial opportunity structure influences how individuals make life decisions through shaping how individuals perceive their ability to access and/or receive information. When it comes to decision-making, individuals are influenced by what they perceive are the more desirable and feasible options for them. These pathways and processes are viewed cumulative across the life course and mutually reinforcing over time. Given the complexity of this model, estimating the causal impacts of spatial context is challenging due to unmeasured confounding, geographic selection bias, timing of events, and instrumental variables for spatial context characteristics. Applying both the Fundamental Cause Theory and the Spatial Opportunity Framework, this study aims to examine the impact of neighborhood socioeconomic status on mental health among women survivors of Hurricane Katrina over time through a multilevel framework.

The overarching purpose of this study is to understand how changes to the social and economic environment shape mental health trajectories among women survivors of Hurricane Katrina, using data from the Gulf Coast Child and Family Health Study (GCAFH). In this longitudinal study, we examined the association between neighborhood socioeconomic status and self-rated mental health among Hurricane Katrina women survivors, and whether these associations were different between those who were permanently displaced and those who stayed or returned to their pre-disaster residence. To our knowledge, there are no longitudinal studies that have investigated neighborhood effects on women's mental health trajectories. Given similar pre-Hurricane Katrina neighborhoods and household economic positions, we hypothesized that increasing neighborhood socioeconomic status would have a positive impact on mental health in our study population.

Methods

Individual-level data and study sample

This study used data from the GCAFH study, a longitudinal cohort of Louisiana and Mississippi households impacted by Hurricane Katrina (Katrina). The cohort comprises 1,079 households randomly sampled from the Federal Emergency Management Agency's list of group sites, commercial trailer sites, and hotels. A baseline survey was conducted 6-12 months post-Katrina (Wave 1) and four follow-up surveys were conducted in 2007 (Wave 2), 2008 (Wave 3), 2009 (Wave 4), and 2015 (Wave 5). The survey includes a range of measures related to physical and mental health, recovery, mobility, social ties, and individual-level demographics and socioeconomic status. The detailed description of the study and recruitment process of the GCAFH cohort have been previously provided (Abramson et al, 2008).

Our study sample included participants who completed Wave 1, Wave 5, and at least one other wave of the survey. We first restricted our sample to women, then further restricted our sample to include participants with complete residential addresses provided during each survey completion for geocoding purposes. We also limited the study sample to those with available data on the outcome of interest, the mental health component summary (MCS) score. This resulted in a final analytical sample of 394 participants.

Outcome Measure

Our outcome of interest was self-rated mental health as derived from a 12-item Short Form Health Survey (SF-12) composed of several physical and mental health domains including physical functioning, role-physical, general health vitality, social functioning, role-emotional, and general health. The SF-12 is a subset of the 36-item Short Form Health Survey (SF-36) and is a validated instrument to measure health-related quality of life measures (Gandek et al., 1998). The instrument generates two summary scores known as the Physical and Mental Component Summary Scores (PCS and MCS, respectively). Scores range from 0-100, where higher scores represent overall better physical or mental health. The SF-12 was administered at each survey wave and we used MCS scores as our outcome measure for self-rated mental health.

Population-based data sources

To examine the social and economic characteristics of neighborhoods, we used census block group level information from the American Community Survey (ACS), an ongoing survey which covers topics about social, economic, demographic, and housing characteristics of the U.S. population (Bureau, n.d.). We selected five-year estimates closely aligned with GCAFH Waves 1-5 surveys (2005-2009, 2006-2010, and 2012-2016). Five-year estimates represent 60 months of collected data. We chose to use five-year estimates due to their statistical reliability for examining less populated areas or geographical units, such as census tracts or census block groups. We also obtained data from the Longitudinal Employer-Household Dynamics (LEHD) Origin-Destination Employment Statistics (LODES)(US Census Bureau Center for Economic Studies, n.d.). We extracted LODES data on the total number of jobs within five miles of census block groups of interest for years 2005, 2007, 2008, 2009, and 2015.

Exposure Measure

We defined neighborhoods using census block groups, statistical divisions of census tracts which contain between 600 and 3,000 people. We geocoded GCAFH participants' addresses provided during each survey completion. Geocoded addresses were then matched to 2000 and 2010 census block group boundaries using spatial files provided by Integrated Public Use Microdata Series (IPUMS) National Historical Geographic Information Systems (NHGIS) (Manson et al., 2020). The spatially joined data were then linked to ACS data. The baseline GCAFH survey data, Wave 1, was linked to ACS 2005-2009, Waves 2-4 were linked to ACS 2006-2010, and Wave 5 was linked to ACS 2012-2016.

The exposure measure, neighborhood socioeconomic status, was conceptualized to represent a range of social and economic factors identified a priori, specifically referencing the neighborhood characteristics from the broader literature on measuring neighborhood-level SES (American Psychological Association, 2015; Chetty et al., 2016; Kolak et al., 2020). We initially selected 12 social and economic factors related to racial and ethnic composition (percentage of non-Hispanic residents and percentage of White residents), head of household (percentage of dual-parent households), housing tenure (percentage of home owners), immigrant status (percentage born in the United States), educational attainment (percentage with Bachelor's degree or higher), percentage above the federal poverty line, employment status (percentage employed), median household income, residential stability (percentage of residents who lived at the same residence address within the past year), and short work commute time (percentage of residents who commute fewer than 15 minutes to work). We also included population density, calculated as the total number of people in the census block group divided by the land area (square miles). All calculations were conducted for each United States census block group for each of the five Waves and then merged with the geocoded GCAFH residential address data. We considered two additional variables, residential mobility and job density (total number of jobs in a census block group divided by land area), but they were subsequently removed because the variables at the time had a large proportion of missing data at the census block group level. We created a summary score measure for neighborhood socioeconomic status via confirmatory factor analysis (CFA) with the 10 identified census block group-level variables related to neighborhood social and economic factors. CFA was used to test our hypothesis on whether an underlying factor explained the correlations among the selected observed variables. A summary score was generated for each individual at each completed Wave to summarize their

neighborhood-level socioeconomic status at a given time point. The factor scores were generated to have a mean of 0 and standard deviation of 1, which were then standardized to range from 0 to 1 and was scaled such that a higher score represented increasing socioeconomic status within the neighborhood. Confirmatory factor analyses were conducted using the R package ‘lavaan’ (Rosseel, 2012)

Additional Covariates

Several individual-level characteristics were considered as potential confounders between neighborhood socioeconomic status and mental health. We included age at the year of Katrina, race/ethnicity, presence of children in the household, and physical health component summary (PCS) score as sociodemographic- and health-related covariates in our analyses. PCS scores were obtained via the SF-12 scale which examines constructs related to physical functioning, role-physical, and general health. Similar to MCS scores, PCS scores range from 0-100, 100 representing perfect health. We also included number of months since Katrina as a time variable, household relative poverty status, and household relative income status. We defined household poverty as a participant’s household income relative to the federal poverty threshold during each survey year. We created a dichotomous variable to indicate whether a participant’s self-reported household income was below (1=yes) or not below (0=no) the federal poverty threshold. Household relative income was also defined as a dichotomous variable to indicate whether a participant’s self-reported household income was below (1=yes) or not below (0=no) their neighborhood-level median household income. We also included variations of several variables to capture a participant’s status at baseline/Wave 1 and before Hurricane Katrina (pre-Katrina). These variables included pre-Katrina neighborhood-level socioeconomic status, baseline household relative poverty status, and baseline household relative income status. Lastly, we created two categorical residential mobility variables. First, we created a dichotomous variable, move status, to indicate those who stayed or returned to the original area of residence at any given timepoint following Katrina and those who moved and never returned to the original area of residence following Katrina. The variable was created by comparing the participants’ self-reported addresses pre-Katrina and at Wave 5.

Statistical Analyses

A three-level multilevel modeling approach was used to test the relationship between neighborhood socioeconomic status and self-rated mental health. The repeated measures of mental composite health scores over time (i) were fully nested within individuals (j), while the neighborhoods determined by census block groups (k) were treated as crossed with individuals since the individuals could have moved to different neighborhoods between Waves (Equation 1). Our general model is as follows:

$$y_{ijk} = \beta_1 + \beta_2 x_j + \zeta_j^{(2)} + \zeta_k^{(3)} + \varepsilon_{ijk}$$

$\zeta_j^{(2)} \sim N(0, \psi^{(2)})$: Random intercept for individual j

$\zeta_k^{(3)} \sim N(0, \psi^{(3)})$: Random intercept for neighborhood k

$\varepsilon_{ijk} \sim N(0, \theta)$: Error term at occasions i for individual j and neighborhood k

A random intercept model was used to test the hypothesis. The interaction term between the main exposure (neighborhood SES score) and time was insignificant, thus it was not included in the model. The sample was divided into two groups by move status: those stayed/returned versus moved/never returned. Visual exploratory analyses were conducted by generating empirical growth plots as well as average change trajectories of the sample to assess how each subject changed over time. Age, as well as the time variable measured in months between Katrina and survey dates, were centered to facilitate the interpretation of results.

Our model building and final model selection came in several stages. First, we fitted a null model with no predictors to estimate the variance components. Intraclass correlation coefficients were calculated to describe the proportions of total variation that is explained by within-subject, between subject, and between block group variation. Next, we ran an unconditional growth model, including the time variable measured by number of months since Katrina. Then, to understand if there was a difference in the rates of change in MCS scores based on the changes in the neighborhood socioeconomic status scores, an interaction term between the neighborhood socioeconomic status scores and the time variable was fitted into the model. However, the interaction was not statistically significant. Thus, we built the intermediate model in which we controlled for age, race/ethnicity, PCS score, move status, household relative poverty status, household relative income status, any children under 18 years old present in the household at baseline, and time. We also included contextual factors at pre-Katrina: neighborhood socioeconomic status score, household relative poverty status, and household relative income status. In addition to these factors being potentially important factors to control for, we were interested in estimating their independent associations on mental health over time. Lastly, we included an interaction term in our final model to assess whether the variable move status modified the association between neighborhood socioeconomic status and mental component score. Our final model included all of the same covariates as the intermediate model.

Restricted maximum likelihood estimation was used for all models, and comparative model fit statistics were calculated using likelihood ratio tests for nested models and Akaike Information Criterion for non-nested models (AIC). Statistical significance was determined at an alpha level of 0.05. All descriptive and statistical analyses were conducted using ArcMap 10.6.1, Stata IC 16.1, and R v. 3.6.1. (Environmental Systems Research Institute, 2011; RStudio Team, 2018; StataCorp, 2019).

Results

Confirmatory Factor Analysis

We used a one-factor model using the percentages of non-Hispanic White, two-parent households, homeownership, US-born, college education, above poverty line, employment, median household income, short work commute time and population density as our neighborhood-level variables manifest variables to indirectly measure the latent variable, neighborhood socioeconomic status. We inspected estimated factor loadings from our model to assess the association between the manifest variables and the latent variable. Among the 10 manifest variables used to create neighborhood SES, we found that living above the federal

poverty line, two-parent household, homeownership, White, median household income, education, employment, and US-born were positively associated with the latent variable. The remaining manifest variables, population density, and short travel time to work were negatively associated with the latent variable. In order to assess how well our data fit the specified one-factor model, we examined several commonly reported approximate fit indices (Hu & Bentler, 1999). Given the increasing controversies surrounding cutoff values for CFA models, we assessed our approximate fit indices with caution (Barrett, 2007; Hayduk et al., 2007). Comparative Fit Index (CFI) and the Tucker-Lewis Index (TLI) values close to 1.0 are generally preferred. Our results demonstrated an adequate fit based on our CFI (0.9) and TLI (0.9) results. We also examined the Root Mean Square of Error of Approximation (RMSEA) and Standardized Root Mean Square Residual (SRMR), non-centrality indices, where values closer to 0 support acceptable fit. Our model SRMR and RMSEA values were 0.08 and 0.10, respectively.

Descriptive findings

The analytical sample included 394 women. Table 1 shows the baseline characteristics of the study samples stratified by the variable move status. In overall, the mean age of women at 42.7 years (Standard Deviation (SD)=13.8) and their average MCS score was 40 (SD=10.7). More than half of the women were Black (52%), non-partnered (62.4%), and had at least 1 child in the household at baseline (60.7%). At the pre-Katrina household level, more than half of the women were below the poverty line and over 70% of them had a household income below their pre-Katrina neighborhood median household income. The majority of women (82.5%) moved out of their pre-Katrina neighborhood and did not return. Those who stayed or returned tended to be older (48.4 years, SD: 13.5) compared to those who moved and did not return to their pre-Katrina neighborhood. Nearly 60 percent of those who permanently moved out of their pre-Katrina neighborhood were living below the poverty line and over 70 percent had a household income below their pre-Katrina's neighborhood's median household income. A higher proportion of those who either stayed or returned were partnered (48.4%) compared to those who moved and did not return (35.3%). The mean neighborhood socioeconomic score of pre-Katrina neighborhoods was higher among those who either stayed or returned (0.57, SD: 0.13) compared to those who moved and did not return (0.53, SD: 0.14).

A thematic depiction of the distribution of and changes in neighborhood socioeconomic scores is presented in two choropleth maps (Figure 1). These maps visualize the derived neighborhood socioeconomic scores during pre-Katrina (1A) and at Wave 5 (1B) for a sample of census block groups in downtown New Orleans. Areas shaded in grey are census block groups in which we were not able to produce scores due to incomplete data for one or more indicator variables. Neighborhood socioeconomic index scores were categorized into quartiles, with darker shades representing high socioeconomic scores (more socioeconomically advantageous) and lighter shades representing low socioeconomic scores (more socioeconomically vulnerable). While some census block groups in New Orleans may have increased in terms of socioeconomic status, this does not necessarily translate to increased socioeconomic status for Katrina survivors many of whom in our study population had moved away from the city.

Main findings

Null and unconditional growth models

Table 2 presents our results from the null and unconditional growth models. The null model shows that the average mental health scores for women in our sample across all time points and all observations was estimated as 44.5. The total variance is largely driven by within-individual variance followed by between individual variance and between block group variances. The intraclass correlation coefficients (ICC) show that 31% of the variability is attributable to between individual characteristics while about 9% of the variability is attributable to census block group characteristics. The estimated variance components showed that there is sufficient variation at each level to warrant further analysis. The unconditional growth model (Table 2) was fitted by adding the time variable as the number of months since Hurricane Katrina. Compared to the null model, a better model fit was achieved by adding the time variable into the model. The slopes were statistically significant, with mean MCS scores estimated to increase by 0.04 for every month post-Katrina. The estimated variance components for census block groups decreased significantly. The declined variances were also reflected in the significant decrease in ICC for neighborhood variability. The unconditional growth model demonstrated that time is a significant factor in explaining MCS trajectories for the study population.

Intermediate and final models

The results of the intermediate and final models are presented in Table 3. Compared to the unconditional growth model, the within-individual variance estimated in the intermediate model decreased from 97.7 to 90.7. This is expected because the model includes significant time-varying variables including PCS score, living below the poverty line at any wave, and having a household income below the neighborhood MHI. Despite adding time-invariant variables in the model including age, race, and any child in the household at baseline, the between-individual variance estimated did not decrease compared to results from the unconditional growth models. Estimates of the census block group variance as well as between-person variance decreased in the final model compared to the intermediate model. Similarly, the ICC for neighborhood variability also decreased, demonstrating the decreased variability attributable to neighborhood characteristics. Lastly, the AIC was slightly lower for the final model compared to the intermediate model.

Compared to the null and unconditional growth models, on average, MCS scores increased over time in both the intermediate and final models when adjusted for neighborhood SES score at pre-Katrina, neighborhood SES scores at any wave, age at baseline, race, any child under 18 years old in the household, PCS, living below the poverty line at pre-Katrina, living below the poverty line at any wave, having a household income below the neighborhood MHI at pre-Katrina, having a household income below the neighborhood MHI at any given wave, and move status. Neither age nor race was an important predictor of MCS in any of the models. PCS score and having a household income below the neighborhood MHI were statistically significant predictors in both the intermediate and final models. For every one unit increase in PCS score, MCS scores were estimated to decrease by an average of 0.02 among women. As for relative economic positioning, women living below neighborhood MHI was statistically negatively associated with MCS score.

The exposure of interest, neighborhood socioeconomic status, was positively associated with MCS in our intermediate model though not statistically significant. The results from the final model for our analysis, in which we assessed for interaction between residential mobility and neighborhood socioeconomic status score, is shown in Table 3. In this final model, we observed a statistically significant coefficient for the neighborhood socioeconomic status score, after including the interaction term for move status. For those who did not move or eventually returned to their pre-Katrina neighborhood, every unit increase in neighborhood socioeconomic status score was associated with an estimated mean MCS score increase by 19.6 (95% CI: 5.8, 33.7). In other words, mental health score improved as neighborhood socioeconomic status increased for those who did not move or eventually returned to their pre-Katrina neighborhood, controlling for all other variables. The interaction term between neighborhood socioeconomic status score and move status was statistically significant, suggesting that the effect of neighborhood socioeconomic status MCS was modified by move status. The coefficient for this interaction term, -13.14 [95% CI: -27.92, 1.63], further indicates that the positive relationship between neighborhood socioeconomic status and MCS was attenuated among those who moved and did not return compared to those who did not move or eventually returned to their pre-Katrina residence. Based on the p-value of the interaction coefficient, the effect of neighborhood socioeconomic status on mental health was modified by move status. To further interpret these findings in a more tangible sense, Figure 2 presents a marginal effects plot to visualize this interaction, how the estimated effect of neighborhood socioeconomic status varies by move status. A marginal effects plot allows one to interpret results from the statistical model by presenting the estimated predicted values generated by the model. These predictions compare how the outcome, MCS score, changes on average, holding the non-focal variables constant. In this figure, MCS scores increase over time for both slopes. However, the slope of those who never moved or returned to their pre-Katrina neighborhood is steeper than the slope of those who moved and never came returned, emphasizing the significance of the interaction.

Discussion

This study examined whether neighborhood socioeconomic status was positively associated with self-related mental health among women survivors up to 10 years after Hurricane Katrina. To our knowledge, this is the first study to examine the impacts of socioeconomic status among disaster survivors, particularly the independent impacts among women, most of whom experienced post-disaster displacement. This research study extends the work of previous research by 1.) examining the association of in neighborhood socioeconomic status and mental health over a 10-year period among disaster women survivors and 2.) investigating how these associations differ by post-disaster move patterns.

There were three main findings from our research study. First, increased neighborhood socioeconomic status is associated with improved mental health among women, which supported our main hypothesis. Second, our interaction analysis indicated that women who stayed or returned to their pre-disaster area of residence, compared to those who never returned, were more likely to experience better mental health living in higher socioeconomic conditions. Third, women's household economic positioning was associated with decreased mental health.

Our first main finding is novel and adds to the growing literature on how neighborhood factors shape mental health among women survivors of a natural disaster. Recent systematic reviews on

neighborhood effects and mental health indicate that previous studies have generally only controlled for gender (Arcaya et al., 2016; Gong et al., 2016; Moore et al., 2018), while our study was limited and focused on women. Findings from an early cross-sectional study in a rural community found that women's perceptions of the social quality of their community (i.e., access to health care, quality of public education, crime) were positively associated with their self-reported physical and mental health status and daily functioning (Molinari et al., 1998). In contrast, perceptions of the physical environment (i.e., air quality, drinking water, waste disposal) were significantly associated among men. A later study also found significantly larger between-neighborhood differences in self-rated health among women than for men (Stafford et al., 2005). More specifically, women's self-related health was more strongly associated with their perception of their neighborhood's socio-political, physical, and economic characteristics compared to men. Some plausible explanations for gender differences are that 1.) men and women perceive their environment differently, 2.) exposure to various aspects of the local environment may differ between men and women, and 3.) the vulnerability to the aspects of the local environment may differ between men and women. Gender differences may also intersect across adult life stages. Another explanation is that there are different levels of exposure to the neighborhood between women and men, in that women may spend more time in the neighborhoods than men, but there is no empirical evidence to support this theory. While findings on gender differences in neighborhood effects are limited, research on gender differences in the context of natural disasters is even more scarce. Before Katrina, a number of Gulf Coast women lived in environments, with poor access to health care, limited healthy food and recreational opportunities, and close proximity to crime and violence (Waters 2016; Curtis et al., 2007; Fussell et al., 2010). Katrina re-shuffled the deck, displacing many women from their pre-Katrina neighborhoods. The neighborhoods to which they moved varied considerably along the dimensions of social and economic status, as well as such structural harms as inequality, segregation, and deficits of social capital (Graif et al., 2015). Though not directly related to the spatial contexts of socioeconomic status, one study's findings showed that community-level social support was a strong predictor of long-term happiness among women exposed to Katrina (Calvo et al., 2015). These findings underscore the need to better understand the impact of neighborhood factors and mental health among women affected by natural disasters, specifically neighborhood-level factors more closely aligned with social capital, crime, and access to health services (both objectively and subjectively).

Our second finding on move status as an effect modifier suggests that women's displacement patterns are an important factor on their mental health over time, in conjunction with their access to a more socioeconomically advantageous neighborhood. Natural hazards which displace large numbers of people hold the potential to serve as natural experiments to understand neighborhood effects on health among community survivors. Katrina was the largest displacement event in modern United States history. After Katrina, survivors were displaced, at least temporarily from New Orleans, and had little or no control over where they were able to relocate to immediately following the storm. This near-random displacement after Katrina created a natural experiment (Schnake-Mahl et al., 2020). A study on displacement patterns among low-income parents (predominantly single mothers) found that participants who returned to their pre-disaster communities had lower levels of psychological distress compared to those who were permanently relocated or in unstable housing (Fussell & Lowe, 2014). It is likely that those who were able to return to their pre-disaster communities reconnected with or had stronger social support networks, which aided their mental health. Individuals who returned to their pre-disaster

communities, particularly areas which were relatively more impacted by the hurricane, may have benefited from the reinvestment and rebuilding of neighborhoods. Though not everyone had an equal opportunity to return. Black and low-income residents returned to New Orleans at slower rates than White individuals and the city became “older, richer, and more White than it was before Katrina” (Waters, 2016). Further exploration of the lived experiences of those who were displaced is needed, particularly the decision-making processes behind relocating and returning.

Our third finding is important in understanding the impact of women’s post-disaster economic positioning on their mental health. We examined the relationship between two relative socioeconomic status measures and mental health, 1.) an individual’s household income relative to their neighborhood’s MHI and 2.) whether an individual’s household income was above or below the federal poverty line. Women’s economic positioning prior to Katrina was not significantly associated with their MCS scores for either indicator. However, women having a household income below the neighborhood MHI at any given wave was a significant predictor for declining mental health score. These findings suggest that economic positioning for women after a disaster has significant impacts on their mental health both in the immediate and long-term. And generally speaking, these results further support the theory of relative socioeconomic status as an important social determinant of health. While the socioeconomic status gradient of health and the dimensions of individual socioeconomic status have been well documented, the relationship between community socioeconomic conditions and health is inconsistent (Adler et al., 1994; Lynch & Kaplan, 2000; Quon & McGrath, 2015). Our findings warrant further investigation on the role of socioeconomic positioning relative to one’s neighborhood across the life span, particularly among disaster survivors who were forced to relocate and adapt in new places.

Strengths and Limitations

Our study was subject to several limitations. We utilized a multi-level framework with the assumption that there was a level of heterogeneity across neighborhoods. While mixed effects models offer flexibility, results should be approached with caution because mixed effects models involve normality assumptions for the error distribution. We were also not able to examine the length of residence at each participant’s address(es) nor the number of times people moved. Long-term residence may be associated with health outcomes as it relates to mechanisms of social integration and social ties (Keene et al., 2013; Klinenberg, 2001). Frequent moves and temporary housing may also impact mental health (Fussell and Lowe, 2014; Waters, 2016). As previous studies have shown, individuals’ subjective experiences or perceptions of the neighborhoods in which they reside play an important role in their health. We utilized an objective measure to conceptualize the latent construct of neighborhood socioeconomic status, which might differ from how individuals perceive their access or potential access or from the resources that are available to them personally. We were limited in using the 2006-2010 5-year ACS estimates (2006-2010) for constructing the census block group-level index for Waves 2-4, thus we were not able to capture any actual neighborhood changes among participants with the same residential address for those given Waves. This implies that our measure may be underestimating the impact of neighborhood socioeconomic changes on health. Additionally, there is no gold standard in neighborhood socioeconomic status, thus our exposure may not be precise. There were other factors we were interested in including in our index, but we were met with challenges in obtaining publicly available data for the years and geographic scale of interest. However, given the limitation in census data, we were able to include the majority of

variables referenced a priori. We measured our outcome of interest, mental health, using the SF-12 MCS, which is a subjective measure and may result in response bias. Furthermore, this measure does not assess for probable diagnosis of a mental health condition but instead measures specific domains of mental health and well-being. Lastly, our study findings may not be generalizable to the general population.

Nonetheless, our study is one of the first studies to examine the relationship between neighborhood socioeconomic status and mental health among natural disaster survivors over time. Our study also contributes to the limited knowledge on how these neighborhood effects impact women survivors. Methodologically, our study has several strengths. First, we were able to assess changes over time with multiple Waves of data up to 10 years following Katrina. We used several rigorous methods to operationalize our exposure and model our research questions. By utilizing a multilevel model approach, we were able to account for intra-individual differences and observe neighborhood-level effects on individual-level outcomes. Our exposure variable, neighborhood socioeconomic status, was a robust measurement scale that included 10 census block-group level variables related to neighborhood social and economic factors. Our method in using confirmatory factor analysis builds upon the existing SES and health literature to develop and refine our latent construct of interest. We also had information on each participant's pre-Katrina address, which allowed us to examine both the movement trajectories and neighborhood changes our study population experienced before, during, and after the disaster. Few studies have any pre-disaster address data, due to the unpredictability of natural disasters, which makes it challenging to examine the extent of these kinds of changes (Raker et al., 2019). We were also able to control for baseline neighborhood conditions and other economic variables including relative neighborhood income and economic deprivation, some of which had statistically significant impacts on mental health.

Conclusion

This study underscores the importance of understanding how neighborhood environments shape mental health over time among women survivors of Hurricane Katrina, a particular vulnerable population who experienced post-disaster displacement and migration. We examined the impact of neighborhood-level social and economic conditions on individual-level mental health via a constructed measure of neighborhood socioeconomic status. We found that increased neighborhood socioeconomic status was associated with increased mental health. Furthermore, women who returned to their pre-disaster communities were predicted to have better mental health compared to women who did not return. Our findings justify further research to understand the mechanisms between displacement and mental health, in addition to exploring other dimensions of neighborhood social and economic conditions which are important for women's mental health and well-being. In addition, our study also indicates the need to connect survivors to mental health services and disaster housing assistance programs both in the short- and long-term aftermath of a natural disaster.

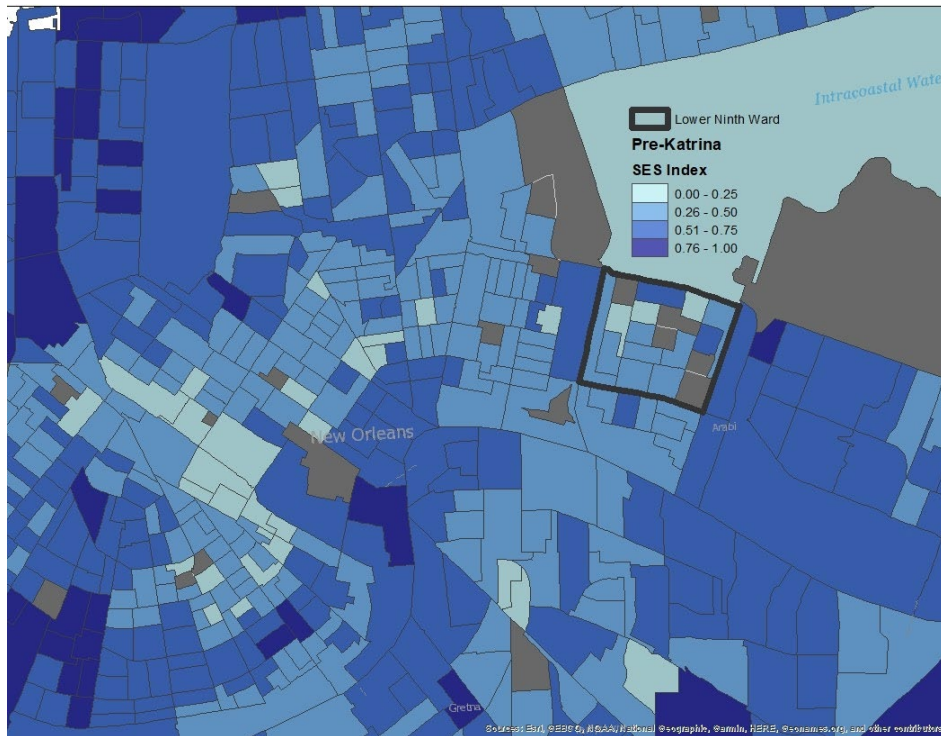
Table 1. Baseline characteristics by move status among the Gulf Child Coast and Family Health women participants

Characteristic	Total N=394	Stayed/Returned N=69 (17.5)	Moved N=325 (82.5)	<i>p</i>
Age (mean, SD)	42.7 (13.8)	48.4 (13.5)	41.5 (13.6)	<i><0.01</i>
Race				<i>0.440</i>
Black	200 (52.0)	31 (45.6)	169 (53.3)	
White	165 (42.9)	34 (50.0)	131 (41.3)	
Other	20 (5.2)	3 (4.4)	17 (5.4)	
MCS (mean, SD) ¹	39.6 (10.7)	38.7 (10.5)	39.8 (10.7)	<i>0.470</i>
PCS (mean, SD) ²	45.5 (14.5)	45.5 (15.8)	45.5 (14.2)	<i>1.000</i>
Marital Status				<i>0.053</i>
Non-Partnered	226 (62.4)	32 (51.6)	194 (64.7)	
Partnered	136 (37.6%)	30 (48.4)	106 (35.3)	
Any children in household				<i>0.457</i>
No	144 (39.3)	27 (43.6)	117 (38.5)	
Yes	222 (60.7)	35 (56.5)	187 (61.5)	
Below poverty line status (Pre-Katrina)				<i><0.01</i>
No	173 (46.0)	46 (69.7)	127 (41.0)	
Yes	203 (54.0)	20 (30.3)	183 (59.0)	
Below neighborhood MHI (Pre-Katrina)				<i>0.041</i>
No	112 (29.0)	27 (39.1)	85 (26.8)	
Yes	274 (71.0)	42 (60.9)	232 (73.2)	
NH Socioeconomic scores (Pre-Katrina)	0.54 (0.14)	0.57 (0.13)	0.53 (0.14)	<i>0.043</i>

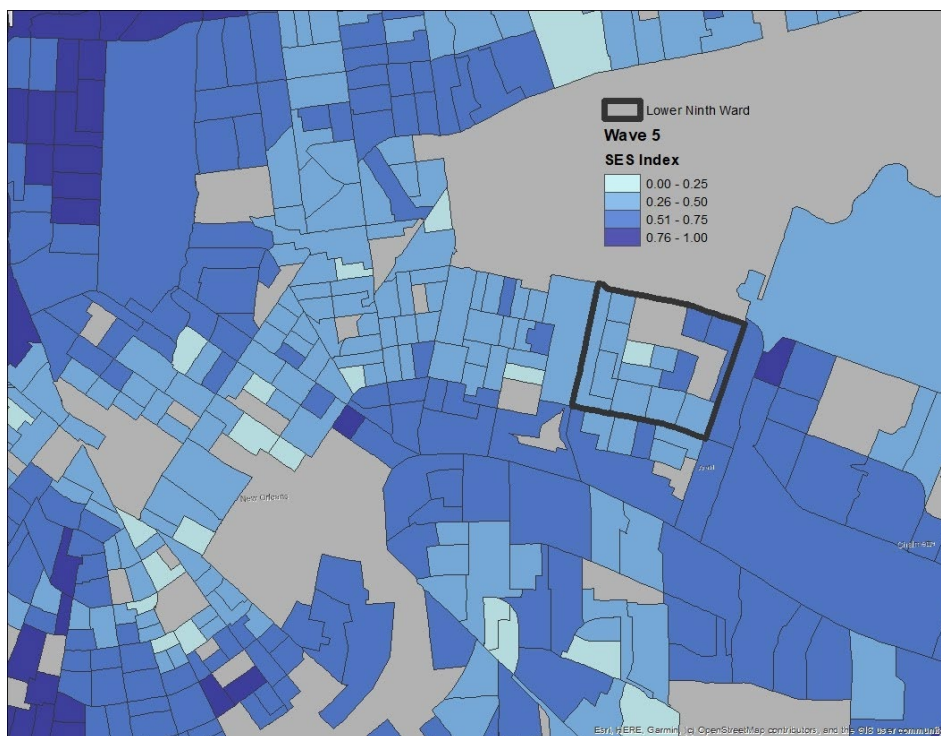
1: Mental Health Component Summary Score

2: Physical Health Component Summary Score

Figure 1: Thematic visualization of neighborhood socioeconomic opportunity in New Orleans at (A) Pre-Katrina and at (B) Wave 5



A: Pre-Katrina



B: At Wave 5

Table 2. Results of null (no predictors included) and unconditional growth models (only time variable included) describing the changes in mental health scores across the Gulf Child Coast and Family Health women participants

	Null	Unconditional Growth
Fixed effect estimates		
MCS ¹	44.5 (43.5, 45.5) *	42.0 (40.9, 43.2) *
Months		0.04 (0.03, 0.05) *
Variance components		
Census block groups	14.1 (7.1, 23.8)	6.4 (0.8, 15.0)
Between individual	50.7 (40.5, 62.6)	52.2 (41.9, 64.1)
Within individual	97.7 (89.9, 106.4)	97.7 (89.8, 106.4)
Intraclass correlation coefficient		
Neighborhood	0.087	0.041
Individuals within neighborhood	0.312	0.334
Model Fit		
AIC	13431.7	13365.3

1: Mental Health Component Summary Score

* Indicates p-value <0.05

Table 3. Nested models describing the associations between neighborhood socioeconomic opportunity and MCS¹ scores after Hurricane Katrina among the Gulf Child Coast and Family Health women participants

Fixed effect estimates		Intermediate Model	Final Model
Intercept		53.0 (46.4, 59.5) *	45.5 (35.7, 55.0) *
NH SES score		6.5 (0.05, 13.0)	19.6 (5.8, 33.7) *
Move status			
Stayed or returned		Reference	Reference
Moved		-1.7 (-4.1, 0.8)	7.3 (-1.4, 16.1)
NH SES score*Move status		-	-15.4 (-30.2, -1.1) *
Age		-0.05 (-0.1, 0.02)	-0.05 (-0.1, 0.02)
Race			
Black		Reference	Reference
White		-2.0 (-4.2, 0.1)	-2.0 (-4.1, 0.2)
Other		-1.2 (-5.1, 2.8)	-1.2 (-5.1, 2.8)
Children in household			
No		Reference	Reference
Yes		-2.0 (-4.1, 0.05)	-2.0 (-0.2, -0.1)
PCS ²		-0.2 (-0.2, -0.1) *	-0.2 (-0.2, -0.1) *
Pre-Katrina NH SES score		2.2 (-5.7, 10.0)	2.0 (-5.8, 9.8)
Poverty line at baseline		0.4 (-1.9, 2.7)	0.4 (-1.8, 2.7)
Poverty line		-1.5 (-3.1, 0.08)	-1.4 (-3.0, 0.2)
Below NH MHI at baseline		-2.0 (-4.5, 0.5)	-2.0 (-4.5, 0.4)
Below NH MHI		-1.7 (-3.4, -0.1) *	-1.8 (-3.5, -0.2) *
Months		0.03 (0.01, 0.04) *	0.03 (0.01, 0.04) *
Variance components			
Census block groups		9.6 (1.5, 20.2)	8.9 (1.2 19.0)
Between individual		54.3 (41.6, 65.9)	53.0 (40.4, 64.4)
Within individual		90.7 (82.1, 99.9)	91.3 (82.6, 100.5)
ICC³			
Neighborhood		0.062	0.058
Individuals within neighborhood		0.351	0.346
Model Fit			
AIC		11237.4	11229.3

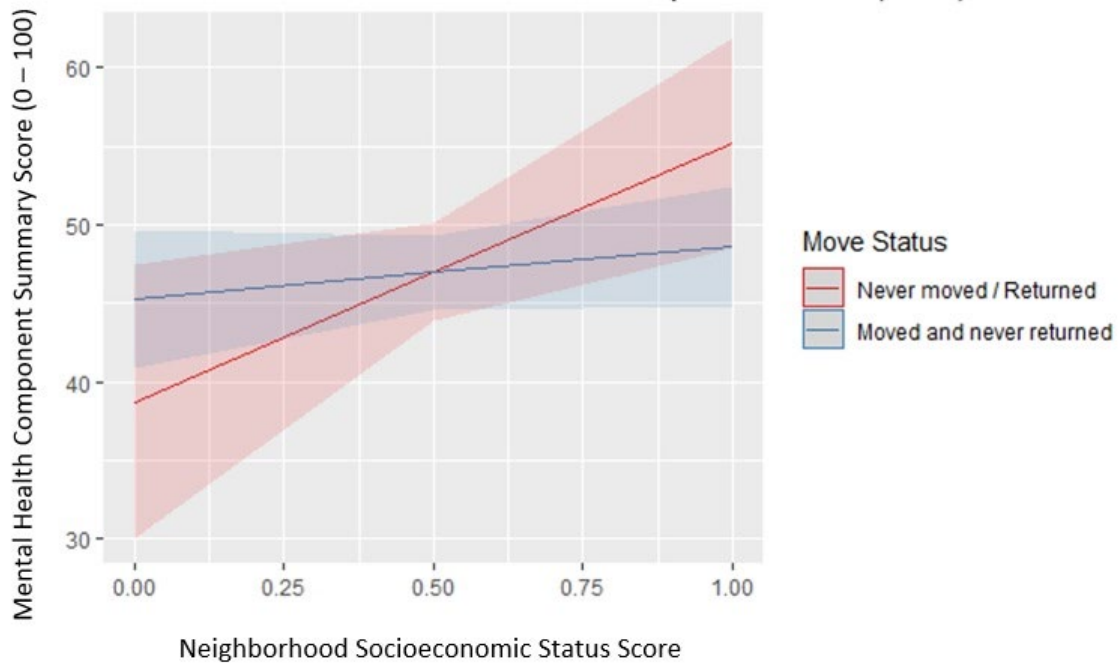
1: Mental Health Component Summary Score

2: Physical Health Component Summary Score

3: Intraclass correlation coefficient

* Indicates p-value <0.05

Figure 2: The effects of neighborhood socioeconomic status score on predicted values of mental health scores by move status among the Gulf Child Coast and Family Health women participants



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Chapter 5: Conclusions

Disasters are, most basically, terrible, tragic, grievous, and no matter what positive side effects and possibilities they produce, they are not to be desired. But by the same measure, those side effects should not be ignored because they arise amid devastation...The positive emotions that arise in those unpromising circumstances demonstrate that social ties and meaningful work are deeply desired, readily improvised, and intensely rewarding. The very structure of our economy and society prevents these goals from being achieved. The factors determining whether you will live or die are the health of your immediate community and the justness of your society.

– Rebecca Solnit (2009)

Summary

The severity and unpredictability of large-scale catastrophes such as natural disasters present opportunities for researchers to understand the short- and long-term impacts among survivors. This work is important for policymakers, both at the local and federal level, to adequately prepare and respond to communities exposed to disasters, particularly ones that are most vulnerable to economic loss, social disruption, and infrastructural damage.

This dissertation is an effort to better understand the long-term mental health outcomes of natural disasters, integrating the phenomena of psychological resilience and complexity of place and health in the context of post-disaster displacement. The increasing interest in understanding resilience due to the increasing frequency of community disasters has resulted in a conceptualization shift in acknowledging the heterogeneity of psychological responses over time. Resilience is now considered a latent process, in that it is not directly observable. However, this conceptualization limits the scope of methodology in how resilience can be examined. A review of the literature to date revealed that most studies are using appropriate group-based methods, but there are still inconsistent/unexplained model specifications and assumptions, ambiguous characterization of trajectories, and misalignment of conceptualization and operationalization of resilience. Findings from the first paper will inform the methods and frameworks in approaching how to conceptualize and measure resilience in the context of natural disasters with potential policy implications related to resource mobilization and response efforts both in the immediate and long-term aftermath of a disaster.

The findings from my first paper further emphasizes that one of the limitations in examining resilience is due to lack of data with sufficient time points and that most studies used measures related to post-traumatic stress disorder. My second paper addressed this barrier by examining whether psychological resilience emerged among a cohort of Hurricane Katrina survivors observed across 10 years. The measure used in this study represented different dimensions of mental health domains and well-being, rather than focused on mental health outcomes. In this study, we observed a trajectory which closely resembled our conceptualization of resilience. We also applied a data-driven method, acknowledging the assumptions and incorporating

recommendations from the recent literature, to identify the trajectories of mental health outcomes as accurately as possible. The study's findings were that employment changes, having received financial resources in the immediate aftermath of Katrina, and frequency of moves were important factors for mental health outcomes. Our findings also emphasize the need for pre-disaster data and for future studies to examine the impacts of community-level resources impact mental health trajectory membership.

Finally, our third paper contributed to the limited literature on neighborhood socioeconomic conditions and mental health among women survivors of Hurricane Katrina. While the place and health literature is vast, there has been little focus on displaced communities. Disaster-exposed and displaced women, in particular, are an important vulnerable population because women are at higher risk of mental health in general and are disproportionately impacted by disasters. The existing literature also indicates that women perceive their neighborhoods and communities differently than men. We examined the association between neighborhood socioeconomic status and mental health among women using a multi-level framework. In this study, we used a constructed measure of neighborhood socioeconomic status to represent access to social and economic resources. We found that, overall, there was a positive association. Increased neighborhood socioeconomic status was associated with increased mental health, but this association was modified by residential mobility. The positive impact of neighborhood social and economic conditions for women's mental health was stronger for women who were able to return to their pre-disaster communities compared to women who relocated away from their pre-disaster communities. While we still need to learn more about the lived experiences of disaster survivors, findings from this study indicate the need for increased access to affordable and stable housing and social support systems.

Future Directions

Most of the existing disaster research to date has focused on the short-term health outcomes of survivors. Vulnerable populations within an already vulnerable population, such as women, children, those with disabilities, and the elderly, remain underexplored. This dissertation work underscores the importance to continue identifying the mechanisms related to long-term and heterogeneous mental health outcomes among disaster survivors.

In the resilience literature, the attention has shifted to examining how resilience is shaped by the communities where people reside and interact with others. Masten describes this as part of the multilevel dynamics of resilience, the most recent and fourth wave of resilience research (Masten, 2007). The relationship between community-level factors and post-disaster psychological resilience remains understudied. Studies to date have used inconsistent measures of community-level variables as proxies for economic and social capital, thus limiting the opportunities for broader interpretation of the results (Frankenberg et al., 2012; Ursano et al., 2014; Wind & Komproe, 2012)

In a more systematic approach, there have been several proposed frameworks in disentangling the myriad of conceptualizations of resilience (Ledesma, 2014). A translational framework was

developed which encompassed multidisciplinary perspectives on the concept of resilience, specifically for research and practice in post-disaster settings (Abramson et al., 2015). In this hypothesis-driven framework, resilience is defined as a process, the ability to withstand, adapt, or recover quickly from a disaster, which relies upon the access to resources at the community- and individual-level. These resources are categorized as four types of “capital”, which are as 1) human (e.g., access to medical care, self-efficacy), 2) economic (e.g., median household income, savings), 3) social (e.g., social networks, perceived social support), or 4) political capital (e.g., capable governance, ability to vote). These resources differ between the community and individual level in terms of existence, accessibility, and capability to maintain, re-establish, acquire, or exchange these critical resources. In other words, access to social resources can “activate resilience attributes that are present in individuals and communities” (Abramson et al., 2015; Hobfoll & Ford, 2007). To date, this framework has yet to be tested. While it encapsulates cross-disciplinary perspectives and a contemporary conceptualization of resilience, there are possible challenges in understanding and applying this framework. Future studies will need to thoughtfully consider how to align their conceptualizations and measurements of capital both at the individual- and community-level.

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