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**Influence of Natural Disasters on the Long-term Incidence of Depressive Symptoms, Cognitive Impairment, and Limitations in Activities of Daily Living Among Older Mexican Americans**

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**Influence of Natural Disasters on the**
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**Among Older Mexican Americans**

**By**

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## Dedication

To my husband, Patrick Louchouarn, who has been beside me from the beginning of this endeavor, cooking gourmet meals and encouraging me with laughter and love. To my family, and especially my parents, Thalia (1953-2014) and Ian Hufton, for instilling in me the love of learning and supporting me in all of my adventures. To my friends who celebrated each milestone along the way and always expressed belief that I would achieve my goal. To the One through which we live and move and exist, thank You.

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The University of Texas Medical Branch, 2023

Supervisor: John Prochaska

## ABSTRACT

**Objectives.** To estimate the risk factors, including exposure to natural disasters, associated with incident depressive symptoms, cognitive impairment, and limitations in activities of daily living among older Mexican Americans.

**Methods.** I performed multivariable logistic regression of the H-EPESE from Wave 5 (2004-2005) to Wave 7 (2010-2011) to examine the incidence of three health outcomes. The analyses were restricted to participants that did not have indicators of 1) depressive symptoms (n=725), 2) cognitive impairment (n=774) and 3) limitations in activities of daily living (n=715) at Wave 5; natural disaster exposure was defined as residing in a county that received public assistance funds from the Federal Emergency Management Agency in 2006-2008.

**Results.** Natural disaster exposure was not a significant risk factor in either of the three incident health outcomes. Self-report of heart attack increased the odds of all three health outcomes. Older age was associated with cognitive impairment and limitations in activities of daily living. Financial strain increased the odds of depressive symptoms and cognitive impairment.

**Conclusions.** Natural disaster exposure is not associated with the incidence of depressive symptoms, cognitive impairment or limitations in activities of daily living between Waves 5 and 7. Understanding risk factors, including the role of natural disaster exposure, associated with the long-term health of aging Hispanic populations is essential, especially considering the increasing representation of this minority group in the US population.

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# List of Abbreviations

| | |
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| ADL | Activities of Daily Living |
| CES-D | Center for Epidemiologic Studies Depression Scale |
| FEMA | Federal Emergency Management Agency |
| H-EPESE | Hispanic Established Population for the Epidemiological Study of the Elderly |
| MMSE | Mini Mental State Examination |
| UTMB | University of Texas Medical Branch |

# Chapter 1. BACKGROUND AND LITERATURE REVIEW

## INTRODUCTION

Climate change has been identified as "the defining issue" for public health in the 21st century by the World Health Organization (Sheehan et al., 2017). While "mega-scale" catastrophes such as floods, tsunamis, earthquakes and volcanic eruptions have occurred through geologic time, there is concern that the global interconnectedness of human societies and the potential anthropogenic aspects of climate change increase the risk of disruptive events and the impacts they have on the health of human populations (Kieffer et al., 2009; Knutson et al., 2020; Leaning & Guha-Sapir, 2013). There is growing consensus that both severity of disasters and human exposure to the impacts of natural disasters are increasing, which is expected to result in negative health outcomes for a substantial portion of the worldwide population (Field et al., 2012; Watts et al., 2019).

Natural disaster events can negatively impact human health and exacerbate existing health inequalities that socioeconomically marginalized populations experience (Shultz et al., 2019). Extreme weather events associated with climate change, which are expected to increase in the future based on the current trajectory of global temperature increase, are estimated to disproportionately impact vulnerable populations globally (Masson-Delmotte et al., 2018; Watts et al., 2019). Identifying populations that are particularly vulnerable to adverse health outcomes resulting from natural disasters continues to be an important focus. Vulnerable populations are groups that experience hardships due to factors like their socio-economic status, race, ethnicity, gender, age, and physical or cognitive abilities (Benevolenza & DeRigne, 2018).

Losses caused by natural disasters have been recorded for over 40 years, documenting over 36,000 single events worldwide, indicating that the rise is predominantly attributable to weather-related events like storms and floods (Hoeppe, 2016). In the United States specifically,

approximately 500 county-level disaster events affected the U.S. each year throughout the 20th century; however, there has been a distinct increase in the number of declared disasters since the 1990's, and average annual declarations now routinely reach roughly 1,500 annual county-level disaster events (Boustan et al., 2020).

The United Nations International Strategy for Disaster Reduction considers disasters as "a serious disruption of the functioning of a community or society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources," a definition that is well-accepted internationally (Yew et al., 2019). In the United States, the Federal Emergency Management Agency (FEMA) statutorily defines disaster as: "Any natural catastrophe (including any hurricane, tornado, storm, high water, wind-driven water, tidal wave, tsunami, earthquake, volcanic eruption, landslide, mudslide, snowstorm, or drought) or, regardless of cause, any fire, flood, or explosion, in any part of the United States, which, in the determination of the President, causes damage of sufficient severity and magnitude to warrant major disaster assistance under the Stafford Act to supplement the efforts and available resources of States, local governments, and disaster relief organizations in alleviating the damage, loss, hardship, or suffering caused thereby."

The three types of Disaster Declarations that FEMA has utilized since 1953 are "major disaster", "emergency," and "fire management assistance," (Federal Emergency Management Agency, 1990). For the purposes of this dissertation, a natural disaster is considered as any natural event (hurricane, tornado, storm, high water, wind-driven water, tidal wave, tsunami, earthquake, volcanic eruption, landslide, mudslide, snowstorm, or drought) for which the President declared a "major disaster".

It is well-understood that natural disasters cause immediate, direct injuries and mortality, but these events also contribute to long-term impacts on health due to the destruction and interruption of infrastructure, living conditions, and livelihoods (Watts et al., 2018). One of the underlying assumptions in disaster and health research is that natural disasters and extreme weather events

cause a heightened level of stress related to the effects and losses of the event. Like other major life stressors and traumas, natural disasters and the resulting interruptions to community norms and individual lives disrupt physiologic equilibrium and overwhelm nonspecific physiological responses that enable the body to cope with the demand (Phifer et al., 1988). Stress associated with disasters has been demonstrated to affect or intensify both adverse mental and physical health outcomes, including anxiety, depression, PTSD, cardiovascular disease, headaches, and respiratory problems (Sandifer & Walker, 2018). The conceptual framework guiding the following analyses and hypotheses being addressed in this dissertation is that climate change is associated with increasing natural disaster events, which negatively impacts and stresses vulnerable populations (both individually and the population as a whole), leading to long-term adverse health outcomes (Fig 1).

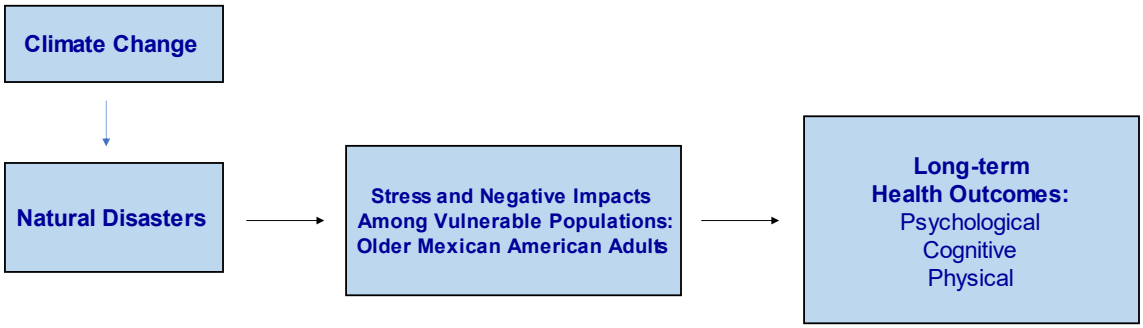


**Figure 1. Conceptual Framework: Natural disasters are associated with stress that leads to adverse health outcomes.**

As climate change is increasingly considered a serious global problem, there is growing demand for detailed information about the impacts of natural disasters on human health, especially among vulnerable communities (Limaye, 2021) so that the disaster management cycle of mitigation, preparedness, response and recovery can be improved. Research is needed to estimate the magnitude and likelihood of climate-related health consequences both in the immediate aftermath of a disaster, as well as longer-term impacts, which would improve the understanding of vulnerability to these increasing events within specific populations and inform strategies to decrease disaster-associated health risks (McMichael et al., 2006).

## BACKGROUND ON NATURAL DISASTERS AND OLDER ADULTS

The heightened vulnerability of older adults has been the subject of several studies on the relationship between natural disasters and health, but the findings are inconsistent and thus far provide evidence for two competing theoretical frameworks: maturation theory and exposure theory. In the natural disaster context, the maturation theory proposes that older adults, compared to younger individuals, are better protected against stressors and are therefore less vulnerable due to more mature coping skills (Knight et al., 2000). Maturation theory is supported by research that indicates that the psychological health of older adults, in comparison to the general adult population, is either less negatively or similarly impacted by disaster events. Several investigations have indicated that older adults may be more resilient to the psychological consequences/manifestations of disasters, likely due to more life experience and exposure to disaster events (Cherniack, 2008). As an example, among survivors of an earthquake in Iran, older adults aged 60 and older scored higher on emotional, social and psychological well-being in comparison to those aged 18-30 after controlling for marital status, sex and employment status (Rafiey et al., 2016). Further, the prevalence of major depression and PTSD of Japanese older adults >=65 affected by 2 earthquakes within the previous three years was found to be comparable to that observed among older adults in non-disaster settings (Suzuki et al., 2011). Older adults

affected by Hurricane Alicia indicate that the impact on depressive symptoms and self-rated health is diminished about 16 months after the event (Krause, 1987). Additionally, a study of the physical health of older adults suggests that they may be quite resilient and that any measured disaster-related health declines in mobility persist only briefly after the disaster, while no differences were found in mortality, self-rated health or self-reported disability four years after the event (Deeg et al., 2005). These findings support the maturation theory and indicate that older adults may be able to respond to a disaster event with maturity and coping skills gained from previous experience or trauma throughout the life course.

A competing theory is the exposure theory, which argues that older adults are less able to recover from a major event due to fewer resources and lower functional capacity (Rafiey et al., 2016). A serious issue identified after Hurricane Katrina was the "the inability of the displaced population to manage their chronic diseases" (Greenough & Kirsch, 2005), an impact which may not be detectable until more than a year post-event. A few studies have investigated the long-term health outcomes in elderly populations with specific diagnoses, such as cancer (Peña-Vargas et al., 2022; Prohaska & Peters, 2019) or diabetes (Quast et al., 2019), and these have indicated that interruptions to chronic disease management in the aftermath of a disaster can have negative long-lasting impacts. This evidence supports the exposure theory that older adults are more susceptible to harmful health outcomes due to limited resources, a higher prevalence of chronic conditions, or a lack of sufficient physical or social coping mechanisms.

Another perspective to consider is that while older adults may be more vulnerable to disaster-related losses, it is not age alone that is the main risk factor, but the intersection of age with other factors such as socioeconomic disadvantage, social isolation, or cognitive and physical frailty (Kawachi et al., 2020). It has been suggested that older adults are especially vulnerable to the impacts of disaster exposure due to a wide range of social and physiological factors, including a higher prevalence of chronic conditions, increased sensitivity to extreme heat, increased social isolation and their lower financial status (Gamble et al., 2013). Poverty and limited resources are

considered a primary contributor to social vulnerability (Cutter et al., 2003), and older adults may additionally lack the financial resources to respond to disaster events (Browning et al., 2006).

Substantial evidence supports that populations over the age of 65 are particularly vulnerable to health effects of climate change and are becoming increasingly so (Watts et al., 2019). Studies of older adult disaster victims indicate that they have an increased risk of negative health outcomes specifically due to distress during disasters, low social support, economic dependency, multiple disaster exposures over the life course, and chronic health conditions (Fatema et al., 2021). Older adults may additionally be more vulnerable to disaster events due to decreased mobility associated with age or restricted access to economic resources, which impacts their capacity to adapt to disaster-related threats or damage (Filiberto et al., 2009). Healthcare utilization in post-disaster settings makes up a substantial portion of the evidence related to our understanding of the influence of natural disasters on general long-term health needs among older adults. Health outcomes related to psychological conditions, cognitive impairment, and physical limitations, which are the focus of this dissertation, have also all been associated with the health sequelae among older adults exposed to a natural disaster. To describe the increased risk of health complications and to the establish the reasoning for choosing depressive symptoms, cognitive impairment, and limitations of activities of daily living for this dissertation, healthcare utilization and these three specific health outcomes in post-natural disaster settings are now discussed in depth.

### *Healthcare Utilization*

Natural disasters and the resulting stress or trauma have been found to increase health care utilization among older adult populations, which may serve as a proxy for exacerbated health problems. As an example, all-cause hospital admissions increased by 4% for older adults in the 30 days after severe tornado activity, compared to the other 11 months of the year in the Southeastern US (Bell et al., 2018). Additionally, in comparison to the same week the year prior, emergency department (ED) utilization among Medicare beneficiaries affected by Superstorm Sandy in 2012

increased by 35.5% in the most affected coastal regions, in comparison to a 14.3% increase statewide (Stryckman et al., 2017). Following Hurricane Sandy's landfall in New York City, older adult utilization of the ED was found to have increased, specifically for dialysis, electrolyte disorders, and prescription refills (Malik et al.). Further, In the first week after a major hurricane, diabetic older adults had a higher risk of acute post-disaster medical needs and emergency department services (Lee, Gupta, et al., 2016).

However, other studies investigating health care utilization or costs among the elderly after natural disaster exposure have shown mixed findings, indicating that managing health may be impeded or complicated in post-disaster settings. For example, among Medicare patients living in U.S. Gulf Coast states, individuals residing in counties with higher natural disaster severity had decreased expenditures, possibly reflecting a delay of services or limited access to health care after severe disasters (Horney et al., 2019). Additionally, Medicare patients residing in counties within the U.S. that had higher natural disaster exposure had higher costs and utilization of Medicare service, but utilization of home health services was lower, suggesting a substitution of services in the post-disaster period (Rosenheim et al., 2018). Similarly, among 303 Medicare Advantage recipients affected by Hurricane Katrina, ED visits and hospitalization rates increased 100% and 66% in the first month, respectively, and still remained 21-23% higher 11 months after the hurricane, while physician office visits decreased during this time and then stabilized to pre-hurricane levels (Burton et al., 2009). Overall, these findings suggest that older adults utilize more emergency medical resources post-disaster, which is likely an indicator for heightened risk for developing new, or experiencing complications of existing, chronic conditions and experiencing worse health outcomes in comparison to younger adults.

***Psychological Health***

Research indicates that natural disasters affect short-term mental health outcomes such as psychiatric disorders and symptoms of posttraumatic stress disorder (PTSD), anxiety and depression among the general population (Neria & Shultz, 2012; Shultz & Galea, 2017; Shultz et al., 2018). Psychological health among older adults is also found to be negatively impacted by natural disaster events, particularly when measured as post-traumatic stress disorder (PTSD). A meta-analysis synthesizing the evidence on disaster-related mental health and distress experienced by older adults also found that this population was more 2.11 times more likely to report PTSD symptoms (Parker et al., 2016). In a comparison between older and younger adults exposed to an earthquake in Australia, older subjects reported higher levels of post-traumatic stress symptoms in the two years following the event, and it was suggested that despite having fewer disaster-related experiences related to that event, older adults may be at more risk for higher stress reactions (Ticehurst et al., 1996). Additionally, one to two years after a flooding event, both adults aged 18-59 years and older adults aged 60 or older had higher odds of PTSD than participants aged 8-17 years (Liu et al., 2006), indicating that increased age may be a risk factor for psychological complications post-disaster. Among adult survivors of the 2008 Sichuan earthquake and in comparison to younger adults, older adults aged >= 60 were more likely to report symptoms of PTSD and general psychiatric morbidity (Jia et al., 2010). Another example is that within the first two months after the 2009 earthquake in L'Aquila the use of antipsychotic drugs and antidepressant agents was found to increase, particularly among women over the age of 75 (Trifiro et al., 2013).

### *Cognitive Impairment*

The role of experiencing natural disasters on cognitive impairment is not well established. Very few studies on cognitive outcomes post-disaster have been conducted among older populations specifically, however, evidence exists that suggests natural disasters impact the cognitive performance of adults in general. For example, 20 days after the Christchurch earthquake event,

young adults aged 21-35 that reported greater cognitive disruption related to the earthquake had worse performance on the Sustained Attention to Response Task (Helton et al., 2011). A study of immediate (4-5 months post-event) storm effects on the cognitive health of adults impacted by Hurricanes Katrina and Rita found decrements in cognitive functioning among middle-aged and older adults, but not among those ≥90 years (Cherry et al., 2010), indicating that disaster-related impacts on cognitive health may be complex. Additionally, older adults exposed to the 2011 Great East Japan Earthquake and Tsunami were found to have higher risks for cognitive decline if they reported major housing damage or the destruction of their home, even six years after the disaster (Hikichi et al., 2016).

***Physical Health***

Several studies have provided evidence that the physical health of adults aged 65 and older are particularly vulnerable to the effects of natural disasters and extreme weather events. Older adults are frequently considered to be among the most vulnerable groups to mortality related to natural disasters (Pekovic et al., 2007), particularly hurricanes, floods, earthquakes and extreme heat events. For example, almost 60% of the flooding-related fatalities following Hurricane Katrina were among persons ≥ 65 years of age (Jonkman et al., 2009), and the elderly population suffered a disproportionately high number of fatalities during the 2007 major earthquake in Japan (Suzuki et al., 2011). Additionally, extreme heat attributed to climate change has been found to increase morbidity and mortality, with older adults considered particularly vulnerable (Watts et al., 2019; Watts et al., 2018). Those aged 85+ experienced the highest crude death rate from both extreme cold and excessive heat events in the United States between 1979 and 2004 (Thacker et al., 2008). A summary of over 50 studies on climate change and six human health-related concerns (heat-related stress problems, respiratory problems, infectious disease, waterborne diseases, food insecurity and mental health) found that the most pronounced increases in morbidity and mortality

is projected to occur among vulnerable populations such as the elderly, young, medically frail, and those living in poverty (Patz et al., 2014).

A review of 45 journal articles related to the impact of natural disasters on older persons concluded that many, but not all, studies have indicated that older adults are more likely to experience adverse physical consequences (Cherniack, 2008). Older adults reporting high levels of disaster-related peritraumatic stress had twice the risk of experiencing a new diagnosis lung disease, arthritis and diabetes four years after Hurricane Sandy (Sands et al., 2022). Six years after Hurricane Sandy, older adults who experienced more peri-traumatic stress related to the disaster reported more functional limitations over time (Pruchno et al., 2020). Natural disasters also have been found to cause substantial damage to infrastructure and interruption to the provision of oncology care among cancer patients, many of which are older adults, but understanding survival outcomes among this group is limited by inadequate follow-up times post-disaster in the current literature (Man et al., 2018).

There is a gap in the research that prevents the complete understanding and characterizing of groups that are vulnerable to adverse health effects related to climate change and natural disasters (McMichael et al., 2006). While there is a growing body of literature that supports that older adults over the age of 65 are distinctively vulnerable to immediate health impacts and loss from natural disasters, there remains a gap in understanding the long-term health outcomes in this population, and whether these are age-related or event-related. Natural disasters are often viewed as social levelers because they occur somewhat randomly and can affect populations, like older adults, with a wide range of socioeconomic or social resources, however, recovery from these events is often inequitable and is more challenging for those with fewer economic resources or increased social isolation (Fothergill & Peek, 2004). Additionally, disasters often reveal, if not exacerbate, underlying conditions that already exist within a community, and social vulnerability to the impacts of a disaster reveal pre-existing differences in resource access (Kawachi et al.,

2020). Together, this suggests the need for further understanding of the post-disaster health outcomes of this vulnerable population of older adults.

## CHALLENGES WITHIN NATURAL DISASTER RESEARCH

One substantial limitation within natural disaster and health research is that due to the somewhat random temporal and geospatial distribution of disasters, longitudinal data collection is rare and most disaster research is cross-sectional. While expected in many disaster settings, the lack of pre-disaster data makes it difficult to discern the causality of post-disaster increases in incidence of new and severity of existing health problems within a population. Long-term data collection combined with pre-disaster baseline health information is better suited for determining whether survivors' health issues are exacerbated by the disaster, and if so, whether these issues return to baseline or continue to deteriorate past the acute post-disaster period.

There are a few noteworthy studies that were able to avoid this common problem due to the commencement of data collection prior to a natural disaster event, providing the opportunity to conduct a natural experiment. The effects of Hurricane Katrina has been studied longitudinally through a study of low-income parents in Louisiana had two waves of pre-disaster data and at least two waves post-disaster (Lowe et al., 2014). Examples of studies that had at least one wave of pre-disaster observations related specifically to the health of older adults include The Longitudinal Aging Study Amsterdam (Deeg et al., 2005), the Japan Gerontological Evaluation Study (Sasaki et al., 2020), a state-wide study of stress, resources and health in older adults in Kentucky (Phifer et al., 1988), and the Ongoing Research on Aging in New Jersey (ORANJ)—Bettering Opportunities for Wellness in Life study (Heid et al., 2016). The above longitudinal datasets facilitated the examination of health outcomes among older adults exposed to an explosion, an earthquake and resulting tsunami, flooding, and Hurricane Sandy, respectively.

Additionally, there is substantial variability in the timing of post-disaster data collection, and most of the relevant research is focused on short-term health outcomes evaluated within two

years of a natural disaster event. There is not currently a recognized classification of post-event time intervals to differentiate acute short-term versus chronic long-term health outcomes related to disaster. While some authors tried to establish categories at 6-months, two years, and beyond two years post-event as short-term, medium-term, and long-term (Carr et al., 1997), this temporal follow-up system is rarely replicated in the literature. In fact, very few studies investigating the health impacts of natural disasters have defined what the authors consider to be "short-term" or "long-term" health outcomes, and the specific time post-event has generally been referred to within each study based on the availability of data collection. An exception to this is a study examining the impact of flood exposure on physical health in a sample of 200 older adults, where the authors state "We define the 'short-term effects' as those occurring one year or less after an incident," and they termed any outcomes occurring after one year as "longer-term." (Phifer et al., 1988). While this may reflect the heterogeneity and challenges of data-collection after a natural disaster, this practice limits the generalizability of most studies. Additionally, understanding the role of stress as a major impact on health can be hindered by not fully understanding the temporal dimensions within the stress process, specifically the time between a stressful event like a natural disaster, symptom appearance, and symptom dissipation (Krause, 1987). Examples of time-varying health outcomes among older adults exposed to natural disasters is discussed below.

Investigations examining mid-term (.5-2 years post-event) and long-term (≥2 years post-event) health outcomes are limited in number, but a few studies suggest that major disasters can have long-lasting impacts on the health of older adults. As an example, fifteen months after Hurricane Katrina, in a survey of adults residing in New Orleans, approximately 50% of respondents reported poor mental and physical health (Kim et al., 2008). Even three years post-disaster, the increase in disability prevalence among older adults aged ≥65 was determined to be significantly higher among those residing in earthquake and tsunami disaster-stricken areas in comparison to non-disaster municipalities (Tomata et al., 2015). A qualitative study of older adults residing in a region affected by a Chilean earthquake and ensuing tsunami in 2010 reported that their physical health

problems had increased considerably in the 4 years following the event (Labra et al., 2018). There are also a few investigations that have explored the long-term health impacts on specific populations like diabetics (Fonseca et al., 2009) and cancer patients (Bell et al., 2020) that indicate that older adults in these populations continue to face difficulty managing their pre-existing health conditions. A study with one of the longest follow-up periods within the literature found that higher peritraumatic stress related to Hurricane Sandy was associated with increased functional limitations as late as six years after the natural disaster (Pruchno et al., 2020).

The impacts of natural disasters may be either short-term or long-term, and acute events may lead to similar outcomes as traumatic stress, whereas the result of prolonged or extreme disaster events can be delayed (Cianconi et al., 2020). Collecting and measuring these outcomes during natural disasters and the resulting recovery process continues to be a substantial challenge due to the disruption of normal health system and societal processes (Bell et al., 2018). Although a stronger understanding in the short-term is developing, the long-term mental and physical health outcomes due to impacts of natural disasters are not fully understood.

### *Natural Disaster Exposure Operationalization*

The third and final challenge discussed in this dissertation regarding research related to disasters and health is the lack of uniformity in how natural disaster exposure is operationalized. Disaster research is complex due to the resulting chaos and disruption, and several authors have noted the heterogeneity in both natural disaster events as well as natural disaster research (Cherniack, 2008). Most investigations examine either a single disaster event, or type of event, or a specific population, which limits the generalizability to other populations affected by natural disaster settings. In the United States, a major focus in the literature has been the health impacts of specific hurricanes, particularly Katrina (Brunkard et al., 2008; Fonseca et al., 2009; Galea et al., 2007; Kessler, 2007), Sandy ((He et al., 2016; Lee, Smith, et al., 2016; Schmeltz et al., 2013), and Harvey (Sansom et al., 2020; Shultz & Galea, 2017), but even those events involve a degree

of heterogeneity in terms of magnitudes of environmental effects and populations impacted. Other studies have focused on specific earthquakes (Giorgini et al., 2013), floods (Du et al., 2012; Milojevic et al., 2017; Phillippi et al., 2019; Sahni et al., 2016). and heatwaves (Knowlton et al., 2009). Another methodological approach has been to focus only on populations with a specific comorbidity, like diabetic patients (Allweiss, 2019; Cefalu et al., 2006; Fonseca et al., 2009; Lee, Gupta, et al., 2016; Quast et al., 2019; Quast & Feng, 2019), or cancer patients (Man et al., 2018; Prohaska & Peters, 2019; Rodriguez-Rabassa et al., 2020).

The vast majority of these studies consider a participant to be exposed if they resided in a location affected by the single natural disaster event of interest. One key limitation of these measurements is that they are unable to account for the effect of multiple disaster events, as this information is not captured using this binary method of operationalization. This method also precludes investigating how the severity or frequency of natural disasters impact health, as these measures only capture, in a limited way, the presence or intensity of a discrete natural disaster event.

Because there is not an established method to determine natural disaster exposure, attempts to measure or operationalize disaster exposure severity are extremely varied in the literature. Combinations of both quantitative and qualitative data may be the most informative methodological approach, when available, and several researchers have employed this technique, especially in longitudinal studies. Despite the lack of uniformity in measuring exposure, several studies that utilized more than one measurement of disaster exposure support that how disaster exposure is operationalized does matter. For example, feelings of depression among adults after a technological disaster were examined using a combination of pre- and post-event medical records, survey questions of stressful experiences related to the disaster, and an indicator of forced relocation related to the disaster (Dirkzwager et al., 2006). In that study, those that experienced a higher degree of exposure, measured by the sum of stressful experiences during the disaster, were more likely to experience increased odds of feelings of depression, at both 3 weeks and 18 months

post-event, but forced relocation was only significantly associated with depression at 3 weeks, and not in the long-term. Disaster-related peritraumatic stress, but not geographic proximity to the event, was associated with long-term health outcomes among those affected by Hurricane Sandy (Sands et al., 2022). In one of the largest epidemiologic studies of PTSD among flood victims (n=33,340), both flood type (soaked flood, collapsed embankment, and flash flood) and flood severity, categorized by area affected were associated with increased odds of PTSD occurrence (Liu et al., 2006). Additionally, the influence of different aspects of natural disaster exposure was demonstrated in older adults impacted by flooding disasters, where both personal loss perceptions and community destruction designation by a state agency predicted short-term health effects (Phifer et al., 1988).

Sometimes investigators construct an index of traumas associated with a specific disaster event with the intent of capturing individual-level heterogeneity in disaster exposure. As an example, the sum of self-reported affirmative responses to ten traumas (neighborhood flooded, relative or friend died, lacked sufficient food, lacked sufficient water, could not access medications, could not access medical care, believed life was in danger, did not know whether child was safe, did not know whether another relative was safe, and had a relative who could not access medical care) was created to examine health outcomes related to Hurricane Katrina (Zacher et al., 2021). Among survivors of the 2004 Indian Ocean tsunami, disaster-exposure questions related to the following events were included in interviews: a) the death of spouse; b) death of a parent, sibling or child; c) direct exposure like being in the water, injured or witnessing others struggle; and d) living in temporary housing within 24 months after the tsunami (Frankenberg et al., 2020). Lowe's study of survivors' physical health problems used three different indices of exposure to Hurricane Katrina, including 1) a bereavement question asking "Did any members of your family, neighbors, or close friends die as a result of the storm or its aftermath?"; 2) the Hurricane-Related Stressors scale assessing experiences during the hurricane and within the week that followed, and 3) relocation of the respondent to a different zip code (Lowe et al., 2014).

Disaster-related damage, self-reported on a scale of 0-100, has also been utilized to assess self-rated mental and physical health outcomes among individuals residing in regions frequently affected by hurricanes (Karaye et al., 2020). Another method of estimating natural disaster impacts, less-frequently available in most population health studies, is a survey question that asks the participant to self-report the damage from the natural disaster (Cherry et al., 2011; Cherry et al., 2017; Karaye et al., 2019). However, no study in my review of the literature has investigated the content validity of these questions; therefore, these questions may be capturing different aspects of damage or loss across different ages or groups.

Tools such as the Richter Scale for earthquakes or the Saffir-Simpson Hurricane Wind Scale for hurricanes are employed to measure the magnitude of disaster events within the natural environment, but because these tools are unable to accurately capture the humanitarian severity, attempts have been made to holistically capture natural disaster vulnerability and exposure indicators. A Hurricane-Related Stressors scale was created based on qualitative interviews of low-income Hurricane Katrina evacuees to the Houston area (Brodie et al., 2006). This scale asks the participant to indicate whether they have experienced any of the following, with scores ranging from 0-8: (a) lacked enough fresh water to drink, (b) lacked enough food to eat, (c) felt their life was in danger, (d) lacked necessary medicine, (e) lacked necessary medical care, (f) had a family member who lacked necessary medical care, (g) lacked knowledge of safety of children, and (h) lacked knowledge of safety of other family members. A team investigating the impact of Hurricane Maria in Puerto Rico developed a tool called the Natural Disaster Outcome questionnaire in which they built upon the Hurricane-Related Stressors Scale by adding factors specific to the disaster experience in Puerto Rico, like long lines at gas stations, traffic jams, cost of generators and maintenance, communication difficulties (Rodriguez-Rabassa et al., 2020). The Yew Disaster Severity Index, as an another example, utilizes two exposure indicators (number of deaths and number of affected persons) combined with 15 vulnerability indicators (Time Occurrence, Impact Time, Topography, Radius from the Impact Site; Accessibility to the Impact Site, Population

Density, Main Source of Economy at the Impact Site, Public Infrastructure/Critical Facilities, Communication, Type of Country, Governance measured by Corruption Perception Index, Water and Sanitation Hygiene, Food Security, Shelter, and Health Care Capacity), and this quantitative tool was envisaged as a guide for disaster management and response (Yew et al., 2019).

Although the operationalization of disaster exposure is evolving, the above methodologies prevent the evaluation of serial disasters, or multiple events affecting a single location, and their impact on health outcomes of populations residing in frequently affected regions. Experts in the field of natural disasters are increasingly recognizing that serial disasters (e.g., multiple exposures to disasters) may have cumulative effects that cannot be measured by solely examining one event or one type of disaster at a time (Cherry et al., 2017; Prohaska & Peters, 2019). As an example of serial natural disaster exposure, three Category 4 or 5 Atlantic hurricanes (Harvey, Irma, and Maria) impacted the southeastern United States and US Caribbean territories within a 5-week period (Martinez et al., 2023). Relatively few studies have assessed health outcomes after consecutive disasters, as opposed to a single disaster event, and these have relied on self-reported exposure information collected shortly after the disasters (Benight, 2004; Cherry et al., 2017; Fernandez et al., 2005).

Other recent research on health outcomes related to the impact of cumulative natural disaster exposure have predominantly quantified the severity of natural disasters in two different ways, both based on the participant's county of residence: 1) affected or unaffected based on FEMA Individual Assistance funds (Quast et al., 2019), and 2) principal component analysis created from FEMA disaster declaration information, specifically the total number of days with a major disaster declared, available public assistance dollars per capita, approved housing assistance dollars per capita, and other needs assistance dollars per capita as the initial variables (Horney et al., 2019; Rosenheim et al., 2018). While residence in a location receiving a disaster declaration may be limited in providing a broader context of an individual's exposure to the impacts of a

disaster, it may be the most informative quantitative measurement available when individual-level qualitative exposure data is unavailable.

The lack of uniformity or standardization in operationalizing disaster exposure limits the ability to communicate clearly to stakeholders and emergency responders about the severity of an event (Caldera & Wirasinghe, 2022). Compared to community impact ratings based on disaster severity, individual-level self-reported disaster impact has been found to be more informative in estimating health care utilization and health issues (Burger et al., 2017), however this qualitative data is not usually readily available among populations affected by a disaster. Additionally, there is currently not a validated and reliable measurement of natural disaster severity in the health context, so exploring the informative ability of these measurements is warranted. In order to strengthen the existing evidence on health outcomes related to natural disasters, research methods should ideally track health data from before and after the event and should incorporate standard questions aimed at defining natural disaster severity (Benevolenza & DeRigne, 2018). Quantifying the impact of natural disasters on society is critical for both planning and recovery in the aftermath of a disaster, but health-related disaster impacts often go underreported (Kishore et al., 2018) because indirect morbidity and mortality is challenging to collect.

### *Hispanic Populations and Disaster-related Health*

There is currently a substantial gap in the literature focused on the impact of natural disasters on the health of elderly Hispanic populations in the United States. This is particularly important, as demographic trends in the United States indicate that the Hispanic American population is a rapidly growing proportion of the total population (Brown & Patten, 2014), and this ethnic group is projected to make up 22% of the elderly population, an estimated 21.5 million people, by 2060, compared to 8% in 2014 (Federal Interagency Forum on Aging-Related Statistics, 2016). While the Hispanic population is very diverse, and can include any racial category, Mexican-origin Hispanics made up 62.3% of the U.S. Hispanic population as of 2017 (Enid Zambrana et al., 2021). Further, older Mexican Americans are characterized by low income, few

years of formal education, low physical activity, high rates of obesity, diabetes and disability, and longer life expectancy (Markides et al., 1999), factors that may influence the way this population's health is affected by natural disasters.

There is a dearth of information in the literature regarding the health of Hispanic populations post-disaster, and many of the studies available are focused on Hispanic Puerto Rican populations. For example, Puerto Ricans exposed to the 1985 flood disaster reported significantly more symptoms related to depression and generalized anxiety, but not PTSD, in comparison to those unexposed (Canino et al., 1990). Also, six months after Hurricane Maria, many older Puerto Rican adults affected by the disaster experienced unmet needs that contributed to both declining emotional and physical health (Andrade et al., 2021). Additionally, official mortality estimate in Puerto Rico from Hurricane Maria was originally reported as 64, but after surveying 3299 households on the island, it was proposed that the actual number of hurricane-related excess deaths was probably more than 70 times this number, and that one third of these excess deaths were attributable to delayed or interrupted healthcare (Kishore et al., 2018). Disasters have been found to be associated with barriers to care among Puerto Rican cancer patients affected by an earthquake (Peña-Vargas et al., 2022). Among Puerto Ricans affected by Hurricane Maria, cancer patients reported increased barriers to accessing healthcare and in comparison to non-cancer patients (Rodriguez-Rabassa et al., 2020), suggesting the importance of providing support to Hispanic older adults who are managing chronic conditions in the aftermath of a disaster.

There are a few studies evaluating the role of race/ethnicity on disaster preparedness, warning communication response, recovery, reconstruction and psychosocial impacts, but most physical health impacts are limited to comparisons between non-Hispanic black and white populations (Fothergill et al., 1999). A few studies indicate that Hispanic populations affected by natural disasters have worse health outcomes compared to non-Hispanic white populations affected by the same event. For example, in comparison to non-Hispanic White population, Hispanic and non-Hispanic Blacks reported needing more access to Federally Qualified Health

Centers in New Jersey after Hurricane Sandy even though the primary medical conditions did not vary between the three ethnic groups (Burger et al., 2019), indicating that minority populations may need additional medical support after natural disasters. Further, six months after Hurricane Andrew, Spanish-preferring Latinos reported the highest rates (38%) of PTSD in comparison to English-preferring Latinos (19%), non-Hispanic Blacks (23%) and non-Hispanic Whites (15%), which the authors interpreted to indicate the importance of culture and ethnicity in some settings (Julia L. Perilla et al., 2002). In contrast, among adults affected by Hurricane Harvey, there was not a significant difference between Hispanic and non-Hispanic White respondents in physical health problems, posttraumatic stress, or access to healthcare (Flores et al., 2020).

There is very little evidence available for how natural disasters affect Mexican Americans specifically. One study found that among those affected by a flood disaster in El Paso County, Texas, which is predominantly composed of Mexican-origin residents, Hispanic ethnicity and a lack of English proficiency was significantly associated with negative physical health outcomes, but not negative mental health or disaster clean-up effects, while being foreign-born was only associated with negative mental health outcomes (Collins et al., 2013). Together, these findings demonstrate the need for further understanding of the post-disaster health outcomes of the older Mexican American population.

## OBJECTIVE, SPECIFIC AIMS AND HYPOTHESES OF DISSERTATION RESEARCH

The objective of this dissertation is to examine the influence of natural disaster exposure and other relevant risk factors on the incidence of depressive symptoms, cognitive impairment, and limitations in activities of daily living (also interchangeably termed “physical limitations”) five years after healthy baseline measurements among older Mexican American adults. The goals of this study are to 1) explore the association of natural disaster exposure and other risk factors on long-term psychological, cognitive and physical health outcomes in elderly Mexican Americans, 2) examine various approaches to the operationalization of disaster exposure in order to optimize

the usefulness of these measurements in a public health context, and 3) explore the potential moderating role of nativity on the relationship between natural disaster exposure and these health outcomes. The overall hypothesis is that those with higher levels of natural disaster exposure, in comparison to those with lower levels, are more likely to experience increased negative psychological, cognitive, and physical health outcomes.

**AIM 1. Describe the risk factors associated with the long-term health outcomes of incident depressive symptoms, cognitive impairment, or physical limitations among older Mexican Americans in the H-EPESE study, using multivariable logistic regression.**

Hypothesis 1: Among older Mexican Americans, natural disaster exposure will be significantly associated with a higher likelihood of developing depressive symptoms, cognitive impairment, or physical limitations.

**AIM 2. Model the effect of three different operationalizations of county-level disaster declarations (i.e., dichotomously, either exposed or unexposed; total Individual Assistance funds disbursed per person living in the county; or as a principal component) on the odds of developing depressive symptoms, cognitive impairment, or physical limitations in older Mexican Americans, using multivariable logistic regression and a sensitivity analysis.**

Hypothesis 2a: The odds of developing depression, cognitive impairment, or physical limitations will be more sensitive to operationalizing disaster severity using a principal component, after controlling for patient-level covariates, compared to binary or funds-per-person operationalization.

Hypothesis 2b: The odds of developing depression, cognitive impairment, or physical limitations will be the least sensitive when operationalizing disaster severity using a binary variable (exposed vs unexposed), compared to funds-per-person or principal component operationalization, after controlling for patient-level covariates.

**AIM 3. Utilizing the appropriate operationalization determined in Aim 2, examine inequalities in developing adverse health outcomes (depressive symptoms, cognitive impairment, or physical limitations) and the potential moderating effect of nativity (US born or other) on natural disaster exposure among older Mexican Americans.**

Hypothesis 3: In comparison to US born Mexican Americans exposed to natural disasters, non-US born Mexican Americans exposed to natural disasters will have higher odds of developing depressive symptoms, cognitive impairment or physical limitations.

This dissertation addresses a current gap in the field of public health and natural disasters by longitudinally examining the association of disaster exposure and health outcomes within an elderly Mexican American population residing in the United States. The need for longitudinal research examining the long-term disaster-related health outcomes among older populations has been emphasized, but due to methodological barriers related to disaster research, few studies have addressed this topic, especially among older Hispanic adults. Further, this work will assess how variations in the operationalization of natural disaster exposure affect health outcome models. The results of this study can identify factors that could be targeted for future research and disaster management interventions and policy.

# CHAPTER 2 DATA AND METHODS

## DATA

The data for this study was obtained from the Hispanic Established Population for the Epidemiological Study of the Elderly (H-EPESE), the Federal Emergency Management Agency (FEMA) publicly available natural disaster declaration data sets (https://www.fema.gov/about/openfema/data-sets), and the 2012 American Community Survey (https://www.census.gov/data/developers/data-sets/acs-5year/2012.html). This study was conducted as a retrospective cohort study design.

The Hispanic Established Population for the Epidemiologic Study of the Elderly (H-EPESE)

The H-EPESE is an on-going longitudinal cohort study of older adult Mexican Americans residing in the five Southwestern states of Arizona, California, Colorado, New Mexico and Texas (Markides, 2009). This study was initiated in 1993-94 with 3,050 participants and provides data on risk factors related to the morbidity and mortality of community-dwelling Mexican Americans. An additional 902 participants aged ≥75 were added to the original cohort at Wave 5.

Two waves of H-EPESE data are included in this study: 1) Wave 5, collected in 2004-05, n=2,069; and 2) Wave 7, collected in 2010-11, n=1,078. Respondents were interviewed in-person in English or Spanish, depending on their preference, and the details of the H-EPESE data collection methods are detailed elsewhere (Markides KS, 1997). Wave 5 was used to identify the study cohort and to establish baseline measures, including depressive symptoms, cognitive functioning, limitations in activities of daily living, sociodemographic characteristics, comorbidities, and geographic location by county of residence. Wave 7 was used to validate a consistent geographical location of residence through the study period and evaluate the development of depressive symptoms, cognitive impairment, and limitations in activities of daily living since Wave 5. These three binary outcomes in Wave 7 were merged with the baseline Wave 5 data to develop the analytical dataset. Specific inclusion and exclusion criteria are further detailed later in this chapter.

Federal Emergency Management Agency (FEMA) Disaster Declarations Data

Under the authority of the Robert T. Stafford Disaster Relief and Emergency Assistance Act (42 U.S.C. 5121-5207), the President of the United States issues disaster declarations for nine types of disasters: earthquakes, fires, floods, hurricanes, severe ice storms, severe storms, snow, tornadoes, and "other" disasters. The Federal Emergency Management Agency (FEMA) is responsible for documenting these declarations, and reports county-level information about each specific disaster declaration, including the type, date and number of days a disaster is declared, and the dollar amounts distributed in the form of federal public assistance grants for disaster response and recovery, which can be used to repair, restore or replace disaster-damaged public facilities. Individuals, categorized as either "renters" or "owners", may also apply for Federal assistance, and this information is reported at the zip-code level and includes the dollar amount granted to the individual for housing or "other" needs related to disaster recovery. This FEMA-reported information related to natural disaster declarations was obtained from the FEMA.gov website (https://www.fema.gov/about/openfema/data-sets) which provides data in three files entitled "Disaster Declarations Summaries", "Public Assistance" funds, and "Individual Assistance." FEMA disaster declaration data prior to January 1, 2006 and later than December 31, 2008 was removed, resulting in three years of disaster declaration data, which was then merged with Wave 5 and Wave 7.

The FEMA data file named "Disaster Declarations Summaries" contains the total number of days in 2006-2008 that the county of residence experienced a disaster declaration, and was downloaded on July 20, 2021 (https://www.fema.gov/openfema-data-page/disaster-declarations-summaries-v1). This file contains all of the disaster declaration summary information from 1953 through 2022 and includes variables that indicate the disaster number (a unique identifier assigned to each individual disaster or incident), the incident beginning and ending dates, the incident type, the state and county Federal Information Processing Standard (FIPS) codes, and the designated areas (statewide or name of counties affected). Within the FEMA datasets, "disaster" and "incident" both indicate a natural disaster event.

The FEMA data file named "Public Assistance Funded Projects Details" contains information related to the public assistance funds disbursed in 2006-2008 and was downloaded on July 20, 2021 (https://www.fema.gov/openfema-data-page/public-assistance-funded-projects-details-v1). This file contains details about the public assistance funds obligated ("financial obligation to grantee") between 1998 and 2022, and includes variables that indicate the disaster number, the incident type, the state and county COFIPS codes, and the total amount of public assistance obligated. According to the FEMA website (https://www.fema.gov/openfema-data-page/public-assistance-funded-projects-details-v1), the total obligated amount is "The federal share of the Public Assistance grant eligible project amount in dollars, plus grantee (State) and sub-grantee (applicant) administrative costs. The federal share is typically 75% of the total cost of the project."

The housing assistance and "other needs" variables were obtained from two FEMA datasets, both available at https://www.fema.gov/about/openfema/data-sets. The "Housing Assistance Program Data- Owners" and the "Housing Assistance Program Data- Renters" were both downloaded on July 20, 2021. Data in both the renters and owners files include the disaster number (starting with 1439 through 9807), state and county, zip code of the registration, and total approved amount (in US dollars), which is the sum of "repair/replace amount", "rental amount" and "other needs amount." The housing assistance (repair/replace summed with rental) approved in 2006-2008 from both the renters and owners datasets were summed, divided by the estimated county population, and merged by zip code with the H-EPESE participant dataset. The "other needs" approved in 2006-2008 from both the renters and owners datasets were summed, divided by the estimated county population to create a standardized number of dollars spent per person, and then these data were merged by zip code to the H-EPESE participant dataset.

American Community Survey

Five county-level covariates were obtained from the U.S. Census 2012 American Community Survey 5-year estimates covering the years 2008 to 2012

(https://www.census.gov/programs-surveys/acs/technical-documentation/table-and-geography-changes/2012/5-year.html), which was downloaded on February 10, 2021. These covariates, all measured continuously, were (1) total population, (2) median household income, (3) percentage of population that self identifies as a racial or ethnic minority (defined as the percentage of the population that is not White, non-Hispanic), (4) percent of the population with less than a high-school degree, and (5) percent of the population living in poverty. These variables were matched to each participant by county of residence and merged with the analytical dataset. The 2012 5-year estimates were selected for this study because this year was the first time that detailed educational attainment levels were available at this geographic resolution for this dataset.

## DESCRIPTION OF STUDY OUTCOMES: DEPRESSIVE SYMPTOMS, COGNITIVE IMPAIRMENT, AND PHYSICAL LIMITATIONS

The three outcomes of interest for this study are: (a) development of depressive symptoms, (b) development of cognitive impairment, and (c) development of a limitation in activities of daily living. Each of these are measured as a binary variable that indicates whether a respondent developed this health outcome between Wave 5 and Wave 7. Table 1 describes the variables used for this dissertation, including the type, coding, and source.

Depressive symptoms in this cohort were measured using the Center for Epidemiologic Studies Depression Scale (CES-D), a 20-item instrument with scores ranging from 0-60, that has been demonstrated to be valid and reliable for use with the community-dwelling elderly (Berkman et al., 1986; Hertzog et al., 1990). The CES-D has also been used frequently with the H-EPESE study population (Downer et al., 2016; Salinas et al., 2018). Using previously established cut-off points, a CES-D score of 16 or greater was chosen to indicate clinically meaningful depressive symptoms (Black et al., 2003), although it is important to note that this does not represent a clinical diagnosis of depression. This variable was measured in Wave 5 (named CESDTOT5) and Wave 7 (named CESDTOT7), and then dichotomized (0 = CES-D score 0-15, 1 = CES-D score 16-60),

with a score of 16 and higher indicating the presence of potentially clinically meaningful depressive symptoms. Those with non-missing covariates, non-missing CES-D scores at Wave 5 and Wave 7, and those with a score less than 16 at Wave 5 were retained in the analytical cohort (n=725) for this portion of the study.

Cognitive impairment was measured with the Mini-Mental State Exam (MMSE) at both Wave 5 and Wave 7. While not a diagnostic tool, the MMSE has been used extensively in epidemiological research of older adults (Dufouil et al., 2000) and older Hispanic adults (Collins et al., 2009; Glenn V. Ostir et al., 2003) and provides an objective measure of global cognitive functioning (Folstein et al., 1975). The English or Spanish, when preferred, versions were administered by an examiner to assess (a) orientation to time and place, (b) registration, (c) recall, (d) language, (e) attention and calculation, (f) constructional praxis and (g) ability to follow verbal commands (Downer et al., 2016). The MMSE score ranges from 0-30, with higher scores indicating higher cognitive functioning. Some studies have used an MMSE cut-off point of <21 to indicate low cognitive ability (Bindawas et al., 2015; Uhlmann et al., 1991), however, low educational attainment is correlated with the number of incorrect responses on the MMSE (Crum et al., 1993). A score of less than 18 was considered to indicate cognitive impairment for this study in order to prevent misclassification of participants who scored lower on MMSE, since the majority of this sample has not completed high school. The total score at Wave 5 was dichotomized so that 0= total score greater than or equal to 18 (healthy); and 1=score less than 18 (cognitively impaired). Those with non-missing covariates, non-missing MMSE scores at Wave 5 and Wave 7, and unimpaired cognition at Wave 5 were retained in the analytical cohort (n=774) for this portion of the study. This analytical cohort was then evaluated to determine any changes in cognitive impairment, as measured by those that had MMSE scores that had dropped below 18 at Wave 7.

Physical limitations were measured using the seven items of the Katz Activities of Daily Living Scale (ADL), which is an index that asks whether respondents need help walking across a small room, bathing, grooming, dressing, eating, transferring, or toileting (Katz et al., 1963). The

ADL instrument has been used extensively to examine aging and health of elderly Hispanics in the H-EPESE study (Howrey et al., 2016; Nam et al., 2017). In the H-EPESE study, the total number of positive responses was summed, ranging from 0-7, with higher scores indicating greater physical disability (Nam et al., 2017; Salinas et al., 2018). This score was then dichotomized (variable named ANYADL5 in Wave 5 and ANYADL7 in Wave 7) into 0= "no help needed" and 1= "help needed with one or more." Those with non-missing covariates, non-missing ADL scores at Wave 5 and Wave 7, and those with no help needed at Wave 5 were included in this analytical cohort (n=715) and were evaluated at Wave 7 to determine the incidence of developing physical limitations.

## DESCRIPTION OF STUDY EXPOSURE: NATURAL DISASTER EXPOSURE

### Disaster Severity

Natural disaster exposure was the primary independent variable of interest in this study; however, there is currently no formal definition of natural disaster exposure. Additionally, self-reported disaster-related questions or measurements are not available in the H-EPESE survey. To create a measurement of natural disaster exposure, FEMA disaster declaration data from January 1, 2006 through December 31, 2008 were merged with Wave 5 data and matched by county or zip code to estimate the extent to which each subject had been exposed to natural disasters in their county of residence between baseline Wave 5 (2004/2005) and follow-up Wave 7 (2010/2011). An important note is that there were no disaster declarations for the five H-EPESE states in 2009, so there was no natural disaster exposure in the year prior to the beginning of Wave 7 data collection.

This information was merged with the analytical dataset, and the natural disaster severity variable was operationalized in three different ways: 1) dichotomously, as exposed or unexposed, based on whether the individual lived in a county that received public assistance funds; 2) continuously, as the federal public assistance dollars spent per person in the county; and 3)

categorically as a principal component that was created using four variables available from the three FEMA data files. These operationalizations and the rationale for their use are further detailed below, as this was a key focus of this dissertation.

**Operationalization of Natural Disaster Exposure for Each Aim**

*AIM 1: NATURAL DISASTER EXPOSURE AS BINARY PREDICTOR*

For Aim 1, natural disaster exposure was dichotomized, where residence in a county that received public assistance funds in 2006-2008 was coded as 1 and all others were coded as 0. This method of operationalizing disaster exposure is similar to research conducted by Horney and colleagues and Rosenheim and colleagues (Horney et al., 2019; Rosenheim et al., 2018). Specifically, participants in this study were determined to have experienced natural disaster exposure if they resided in a county that received public assistance funds following a natural disaster declaration from the Federal Emergency Management Agency in 2006-2008.

*AIM 2: NATURAL DISASTER EXPOSURE AS CONTINUOUS PREDICTOR AND PRINCIPAL COMPONENT*

For Aim 2, the sensitivity of the outcomes to the operationalization of natural disaster exposure was examined by modeling, in addition to the binary exposure variable, two further county-level measurements of natural disaster severity and frequency: 1) the total FEMA public assistance dollars allocated per person in the county; 2) a principal component derived from four FEMA variables. The development of the principal component in this study used the following process, using the FEMA data related to disasters occurring between January 1, 2006 through December 31, 2008.

The practice of using a principal component analysis to examine natural disaster exposure is relatively new, and conducted in this study based on methods from two studies completed by Horney and Rosenheim in 2018-2019 (Horney et al., 2019; Rosenheim et al., 2018). To account

for differences in natural disaster exposure severity in those two studies, the authors used FEMA variables to create a disaster exposure variable from a principal component analysis using (1) total number of days that the county of residence was under a major disaster declaration, (2) the available public assistance divided by estimated county population, (3) individual housing (both renters and owners) assistance dollars approved divided by populations in all designated counties for the related disaster, and (4) other needs individual assistance dollars approved divided by populations in all designated counties for the related disaster. At the time of Rosenheim's analysis, FEMA combined "Owners" and "Renters" into one file of "Individual Assistance" (personal communication with Rosenheim), however, at the time of the analysis for this dissertation, FEMA had two separate data files for "Individual Assistance", one file for "Owners" and one for "Renters", which needed to be combined prior to moving forward.

The principal component analysis (PCA) was performed by using the PCA command series in STATA. This allowed for the analyst to review loadings and varimax rotation, which assists in clarifying the relationship among factors. The Kaiser-Meyer-Olkin (KMO) test for sampling adequacy was conducted, and the result was compared to a value of |.5|, above which indicates the justification of using PCA with these variables. The principal component variable was then mean-centered and categorized by increments of the standard deviation (1.451163) to create four natural disaster exposure levels: "none" (if all values of the four input variables were equal to zero), "some" (a value greater than minimum and less than one standard deviation from the mean), "high" (between one and two standard deviations from the mean), or "extreme" (defined as greater than two standard deviations from the mean).

## COVARIATES

Covariates for these analyses include participant-level demographics and health measurements, all collected at Wave 5, as well as county-level characteristics, all of which are

known to be important confounders. Specific covariates that were included in these analyses are discussed below.

*Participant-level Covariates*

Self-reported participant demographics include age in years (continuous variable) and sex (binary variable where 0=male and 1=female), nativity (country of respondent's birth measured as 0= US born and 1= foreign born) and marital status (binary variable coded as 0=married and 1=unmarried, including widowed, divorced or never married). Self-reported educational attainment was categorized into either less than 12 years of education or 12 or more years of education.

Financial strain was assessed by the respondent's answers to two questions regarding a) difficulty paying bills or b) not having enough money left at the end of the month. Those responding affirmative to either of these questions were coded as 1, and everyone else was coded as 0 (Angel et al., 2003; Howrey et al., 2018). Social support was based on responses to two questions: "Can you talk to family/friends regarding problems?" and "Can you count on at least some of the family?" If participants responded "most of the time" to both questions, then social support was coded as 1; otherwise it was coded as 0 (Howrey et al., 2015). Language of interview, conducted in either English (coded as 0) or Spanish (coded as 1), was also included as a measure of acculturation based on prior research (Angel et al., 2003).

Participants self-reported comorbidities of cancer, stroke, heart failure, hypertension, diabetes, and arthritis in response to questions inquiring "Has a Dr. ever told you that you had ____?", where the blank represents each of the above-mentioned comorbidities. For each individual comorbidity, responses of either "don't know" or "refused" were categorized as missing values. The number of these designated missing values ranged from zero for the question about stroke to 18 for the question regarding arthritis. Body mass index (BMI) was calculated from height, which was measured using a tape measure placed against the wall, and weight, which was measured using a Metro 9,800 scale (Markides et al., 1996). BMI was obtained by the interviewee

at Wave 5, but over 20% (n=539) of the participants had missing values for this variable. Therefore, based on prior literature, this variable was categorized as 0= BMI<30 and 1= BMI ≥ 30, and 2= "missing" in order to avoid losing these participants in the analysis (Mutambudzi et al., 2016; Nam et al., 2017). Limitations in activities of daily living were included as a dichotomous independent variable (either as none or as 1 or greater), and this variable was not included as a comorbidity in the model examining activities of daily living as an outcome.

*County-specific Covariates*

To control for the effects of community-level factors on the outcomes, five county-level variables (total population, median household income, percent of the county population that is either non-white or Hispanic, percent of the population with less than a high-school degree, and percent of the population living in poverty) were included. These were obtained from the U.S. Census 2012 American Community Survey 5-year estimates and are all measured continuously. Including these variables enabled these analyses to adjust for how societal and community factors might influence the outcomes.

Table 1. Study outcomes, focal variables, and covariates

| NAME/DESCRIPTION | TYPE | LEVEL | DATA SOURCE |
|---|---|---|---|
| **Outcome Variables** | | | |
| *Depressive symptoms (CES-D>=16)* | Binary | Participant | H-EPESE (Waves 5,7) |
| 0: no | | | |
| 1: yes | | | |
| *Cognitive impairment (MMSE <18)* | Binary | Participant | H-EPESE (Waves 5,7) |
| 0: no | | | |
| 1: yes | | | |
| *Activities of Daily Living (ADL) summary score* | Binary | Participant | H-EPESE (Waves 5,7) |
| 0: no help needed | | | |
| 1: help needed with one or more | | | |
| | | | |
| **Focal Variables- Natural Disaster Severity** | | | |
| *Exposed (1)/ Unexposted (0)* | Binary | County | FEMA |
| *Public dollars Distributed per person* | Continuous | County | FEMA |
| *Principal component analysis* | Categorical | County | FEMA |
| | | | |
| **Demographic Covariates** | | | |
| *Participant age in years* | Continuous | Participant | H-EPESE (Wave 5) |
| *Biological sex (0: male, 1: female)* | Binary | Participant | H-EPESE (Wave 5) |
| *Marital status (0:married, 1: not married)* | Binary | Participant | H-EPESE (Wave 5) |
| *Nativity (0: US born, 1: non-US born)* | Binary | Participant | H-EPESE (Wave 5) |
| *Education (0: < HS, 1: HS diploma or higher)* | Binary | Participant | H-EPESE (Wave 5) |
| *Financial Strain (0: No, 1: Yes)* | Binary | Participant | H-EPESE (Wave 5) |
| *Social Support (0: low, 1: high)* | Binary | Participant | H-EPESE (Wave 5) |
| **Comorbidities** | | | |
| *Cancer (0: No, 1: Yes)* | Binary | Participant | H-EPESE (Wave 5) |
| *Stroke (0: No, 1: Yes)* | Binary | Participant | H-EPESE (Wave 5) |
| *Heart Attack (0: No, 1: Yes)* | Binary | Participant | H-EPESE (Wave 5) |
| *Hypertension (0: No, 1: Yes)* | Binary | Participant | H-EPESE (Wave 5) |
| *Diabetes (0: No, 1: Yes)* | Binary | Participant | H-EPESE (Wave 5) |
| *Arthritis (0: No, 1: Yes)* | Binary | Participant | H-EPESE (Wave 5) |
| *BMI (0: ≤ 30, 1: >30, 2: missing)* | Categorical | Participant | H-EPESE (Wave 5) |
| | | | |
| **County-level Covariates** | | | |
| *Total population* | Continuous | County | American Community Survey- 5 year estimates: 2008-2012 |
| *Median household income* | Continuous | County | American Community Survey- 5 year estimates: 2008-2012 |
| *% minority population* | Continuous | County | American Community Survey- 5 year estimates: 2008-2012 |
| *% with less than high-school degree* | Continuous | County | American Community Survey- 5 year estimates: 2008-2012 |
| *% poverty* | Continuous | County | American Community Survey- 5 year estimates: 2008-2012 |

## ANALYTICAL SAMPLE SELECTION CRITERIA

Participants were included if they participated in both Wave 5 and Wave 7, had complete age and sex demographic information at Wave 5, and had not relocated outside of their Wave 5 county of residence by Wave 7 (n=998). For each of the three distinct outcomes (development of

depressive symptoms, cognitive impairment, and any limitations in activities of daily living), respondents were included if they 1) had baseline measures with negative (healthy) indicators of that health outcome, as defined below, at Wave 5 and 2) had complete responses about that specific health outcome at Wave 7. For the purposes of this study, and based on prior research, negative indicators of the health outcome at baseline were considered: 1) a Center for Epidemiologic Studies Depression Scale (CES-D) score of <16 to evaluate depressive symptomology (n=725); 2) a Mini-Mental State Exam (MMSE) score greater than 17 to evaluate cognitive impairment (n=774); and 3) not needing any assistance with any activities of daily living (ADLs) to evaluate disability (n=715). Figure 2 displays the inclusion and exclusion criteria for each of the analytic samples for this study.

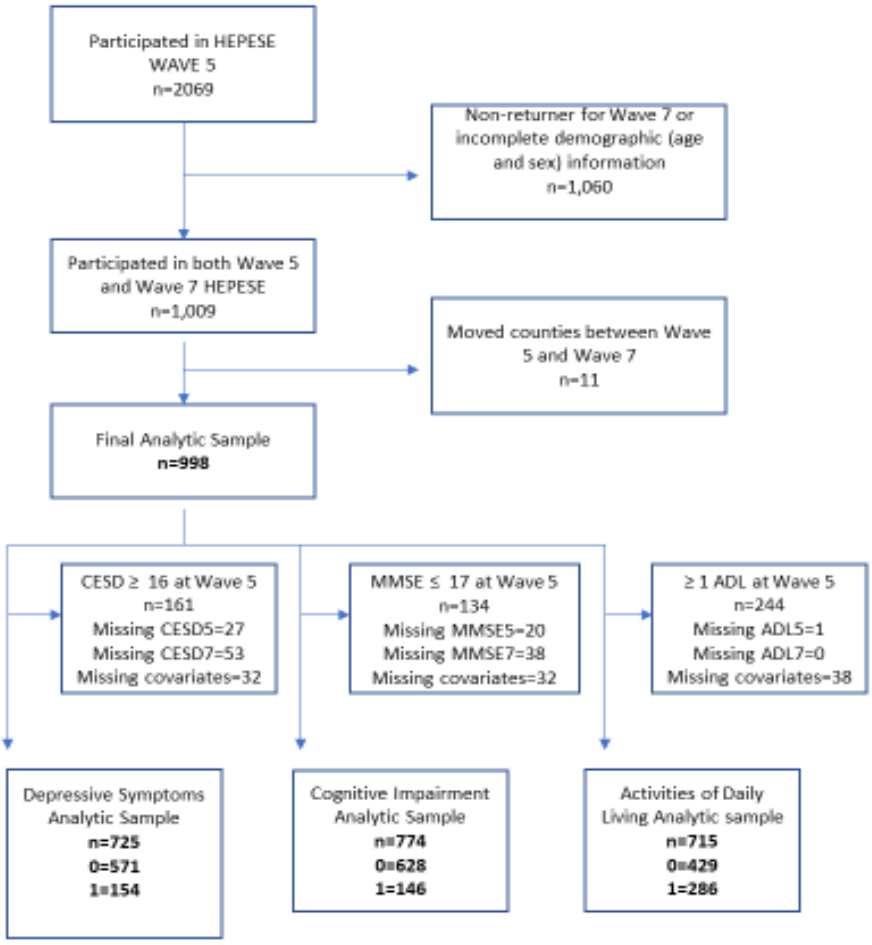


**Figure 2. Derivation of analytic samples.**

Participants who relocated outside of their Wave 5 county of residence in Wave 7, or had missing data on the specific outcome of interest in Wave 5 or 7, or had missing responses on socio-demographic variables or comorbidities at Wave 5, were excluded from that specific sub-analysis. After the overall analytical sample (n=998) was established based on inclusion criteria, I compared the excluded participants (n=1,071) to examine possible contributions to bias in this study.

Table 2 describes the bivariate analysis of characteristics between those participants included and those excluded. There was no statistical difference in the natural disaster exposure measured dichotomously ($p=0.441$), or in the number of declared disaster days in 2006-2008 ($p=0.6629$), or in the amount of public assistance per person residing in the county ($p=0.1518$). This suggests that survivor bias after natural disaster events is unlikely to play a role in the findings of this dissertation. The excluded participants had a significantly higher percentage of males ($p<0.001$) and were on average older ($p<0.001$). The included participants were more likely to be married ($p=0.01$) and report high social support ($p<0.001$). A comparison of the participants comorbidities indicates that those excluded were more likely to have at least one limitation in the activities of daily living ($p<0.001$) or to report a history of stroke ($p<0.001$), heart failure ($p<0.001$), diabetes ($p=0.008$). The excluded participants were also more likely to have a BMI greater than 30 or to have a missing value for BMI ($p<0.001$).

**Table 2. Comparison of included and excluded participants**

| | Included (n=998) | Excluded (n=1071) | p-value |
|---|---|---|---|
| Natural Disaster Exposure, n (%) | 828 (82.97%) | 902 (84.22%) | 0.441 |
| Natural Disaster Days 2006-2008, mean (sd) | 115.73 (132.25) | 113.25 (126.24) | 0.6629 |
| Public Assistance $/county population, mean (sd) | 463.03 (1834.38) | 598.00 (2388.24) | 0.1518 |
| Age, mean (sd) | 80.59 (3.99) | 83.18 (5.76) | <0.001 |
| Female, n (%) | 653 (65.43%) | 620 (57.89%) | <0.001 |
| Unmarried, n (%) | 544 (54.56%) | 644 (60.19%) | 0.01 |
| >=12 years of education, % | 121 (12.12%) | 110 (10.27%) | 0.181 |
| US born, n (%) | 548 (54.91%) | 610 (56.96%) | 0.349 |
| Spanish language preferred, n (%) | 793 (79.46%) | 868 (81.05%) | 0.365 |
| Financial strain, n (%) | 278 (28.22%) | 290 (29.09%) | 0.671 |
| High Social Support, n (%) | 688 (68.94%) | 667 (62.28%) | 0.001 |
| Cancer, n (%) | 62 (6.23%) | 87 (8.16) | 0.091 |
| Stroke, n (%) | 58 (5.84%) | 115 (10.83%) | <0.001 |
| Heart Attack, n (%) | 218 (22.09%) | 325 (30.72%) | <0.001 |
| Hypertension, n (%) | 630 (63.64%) | 656 (62.12%) | 0.478 |
| Diabetes, n (%) | 305 (30.62%) | 385 (36.12%) | 0.008 |
| Arthritis, n (%) | 594 (60.67%) | 631 (59.87%) | 0.71 |
| BMI >30, n (%) | 273 (27.35%) | 188 (17.55%) | |
| BMI=missing, n (%) | 103 (10.32%) | 323 (30.16%) | <0.001 |
| >=1 ADL limitations, n (%) | 244 (24.47%) | 517 (48.27%) | <0.001 |

## STATISTICAL METHODS

*Analytic Sample Derivation*

After the analytical sample was established based on inclusion and exclusion criteria (detailed earlier), bivariate analyses, using t-tests and chi-squared tests as appropriate, were conducted to compare the included and excluded participants across sociodemographic and comorbidity variables, as well as residence in counties impacted by disaster during the study period. These analyses were conducted to identify what, if any, differences existed between the included and excluded participants in this study.

***AIM 1: Risk factors associated with long-term health outcomes***

Bivariate descriptive analyses were performed to compare those participants with the outcome of interest to those without the outcome using a t-test for continuous variables and chi-square tests for categorical variables. Each outcome (depressive symptoms, cognitive impairment, and physical limitations) was modeled using multivariable logistic regression to examine the influence of risk factors, including natural disaster exposure measured dichotomously, while controlling for known comorbidities, sociodemographic factors, and other variables. The odds ratio, and corresponding confidence interval and p-value (determined to be statistically significant at a significance level of less than 0.05), for each parameter was examined to determine the explanatory power and the effect size of each predictor with the outcome.

To determine if the individual participants' responses were nested within counties, which would require statistical accounting in subsequent multi-level regression models, intraclass correlation coefficients (ICC) were calculated for each analytical sample's outcome variable. The ICC can be interpreted as the "proportion of the variance explained by the grouping structure within the population" (Hox et al., 2017). ICCs of 0.10 or greater would suggest the data were nested within counties, rather than being randomly distributed (Park & Lake, 2005).

### *AIM 2: Effect of three different operationalizations on long-term health outcomes*

As discussed earlier, there are multiple approaches to operationalizing natural disaster severity, and this study proposed to examine three prevalent methods for characterizing natural disasters (detailed earlier in this chapter). The bivariate associations of each method of operationalization of natural disaster severity (1) dichotomously as either affected or unaffected based on public assistance funds disbursed; 2) total public assistance funds disbursed per person in the county; or 3) the principal component factor) with each of the three outcomes (incident depressive symptoms, cognitive impairment, and physical limitations) were evaluated with t-tests for continuous variables and chi-square tests for categorical variables. Multivariable logistic regression models were then used to estimate (independently) the association between disaster

severity (across all three approaches to operationalization) and the three separate health outcomes, controlling for patient- and county-level covariates (for a total of 9 regression models). The adjusted $R^2$, Nagelkerke adjusted $R^2$, and other measures of model fit (e.g., AIC, BIC) for each of the three models for a given outcome were compared to determine which operationalization of disaster severity is more predictive of that specific outcome. Such a sensitivity analysis allowed for the comparison of how adjustments in the operationalization of natural disaster severity affects the ability to evaluate the strength of the explanatory power of disaster severity on the outcomes. For any operationalizations of natural disaster that were significantly associated with the health outcome, marginal analyses were conducted to measure the change in the probability of the health outcomes for a change in disaster severity, holding the covariates constant, in order to further examine the relationship between natural disaster exposure and the health outcomes (Long, 2014).

***AIM 3: Moderating Effect of Nativity (US-born or other)***

Bivariate descriptive analysis comparing native and foreign-born participants using t-tests for continuous variables and chi-square tests for categorical variables were performed on the participant level characteristics. Multivariable logistic regression models were used to determine any moderating effect of nativity (US born or non-US born) on the relationship between disaster severity and the three distinct outcomes: depressive symptoms, cognitive impairment, and physical limitations, adjusting for patient- and county-level characteristics. The possible moderation of nativity on natural disaster exposure was examined with an interaction term between nativity and natural disaster exposure in the regression model. The statistical significance of the interaction was examined to determine if nativity is moderating the relationships between disaster severity and the health outcomes.

All analyses described above were completed using Stata (StataCorp. 2017. *Stata Statistical Software: Release 15*. College Station, TX: StataCorp LLC). Table 3 provides a summary of statistical analyses for each aim of this study.

**Table 3. Description of statistical analyses completed for each aim**

| Objective | Statistical Analysis completed |
|---|---|
| Analytic Sample Derivation | • Descriptive Analysis<br>- Comparison of baseline characteristics between included and excluded participants<br>- Chi-squared tests for categorical variables and t tests for continuous variables |
| Aim 1: Risk factors associated with the long-term health outcomes | • Descriptive Analysis<br>- Comparison of baseline characteristics between those affected and unaffected by natural disaster<br>• Regression Analysis<br>- Logistic regression to test the effect of natural disaster and covariates on the development of depressive symptoms<br>- Logistic regression to test the effect of natural disaster and covariates on the development of cognitive impairment<br>- Logistic regression to test the effect of natural disaster and covariates on the development of limitations in activities of daily living |
| Aim 2: Effect of three different operationalizations on long-term health outcomes | • Descriptive Analysis<br>- Comparison of baseline characteristics between three operationalizations of natural disaster exposure<br>• Regression Analysis<br>- Logistic regression models for each study outcome with three operationalizations of natural disaster exposure<br>- |
| Aim 3: Moderating Effect of Nativity | • Regression Analysis<br>- Logistic regression to test if effects of natural disaster exposure, operationalized three different ways, is moderated by nativity. |

# CHAPTER 3: AIM 1 RESULTS- RISK FACTORS ASSOCIATED WITH DEPRESSIVE SYMPTOMS, COGNITIVE IMPAIRMENT AND PHYSICAL LIMITATIONS

The first aim in this study was to use multivariable logistic regression to estimate the odds of association between natural disaster exposure and other potential risk factors and the long-term health outcomes of incident depressive symptoms, cognitive impairment, and physical limitations among Mexican Americans in the H-EPESE study. The hypothesis was that among Mexican Americans, in comparison to those participants without natural disaster exposure, those with natural disaster exposure would have a higher likelihood of developing these adverse health outcomes.

Table 4 displays the univariate characteristics of the final sample and the analytical sample for each of the three health outcomes. Using the dichotomous operationalization of natural disaster exposure (based on residence in a county that received public assistance funds in 2006-2008), 82.97% of the participants lived in a county that was impacted by a natural disaster (defined as having received public assistance funding from FEMA). The average age of the final sample was 80.6 years and consisted of 65.43% females. Within the final sample, 12.12% of participants had completed at least 12 years of education, 54.91% of the participants were born in the United States, and 79.46% of the participants preferred Spanish during the interview. Hypertension and arthritis were the most prevalent comorbidities, at 63.13% and 59.52% respectively.

**Table 4. Participant characteristics for the overall sample and specific health outcome analytic samples**

| Variable | Overall Sample | CES-D Sample | MMSE Sample | ADL Salmple |
|---|---|---|---|---|
| n | **998** | **725** | **774** | **715** |
| New onset of outcome since Wave 5, % | --- | 20 | 21.73 | 20.45 |
| Affected by Natural Disaster, % | 82.97 | 83.45 | 83.59 | 82.24 |
| Age, mean (SD) | 80.6 (3.99) | 80.5 (3.93) | 80.33 (3.84) | 80.30 (3.82) |
| Female, % | 65.43 | 62.62 | 64.47 | 60.42 |
| Unmarried, % | 54.51 | 50.62 | 52.97 | 51.05 |
| >=12 years of education, % | 12.12 | 13.66 | 14.21 | 12.73 |
| US born, % | 54.91 | 57.1 | 56.33 | 55.66 |
| Spanish language preferred | 79.46 | 80.55 | 79.33 | 78.74 |
| Financial strain, % | 21.34 | 18.52 | 20.14 | 18.46 |
| Social Support, % | 68.94 | 71.36 | 68.96 | 68.39 |
| Cancer, % | 6.21 | 5.8 | 6.28 | 6.24 |
| Stroke, % | 5.81 | 4.81 | 5.33 | 4.91 |
| Heart Attack, % | 21.84 | 20.62 | 21.56 | 18.19 |
| Hypertension, % | 63.13 | 62.1 | 63.15 | 62.15 |
| Diabetes, % | 30.56 | 31.48 | 30.92 | 29.35 |
| Arthritis, % | 59.52 | 56.67 | 59.48 | 54.45 |
| BMI >30, % | 27.35 | 27.28 | 28.55 | 26.03 |
| BMI=missing, % | 10.32 | 6.76 | 6.46 | 4.34 |
| >=1 ADL limitations, % | 24.45 | 20.37 | 20.97 | --- |
| County Population, mean (SD) | 1,379,144 (2,760,209) | 1,275,302 (2,68,816) | 1,296,409 (2,819.476 ) | 1,409,380 (2,777,341) |
| County Median Household Income, mean (SD) | $48,841 ($11,501) | $48,476 ($11,355) | $48,780 ($11,563) | $49,382 ($11,819) |
| % Minority in County, mean (SD) | 45.81 (20.34) | 45.01 (20.39) | 45.94 (20.34) | 46.13 (20.35) |
| % with < HS diploma in County, mean (SD) | 20.42 (5.65) | 20.47 (5.59) | 20.43 (5.58) | 20.31 (5.77) |
| % below poverty in County, mean (SD) | 16.79 (4.95) | 16.64(4.82) | 16.74 (4.85) | 16.74 (4.94) |

The bivariate analyses of the covariates and the three health outcomes are displayed in Table 5. In the unadjusted results, those that were unmarried had increased odds of depressive symptoms (OR=1.725, CI [1.209-2.461]), cognitive impairment (OR=1.480, CI [1.034-2.116], and physical limitations (OR=1.389, CI [1.037-1.861]). A history of heart failure also increased the odds of depressive symptoms (OR=2.150, CI [1.451-3.187]), cognitive impairment (OR=1.738, CI [1.167-2.589]), and physical limitations (OR=1.649, CI [1.136-2.394]). Educational attainment equivalent to a high school diploma decreased the odds of depressive symptoms (OR=0.318, CI [0.156-0.644]), cognitive impairment (OR=0.504, CI [0.275-0.925]), and physical limitations (OR=0.533, CI [0.333-0.854]). Natural disaster exposure, nativity, social support, cancer, stroke, hypertension, diabetes and BMI > 30 were not associated with depressive symptoms, cognitive impairment or physical limitations. Older participants had an increased odds of developing cognitive impairment (OR=1.113, CI [1.065-1.163]) and physical limitations (OR=1.128, CI [1.084-1.175]). Females had an increased odds of developing depressive symptoms (OR=1.746, CI [1.193-2.555]) and physical limitations (OR=1.498, CI [1.107-2.26]). Financial strain was

associated with depressive symptoms (OR=1.984, CI [1.32-2.981]) and cognitive impairment (OR=1.743, CI [1.163-2.613]). Additionally in the unadjusted models, the odds of developing physical limitations were associated with the county-level % minority population (OR=0.985, CI [0.978-0.993]) and the county-level % with less than a high school diploma (OR=0.962, CI [0.937-0.988]).

**Table 5. Bivariate association of each variable with incidence of health outcomes**

| **Variable** | **CES-D (n=725)** | | | **MMSE (n=774)** | | | **ADL (n=715)** | | |
|---|---|---|---|---|---|---|---|---|---|
| | OR | 95% CI | p-value | OR | 95% CI | p-value | OR | 95% CI | p-value |
| Natural Disaster Exposure | 1.095 | 0.672-1.783 | 0.716 | 0.884 | 0.550-1.422 | 0.612 | 1.166 | 0.784-1.732 | 0.448 |
| Age | 1.037 | .992-1.084 | 0.108 | **1.113** | **1.065-1.163** | **<0.001** | **1.128** | **1.084-1.175** | **<0.001** |
| Female | **1.746** | **1.193-2.555** | **0.004** | 1.175 | 0.811-1.703 | 0.394 | **1.498** | **1.107-2.026** | **0.009** |
| Unmarried | **1.725** | **1.209-2.461** | **0.003** | **1.480** | **1.034-2.116** | **0.032** | **1.389** | **1.037-1.861** | **0.028** |
| >=12 years of education | **0.318** | **0.156-0.644** | **0.001** | **0.504** | **0.275-0.925** | **0.027** | **0.533** | **0.333-0.854** | **0.009** |
| US born | 0.835 | 0.589-1.184 | 0.311 | 0.775 | 0.545-1.100 | 0.154 | 0.881 | 0.658-1.18 | 0.396 |
| Spanish language preferred | **2.074** | **1.220-3.526** | **0.007** | 1.405 | 0.872-2.264 | 0.162 | 1.103 | 0.763-1.594 | 0.601 |
| Financial strain | **1.984** | **1.32-2.981** | **0.001** | **1.743** | **1.163-2.613** | **0.007** | 1.226 | 0.845-1.778 | 0.282 |
| Social Support | 1.098 | 0.742-1.624 | 0.640 | 1.034 | 0.707-1.513 | 0.864 | 1.087 | 0.792-1.493 | 0.605 |
| Cancer | 1.249 | 0.617-2.529 | 0.537 | 0.814 | 0.375-1.773 | 0.604 | 1.099 | 0.605-1.998 | 0.756 |
| Stroke | 1.087 | 0.484-2.441 | 0.840 | 1.574 | 0.770-3.214 | 0.213 | 1.581 | 0.816-3.066 | 0.175 |
| Heart Attack | **2.150** | **1.451-3.187** | **<0.001** | **1.738** | **1.167-2.589** | **0.007** | **1.649** | **1.136-2.394** | **0.009** |
| Hypertension | 1.345 | .928-1.949 | 0.117 | **0.685** | **0.480-0.978** | **0.037** | 0.943 | 0.697-1.276 | 0.705 |
| Diabetes | 1.419 | .987-2.041 | 0.059 | 1.095 | 0.751-1.595 | 0.636 | 1.128 | 0.820-1.551 | 0.459 |
| Arthritis | **1.917** | **1.316-2.792** | **0.001** | 0.978 | 0.680-1.406 | 0.905 | 1.593 | 1.179-2.151 | **0.002** |
| BMI >30 | 1.357 | .916-2.039 | 0.126 | 0.888 | 0.581-1.356 | 0.582 | 1.154 | 0.818-1.628 | 0.413 |
| BMI=missing | **2.302** | **1.224-4.328** | **0.010** | **2.782** | **1.505-5.143** | **0.001** | 1.948 | 0.938-4.042 | 0.073 |
| >=1 ADL limitations | **2.531** | **1.71-3.745** | **<0.001** | **1.866** | **1.254-2.776** | **0.002** | - | - | - |
| County Population | 1.000 | 1.000-1.000 | 0.412 | 1.000 | 1.000-1.000 | 0.698 | **1.000** | **1.000-1.000** | **0.010** |
| County Median HH Income | 1.000 | 1.000-1.000 | 0.400 | 1.000 | 1.000-1.000 | 0.260 | 1.000 | 1.000-1.000 | 0.430 |
| % Minority in County | 0.999 | 0.990-1.008 | 0.805 | 0.999 | 0.990-1.008 | 0.847 | **0.985** | **0.978-0.993** | **0.001** |
| % with < HS diploma in County | 1.022 | 0.991-1.055 | 0.179 | 1.014 | 0.982-1.048 | 0.383 | **0.962** | **0.937-0.988** | **0.005** |
| % below poverty in County | 0.995 | 0.959-1.032 | 0.786 | 1.005 | 0.969-1.043 | 0.782 | 0.970 | 0.941-1.000 | 0.054 |

Using logistic regression models that controlled for sociodemographic factors, comorbidities, and county-level characteristics, exposure to a natural disaster, again, was not significantly associated with the development of depressive symptoms, cognitive impairment, or physical limitations (Table 6). Those that had a history of heart failure had higher odds of

developing depressive symptoms (OR=2.111, CI [1.345-3.312]), cognitive impairment (OR=1.936, CI [1.225-3.059], and physical limitations (OR=1.643, CI [1.082-2.495]).

In the fully adjusted model for depressive symptoms, the odds of developing the outcome were increased by being unmarried (OR=1.629, CI [1.067-2.485]), financial strain (OR=1.534, CI [1.006-2.340]), and preferring Spanish for the interview (OR=1.947, CI [1.084-3.495]). An educational attainment of the equivalent of a high school diploma decreased the odds of developing depressive symptoms (OR=0.294, CI [0.135-0.638]).

In the fully adjusted model for cognitive impairment, older age (OR=1.123, CI [1.068-1.179]) and financial strain (OR=1.597, [1.045-2.441]) increased the odds of developing cognitive impairment. Having a missing BMI measurement (CI=2.529, [1.222-5.235]) was also significantly associated with the development of cognitive impairment. Hypertension was protective against developing cognitive impairment (OR=0.528, CI [0.347-0.803]). Further analysis of those participants who reported a history of hypertension revealed that of the 490 participants in the cognitive impairment analytical sample having been told by a healthcare provider that they had high blood pressure or that high blood pressure was suspected to be possible, 442 (90.2%) of them also reported that they were currently taking medication for high blood pressure.

In the full model for limitations in ADLs, older participants (OR=1.132, CI [1.082-1.185]) and females (OR=1.572, CI [1.087-2.272]) both had increased odds of developing physical limitations. Having a doctor's diagnosis of arthritis (OR= 1.437, CI [1.029-2.007]) and having a missing BMI value (OR=2.196, CI [1.000-4.828]) was found to increase the odds of physical limitations. In summary, contrary to the hypothesis for this aim, natural disaster exposure was not significantly associated with all three health outcomes. These results suggest that impacts on these health outcomes related to natural disaster exposure may be mitigated or resolved by other factors in longer-term studies, or that this sample may be resilient to natural disaster exposure in ways not fully captured in this study.

**Table 6. Multivariable logistic models for depressive symptoms, cognitive impairment, and limitations in activities of daily living**

| | CES-D (n=725) | | MMSE (n=774) | | ADL (n=715) | |
|---|---|---|---|---|---|---|
| **Variable** | Odds Ratio | 95% CI | Odds Ratio | 95% CI | Odds Ratio | 95% CI |
| Affected by Natural Disaster | 0.987 | 0.553-1.723 | 0.753 | 0.431-1.316 | 1.118 | 0.710-1.760 |
| Age | 1.020 | 0.969-1.073 | **1.123** | **1.068-1.179*** ** | **1.132** | **1.082-1.185*** ** |
| Female | 1.446 | 0.918-2.277 | 1.205 | 0.766-1.895 | **1.572** | **1.087-2.272*** |
| Unmarried | **1.629** | **1.067-2.485*** | 1.301 | 0.850-1.993 | 1.113 | 0.778-1.593 |
| >=12 years of education | **0.294** | **0.135-0.638**** | 0.628 | 0.324-1.219 | 0.738 | .0437-1.246 |
| US born | 1.114 | 0.738-1.681 | 0.881 | 0.538-1.344 | 0.834 | 0.583-1.703 |
| Spanish Language Preferred | **1.947** | **1.084-3.495*** | 1.240 | 0.713-2.158 | 1.104 | 0.716-1.703 |
| Financial strain | **1.534** | **1.006-2.34*** | **1.597** | **1.045-2.441*** | 1.176 | 0.806-1.715 |
| Social Support | 0.961 | 0.622-1.485 | 1.034 | 0.675-1.584 | 1.123 | 0.790-1.597 |
| Cancer | 1.219 | 0.551-2.698 | 0.683 | 0.286-1.630 | 1.235 | 0.637-2.392 |
| Stroke | 0.773 | 0.301-1.983 | 1.579 | 0.707-3.524 | 1.792 | 0.847-3.791 |
| Heart Attack | **2.111** | **1.345-3.312***** | **1.936** | **1.225-3.059**** | **1.643** | **1.082-2.495*** |
| Diabetes | 1.422 | 0.94-2.152 | 1.437 | 0.940-2.196 | 1.258 | 0.878-1.802 |
| Hypertension | 1.001 | 0.654-1.53 | **0.528** | **0.347-0.803**** | 0.758 | 0.534-1.076 |
| Arthritis | 1.389 | 0.918-2.104 | 0.701 | 0.465-1.059 | **1.437** | **1.029-2.007*** |
| BMI >30 | 0.972 | 0.623-1.518 | 0.883 | 0.556-1.402 | 1.232 | 0.846-1.794 |
| BMI=missing | 1.517 | 0.738-3.117 | **2.529** | **1.222-5.235*** | 2.196 | 0.999-4.828 |
| >=1 ADL limitations | 1.567 | 0.984-2.496 | 1.282 | 0.789-2.084 | ---- | ---- |
| County Population | 1.000 | 0.999-1.000 | 1.000 | 0.999-1.000 | 1.000 | 0.999-1.000 |
| County Median Household Income | 1.000 | 0.999-1.000 | 1.000 | 0.999-1.000 | 1.000 | 0.999-1.000 |
| % Minority in County | 1.010 | 0.984-1.036 | 1.011 | 0.988-1.034 | 0.991 | 0.972-1.010 |
| % with < HS degree in County | 1.044 | 0.984-1.108 | 1.014 | 0.960-1.072 | 0.980 | 0.937-1.025 |
| % below poverty in County | 0.922 | 0.837-1.016 | 0.951 | 0.872-1.037 | 1.002 | .932-1.077 |

*0.01<p<0.05, **0.001 <p≤0.01, ***p≤0.001

## CHAPTER 4

## AIM 2 SENSITIVITY ANALYSIS RESULTS:

## EXAMINING THE OPERATIONALIZATION OF NATURAL DISASTER EXPOSURE

The second aim of this study was to estimate the relationship between natural disaster severity (based on three different operationalizations of natural disaster exposure) on the odds of developing depressive symptoms, cognitive impairment, or physical limitations in Mexican Americans, using multivariable logistic regression and a sensitivity analysis. Additionally, the intraclass correlation coefficients (ICC) for each health outcome were tested, resulting in 0.086 for depressive symptoms, 0.058 for cognitive impairment, and 0.080 for physical limitations. Since all of these ICCs were less than 0.10, I determined that the health outcomes were not nested by county, eliminating the need for mix-effect models or for including the county level variables in subsequent models. The three operationalizations of natural disaster exposure were determined from FEMA county-level disaster data and include 1) the same dichotomous variable used in Aim 1 analyses (1= living in county that received FEMA public assistance funds; 0=living in a county that did not receive FEMA public assistance funds), 2) a continuous variable (total public assistance funds disbursed to a given county between January 1, 2006 to December 31, 2008 divided by the estimated population in the county, expressed in dollars per person), and 3) as a principal component factor described in Chapter 2. For each of the three health outcomes, these three operationalizations of natural disaster exposure were then included in logistic regression models, controlling for sociodemographic variables and comorbidities. Table 7 further details this third method of operationalizing natural disaster exposure by presenting the FEMA variables utilized to operationalize all three versions of the natural disaster exposure variable and perform the principal component analysis, as well as the distribution of these variables across the analytical samples.

In the final analytic sample of 998 participants, 85.47% resided in a county that was affected by a natural disaster in 2006-2008, and the mean number of declared disaster days was 115.73 days (Table 7). The mean “Public Assistance”, “Housing Assistance”, and “Other Needs”

funds disbursed per person in the county was $463.03, $17.92, and $4.03, respectively. The disaster severity variable from the principal component factor (PCA) had a mean of 0.00, a standard deviation of 1.451162 and ranged from -1.21 to 11.23. This variable was further categorized into four groups, following methods developed by Horney et al to investigate the impact of natural disasters on Medicare costs (Horney et al., 2019). First, no disaster exposure was defined as counties that experienced zero days of disaster declarations and received no public or individual assistance funds (n=53). Some disaster severity was defined as a PCA factor value from the minimum value to one standard deviation greater than the mean (n=831). High disaster severity was defined as a PCA factor value from greater than one standard deviation to two standard deviations above the mean (n=32). Extreme disaster severity was defined as greater than 2 standard deviations above the mean (n=82).

## Table 7. Natural disaster variables utilized for sensitivity analyses

| Variable Name | Variable Description | Operationalization Inclusion | Data source | Analytic Sample (n=998) | Depressive Symptoms (n=725) | Cognitive Impairment (n=774) | Physical Limitations (n=715) |
|---|---|---|---|---|---|---|---|
| | | | | | n (%) or mean (sd) | | |
| disasterPAdi060708 | Exposed based on Public Assistance Funds Distributed by FEMA | Dichotomous | FEMA Public Assistance | 828 (82.97%) | 605 (83.45%) | 647 (83.59%) | 588 (82.24%) |
| ddays060708 | # of Days county was affected | PCA | FEMA Declaration Summaries | 115.73 (132.25) | 110.20 (128.18) | 115.83 (132.69) | 116.68 (134.62) |
| PA3yrspercountypopulation | Total Public Assistance dividied by county population | Continuous, PCA | FEMA Public Assistance (numerator) and American Community Survey (denominator) | 463.03 (1834.38) | 520.41 (1940.18) | 502.03 (1972.04) | 430.60 (1735.73) |
| PCAROhousingpercntycap060708 | Housing Assistance (Renters and Owners) divided by county population | PCA | FEMA Renters and Owners Assistance (numerator) and American Community Survey (denominator) | 17.92 (39.34) | 20.02 (41.32) | 18.55 (39.91) | 17.59 (40.47) |
| PCAROotherneedspercntycap060708 | Other needs (Renters and Owners) per person in the county | PCA | FEMA Renters and Owners Assistance (numerator) and American Community Survey (denominator) | 4.03 (9.45) | 4.50 (9.97) | 4.26 (9.82) | 4.16 (10.05) |
| pca1 | Principal Component Factor created from: ddays060708, PA3yrspercountypopulation, PCAROotherneedspercntycap060708, PCAROhousingpercntycap060708 | PCA | As stated above for each variable | 1.51e-10 (1.45) | 0.09 (1.52) | 0.32 (1.49) | -0.004 (1.50) |
| pcacat=0 | No disaster severity | PCA | Categorization of pca1 | 53 (5.31%) | 42 (5.79%) | 41 (5.3%) | 38 (5.31%) |
| pcacat=1 | Some disaster severity | PCA | Categorization of pca1 | 831 (83.27%) | 589 (81.24%) | 639 (82.56%) | 591 (82.66%) |
| pcacat=2 | High disaster severity | PCA | Categorization of pca1 | 32 (3.21%) | 29 (4.00%) | 30 (3.88%) | 28 (3.92%) |
| pcacat=3 | Extreme disaster severity | PCA | Categorization of pca1 | 82 (8.22%) | 65 (8.97%) | 64 (8.27%) | 58 (8.11%) |

**Depressive Symptoms and Natural Disaster Exposure**

Natural disaster exposure, measured as either a binary, continuous, or principal component factor variable, was not significantly associated with developing depressive symptoms between Wave 5 and Wave 7 (Table 8). The odds ratios and confidence intervals for significantly associated confounders are reported in Table 8. Consistently across all three models using different operationalizations of natural disaster severity, the following covariates were found to increase the odds of developing depressive symptoms: being unmarried (56-60% increase), preferring Spanish language during the interview (109-112% increase), financial strain (56-57% increase), diagnosis of a heart attack (102-108% increase) and having limitations in ADLs (60-66% increase). In all three models, having had 12 years or more of education was consistently found to decrease the odds of developing depressive symptom by between 67.4% to 69.8%. In addition, the range of the odds ratios across all three models was remarkably small. The largest difference in odds ratios in the depressive symptoms model was found in the limitations in Activities of Daily Living, which was largest in the model with natural disaster exposure operationalized as a principal component factor (OR=1.660, CI [1.047-2.263]) and smallest in the model with natural disaster exposure operationalized as a dichotomous variable (OR=1.596, CI [1.009-2.524].

**Table 8. Sensitivity of depressive symptoms with binary, continuous, and principal component operationalization of natural disaster exposure**

| **Operationalization** | **Binary** | | **Continuous** | | **Principal Component** | |
|---|---|---|---|---|---|---|
| **n=725** | OR | 95% CI | OR | 95% CI | OR | 95% CI |
| Age | 1.017 | 0.967-1.070 | 1.018 | 0.968-1.071 | 1.021 | 0.971-1.074 |
| Female | 1.407 | 0.899-2.203 | 1.417 | 0.905-2.219 | 1.391 | 0.887-2.182 |
| Unmarried | **1.580** | **1.039-2.402*** | **1.560** | **1.028-2.368*** | **1.599** | **1.050-2.435*** |
| >=12 years of education | **0.325** | **0.152-0.696**** | **0.326** | **0.152-0.695**** | **0.302** | **0.140-0.653**** |
| US born | 1.125 | 0.754-1.678 | 1.110 | 0.745-1.655 | 1.112 | 0.743-1.665 |
| Spanish language preferred | **2.093** | **1.176-3.727*** | **2.119** | **1.188-3.778*** | **2.121** | **1.185-3.798*** |
| Financial strain | **1.560** | **1.033-2.357*** | **1.570** | **1.042-2.365*** | **1.560** | **1.032-2.358** |
| High Social Support | 0.979 | 0.638-1.504 | 0.972 | 0.633-1.493 | 1.013 | 0.657-1.560 |
| Cancer | 1.241 | 0.562-2.740 | 1.236 | 0.560-2.729 | 1.218 | 0.551-2.692 |
| Stroke | 0.750 | 0.296-1.904 | 0.756 | 0.298-1.917 | 0.731 | 0.288-1.852 |
| Heart Attack | **2.047** | **1.313-3.190**** | **2.021** | **1.295-3.153**** | **2.078** | **1.330-3.248***** |
| Hypertension | 1.017 | 0.668-1.548 | 1.006 | 0.660-1.533 | 1.012 | 0.663-1.543 |
| Diabetes | 1.418 | 0.941-2.137 | 1.422 | 0.944-2.143 | 1.465 | 0.968-2.217 |
| Arthritis | 1.390 | 0.924-2.090 | 1.391 | 0.924-2.092 | 1.348 | 0.893-2.034 |
| BMI >30 | 1.025 | 0.661-1.589 | 1.043 | 0.672-1.620 | 1.070 | 0.689-1.663 |
| BMI=missing | 1.527 | 0.754-3.129 | 1.565 | 0.761-3.216 | 1.549 | 0.752-3.189 |
| >=1 ADL limitations | **1.596** | **1.009-2.524*** | **1.613** | **1.020-2.553*** | **1.660** | **1.047-2.633*** |
| Affected by Natural Disaster | 1.129 | 0.668-1.908 | | | | |
| PA$/county population | | | 1.000 | 1.000-1.000 | | |
| Some Natural Disaster Severity | | | | | 1.159 | 0.514-2.612 |
| High Natural Disaster Severity | | | | | 2.549 | 0.796-8.166 |
| Extreme Natural Disaster Severity | | | | | 0.764 | 0.275-2.120 |
| **Pseudo R2 (Model Fit)** | 0.0976 | | 0.0984 | | 0.1036 | |

*0.01<p<0.05, **0.001 <p≤0.01, ***p≤0.001

## Cognitive Impairment and Natural Disaster Exposure

In the sensitivity analysis with cognitive impairment as the outcome, natural disaster exposure, measured as either a binary, continuous, or principal component factor variable, was not significantly associated with the development of cognitive impairment between Wave 5 and Wave 7 (Table 9). Consistently across all three models using different operationalizations of natural disaster exposure, the following covariates were found to increase the odds of developing cognitive impairment: age (by 12%), financial strain (by 57-61%), heart attack (by 92-94%) and having a missing value for BMI (by 157-169%). In all three models of cognitive impairment, and similar to the finding in Aim 1, having hypertension was consistently found to decrease the odds of

developing cognitive impairment by approximately 47%. Table 9 reports the odds ratios and confidence intervals for all variables in the models.

The odds ratios of age, financial strain, heart attack, hypertension and a missing BMI value were highly consistent across all three models. The largest difference in odds ratios was found in having a missing BMI value, which was highest in the model with natural disaster exposure operationalized as a continuous variable (OR=2.687, CI [1.304-5.536) and smallest in the model with natural disaster exposure operationalized as a binary variable (OR=2.571, [1.250-5.288].

**Table 9. Sensitivity of cognitive impairment with binary, continuous, and principal component operationalization of natural disaster exposure**

| **Operationalization** | **Binary** | | **Continuous** | | **Principal Component** | |
|---|---|---|---|---|---|---|
| **n=774** | OR | 95% CI | OR | 95% CI | OR | 95% CI |
| Age | **1.118** | **1.065-1.174*** ** | **1.118** | **1.065-1.174*** ** | **1.119** | **1.065-1.175*** ** |
| Female | 1.196 | 0.763-1.876 | 1.199 | 0.764-1.880 | 1.197 | 0.763-1.878 |
| Unmarried | 1.258 | 0.824-1.920 | 1.266 | 0.830-1.932 | 1.269 | 0.831-1.938 |
| >=12 years of education | 0.663 | 0.343-1.281 | 0.645 | 0.334-1.247 | 0.651 | 0.336-1.262 |
| US born | 0.904 | 0.598-1.367 | 0.906 | 0.559-1.369 | 0.904 | 0.597-1.366 |
| Spanish language preferred | 1.257 | 0.737-2.144 | 1.259 | 0.738-2.147 | 1.208 | 0.707-2.065 |
| Financial strain | **1.610** | **1.060-2.447*** | **1.595** | **1.039-2.388*** | **1.565** | **1.031-2.376*** |
| High Social Support | 1.048 | 0.689-1.596 | 1.040 | 0.683-1.584 | 1.042 | 0.683-1.589 |
| Cancer | 0.687 | 0.287-1.644 | 0.684 | 0.286-1.637 | 0.686 | 0.285-1.647 |
| Stroke | 1.514 | 0.686-3.339 | 1.477 | 0.670-3.256 | 1.492 | 0.677-3.289 |
| Heart Attack | **1.935** | **1.230-3.046**** | **1.919** | **1.218-3.022**** | **1.940** | **1.231-3.057**** |
| Hypertension | **0.534** | **0.352-0.810**** | **0.529** | **0.348-0.803**** | **0.534** | **0.352-0.811**** |
| Diabetes | 1.437 | 0.943-2.190 | 1.450 | 0.951-2.211 | 1.451 | 0.951-2.215 |
| Arthritis | 0.701 | 0.466-1.053 | 0.698 | 0.465-1.050 | 0.708 | 0.469-1.067 |
| BMI >30 | 0.909 | 0.575-1.438 | 0.926 | 0.585-1.466 | 0.913 | 0.577-1.445 |
| BMI=missing | **2.571** | **1.250-5.288**** | **2.687** | **1.304-5.536**** | **2.619** | **1.269-5.404**** |
| >=1 ADL limitations | 1.316 | 0.812-2.133 | 1.306 | 0.806-2.115 | 1.306 | 0.807-2.115 |
| Affected by Natural Disaster | 0.831 | 0.499-1.383 | | | | |
| PA$/county population | | | 1.000 | 1.000-1.000 | | |
| Some Natural Disaster Severity | | | | | 0.927 | 0.408-2.113 |
| High Natural Disaster Severity | | | | | 1.353 | 0.393-4.653 |
| Extreme Natural Disaster Severity | | | | | 1.133 | 0.416-3.090 |
| **Pseudo R2 (Model Fit)** | 0.0906 | | 0.0906 | | 0.0910 | |

*0.01<p<0.05, **0.001 <p≤0.01, ***p≤0.001

**Limitations in Activities of Daily Living and Natural Disaster Exposure**

Table 10 displays the models of the sensitivity analyses with limitations in Activities of Daily Living as the outcome. Natural disaster exposure, measured as either a binary, continuous or principal component variable was not significantly associated with physical limitations between Wave 5 and Wave 7. Consistently across all three models using different operationalizations of natural disaster exposure, the following covariates were found to increase the odds of developing physical limitations: age (by 13%), female sex (by 52-54%), and heart attack (by 69-70%). Having a missing value for BMI were also found to increase the odds of developing cognitive impairment 120% when natural disaster exposure was operationalized as a binary or principal component variable. Arthritis was only found to significantly increase the odds (by 39.5%) of developing a limitation in the Activities of Daily Living when natural disaster exposure was operationalized as a principal component in the model.

The odds of developing a limitation in Activities of Daily Living were more sensitive to the operationalization of natural disaster operationalization in comparison to the other two health outcomes studied. Specifically, arthritis was significantly associated with the outcome in the model with natural disaster operationalized as a principal component. Additionally a missing BMI value was significantly associated with the outcome in only the models with natural disaster operationalized as a binary variable and a principal component. The odds ratios of age, sex and a history of heart failure were highly consistent across all three models and therefore not sensitive to the operationalization of natural disaster exposure. The largest difference in odds ratios was quite small, and was found in having a doctor's diagnosis of heart attack, which was largest in the models with natural disaster exposure operationalized as a continuous variable (OR=1.700, CI [1.126-2.567]) and principal component (OR=1.700, CI [1.125-2.567]) and smallest in the model with natural disaster exposure operationalized as a binary variable (OR=1.686, CI[1.117-2.546]).

**Table 10. Sensitivity of limitations in activities of daily living models with binary, continuous, and principal component operationalization of natural disaster exposure**

| **Operationalization** | **Binary** | | **Continuous** | | **Principal Component** | |
|---|---|---|---|---|---|---|
| **n=715** | OR | 95% CI | OR | 95% CI | OR | 95% CI |
| Age | **1.132** | **1.082-1.183*** ** | **1.130** | **1.081-1.182*** ** | **1.129** | **1.079-1.180*** ** |
| Female | **1.527** | **1.062-2.197*** | **1.519** | **1.055-2.186*** | **1.538** | **1.069-2.213*** |
| Unmarried | 1.098 | 0.772-1.562 | 1.092 | 0.768-1.553 | 1.084 | 0.761-1.544 |
| >=12 years of education | 0.716 | 0.427-1.202 | 0.728 | 0.434-1.220 | 0.730 | 0.435-1.225 |
| US born | 0.953 | 0.675-1.346 | 0.951 | 0.673-1.343 | 0.947 | 0.670-1.340 |
| Spanish language preferred | 1.122 | 0.738-1.706 | 1.129 | 0.742-1.716 | 1.112 | 0.729-1.695 |
| Financial strain | 1.254 | 0.868-1.812 | 1.272 | 0.882-1.837 | 1.259 | 0.870-1.822 |
| High Social Support | 1.151 | 0.814-1.627 | 1.159 | 0.820-1.639 | 1.140 | 0.806-1.614 |
| Cancer | 1.199 | 0.627-2.292 | 1.199 | 0.628-2.291 | 1.219 | 0.637-2.333 |
| Stroke | 1.739 | 0.834-3.626 | 1.764 | 0.846-3.675 | 1.786 | 0.856-3.726 |
| Heart Attack | **1.686** | **1.117-2.546*** | **1.700** | **1.126-2.567*** | **1.700** | **1.125-2.567*** |
| Hypertension | 0.736 | 0.521-1.039 | 0.741 | 0.525-1.046 | 0.747 | 0.529-1.055 |
| Diabetes | 1.212 | 0.850-1.728 | 1.214 | 0.852-1.731 | 1.202 | 0.842-1.716 |
| Arthritis | 1.372 | 0.989-1.904 | 1.374 | 0.990-1.907 | **1.395** | **1.004-1.939*** |
| BMI >30 | 1.215 | 0.839-1.760 | 1.198 | 0.825-1.738 | 1.213 | 0.837-1.757 |
| BMI=missing | **2.207** | **1.015-4.800*** | 2.162 | 0.995-4.699 | **2.202** | **1.010-4.799*** |
| >=1 ADL limitations | | | | | | |
| Affected by Natural Disaster | 1.200 | 0.787-1.830 | | | | |
| PA$/county population | | | 1.000 | 1.000-1.000 | | |
| Some Natural Disaster Severity | | | | | 0.998 | 0.488-2.037 |
| High Natural Disaster Severity | | | | | 0.836 | 0.282-2.472 |
| Extreme Natural Disaster Severity | | | | | 1.350 | 0.557-3.274 |
| **Pseudo R2 (Model Fit)** | 0.072 | | 0.072 | | 0.073 | |

*0.01<p<0.05, **0.001 <p≤0.01, ***p≤0.001

Contrary to the hypotheses for this aim, all of the operationalizations of natural disaster exposure were insignificantly associated with all three health outcomes. The results of the sensitivity analysis examining the operationalization of natural disaster exposure indicated very similar results in model fit (Pseudo $R^2$ ranged from 0.0976-.1036 for depressive symptoms, 0.0906-0.0910 for cognitive impairment, and 0.072-0.073 for limitations in ADLs).

## CHAPTER 5

## AIM 3 EXAMINING THE POTENTIAL MODERATING ROLE OF NATIVITY AMONG AGING MEXICAN AMERICANS EXPOSED TO NATURAL DISASTERS

The third aim of this study was to examine inequalities in these health outcomes by evaluating the potential moderating effect of nativity (US born or other) on natural disaster exposure in aging Mexican Americans. The hypothesis was that in comparison to US-born Mexican Americans exposed to natural disasters, non-US-born Mexican Americans exposed to a natural disaster would have higher odds of developing depressive symptoms, cognitive impairment or physical limitations. Since none of the natural disaster operationalizations in Aim 2 were significantly associated with the health outcomes, and therefore none of them were more informative than the others, the potential moderation of nativity was evaluated with all three of the operationalizations, for all three of the health outcomes.

Moderation was evaluated by conducting simple logistic regression analysis with an interaction term including nativity and natural disaster exposure. A statistically significant p-value for an interaction indicates that the slope of one independent variable differs by levels of a second independent variable. If the p-value of the interaction term is not significant, then the main effects of two independent variables should be examined for statistical significance. If the p-value of the interaction terms is statistically significant, then the investigator must consider the interaction effect to understand the main effects of two independent variables. Specifically in this analysis, the p-value of the interaction term was examined to determine whether the effect of natural disaster exposure varied by nativity. The presence of moderation indicates that the strength and the direction of a relationship between two variables are dependent on a third variable (Hair et al., 2021). Moderation should be considered as a means of accounting for heterogeneity in the data, and specific to this dissertation, moderation was evaluated to determine whether the effect of disaster on these three health outcomes varied by nativity.

Nine total interaction models were examined: three models for each of the three health outcomes, each based on the three operationalizations of natural disaster exposure utilized in Aim 2. These models included the main effects of two variables and the interaction term of those two variables and did not control for sociodemographic variables or comorbidities. The results related to the moderating effect (i.e., interaction term) of nativity on the binary operationalization of natural disaster exposure for the health outcomes of depressive symptoms, cognitive impairment and limitations in activities of daily living are reported in Table 11. In all three models the interaction terms were found to be statistically nonsignificant, or greater than 0.05. Additionally, the p-values for the main effects of natural disaster exposure and nativity were also all statistically nonsignificant.

**Table 11. Moderation of nativity and dichotomous natural disaster exposure variable**

| | **CES-D** | | | **MMSE** | | | **ADL** | | |
|---|---|---|---|---|---|---|---|---|---|
| | OR | 95% CI | p-value | OR | 95% CI | p-value | OR | 95% CI | p-value |
| Natural Disaster Exposure | 0.768 | 0.340-1.733 | 0.525 | 0.775 | 0.347-1.728 | 0.533 | 1.448 | 0.696-3.011 | 0.322 |
| US born | 0.748 | 0.285-1.960 | 0.555 | 0.644 | 0.243-1.706 | 0.376 | 1.333 | 0.575-3.094 | 0.503 |
| Natural Disaster Exposure##Nativity | 1.240 | 0.439-3.502 | 0.685 | 1.348 | 0.472-3.850 | 0.578 | 0.066 | 0.269-1.635 | 0.372 |

The results related to the moderating effect (i.e., interaction term) of nativity on the continuous operationalization of natural disaster exposure for the health outcomes of depressive symptoms, cognitive impairment and limitations in activities of daily living are reported in Table 12. For all three models the interaction terms were found to be statistically nonsignificant. Additionally, the p-values for the main effects of natural disaster exposure and nativity were also all statistically nonsignificant.

**Table 12. Moderation of nativity on natural disaster exposure operationalized continuously as public assistance dollars per county population**

| | CES-D | | | MMSE | | | ADL | | |
|---|---|---|---|---|---|---|---|---|---|
| | OR | 95% CI | p-value | OR | 95% CI | p-value | OR | 95% CI | p-value |
| Public Assistance per county population | 0.999 | 0.998-1.001 | 0.569 | 0.998 | 0.996-1.000 | 0.055 | 0.999 | 0.997-1.000 | 0.134 |
| US born | 0.798 | 0.495-1.287 | 0.355 | 0.631 | 0.392-1.018 | 0.059 | 0.861 | 0.574-1.289 | 0.467 |
| Affected##Nativity | 1.001 | 0.998-1.004 | 0.431 | 1.002 | 0.999-1.005 | 0.137 | 1.000 | 0.998-1.002 | 0.916 |

The results related to the moderating effect of nativity on the operationalization of natural disaster exposure as a principal component for the health outcomes of depressive symptoms, cognitive impairment and limitations in activities of daily living are reported in Table 13. For all three models the interaction terms were found to be statistically nonsignificant. Additionally, the p-values for the main effects of natural disaster exposure and nativity were also all statistically nonsignificant.

**Table 13. Moderation of nativity and natural disaster principal component variable**

| | CES-D | | | MMSE | | | ADL | | |
|---|---|---|---|---|---|---|---|---|---|
| | OR | 95% CI | p-value | OR | 95% CI | p-value | OR | 95% CI | p-value |
| Some disaster exposure | 0.524 | 0.127-2.164 | 0.372 | 0.871 | 0.176-4.306 | 0.866 | 0.862 | 0.189-3.927 | 0.848 |
| High disaster exposure | 2.000 | 0.312-12.840 | 0.465 | 1.167 | 0.151-9.006 | 0.882 | 0.889 | 0.125-6.310 | 0.906 |
| Extreme disaster exposure | 0.560 | 0.111-2.829 | 0.483 | 1.021 | 0.172-6.070 | 0.982 | 1.743 | 0.331-9.189 | 0.512 |
| US born | 0.538 | 0.107-2.715 | 0.453 | 0.980 | 0.165-5.817 | 0.982 | 1.098 | 0.210-5.750 | 0.912 |
| Some ##US Born | 1.880 | 0.355-9.954 | 0.458 | 0.806 | 0.130-5.006 | 0.817 | 0.910 | 0.168-4.927 | 0.913 |
| High ## US Born | 0.495 | 0.049-5.026 | 0.552 | 0.612 | 0.049-7.709 | 0.704 | 0.525 | 0.051-4.927 | 0.587 |
| Extreme ## US Born | 1.184 | 0.152-9.251 | 0.872 | 1.312 | 0.158-10.861 | 0.801 | 0.451 | 0.064-3.196 | 0.425 |

# CHAPTER 6 DISCUSSION AND CONCLUSION

In this dissertation, the potential impact of natural disaster exposure on psychological, cognitive, and physical health outcomes among a large dataset of older Mexican Americans was assessed. The potential association of natural disaster exposure, as defined by FEMA disaster declaration information, with negative health outcomes was assessed in diverse ways, based on different operationalizations of natural disaster exposure. Although there are several studies that indicate the health of older adults is negatively affected after natural disasters, the results from this study with a long-term follow-up indicate that after controlling for several sociodemographic indicators and comorbidities, natural disaster exposure did not increase the odds of depressive symptoms, cognitive impairment or physical impairment among H-EPESE participants four years after baseline measurements. This chapter will discuss the main findings of the three aims presented in Chapters 3, 4 and 5, highlighting the significant predictors of risk and protection for each health outcome.

## *Aim 1: Factors Associated with Long-term Health Outcomes*

### *Natural Disaster Exposure and Long-term health Outcomes*

Natural disaster exposure, operationalized dichotomously, was not significantly associated with the development of depressive symptoms, cognitive impairment or limitations in activities of daily living in this analysis. This is unlikely to be a survivor effect, based on the comparison of those included to those who either moved or were lost to follow-up demonstrated that there were no significant differences in dichotomous exposure, total number of days of disaster declarations, or in the FEMA public assistance dollars granted per person in residing in the county. These findings suggest that the dichotomous operationalization of natural disaster exposure based on county-level FEMA disaster declarations may not be able to capture the impacts of these events.

This would indicate that in order to fully understand the impacts of natural disasters on health, investigators should include more specific and sensitive measurements of natural disaster exposure, such as individual-level surveys, or possibly measurements of disaster severity that are aggregated at a finer geospatial level, such as census tract. Alternatively, these findings might support the possibility that among older Mexican Americans, natural disaster exposure does not influence the incidence of these health effects in a longer-term time period. This would contribute evidence to support the theory that older Mexican Americans may be more resilient than expected, perhaps due to factors that have been found to decrease vulnerability, such as social support.

*Covariates Associated with Long-term Depressive Symptoms*

The risk factors associated with depressive symptoms found in Chapter 3 are supported by other investigations of depression within this population, specifically heart attack (Black et al., 1998), financial strain (Angel et al., 2003; Black et al., 1998; Chiriboga et al., 2002) and being unmarried (Markides & Farrell, 1985). These results also indicate that a higher level of education is a protective factor and that preferring Spanish during the interview is a risk factor of high depressive symptoms, which echoes a study evaluating depression within the initial wave of H-EPESE participants (Black et al., 1998).

*Covariates Associated with Long-term Cognitive Impairment*

Risk factors associated with cognitive impairment were age, financial strain, a missing BMI category, and a physician's diagnosis of heart attack. Older age as a risk factor is supported by other studies on cognition in this population (Alfaro-Acha et al., 2006) and other populations (Crum et al., 1993; Dufouil et al., 2000). Financial strain was associated with cognitive capacity (Angel et al., 2003) and reduced MMSE score in H-EPESE participants with stable cognitive function (Howrey et al., 2015). No other studies in my review of the literature have found a

relationship between missing BMI and cognition, and this issue of missing values at Wave 5 of the H-EPESE population has not fully explained or explored in the literature.

The relationship between heart disease and cognition has been studied previously in the H-EPESE population and other Hispanic cohorts, however the findings have been mixed. Among older Hispanic adults aged 45-74, cardiovascular disease risk factors have been found to be associated with lower levels of cognitive performance, measured with four cognitive tests but not including the MMSE (Lamar et al., 2019). The findings in Aim 1 are somewhat surprising considering other research on similar time periods within the H-EPESE cohort. Controlling for health conditions such as heart disease and hypertension has been found to explain very little in models of incident cognitive impairment in the 2004-2005 H-EPESE cohort specifically (Downer et al., 2018). Additionally, heart disease was not found to be associated with cognitive trajectories in H-EPESE participants when studied between Wave 5 and Wave 8 (Downer et al., 2017), but these differences might be explained by the use of continuous MMSE scores compared to the dichotomous MMSE outcome used in this dissertation.

The only protective factor for cognitive impairment in this analysis was hypertension, perhaps a seemingly surprising result. However, since 90.2% of these hypertensive participants reported that they currently took medication for high blood pressure, this finding supports other results related to the protective effects of blood pressure medication described in the literature. Because consistent associations have been found between arterial stiffness, compromised blood flow and cognitive impairment in older Hispanic populations, blood pressure management is commonly advised in mitigating this relationship (Tarraf et al., 2017). Blood pressure control has been reported to significantly reduce the risk of mild cognitive impairment (Group, 2019), and the function of the aging brain may be protected from mild cognitive impairment by hypertension treatment (Wahidi & Lerner, 2019). Another possible explanation for this finding is that it has been suggested that as a person ages, the effect of elevated blood pressure is less harmful on cognitive

impairment risks, due to natural declines in blood pressure related to weight loss, vessel stiffening and changes in blood flow regulation (Reitz & Luchsinger, 2007).

*Covariates Associated with Long-term Limitations in Activities of Daily Living*

Older age, heart attack and arthritis were found to be significant predictors of increased odds of physical limitations. Similar to results found in other studies examining risk factors associated with physical limitations in H-EPESE participants (Angel et al., 2003; Black et al., 2003; Salinas et al., 2018), older age was significant risk factor for developing this health outcome. Heart attack has also previously been found to be a risk factor for increased limitations in activities of daily living among H-EPESE participants with a stable trajectory of physical limitations (Howrey et al., 2016). However, the results from Aim 1 contradict other studies' results that indicated heart attack was not associated with limitations in ADL in cross-sectional analyses of Wave 5 H-EPESE participants (Nam et al., 2015; Nam et al., 2017). Arthritis was also associated with increased odds of developing physical limitations, and other studies on the H-EPESE population have indicated that comorbidities, such as arthritis, cancer, diabetes, stroke, heart attack, and hip fracture are associated with increase odds of impairments of some activities of daily living (Markides et al., 1996).

The results from Chapter 3 also found that a missing BMI value increased the odds of developing physical limitations. Using Wave 5 in H-EPESE, another study also created a category for missing BMI values in order to avoid losing observations to missing data, and found that in comparison to normal BMI, missing BMI significantly increased the odds of reporting all seven items of the activities of daily living scale (Nam et al., 2017). Creating a missing BMI category, instead of excluding these participants based on missing data, prevents nonresponse bias, but the relationship between a missing BMI value and increased odds of developing physical limitations within the H-EPESE population is not effectively explained and may warrant further investigation.

***Aim 2: Operationalization of Natural Disaster Exposure***

Contrary to the hypotheses for Aim 2, none of the operationalizations of natural disaster exposure were associated with the any of the three health outcomes in any of the models. The results from Chapter 4 demonstrate that the variables associated with the odds of developing depressive symptoms or cognitive impairment remain quite consistent across all three of the models for each outcome, and the three health outcomes are not sensitive to this study's operationalization of natural disaster exposure. In addition to the factors associated with depressive symptoms discussed above, limitations in Activities of Daily Living became significantly associated with increased odds of depressive symptoms once the county-level variables had been removed from the model. This association was also indicated by the bivariate analysis of these two variables, and limitations in ADLs have been found to be associated with increased depressive symptoms in another study of older Mexican Americans (G. V. Ostir et al., 2003).

In contrast to the other two health outcomes, the models for physical limitations indicated that while natural disaster exposure was still not significantly associated with the outcome, the odds of the outcome related to other covariates were sensitive to the operationalization of natural disaster exposure. For example, arthritis was only a significant risk factor for developing limitations in activities of daily living when natural disaster exposure was operationalized as a principal component, and not when natural disaster exposure was operationalized as either a dichotomous or continuous variable. Additionally, a missing BMI value was a significant risk factor for the development of physical limitations, but only when natural disaster exposure was operationalized dichotomously or as a principal component. For both arthritis and missing BMI, the odds ratios remained relatively consistent across the three models, but were only significant in the models mentioned above. The fact that model fit is slightly stronger with the principal component analysis operationalization, and that this operationalization is consistent with simpler operationalizations of natural hazard but is also able to indicate a significant association with arthritis may be important to consider in further research. Additional consideration of the value

and usefulness of creating a PCA instead of relying on a dichotomous natural hazard exposure variable is warranted.

Although there is substantial evidence that natural disaster exposure is associated with adverse health outcomes in older adult populations, as discussed in the introduction, the results from Chapters 3 and 4 indicate that this association is not significant in long-term (e.g., approximately four years) evaluations within this sample of older Mexican Americans. A few explanations for these findings are plausible. First, it is possible that defining natural disaster exposure by county-level FEMA disaster declaration information does not accurately capture the severity of disaster events in a way that is meaningful for health outcomes research. This method of measuring disaster exposure cannot capture individual-level disaster exposure, which causes analyses that use county-level data to be susceptible to ecologic fallacy.

The vast majority of previous disaster research that has demonstrated a significant association between health outcomes and natural disasters has focused on regional or individual exposure to a single disaster event. It is plausible that this approach may be able to measure the health-related impacts in a short period of time, but it prevents the ability to evaluate cumulative health effects of natural disasters. In light of increasingly frequent natural disaster events, exploring methods to capture the health-related impacts of serial disaster events, or natural disaster exposure over the life course, is worth further investigation.

Another possible explanation is that while disasters may immediately and directly affect the short-term health of older adults within a year of the natural disaster exposure, over longer periods of time, age and other sociodemographic factors or comorbidities like heart failure are more influential in the long-term development or maintenance (if pre-existing) of the health outcomes studied in this dissertation. Because there were no disaster declarations for the five H-EPESE states in 2009, there is a year within this follow-up period when no natural disaster exposure occurred, between the last year of natural disaster exposure (2008) and the beginning of Wave 7 survey collection (2010). It's possible that had any of these health outcomes developed

related to disasters in 2006-2008, there was sufficient recovery time in this final year prior to Wave 7 without any natural disaster declarations, which may have created a "washout" effect that removed any associations of natural disaster exposure and these health outcomes. A washout period is considered a time between treatments (or exposures) that is intended to prevent misinterpreting observations about outcomes that might be related to prior therapies or exposures (Harvey et al., 2021).

A final explanation posited here is that it is possible that this sample of older Mexican Americans are particularly resilient to long-term negative impacts of disaster events due to other factors not captured in this study, such as social capital, religiosity or past experience with disaster exposure. Additionally, since just under half of the sample for these analyses are not US-born, there could be an immigrant health advantage as immigrants may be composed of a group that is healthier than those individuals that stay in their country of origin (Marmot et al., 1984).

### *Aim 3: Interaction of natural disaster exposure and nativity*

In all nine models, and in contrast to this aim's hypothesis, nativity, measured as US-born or foreign-born, was not found to be a moderator of the effect of natural disasters on depressive symptoms, cognitive impairment, nor physical limitations. The conceptual framework of this aim's hypothesis was based on the "Hispanic Paradox", which refers to the phenomena observed across a range of health outcomes in which foreign-born Mexican Americans have been found to fare better than expected given this population's generally lower levels of socioeconomic status (Weden et al., 2017). Nativity has been emphasized as an important differentiation to include when examining health outcomes among Mexican Americans (Hunt et al., 2002) due to potential differences in socio-economic status, English language skills, and access to healthcare between immigrants and US-born Mexican Americans. The lack of significant interaction between nativity and disaster exposure may simply be due to the complete lack of association between natural

disasters and health outcomes in this analysis, but the evidence of the role of nativity in health outcomes is mixed.

The literature specifically related to cognitive impairment contains inconsistent findings related to the role of nativity on health outcomes. Among both adult men and women over the age of 50 in the Health and Retirement Study, in comparison to non-Hispanic whites, US-born and foreign-born Hispanic people spend a larger portion of their remaining years with cognitive impairment and dementia. Further, foreign-born Hispanics had the worst outcomes out of these three groups (Garcia et al., 2019). Alternatively, in a study investigating nativity, sex and the age of migration among older Mexican-Americans, the incidence of cognitive impairment did not differ for early-life and midlife immigrant women relative to U.S.-born women, but late-life immigrant women had a 46% higher risk of cognitive impairment relative to US-born Mexican American women, while midlife immigrant men had a 29% lower risk of cognitive impairment in comparison to US-born Mexican American men (Garcia et al., 2018). Another example of the role of nativity on health outcomes is that among H-EPESE Wave 5 participants, nativity significantly moderated effect of sex on limitations of Activities of Daily Living, indicating that Mexican-born women were more "disabled" than the US-born women, while the opposite was true for men (Nam et al., 2015).

The concept of acculturation, which is often operationalized by nativity, is rooted in social science and is considered a process closely related to the health status of minority populations living in a multicultural society. Measures of acculturation have the potential to identify risk factors associated with increased chronic disease prevalence, but some authors argue that nativity may not be an accurate proxy of acculturation (Collins et al., 2013). Some propose that discordant findings in health research on US Hispanics could be at least partially due to incomplete dimensions in the concept of acculturation, or possibly not accounting for how dynamic and varied this process is (Chakraborty & Chakraborty, 2010). Attempting to characterize culture or acculturation with a single categorical variable, like nativity, may be insufficient to create thorough

analyses of its role in health outcomes, which has led some investigators to suggest the use of both qualitative and quantitative methods (Page, 2005). Additionally, language abilities, length of residency in the United States, and age at migration into the United States are considered important aspects of acculturation, yet there are several other cultural factors that may interact to play a substantial role on health outcomes, such as socioeconomic background, education, country of origin, stress levels, social support, and spirituality (Siatkowski, 2007). Essentially, nativity as a dichotomous variable may not fully capture the complexity of acculturation, particularly in the natural disaster context where response and recovery processes rely heavily on access to resources and information.

While nativity has been used in several health studies, for investigations related to natural disasters, it may have been more informative to consider age at migration or citizenship, which is an area slated for future study following this dissertation. These two other variables may be more informative at estimating the cultural background or ability and resources to prepare for and respond to a natural disaster. Some investigators examining acculturation and health have constructed four nativity categories for Mexican Americans: 1) those born in the United States; 2) those that migrated to the US before the age of 20; 3) those that migrated to the US between the ages of 20-49; and 4) those that migrated to the US at the age of 50 or older (Angel & Angel, 1992; Vásquez et al., 2021). Citizenship may indicate what formal resources are available to disaster survivors, evidenced by a study demonstrating that among those affected by Hurricane Harvey, foreign-born Hispanics without US citizenship were more likely to experience unmet needs and adverse events in comparison to Hispanic US citizens (Flores et al., 2020). Other researchers have used both age at immigration and citizenship to create a variable with three categories: 1) US-born; 2) foreign-born and migrated before the age of 20, or "early arrivers"; and 3) foreign-born and migrated at age 20 or older, termed "late arrivers" (Gubernskaya, 2014; Kimbro, 2009; Zhang et al., 2021).

Another neighborhood-level characteristic that may be informative in natural disaster research is the role of "immigrant enclaves," which refers to a higher level of ethnic homogeneity within a community. As an example of the protective effects of immigrant enclaves, among community-dwelling older adults in the Health and Retirement Study, foreign-born Mexican Americans were found to have decreased odds of prevalent cognitive impairment in comparison to US-born non-Hispanic whites, and this was protective effect was attributed to residence in an immigrant enclave (Weden et al., 2017). Additionally, in addition to individual characteristics, residence in an ethnically dense Mexican-American neighborhood conferred protective effects on frailty (Aranda et al., 2011). The importance of considering community-level factors such as ethnic enclaves was highlighted by a finding that indicated that Mexican Americans living in neighborhoods with a higher percentage of Mexican American population had lower CES-D scores (G. V. Ostir et al., 2003). Immigrant enclaves may also provide an advantage that enables Mexican Americans to access information and resources that protect them from the damaging impacts or losses related to a natural disaster.

While immigrants to the United States are less likely to have chronic health conditions, appropriate health care policies are needed to reduce inequities between noncitizen immigrants and US-born residents (Bustamante et al., 2021), and this perspective can also enlighten disaster management policy and planning. Some authors have argued that social and economic determinants of health are more important predictors than culture or acculturation and that health disparities would be more effectively decreased by improving the material conditions of low-income Latinos (Zambrana & Carter-Pokras, 2010). However, culture is a core issue in health disparities research, and should be included to help identify relationships between structural factors like education and socioeconomic status and cultural factors like knowledge, beliefs and attitudes about health (Page, 2005). Additionally, minoritized groups are often marginalized in locations with higher risks of natural disaster exposure and impacts (Julia L. Perilla et al., 2002). Future

research could investigate the potential moderating effect of preferred language, social support, or financial strain.

## FUTURE DIRECTIONS AND CHALLENGES OF NATURAL DISASTER RESEARCH

This dissertation addresses a gap in the literature by being one of the first studies to examine how natural disaster severity influences the long-term health outcomes in Mexican Americans residing in the United States. This study also explores how natural disaster severity can most accurately be operationalized so that researchers and stakeholders can fully capture the impact of natural disasters on human health. Three opportunities for further investigation are discussed below.

First, measuring natural disaster exposure is a broadly recognized challenge in the literature, and it is important the future studies carefully consider the operationalization of natural disaster exposure to better understand health outcomes related to these events. Researchers investigating the relationship between environmental exposures and health have noted the weakness of operationalizing exposure on local scales due to the modifiable areal unit problem (MAUP) and have expressed the need for alternative measurements (Parenteau & Sawada, 2011); however, it is also important to consider the role of community-level characteristics in health outcomes and disaster response and recovery. Future studies could advance the field by including measurements of both individual- and community-level natural disaster severity. The validity of objective, community-level disaster severity measurements, like FEMA disaster declarations, could be evaluated by comparing these measurements, which are usually reported on a larger geographical scale, to self-reported individual measurements obtained from residents in areas affected by natural disasters. Alternatively, one of the many indices of disaster-related experiences that has been developed could be more widely adopted in natural disaster research, which would allow investigators to evaluate more consistent measures of exposure and enable comparisons between groups affected by different types of disasters. Most disaster management publications

over the last 75 years has been overwhelmingly descriptive of a single disaster event (Smith et al.) and there is a need for more enhanced measures of natural disaster exposure in order to improve generalizability.

Second, future studies should consider the cumulative effects of multiple exposures of natural disasters. Currently, comparisons of the role of natural disasters on health are particularly hindered because most of the health-related literature focuses on a single disaster event, like Hurricane Katrina, Hurricane Sandy, or the Great East Japan Earthquake and Tsunami. In an attempt to address this limitation in the literature, this study evaluated the total days that a disaster declaration was in place, as well as the total dollars spent on disaster-related damage over a span of three years. However, due to the time-varying interview days within Wave 5 and Wave 7, it is possible that disaster exposure in this study is underreported due to disaster events that may have affected an individual after their interview but prior to January 1, 2006, or before their Wave 7 interview but after December 31, 2009. Further studies could improve on this by having more precise start/end dates, by increasing the time reviewed to consider longer-term exposure, and also by comparing participants with exposure to a single natural disaster versus serial or multiple exposures.

Third, based on previous research, including an evaluation of the protective role of social resources and neighborhood characteristics may be an important consideration in health outcomes related to stressful events, including natural disaster. Social support may be a potential moderator of natural disaster exposure on health outcomes, and evidence indicates that it may be relevant in the disaster recovery context. For example, lower social support was associated with PTSD symptoms in older adults exposed to Hurricane Sandy (Heid et al., 2016). Perceived social support buffered the development of depressive symptoms in adults exposed to Hurricane Katrina (McGuire et al., 2018). Social support was also found to moderate the stressor-distress relationship among adult tourists exposed to the 2004 Indian Ocean tsunami (Arnberg et al., 2012). Pre-disaster perceived social support decreased self-reported exposure to natural disasters as well as the

negative psychological effects of natural disaster exposure in low-income mothers affected by Hurricane Katrina (Lowe et al., 2010). Older adults who had increased neighborhood ties were less likely to have depressive symptoms 2.5 years after the 2011 Great East Japan Earthquake and Tsunami, even after controlling for damaged suffered, (Sasaki et al., 2020). The potentially beneficial role of social support in mitigating psychological suffering post-disaster should be further explored to better inform policy recommendations in vulnerable populations.

Social support has also been found to be associated with other factors, like disaster preparedness, that may be related to long-term health outcomes. Among Mexican Americans living in three Texas counties noted for high poverty levels and frequent hurricane exposure, higher perceptions of trust and fairness were associated with higher prevalence of disaster preparedness (Reininger et al., 2013). Additionally, during the 1995 Chicago heat wave, areas with higher concentrations of older adults had lower mortality rates, indicating that there may be an advantage to a shared social support network (Browning et al., 2006). Social support is often considered to be a known protective factor against negative psychological outcomes of natural disasters (McGuire et al., 2018), however older adults have also been found to perceive and report lower social capital ties, particularly those that may counteract social vulnerabilities to disaster impacts (Meyer, 2017). These findings support the importance of prioritizing future research on social support and social capital among older adults to better understand how to incorporate these resources in effective disaster preparedness and recovery strategies.

## LIMITATIONS AND STRENGTHS

There are a few limitations of this study that should be discussed. Most importantly, the data available from FEMA is that the natural disaster exposure-related variables are reported by county or zip code, and these results are vulnerable to ecological fallacy. Therefore, exposure to natural disasters is measured equally for individuals living in the same geographical unit, even though they may not have experienced the same damage, trauma or loss from a natural disaster.

While this is a common limitation in natural disaster research, the modifiable areal unit problem factors into this study, and examining disaster severity at other levels (e.g., self-report or census tracts) could lead to different conclusions. Additionally, information about individual-level exposure to natural disasters is not included in the H-EPESE survey, therefore there isn't currently a method of examining the potential of FEMA disaster declarations as a proxy measurement of individual exposure. If an individual-level measurement of natural disaster exposure could be measured more specifically (perhaps through a prospective cohort study dedicated to examining the impacts of natural disaster on long-term individual health outcomes of aging Mexican Americans), then the impacts of natural disasters on depressive symptoms, cognitive impairment and physical limitations could be more accurately estimated.

Another limitation related to the data used for this analysis is that estimates of county population were obtained from the 2010 American Community Survey. These estimates served as the denominator when creating the public assistance disbursed per person in the county, so this operationalization of natural disaster exposure may over- or under-estimate the dollars spent per person. However, this is currently the most accurate public use data we have available that was valid for this study population.

This study also only examines natural disaster exposure in the four years between the baseline and final outcomes measured at Wave 5 and 7 respectively, and therefore cannot account for exposure to natural disasters over the life course, so these results may be underestimated or confounded by prior disaster experiences. Additionally, it is possible that some participants were lost to follow-up due to harm or displacement from a natural disaster, in which case the results may be underestimated.

This study sample consists of a representative sample of older adults of Mexican origin from five southwestern U.S. states, thus the findings of this study may not be generalizable to the broader U.S. population or even those with other Hispanic origins, as Hispanic groups are not homogenous. Investigating the effects of natural disasters on health outcomes was not one of the

aims of the original study design of H-EPESE, so there may be potential confounders that cannot be accounted for this study. Finally, while the outcomes in this study are based on self-report by the participant, which can be subject to recall bias, these measurements are applied consistently in the H-EPESE survey waves, so I estimated that these outcomes were appropriate measures to detect change in depressive symptoms, cognitive impairment, and physical limitations.

Despite these limitations, this study has several strengths. Importantly, based on my review of the literature, it is the first to examine the influence of cumulative, multi-year natural disaster exposure on long-term health outcomes in a large, representative aging Mexican American population. Another strength is that this study evaluates measures of psychological, cognitive, and physical health, which, in comparison to studies that focus on a single health outcome, enables a more thorough evaluation of the impact of natural disasters on human health. Additionally, no studies have yet assessed the role of nativity on health outcomes in the Mexican American population impacted by multiple natural disasters in the United States.

While this study is not able to include individual-level natural disaster exposure, the application of multiple operationalizations of FEMA natural disaster declaration information provides an additional method to consider when investigating health outcomes related to disasters. This project attempts to address the gap in the literature by examining how natural disaster severity can best be operationalized so that researchers can most accurately capture the impact of natural disasters on human health. Lastly, this study evaluates risk factors associated with the health of minoritized elderly individuals and enables a comparison of participants residing in counties with varying levels of natural disaster exposure.

## CONCLUSIONS AND IMPLICATIONS

In conclusion, this study demonstrated that between Wave 5 and Wave 7 of the H-EPESE study, natural disaster exposure was not a statistically significant predictor of long-term depressive symptoms, cognitive impairment, or limitations in activities of daily living among older Mexican

Americans. Natural disaster exposure was measured cumulatively for three years based on participants' county of residence, but this exposure did not affect the odds of developing adverse health outcomes four years after the baseline health measurements. Another conclusion of this study is that nativity is neither a significant main effects predictor for depressive symptoms, cognitive impairment or physical limitations, nor does it moderate a relationship between natural disaster exposure and adverse health outcomes.

The lack of an association between disaster exposure and long-term health outcomes supports the maturation theory, suggesting that these older Mexican American adults may be more resilient to stress, loss or damage related to natural disasters. However, as this is one of the first studies to examine the influence of natural disasters on the health of older Mexican American, researchers and emergency planners should interpret these results with caution, and with the understanding that further research should be conducted before concluding that this population is not vulnerable to extreme weather events at other times or in other conditions. The role of culture, social support and other coping strategies should be further examined to understand how these resources influence the way natural disasters affect health among older Mexican Americans.

This study emphasizes the challenges and limitations of measuring and operationalizing cumulative natural disaster exposure. Understanding the long-term effects of natural disasters on health outcomes among vulnerable populations is important, particularly as communities prepare and respond to increasing numbers of disaster events. The operationalization of natural disaster exposure is an important component of methodological framework utilized for this study and researchers should consider including both individual-level perceived exposure as well as environmental or aggregated measures of exposure based on factors related to the impacts of the event.

Considering current research gaps in how natural disasters affect both the short-term and long-term health of the expanding elderly Hispanic population in the United States, it is critical to improve the understanding of how these events are measured as well as how this population's

health is impacted by natural disasters. Considering the predictions of increased natural disaster frequency and severity in the near future, these findings may inform the four phases of disaster management in communities with a substantial proportion of elderly Mexican Americans. These results can inform the disaster management process in anticipation of changing demographic composition and continued human exposure to natural disasters in the United States.

## HUMAN PARTICIPANT PROTECTION

This retrospective cohort study is using secondary data which is completely de-identified. As such, it is exempt from the institutional board review and does not require human research-related instruments nor human subject consent forms. The Institutional Review Board of the University of Texas Medical Branch (UTMB) approved the initial H-EPESE study, all research protocols and informed consents, in 1993 as well as annual continuing review applications since then.

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# VITA

AMIE HUFTON

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## EDUCATION

Exp 2023 **ABD; PhD in Population Health Sciences, University of Texas Medical Branch**
DISSERTATION: "The Influence of Natural Disaster Severity on Incident Adverse Health Outcomes Among Mexican Americans"
COMMITTEE: John Prochaska (Chair), Daniel Jupiter, Kyriakos Markides, Bret Howrey, Wesley Highfield

2010 **Masters in Marine Resource Management, Texas A&M University at Galveston**
Graduate Assistant for Hurricane Ike Community Resiliency Project (PI Shannon Van Zandt); Hazard Reduction & Recovery Center, Texas A&M University

2002 **B.S., Marine Biology, Honors, Texas A&M University at Galveston**

## PROFESSIONAL APPOINTMENTS

2022-present The Ohio State University
Associate Professor of the Practice, Division of Epidemiology

2021-2022 Texas A&M University at Galveston
Instructional Professor, Department of Liberal Studies Joint-appointed in Department in Foundational Sciences

2016-2021 Texas A&M University at Galveston
Instructional Associate Professor, Department of Liberal Studies

2012-2016 Texas A&M University at Galveston
Instructional Assistant Professor, Department of Liberal Studies

2008-2012 Texas A&M University at Galveston
Lecturer, Department of General Academics

## AWARDS AND HONORS

2022 Texas A&M University at Galveston Vice President's Meritorious Service Award in Outstanding Classroom Teaching (1 annual awardee amongst approximately 150 faculty within the regional campus)

2022 The Association of College and University Educators (ACUE) and the American Council on Education Certificate in Effective College Instruction

2021 Member of the Winning Team in the "Interprofessional Education Case Competition for the Pursuing Health Equity" sponsored by the Texas Area Health Education Centers (AHEC) East at the University of Texas Medical Branch (awarded $500)

2020 Michael Gilles Purgason Memorial Scholarship, Graduate School of Biomedical Sciences, University of Texas Medical Branch

2019 Laura Ray Scholarship, Graduate School of Biomedical Sciences, University of Texas Medical Branch

2019 Galveston County "40 Under 40" Honoree; Awarded by the Galveston County Daily News in recognition of Galveston County's outstanding professionals under the age of 40. "These individuals have demonstrated personal and professional success and a commitment to the community."

## RESEARCH INTERESTS

- Recovery strategies of minoritized populations affected by natural disasters
- Risk factors associated with adverse physical, mental and cognitive health in aging minoritized populations
- Costs and disparities associated with drowning and submersion injuries
- Application of GIS to public health issues and community based participatory research

## EXTERNAL FUNDING

2021-2022 $27,000 1-year pilot grant from Texas Resource Center for Minority Aging Research; Supported by Grant Number P30AG05930101 from National Institutes of Health and National Institute on Aging. Project Title: "The Influence of Natural Disaster Severity on Incident Adverse Health Outcomes Among Mexican Americans"
Role: Principal Investigator; Research Team: Hufton, Prochaska

## PUBLICATIONS

Merrell, W., L. Reynolds, A. Cardenas, J. Gunn, and **A. Hufton**, The Ike Dike: A Coastal Barrier Protecting the Houston/Galveston Region from Hurricane Storm Surge, In: Macro-engineering Seawater in Unique Environments, Viorel Badescu ed., Springer Press, 691-716, 2011

## CONFERENCE PRESENTATIONS

04/22 "The Influence of Natural Disaster Severity on Incident Adverse Health Outcomes Among Mexican Americans"; Twitter Poster Session for Resource Centers for Minority Aging Research (RCMAR) Annual Meeting

10/21 "Prevalence and cost associated with submersion injuries in the US: A cost of injury analysis of ED and inpatient care"; Regina Hansen, MPH, **Amie Hufton**, MARM and Michael Hansen, MD, MPH, MS; American Public Health Association Annual Meeting and Expo

10/21 "Evaluation of natural disasters as a risk factor of incident health outcomes among Mexican Americans"; Poster Session at Forum on Aging, Sealy Center of Aging, University of Texas Medical Branch

5/21 "Spatial and temporal distribution of open water aquatic injuries and drownings in Galveston, Texas"; **Amie Hufton**, MARM; Leyha Williams (high school student); Regina Hansen (MPH student); and John Prochaska, DrPH, MPH; Presentation at Estuaries and the Anthropocene Virtual Symposium, Texas A&M University at Galveston

4/21 "Evaluation of natural disaster exposure as a risk factor of incident depressive symptoms among Mexican Americans"; Remote Poster Session at University of Texas Medical Branch 2021 Public Health Symposium

11/20 "Questioning if society might have a stronger influence on identity than we realize"; Panel Member, Texas A&M University at Galveston Common Reader Program Panel Discussion

4/19 "Spatial and temporal distribution of open water aquatic injuries and drownings in Galveston, Texas"; Poster Session at 2020 Public Health Symposium, University of Texas Medical Branch; *Event canceled due to COVID-19*

9/18 "Critical Reflections on the TAMUG Common Reader"; Panel Member for roundtable at Texas A&M University at Galveston Conference on Inclusion and Diversity for Higher Education in Galveston, Texas

5/17 "Just Add Water- Engaging college students and youth"; Presentation at National Association of Underwater Instructors (NAUI), International Conference on Underwater Education (ICUE), Long Beach, California