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# An Environmental Justice Examination of Hispanic Immigrants' Flood Hazard Exposure and Vulnerability in the Miami and Houston Metro Areas

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AN ENVIRONMENTAL JUSTICE EXAMINATION OF HISPANIC  
IMMIGRANTS' FLOOD HAZARD EXPOSURE AND  
VULNERABILITY IN THE MIAMI AND HOUSTON METRO AREAS

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AN ENVIRONMENTAL JUSTICE EXAMINATION OF HISPANIC  
IMMIGRANTS' FLOOD HAZARD EXPOSURE AND  
VULNERABILITY IN THE MIAMI AND HOUSTON METRO AREAS

by

Alejandra Maldonado, B.A.

THESIS

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## Abstract

Research reveals that disasters are particularly debilitating for racial/ethnic minorities. However, prior studies of racial/ethnic dimensions of disaster vulnerability have lumped people together in broad categories (e.g. Hispanic) without regard for substantial within-group heterogeneity. As a result, aspects of disaster vulnerability experienced by Hispanic immigrants (distinguished from US-born Hispanics) have been concealed. Using survey data from 1,283 adult householders in the Houston and Miami Metropolitan Statistical Areas and follow-up interview data from a subset of survey respondents, this thesis addresses that limitation by examining whether Hispanic immigrants experience heightened flood risk relative to other social groups. The thesis is comprised of two studies. The first study uses generalized estimating equations with binary logistic specifications adjusted for county-level clustering to clarify determinants of exposure to residential flood hazards among survey respondents. The second study uses a subset of survey and follow-up interview respondents residing in flood zones and employs mixed methods to analyze differences in self-protective action, risk perception, and hazard-specific knowledge between Hispanic immigrants, US-born Hispanics, and US-born non-Hispanic Whites. Results from the first study indicate Hispanic immigrants are significantly more likely to reside in 100-year flood zones in Houston and significantly less likely in Miami, compared to non-Hispanic Whites. Results from the second study indicate Hispanic immigrants experience greater flood hazards vulnerability in terms of significantly lower levels of self-protection and hazard-specific knowledge, despite their significantly higher levels of risk perception. Future research should move beyond the monolithic treatment of the US Hispanic/Latino population and assess contextual influences on risk disparities, while risk reduction programs should target the particular vulnerabilities of Hispanic immigrants.

## Table of Contents

Abstract.....	iii
1. Introduction.....	1
1.1. Background & Overview.....	1
1.2. Research Questions & Hypotheses.....	2
1.3 Statement of Collaboration .....	3
1.4. Significance .....	4
2. Exposure to Flood Hazards in Miami and Houston: Are Hispanic Immigrants at Greater Risk Than Other Groups?.....	5
2.1. Introduction .....	5
2.2. Literature Review.....	7
2.2.1. Race, Ethnicity, SES & Environmental Justice in Flood Hazard Exposure.....	7
2.2.2. Water-based Amenities and Flood Exposure.....	9
2.2.3. Self-protection from Flood Hazards.....	10
2.2.4. Risk Perceptions and Flood Hazards.....	11
2.3. Study Areas & Data .....	12
2.3.1. Study Areas: The Houston and Miami MSAs .....	12
2.3.2. Data Collection .....	16
2.3.3. Analysis Variables .....	17
2.3.3.1. Independent Variables.....	17
2.3.3.1.1. Race/Ethnicity/Nativity.....	17
2.3.3.1.2. Socioeconomic Status (SES).....	22
2.3.3.1.3. Water-based Amenities.....	23
2.3.3.1.4. Self-Protection .....	23
2.3.3.1.5. Flood Risk Perceptions.....	24

2.3.3.2. Dependent Variable: Residential Exposure to 100-Year Flood Risk.....	24
2.4. Analytic Strategy.....	25
2.5. Results.....	26
2.5.1. Bivariate Group Comparisons.....	26
2.5.2. Generalized Estimating Equations.....	28
2.6. Discussion.....	31
2.7. Conclusion.....	37
3. Hispanic Immigrants' Vulnerabilities to Flood and Hurricane Hazards.....	40
3.1. Introduction.....	40
3.2. Data & Methods.....	43
3.2.1. Study Communities.....	43
3.2.2. Data Collection.....	44
3.2.3. Quantitative Measures.....	50
3.2.4. Analysis Methods.....	53
3.3. Results.....	55
3.3.1. Research Question 2.....	55
3.3.1.1. Differences in Self-Protection.....	55
3.3.1.2. Differences in Risk Perception.....	57
3.3.2. Research Question 3: Why do differences in self-protection and risk perceptions exist between the three groups?.....	57
3.3.2.1. Divergent Housing Tenure Arrangements.....	58
3.3.2.2. Inequitable Access to Resources Based on Socioeconomic and Immigrations Status.....	59
3.3.2.3. Gaps in Knowledge.....	63
3.3.2.4. Risk Perceptions: Possible Explanations for Observed Differences.....	64

3.4. Conclusion.....	66
4. Summary and Implications.....	70
4.1. Summary.....	70
4.2. Policy Implications.....	71
4.3. Directions for Future Research.....	73
5. References.....	74
6. Vita.....	91

## List of Tables

### Chapter 2

Table 2.1. Variables, Curvey Questions & Coding .....	19
Table 2.2. Descriptive Statistics.....	21
Table 2.3. Group Comparisons by Presence/Absence in 100-Year Flood Zone.....	28
Table 2.4. Generalized Estimating Equations: Pooled Results for Models Predicting 100-Year Flood Zone Exposure.....	31

### Chapter 3

Table 3.1. Characteristics of Survey Respondents by Group.....	48
Table 3.2. Characteristics of Interview Participants.....	49
Table 3.3. Quantitative Measures: Variables, Survey Questions, & Coding.....	53
Table 3.4. Comparison of Flood/Hurricane Self-protection and Risk Perception by Group.....	56



## List of Figures

### Chapter 2

Figure 2.1. Flood Zones & Approximate Locations of Survey Respondents in the Houston MSA, Texas Study Area .....	14
Figure 2.2. Flood Zones & Approximate Locations of Survey Respondents in the Miami MSA, Florida Study Area.....	15

## 1. Introduction

### 1.1. Background & Overview

According to the US Geological Survey, floods are the leading cause of natural disaster losses in the US with damages averaging almost 8 billion dollars and over ninety human lives per year (USGS 2016). Although floods can impact any community, research shows that members of some social groups may be disproportionally exposed to and impacted by environmental hazards. Due to their disadvantaged social status, Hispanic immigrants may be subjected to higher flood risks than many other social groups. However, despite the fact that Hispanic immigrants may face acute challenges in protecting themselves against flood risks, most studies that have been conducted on hazard vulnerability and environmental justice (EJ) have treated the Hispanic population as a homogeneous group (Bolin 2007; Grineski et al. 2014). Lumping all Hispanic people together in hazards and EJ scholarship forecloses our ability to clarify the distinctive vulnerabilities of Hispanic immigrants (relative to US-born Hispanics, US-born non-Hispanic Whites, or other social groups) deriving from factors such as immigration status and linguistic isolation. Failing to take into consideration characteristics that are particularly pertinent to Hispanic immigrants leaves a substantial gap in hazards and EJ scholarship, as salient differences between Hispanic subpopulations that may shape experiences of vulnerability are ignored (Collins et al. 2011; Grineski et al. 2014). This gap in the research means that hazard reduction efforts may fail to properly serve groups such as Hispanic immigrants. As the Hispanic immigrant population continues to grow, with this group already encompassing 6.6% (or 21 million) of the US population, it is increasingly important to expand knowledge regarding the sources and consequences of the hazard vulnerabilities and environmental injustices they experience.

This thesis is comprised of two related yet distinct studies, based on data collected through surveys and interviews with residents of the flood-prone metro areas of Houston and Miami. Each study seeks to examine the flood risks confronting Hispanic immigrants in comparison to other social groups. Following prior distributive EJ research, Chapter 2 of the thesis consists of a first study that quantitatively analyzes whether Hispanic immigrants experience disproportionate exposure to flood risks compared to other groups. Chapter 3 of the thesis consists of a second study focused specifically on study participants living in locations at high risk to flooding; this study employs a mixed method approach to describe and explain differences in levels of flood self-protection, risk perception, and hazard-specific knowledge between Hispanic immigrants, US-born Hispanics, and US-born non-Hispanic Whites. Since the emphasis on flood risks experienced by Hispanic immigrants in the US context is novel, findings from this thesis contribute to the literatures on EJ and social vulnerability to hazards and disasters.

## 1.2. Research Questions & Hypotheses

Study 1 addresses the following research question (RQ) and hypothesis (H):

RQ1: Are Hispanic immigrants disproportionately exposed to risks from flood hazards, adjusting for relevant covariates, including other race/ethnicity/nativity categories, housing tenure,

household income, educational attainment, and the desire to live close to water-based amenities?

H1: Hispanic immigrants are disproportionately exposed to risks from flood hazards compared to other social groups, accounting for the effects of other relevant variables.

The following RQs and Hs are addressed by Study 2:

RQ2: What differences exist in self-protective actions and perceptions of risk between Hispanic immigrants, US-born Hispanics, and US-born non-Hispanic White residents who live at high risk to flooding and hurricanes?

H2: Hispanic immigrants take less protective action against flood and hurricane risks, and exhibit higher levels of risk perception, as compared to US-born Hispanics and US-born non-Hispanic Whites.

RQ3: Why do differences in self-protective actions taken and perceptions of risk exist between Hispanic immigrants, US-born Hispanics, and US-born non-Hispanic White residents?

H3: Hispanic immigrants exhibit a reduced likelihood of having flood hazard mitigation measures implemented at their home sites due to factors such as socioeconomic status, residency status and language barriers. Hispanic immigrants exhibit higher levels of flood risk perception due to their relatively low socioeconomic status, disadvantaged minority status, and insecure US residency status (in some cases).

### 1.3. Statement of Collaboration

As previously mentioned, this thesis consists of two distinct studies. Both studies have been accepted and published by peer-reviewed academic journals. These studies were completed in collaboration with specific members of the thesis committee. Most of the research was conducted by the first author under the guidance and with the ongoing feedback of the committee members.

Chapter 2: Maldonado, A., Collins, T. W., Grineski, S. E., & Chakraborty, J. (2016). Exposure to Flood Hazards in Miami and Houston: Are Hispanic Immigrants at Greater Risk than

Other Social Groups? *International Journal of Environmental Research and Public Health*, 13 (8), 775.

Chapter 3: Maldonado, A., Collins, T. W., & Grineski, S. E. (2016). Hispanic Immigrants' Vulnerabilities to Flood and Hurricane Hazards in Two US Metropolitan Areas. *Geographical Review*, 106 (1), 109-135.

#### 1.4. Significance

This thesis contributes to hazards and environmental justice (EJ) research on several levels. First, it enables multi-dimensional examination of environmental injustices faced by Hispanic immigrants, by comparing their predicament relative to other groups based on multiple measures of vulnerability to flood hazards. The measures of vulnerability to flooding examined include residents' exposure to risks from flood hazards, perception of flood risk and self-protection against flood hazards. This is significant because prior studies have almost exclusively focused on one measure of vulnerability. Second, instead of providing an analysis at the neighborhood level, as nearly all previous studies have done, this research provides among the first quantitative analyses of vulnerability to flooding conducted at the individual/household level from an EJ perspective. Finally, in addition to contributing to the emerging literature on EJ and flood hazards, findings from this thesis may provide a foundation for targeted interventions for Hispanic immigrants that successfully reduce their risks to flooding.

## 2. Exposure to Flood Hazards in Miami And Houston: Are Hispanic Immigrants at Greater Risk Than Other Groups?

### 2.1. Introduction

Hazards and environmental justice (EJ) research reveals that socially marginalized groups are typically highly vulnerable to risks and disasters (Collins 2010; Morse 2008; Wisner et al. 2004; Zahran 2008). This includes people of Hispanic/Latino origin in the US, who have been found to experience disproportionate exposure to hazards, as well as a constrained ability to prepare for and recover from disasters (Maldonado et al. 2016; Montgomery & Chakraborty 2015; Hernandez et al. 2015; Flanagan et al. 2011; Pulido 2000). Despite the fact that hazards and EJ studies have examined the social vulnerabilities of Hispanics, almost all have treated the Hispanic population as a single homogeneous group (except for Hernandez et al. 2015; Collins et al. 2011; Chakraborty et al. 2016; Bolin 2007; Grineski et al. 2015). This is problematic because it conceals substantial differences in language, nativity and social class. For example, foreign-born Hispanics (i.e., Hispanic immigrants) may be particularly vulnerable to disasters due to their insecure residency status, lower incomes, and English language deficiencies. However, when all Hispanic people are lumped together in one category, as has been done in most prior analyses, the distinctive characteristics of Hispanic immigrants are concealed. Hispanic immigrants are distinct from US-born Hispanic people and other racial/ethnic groups not only in terms of immigration status but also linguistically and culturally. Disregarding those and other differences leaves a significant gap in hazards and EJ research, as has been pointed out in previous studies (Collins et al. 2011; Chakraborty et al. 2016; Grineski et al. 2013). Due to this gap, hazard reduction efforts may fail to properly serve groups such as Hispanic immigrants. As the Hispanic immigrant population continues to grow in the US (Colby & Ortman 2015), it is of

increasing practical importance to expand knowledge regarding the sources and consequences of the environmental injustices and hazard vulnerabilities they experience.

Although there is a dearth of hazards and EJ research focused on the disproportionate risks experienced by Hispanic immigrants, research shows that floods are a significant threat to humans. Due to growing populations and assets invested in coastal cities, societal exposures to flood hazards are increasing throughout the world (Hallegatte et al. 2013; Muis et al. 2015). Over 50% of the US population lives in coastal zones, with this proportion projected to increase (Douglas et al. 2012). Furthermore, due to climate change and sea level rise, flood exposure is generally increasing, even without accounting for demographic shifts (Yamananka et al. 2015; Zhang et al. 2000). This is especially true along the US eastern seaboard and Gulf Coast regions, which are at high risk to sea level rise (Ezer & Atkinson 2014). Given the heightening risks, it is important to enhance our knowledge of human exposure to flooding, especially for the purposes of better protecting those who are at greatest risk to these hazards.

In order to provide an understanding of EJ issues specific to Hispanic immigrants, we analyze residential flood risk at the household level, with a focus on Hispanic immigrants in comparison to other social groups within the Miami and Houston metro areas, both of which are flood prone and contain large Hispanic populations. This analytical approach is novel, as previous studies have used aggregated census data and tended to treat Hispanics/Latinos as a monolithic group. By comparing Hispanic immigrants to other social groups, including US-born Hispanics, our study is designed to clarify whether they experience disproportionate exposure to flood risk, adjusting for other variables known to influence flood risk.

Our primary research question is: Are Hispanic immigrants disproportionately exposed to risks from flood hazards, adjusting for other race/ethnicity/nativity categories, housing tenure,

socioeconomic status, flood self-protection, flood risk perception, and the desire to live near water-based amenities? Based on previous hazards research, we hypothesize that Hispanic immigrants will experience disproportionate exposure to flood risks when compared to other social groups, including US-born Hispanics, non-Hispanic Blacks, non-Hispanic other minorities and non-Hispanic Whites. In what follows, we first review the literature on EJ in relation to flooding, as well as studies focused on other variables known to influence flood risk at the household level. We then introduce our study methods, before presenting and discussing analysis results. We conclude by highlighting the scholarly and practical relevance of the study findings.

## 2.2. Literature Review

### 2.2.1 Race, Ethnicity, SES & Environmental Injustice in Flood Hazard Exposure

Despite flood hazards being framed as an environmental injustice issue by only a small body of literature (Walker & Burningham 2011), studies on race/ethnicity and flood exposure have found that minorities may be disproportionately exposed in some contexts (Bolin 2007; Adams et al. 2013; Baird 2008; Highfield et al. 2014; Montgomery 2014; Peacock et al. 2015), and that the heightened exposure of minorities to hazards often has historically unjust roots. In Austin (Texas), periodic flooding was a factor in the racial segregation of the city, where Hispanics and Blacks were marginalized to areas most prone to flooding (Tretter & Adams 2012). Austin has remained racially segregated, with marginalized groups disproportionately exposed to hazards (Walsh & Sletto 2007). In metro Miami, non-Hispanic Black and Hispanic populations were found to be significantly more likely to reside within areas exposed to inland flood risks (Chakraborty et al. 2014). In New York City, even though minorities were not disproportionately represented within 100-year flood zones on a city-wide basis, they were overrepresented in flood zones of several of the city's boroughs (Maantay & Maroko 2009). In



California, Hispanic residents were found to be overrepresented as residents of floodplains when compared to other groups (Troy & Romm 2006). In terms of the consequences of residential flood exposures, a lack of US citizenship and Hispanic ethnicity were associated with significantly worse health outcomes among people in homes impacted by a flood disaster in El Paso, Texas (Collins et al. 2013). Other studies have not found that minority groups experience disproportionate exposure to flood hazards. Some studies, in fact, have yielded contradictory findings. For example, in metro Miami, it was found that non-Hispanic Whites were overrepresented, while non-Hispanic Black and Hispanic people were underrepresented, as residents of areas at risk to coastal flooding (Chakraborty et al. 2014). Due to these divergent findings, it is important that research takes contextual factors into consideration when examining flood risk disparities between racial/ethnic groups.

In terms of socioeconomic status (SES), numerous post-event studies of flood disasters reveal that low SES groups tend to experience greater vulnerability. However, distributive EJ studies of pre-event relationships between social characteristics and spatial exposures to flood risks have produced less conclusive results. Post-event, low SES can increase vulnerability to flood-related challenges, as has been found to be the case in multiple studies across different contexts (Rufat et al. 2015; Lowe et al. 2013). Lower SES reflects poverty, lower educational attainment, and livelihood insecurity, and is often associated with renter home occupancy and poorly constructed or maintained housing, as well as reduced capacities to mitigate hazards (Collins 2010; Highfield et al. 2014; Peacock et al. 2015; Maantay & Maroko 2009). For example, Burton & Cutter (2008) found that in the California counties of San Joaquin, Sacramento and Yolo, areas with low SES were disproportionately exposed to flood risks associated with failure-susceptible levees. Despite such studies documenting that those of lower

SES are typically constrained in their capacities to prepare for, respond to and recover from floods and other hazards (Cutter et al. 2003; Fothergill & Peek 2004; Masozera et al. 2007; Grineski et al. 2015; Chakraborty et al. 2011; Mohai et al. 2009; Walker 2012), distributional EJ studies focused instead on pre-event relationships between SES and flood hazard exposure have yielded ambiguous findings. For instance, in the US and UK, several studies have found that in certain contexts, socially-advantaged individuals may experience the greatest pre-event flood exposure (Grineski et al. 2013; Chakraborty et al. 2014; Fielding & Burningham 2005; Montgomery & Chakraborty 2013). Taken together, these findings suggest that SES must be accounted for when examining relationships between racial/ethnic status and flood risks.

#### 2.2.2. Water-based Amenities and Flood Exposure

Water-based amenities are often correlated with heightened exposure to flood hazards, since such amenities and flood risks are not easily divisible from one another (or easy to separate from one another, as both are natural features of proximity to bodies of water) (Montgomery 2014; Bin et al. 2008; Atreya & Czajkowski 2014; Kauko 2013). Thus, living at risk to flooding may be driven in part by corresponding locational environmental benefits (Collins 2010). For example, economists have found that properties located within the 100-year coastal flood zone on North Carolina's Outer Banks had higher cash values relative to similar properties outside of coastal flood zones (Bin & Kruse 2006). In fact, some of the most expensive real estate in the US is located in areas at high risk to flooding (US Army Engineer Institute for Water Resources 2009). This means that flooding can devastate even wealthy predominantly White waterfront communities that enjoy the benefits of access to coastal amenities, as was the case in some affluent areas of New Orleans during Hurricane Katrina (Morse 2008). Research at the neighborhood level in metro Miami suggests that racial/ethnic minority groups tend be

overrepresented as residents in areas exposed to inland flood risks with fewer water-related amenities (Chakraborty et al. 2014; Montgomery & Chakraborty 2015), while residents who are economically advantaged and non-Hispanic White are overrepresented in amenity-rich coastal areas at risk to flooding (Montgomery & Chakraborty 2015). Although advantaged groups may inhabit areas at high risk due to the associated locational benefits, they also typically have greater capacity to mitigate the risks associated with residential flooding (Collins 2010; Garcia & Baltodano 2005). For instance, wealthier communities are able to reduce flood risks through self-protective actions such as making (expensive) home modifications, maintaining flood insurance to fully compensate for property damages or losses, and by exercising their collective social power to receive improved community flood protections from government sources (e.g., flood walls, levees, beach nourishment programs, etc.) (Collins 2010; Montgomery & Chakraborty 2015). Since the pursuit of water-based amenities by economically affluent people may confound relationships between social variables of interest and flood exposure, it is necessary to account for the effects of water-based amenities in EJ analyses of flood hazard exposure.

### 2.2.3. Self-protection from Flood Hazards

Self-protection strategies allow residents to defend themselves from the devastating impacts of flooding. In the context of flood hazards, self-protection can include structural changes to the home and nonstructural actions. Structural mitigation actions include elevating and flood-proofing homes, both of which are effective means of mitigating flood losses (FEMA 2014; Botzen et al. 2013; de Moel et al. 2014; Kreibich et al. 2005; Poussin et al. 2012).

Elevation involves raising the home so that the lowest floor and critical infrastructure systems are above the flood level. Elevation can reduce flood losses to near zero. Studies have found that flood-proofing can reduce flood losses by 21 to 89%, depending on whether wet proofing (i.e.,

when portions of the home are allowed to flood) and/or dry-proofing (i.e., when actions are taken to prevent entrance and enable removal of floodwaters) have been implemented (de Moel et al. 2014; Kreibich et al. 2005; Poussin et al. 2012).

In terms of nonstructural self-protection strategies, in the US, flood insurance plays an important protective role, since it provides compensation for property losses due to flooding. In 100-year flood zones (i.e., designated by the US Federal Emergency Management Agency [FEMA] as “Special Flood Hazard Areas”), where there is at least a 25% chance of flooding during a 30-year mortgage period, flood insurance is required in homes and buildings with mortgages from federally-regulated or insured lenders. Coverage may be obtained through private insurers, but the vast majority of flood insurance policies in the US are acquired through the National Flood Insurance Program (NFIP), which is administered by the FEMA. While mortgage holders or owners (unlike non-owners or renters) are responsible for maintaining flood insurance for home structures, any household—no matter whether they rent the home, are paying on the home, or own the home outright—may purchase flood insurance coverage for the home’s contents through the NFIP. Because these structural and nonstructural self-protection strategies can measurably mitigate or compensate for the impacts of flood hazards, they are important to control for when analyzing the relationship between social variables and exposure to flood risks.

#### 2.2.4 Risk Perceptions and Flood Hazards

Although multiple factors influence individuals’ risk perceptions (e.g., age, ethnicity and previous experiences with natural hazards), risk perceptions may be significantly related to proximity to a hazard (Luaja et al. 2015; Wachinger et al. 2012; Kellens et al. 2012). For example, Heitz et al. (2009), Kellens et al. (2011) and Lindell & Hwang (2008) found that higher levels of risk perception were associated with residents’ locations in flood zones. Furthermore, it

has been found that individuals' residential proximity to flood hazards may influence their self-protective intentions and behaviors (Kellens et al. 2012; Heitz et al. 2009; Kellens et al. 2011; Lindell & Hwang 2008; Ge et al. 2011). Thus, adjusting for flood risk perception is necessary in order to clarify relationships between social variables of EJ interest and flood risk exposure, since a householder's perception of flood risk may shape their decision-making in manner that leads them to select a residence at lower vs. higher flood risk.

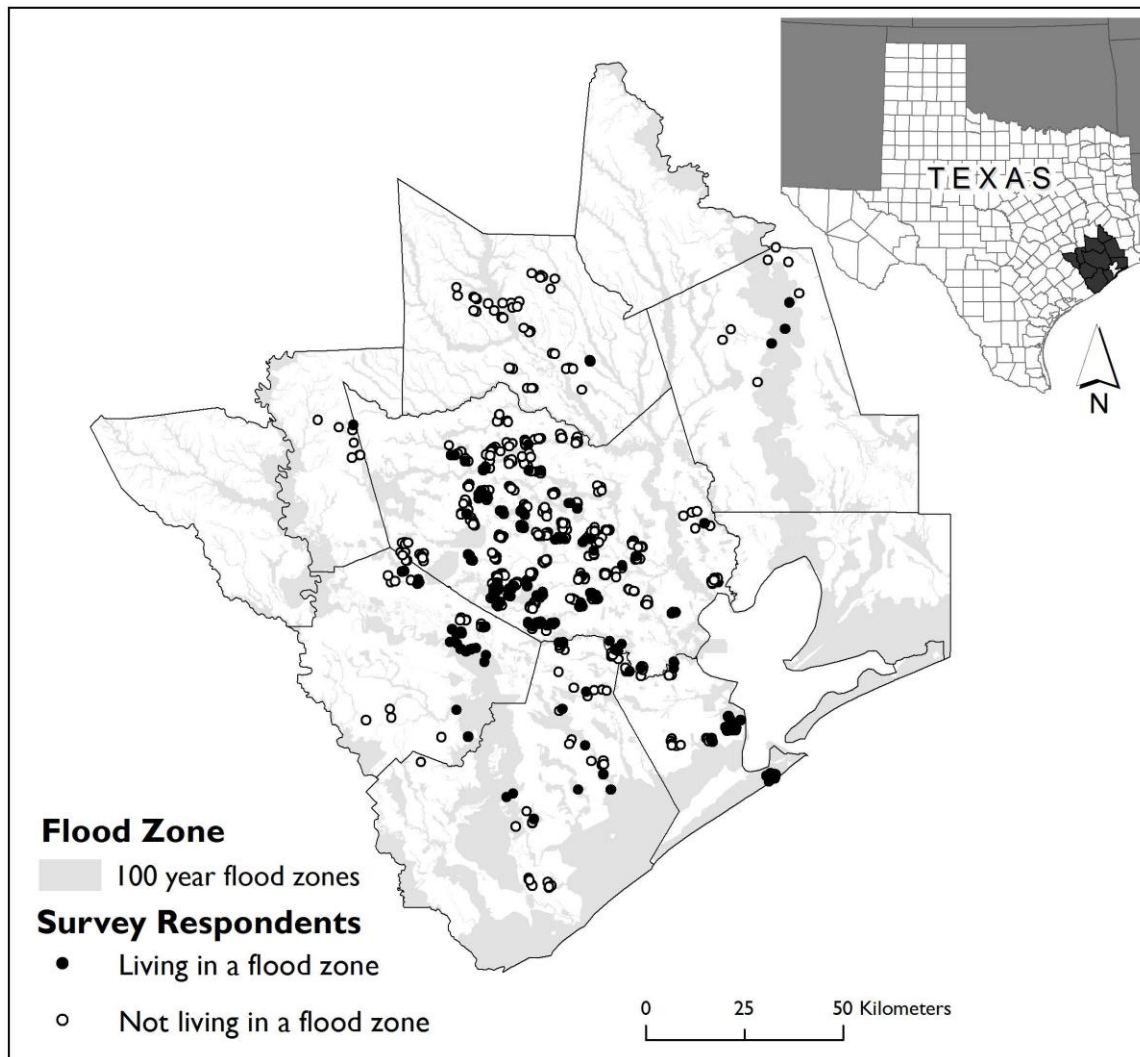
### 2.3. Study Areas & Data

#### 2.3.1. Study Areas: The Houston and Miami MSAs

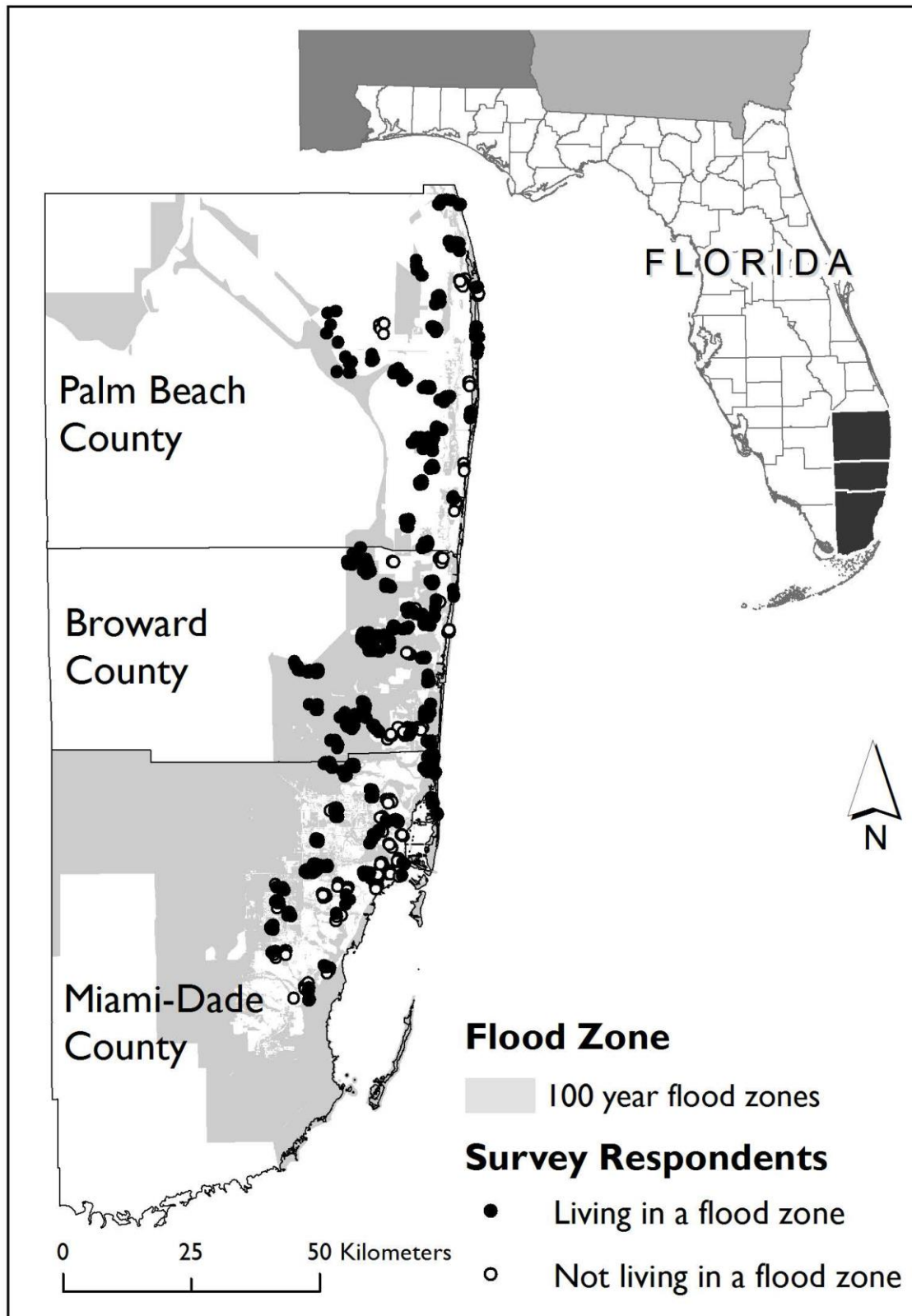
In addition to being home to more than 900,000 Hispanic immigrants, the Houston-Sugar land-Baytown (Houston) and Miami-Fort Lauderdale-West Palm Beach (Miami) Metropolitan Statistical Areas (MSAs) face high levels of exposure to flood risk. With a total population of just under 6.5 million residents, the Houston MSA is the sixth largest in the US. According to the ACS 2014 1-year estimates, Non-Hispanic Whites comprise 38% of the Houston MSA population, followed by Hispanics (36%), and non-Hispanic Blacks (17%). Hispanic immigrants comprise 14% of the Houston MSA population. Hurricanes and flooding have posed serious and recurring problems in Houston and more than US \$112 billion in property assets are covered under the NFIP (FEMA 2010). According to the National Weather Service, Houston has been hit with hurricanes and flooding that have led to deaths as well as billions of dollars in damage. In April 2016, a major flood event left 7 dead, damaged thousands of homes, and caused at least \$5 billion in damage (Yan & Lavandera 2016). In May 2015, the Houston area was affected with flooding that damaged thousands of homes and left at least 4 dead and many more displaced (BBC 2015). Other events include Tropical Storm Allison (2001), which killed 22 people, damaged thousands of homes, and caused widespread flooding;

Hurricane Rita (2005), which was responsible for damages due to strong winds and disastrous storm surge flooding that led to 7 deaths and an estimated \$10 billion in damage; and Hurricane Ike (2008), which caused 28 deaths and more than \$1 billion in property damage.

With a total population of over 5.9 million (ACS 2014 1-year estimates), the Miami MSA is the seventh largest in the US. Hispanics comprise 43% of the population, followed by non-Hispanic Whites (32%) and non-Hispanic Blacks (20%). Hispanic immigrants comprise 26% of the population. A study of coastal flood risk ranked Miami first in asset exposure and fourth in population exposure for cities worldwide (Nicholls et al. 2008). Over US \$212 billion in property assets are covered under the NFIP (FEMA 2010). Because of its location between the Gulf of Mexico and the Atlantic Ocean, Miami is one of the most hurricane-prone urban areas in the world. Hurricane Andrew provides an example of the devastation experienced in Miami due to hurricanes. Andrew struck southern Florida and south-central Louisiana in 1992 and was the costliest natural disaster in US history at the time with damage estimated at nearly US \$25 billion. Hurricane Andrew hit Miami-Dade County especially hard, resulting in at least 15 deaths and leaving up to one-quarter million individuals homeless (Rappaport 1993). Figures 2.1 and 2.2 depict the geographic contexts of the two study areas, including flood zone boundaries and the approximate home locations of the study participants.



2.1. Flood Zones and Approximate Locations of Survey Respondents in the Houston, MSA, Texas Study Area



2.2. Flood Zones and Approximate Locations of Survey Respondents in the Miami MSA, Florida Study Area



### 2.3.2. Data Collection

This study reports data collected by a research team from The University of Texas at El Paso as part of a National Science Foundation-funded project. The human subjects research protocol (FWA #: 00001224; internal IRB reference #: 261207-4) was approved by The University of Texas at El Paso IRB on 18 May 2012. An Institutional Review Board (IRB)-approved telephone survey was administered among 1,283 randomly selected adults living in the Houston and Miami MSAs from June through July 2012. Survey participants were selected using probability-based methods and a two-stage sampling strategy in order to obtain a sample that was socially and spatially representative of the MSAs (for additional details, see Collins et al. 2015). The two-stage sampling strategy implemented for each MSA consisted of the following. First, quadrants containing the same number of tracts in each MSA were defined, and within each quadrant, census tracts were stratified into quintiles based on a measure of race/ethnicity and socioeconomic status (i.e., percent non-Hispanic white and median household income), which was created from US census data. Within each quintile (of each quadrant) 6 census tracts were randomly selected, for a total of 30 census tracts per quadrant. Within each of the 120 selected census tracts in each MSA, phone-based structured surveys were then completed with at least 5 randomly selected householders. The goal was to complete 600 householder surveys within each MSA. Here, we analyze data for 546 householders from the Houston MSA and 560 from the Miami MSA for whom we had complete data for the majority of analysis variables (derived from the survey).

The survey had a response rate of 33%, which is comparable to that achieved in recent published studies based on random digit dialing surveys (Mumpower et al. 2013). Most socioeconomic and demographic survey items were derived from the American Community Survey instrument (version 2011).

The survey was conducted in English and Spanish. It was written in English, and then subjected to three translation iterations, including a back translation. The telephone interviews were conducted by trained, English-Spanish bilingual interviewers employed by a firm with expertise in survey research with Hispanic populations. Incentives of \$10 in cash were provided to all survey participants. All responding householders verbally consented to participate and were 18 years of age or older.

### 2.3.3. Analysis Variables

#### 2.3.3.1. Independent Variables

##### 2.3.3.1.1. Race/Ethnicity/Nativity

The study employs categorical race/ethnicity measures, which were constructed by re-coding self-identified data from householders on ethnic status, racial status and, for Hispanic participants, nativity status in order to define the groups. The following categorical measures of race/ethnicity/nativity are employed in analyses: *1* for “Hispanic immigrants” (Hispanic respondents born outside of the US) and *0* for not; *1* for “US-born Hispanic” (Hispanic respondents born inside the US) and *0* for not; *1* for non-Hispanic “Black” (Black/African American respondents who were not Hispanic) and *0* for not; *1* for non-Hispanic “Other Minority” (American Indian/Alaska Native, Asian/Pacific Islander, or “other race” respondents who were also not Hispanic and not Black) and *0* for not; and *1* for non-Hispanic “White” (White only respondents who were not Hispanic) and *0* for not. Since our focus is on whether or not Hispanic immigrants experience disproportionate risks in terms of exposure to flood hazards, we utilize the Hispanic immigrant group as the reference group in our models. Table 2.1 provides details on the construction of the analysis variables. Table 2.2 reports descriptive

statistics for the analysis variables; for all dichotomous variables, the mean is interpretable as a proportion.

Table 2.1. Variables, Survey Questions & Coding

Variable	Survey Questions	Coding used in analysis
Hispanic Immigrant	(1) Were you born outside the US? (2) Are you of Hispanics, Latino, or Spanish origin?	0 = No 1 = Yes
US-born Hispanic	(1) Were you born outside the US? (2) Are you of Hispanics, Latino, or Spanish origin?	0 = No 1 = Yes
Non-Hispanic Black	(2) Are you of Hispanics, Latino, or Spanish origin? (3) Which of the following best describes your race? Black of African-American	0 = No 1 = Yes
Non-Hispanic Other	(2) Are you of Hispanics, Latino, or Spanish origin? (3) Which of the following best describes your race? American Indian or Alaskan Native, Asian, Pacific Islander, or Some other race	0 = No 1 = Yes
Non-Hispanic White	(2) Are you of Hispanics, Latino, or Spanish origin? (3) Which of the following best describes your race? White	0 = No 1 = Yes
SES Factor		Continuous
Education	Thinking about the person in your household who is 18 years of age or older with the highest educational degree received or level of school completed – what is the highest grade or level of school that this person has completed? 0 = No formal education – 21 = Ph.D. degree	
Median Household Income (2011 \$US)	What was your total HOUSEHOLD income for the year 2011 before taxes? 1 = <\$10,000 2 = \$10K–19,999 3 = \$20K–29,999 4 = \$30K–39,999 5 = \$40K–49,999 6 = \$50K–74,999 7 = \$75K–99,999 8 = \$100K–149,999 9 = \$150K–249,999 10 = > \$249,999	
Housing Tenure	Is this home...? (1) ... owned by you or someone in this household with a mortgage or loan – including home equity loans? (2) ... owned by you or someone in this household free and clear – without a mortgage or loan? (3) ... rented? (4) ... occupied without payment of rent, but not owned?	0 = Owner (options 1-2, 4) 1 = Renter (option 3)
Proximity to Coast or Beach	What level of consideration was given to “Proximity to Coast or Beach” when you constructed, purchased or rented your current home?	1 = Not a consideration at all – 5 = A very important consideration

Table 2.1. Variables, Survey Questions & Coding Continued

Proximity to River or Lake	What level of consideration was given to “Proximity to River or Lake” when you constructed, purchased or rented your current home?	1 = Not a consideration at all – 5 = A very important consideration
Flood Mitigation Composite	Which of the following flood protection methods have been used to protect the home site you occupy from flooding? (1) Home structure elevated to protect against flooding (2) Electric components of the home were elevated (3) Indoor heating, ventilation and air conditioning system components were elevated (4) Outdoor service equipment were elevated (5) Floodwalls, berms or levees were built on site (6) Back flow valves or check valves were installed (7) Interior drainage system was installed	0 = no mitigation actions taken – 7 = all 7 mitigation actions taken
Flood Insurance (Contents)	Are the contents of the home currently covered by the NFIP?	0 = not covered by NFIP 1 = covered by NFIP
Risk Perception Factor		Continuous
Risk Perception (General)	How much of a problem do you think flooding is in the Metro Area? 1 = “not a problem at all”— 5 = “a very serious problem”	
Risk Perception (Property)	How concerned are you about the possibility of a flood causing damage to your home or property? 1 = “not concerned at all”— 5 = “extremely concerned”	
Risk Perception (Health)	How concerned are you about the possibility of a flood causing injuries or health problems to you or to members of the household? 1 = “not concerned at all”— 5 = “extremely concerned”	
Risk Perception (Livelihood)	How concerned are you about the possibility of a flood preventing your or members of your household from being able to work or causing disruption to daily activities? 1 = “not concerned at all”— 5 = “extremely concerned”	
100-Year Flood Risk		0 = outside of a 100-year flood zone 1 = within a 100-year flood zone

Table 2.2. Descriptive Statistics

Variable	MSA	N	Min	Max	Mean	SD	% Missing
Hispanic Immigrant	Houston	69 (1) 459 (0)	0	1	.131	N/A	3.297
	Miami	144 (1) 403 (0)	0	1	.263	N/A	2.321
US-Born Hispanic	Houston	45 (1) 483 (0)	0	1	.085	N/A	3.297
	Miami	31 (1) 516 (0)	0	1	.057	N/A	2.321
Non-Hispanic Black	Houston	101 (1) 423 (0)	0	1	.193	N/A	3.846
	Miami	75 (1) 470 (0)	0	1	.138	N/A	2.679
Non-Hispanic Other	Houston	18 (1) 500 (0)	0	1	.035	N/A	5.128
	Miami	10 (1) 524 (0)	0	1	.019	N/A	4.643
Non-Hispanic White	Houston	298 (1) 227 (0)	0	1	.568	N/A	3.846
	Miami	289 (1) 257 (0)	0	1	.529	N/A	2.500
SES Factor	Houston <sup>1</sup>	N/A	-3.1	2.3	.000	1.000	N/A
	Miami <sup>2</sup>	N/A	-2.4	2.1	.000	1.000	N/A
Education Level	Houston	N/A	1	21	14.831	3.150	1.099
	Miami	N/A	0	21	15.029	3.253	1.071
Household Income	Houston	N/A	1	10	4.766	2.602	23.443
	Miami	N/A	1	10	4.376	2.549	25.536
Housing Tenure	Houston	100 (1) 432 (0)	0	1	.188	N/A	2.564
	Miami	115 (1) 424 (0)	0	1	.213	N/A	3.750
Proximity to Coast or Beach	Houston	N/A	1	5	2.449	1.533	9.890
	Miami	N/A	1	5	2.340	1.481	8.036
Proximity to River or Lake	Houston	N/A	1	5	2.072	1.473	10.440
	Miami	N/A	1	5	2.183	1.483	8.036
Flood Mitigation Composite	Houston	N/A	0	7	3.610	1.585	43.407
	Miami	N/A	0	7	3.974	1.604	45.000
Home Elevated	Houston	227 (1) 211 (0)	0	1	.518	N/A	19.780
	Miami	219 (1) 240 (0)	0	1	.477	N/A	18.036
Home Electric Components Elevated	Houston	339 (1) 114 (0)	0	1	.748	N/A	17.033
	Miami	361 (1) 115 (0)	0	1	.758	N/A	15.000
Home Ventilation System Elevated	Houston	448 (1) 83 (0)	0	1	.844	N/A	2.747
	Miami	474 (1) 70 (0)	0	1	.871	N/A	2.857

Table 2.2. Descriptive Statistics Continued

Outdoor Service Equipment Elevated	Houston	322 (1) 204 (0)	0	1	.612	N/A	3.663
	Miami	408 (1) 121 (0)	0	1	.771	N/A	5.536
Floodwalls, Berms, or Levees Installed	Houston	162 (1) 349 (0)	0	1	.317	N/A	6.410
	Miami	251 (1) 258 (0)	0	1	.493	N/A	9.107
Backflow Valves Or Check Vales Installed	Houston	185 (1) 200 (0)	0	1	.481	N/A	29.487
	Miami	183 (1) 216 (0)	0	1	.459	N/A	28.750
Interior Drainage System Installed	Houston	72 (1) 364 (0)	0	1	.165	N/A	20.147
	Miami	73 (1) 372 (0)	0	1	.164	N/A	20.536
NFIP Contents Insurance	Houston	243 (1) 273 (0)	0	1	.470	N/A	5.495
	Miami	257 (1) 253 (0)	0	1	.504	N/A	8.929
Risk Perception Factor	Houston <sup>3</sup>	N/A	-1.8	1.7	.000	1.000	N/A
	Miami <sup>4</sup>	N/A	-1.8	1.6	.000	1.000	N/A
How Much of a Problem is Flooding	Houston	N/A	1	5	3.660	1.239	2.015
	Miami	N/A	1	5	3.766	1.136	.893
Property Damage	Houston	N/A	1	5	2.782	1.393	.000
	Miami	N/A	1	5	2.791	1.433	.179
Health Problems	Houston	N/A	1	5	2.730	1.392	.183
	Miami	N/A	1	5	2.810	1.418	.536
Disruption to Daily Activities	Houston	N/A	1	5	2.954	1.426	.549
	Miami	N/A	1	5	3.018	1.408	.357
100-Year Flood Risk	Houston	74 (1) 472 (0)	0	1	.136	N/A	.000
	Miami	293 (1) 267 (0)	0	1	.523	N/A	.000

<sup>1</sup>Cronbach's alpha = .609; <sup>2</sup>Cronbach's alpha = .633; <sup>3</sup>Cronbach's alpha = .860; <sup>4</sup>Cronbach's alpha = .873;

Notes: Means for the dichotomous indicators are presented because they can be interpreted as the proportion of the respondents in the category coded as 1. For example, the mean for Hispanic immigrant in Houston is 0.131, which means that 13.1% of respondents in Houston are Hispanic immigrants.

#### 2.3.3.1.2. Socioeconomic Status (SES)

Respondents' SES is analyzed using two variables. First, we use a factor comprised of two variables consisting of educational attainment and household income (Houston Cronbach's Alpha = 0.609; Miami Cronbach's Alpha = 0.633). Educational attainment is measured based on a survey question that gauged for the level of education obtained by the individual in the

household with the highest level of education. Household income is measured based on response options to a survey question that gauged the total household income of survey respondents in 2011 before taxes. We use renter-occupancy as a second SES indicator, measured by a survey item that determined whether they rented or owned their residences. For this variable, the survey asked householders to indicate if their home was (i) owned by them or someone in the household with a mortgage or loan; (ii) owned by them or someone in the household free and clear; (iii) rented; or (iv) occupied without payment of rent, but not owned. For our analysis, this variable was coded as *1* for renter (iii) and *0* for owner (i, ii, or iv).

#### 2.3.3.1.3. Water-based Amenities

We measure the role of water-based amenities in residential decision-making among householders using survey items that gauge their preferences when making residential location choices. Two survey measures that represent the degree to which survey respondents were influenced in moving to their current residences by specific considerations are used, which focus on the following features: (i) proximity to the coast or beach, and (ii) proximity to a river or lake. Survey respondents indicated the importance of each of those two features in the choice of their current home using a scale ranging from *1* to *5*, with *1* = “not a consideration at all” to *5* = “a very important consideration.”

#### 2.3.3.1.4. Self-Protection

##### Structural: Flood Mitigation

The composite variable for flood mitigation is based on yes/no responses to seven survey items that gauge whether protective action against flooding had been taken at respondents' home sites (Table 2.1). Responses to each were coded as *1* for “yes” and *0* for “no” and all seven items



were summed into one composite variable that ranges from 0 -7, indicating how many flood mitigation actions were implemented at each home site.

#### Non-Structural: Flood Insurance

For the flood insurance measure, a survey question gauged whether or not the contents of respondents' homes were insured through the National Flood Insurance Program. We focus on maintenance of contents insurance since homeowners and renter-occupants alike are eligible to maintain NFIP contents insurance, whereas only homeowners are eligible to maintain insurance for home structures. "Yes" responses are coded *1* and "no" options as *0*.

#### 2.3.3.1.5. Flood Risk Perceptions

Four Likert-scale type survey items were used to assess respondents' perceptions regarding the seriousness of flood problems in their community as well as their levels of concern regarding potential flood impacts upon their households. Table 2.1 reports coding each of the 4 items used to construct the flood risk perception measure. Responses to these 4 items were applied to create 1 factor for each metro area that was used for our analysis (Houston Cronbach's alpha = 0.860; Miami Cronbach's Alpha = 0.873).

#### 2.3.3.2. Dependent Variable: Residential Exposure to 100-Year Flood Risk

Our dependent variable is a measure of the presence/absence of respondents' homes in the 100-year flood zone. This variable was derived using householders' geocoded home locations and FEMA Digital Flood Rate Maps (DFIRMs). This dependent variable measures each respondent's risk as *1* for within a 100-year flood zone and *0* for outside of 100-year flood zone.

## 2.4. Analytic Strategy

We conducted preliminary bivariate group comparisons to explore differences between our independent variables with respect to flood risk. To do so, we analyzed the relationship between our binary independent variables—which consist of our race/ethnicity/nativity categories, renter status and NFIP contents insurance—and our dependent variable by employing Pearson chi-square tests for differences between presence vs. absence within flood zones. Next, we used Mann-Whitney U tests to analyze relationships between our scale variables—which include our SES, water-based amenities, structural self-protection, and flood risk perception measures—and our dependent variable.

Then, we employed generalized estimating equations (GEEs), a multivariate analysis technique appropriate for dealing with clustered data, in order to analyze determinants of residential flood risk. Prior to modeling GEEs, we applied multiple imputation (MI) to address missing values in the survey data and reduce non-response bias. MI techniques appropriately adjust the standard errors for missing data (Enders 2010) and MI is considered a best practice for dealing with missing data in statistical analysis (Baraldi & Enders 2010; McPherson et al. 2012; Van Buuren 2012). We imputed missing values for 20 datasets to ensure that the multi-parameter significance tests for our pooled models were valid (Enders 2010). We report pooled GEE results from analyses of all 20 datasets. Data were analyzed by modeling two GEEs (one for each MSA) using the independent variables described above as predictors and the 100-year flood risk measure as the outcome, while accounting for clustering at the county level. The models adjust for clustering based on the county of residence because previous studies of EJ and vulnerability in the context of flood hazards have identified counties as units that strongly influence human-flood hazard relationships in the US (Montgomery & Chakraborty 2015; Brody et al. 2009;

Brody et al. 2008; Brody et al. 2007). GEEs are an appropriate method of analysis for this study given that they provide a general method of clustered dichotomous variables and relax several assumptions of traditional regression models (Collins et al. 2015). Binary logistic GEEs were specified, based on the distribution of the dependent variables (binomial), and the working correlation matrix structure was specified as exchangeable, since this assumes constant intracluster dependency (Garson 2013).

Data for Houston and Miami were analyzed separately, with results for each city examined comparatively to explore contextual differences and similarities. Datasets were created for each of the two study areas, each consisting of identical analysis variables, and the datasets for each city were statistically analyzed in parallel manner. The Hispanic immigrant category was left out of the GEEs, meaning that it serves as the reference group for the other race/ethnicity/nativity categories. Linear binary logistic regression diagnostic tests showed no multicollinearity issues among analysis variables for either study area.

## 2.5. Results

### 2.5.1. Bivariate Group Comparisons

Table 2.3 reports bivariate group comparison results in terms of differences in survey respondents' characteristics based on their residence within vs. outside 100-year flood zones. Pearson chi-square test results are reported as the percentages of individuals residing inside vs. outside the 100-year flood zone for each of the dichotomous independent variables. Mann Whitney U test results are reported as mean values for each scale independent variable in terms of households residing within vs. outside 100-year flood zones. In Houston, representation within vs. outside 100-year flood zones is statistically significant for three of the race/ethnicity/nativity groups. Hispanic immigrant and "other minority" households are

overrepresented as residents of flood zones (vs. non-Hispanic immigrant and non-“other minority” groups, respectively), while non-Hispanic White households are underrepresented in flood zones. Additionally, mean flood mitigation is significantly higher among households not residing within 100-year flood zones. None of the bivariate relationships between the other independent variables and flood risk are statistically significant.

In Miami, none of the racial/ethnic/nativity groups are significantly over- or under-represented in 100-year flood zones, although the result for non-Hispanic Whites approaches statistical significance for overrepresentation. A significantly higher proportion of households with (as compared to those without) NFIP contents insurance reside in flood zones. Higher mean SES approaches statistical significance in terms of the association with residence in flood zones. None of the bivariate relationships between the other independent variables and flood risk approaches statistical significance in Miami.

Table 2.3. Group Comparisons by Presence/Absence in 100-Year Flood Zone

Variable	Houston			Miami		
	Outside Flood Zone	Inside Flood Zone	<i>p</i> -value	Outside Flood Zone	Inside Flood Zone	<i>p</i> -value
Hispanic Immigrant <sup>1</sup>	71.0	29.0	.000	50.0	50.0	.522
US-Born Hispanic <sup>1</sup>	91.1	8.9	.330	58.1	41.9	.235
Non-Hispanic Black <sup>1</sup>	87.1	12.9	.818	49.3	50.7	.761
Non-Hispanic Other Minority <sup>1</sup>	61.1	38.9	.002	70.0	30.0	.138
Non-Hispanic White <sup>1</sup>	90.2	9.8	.002	44.3	55.7	.099
SES <sup>2</sup>	-.0	.0	.776	-.1	.1	.059
Renter <sup>1</sup>	83.0	17.0	.326	50.4	49.6	.505
Proximity to Coast/Beach <sup>2</sup>	2.5	2.2	.081	2.2	2.4	.114
Proximity to River/Lake <sup>2</sup>	2.1	1.9	.427	2.2	2.2	.623
Flood Mitigation Composite <sup>2</sup>	3.8	3.1	.022	4.0	3.1	.714
NFIP Contents Insurance <sup>1</sup>	84.3	15.7	.148	37.4	62.2	.000
Risk Perception Factor <sup>2</sup>	.0	-.2	.099	-.0	.0	.668

<sup>1</sup>Pearson chi-square was used to test the significance of differences in proportions; percentages are reported; <sup>2</sup>Mann Whitney U test was used to test the significance of differences in mean ranks; mean values rather than ranks for each of the groups are reported for descriptive purposes.

### 2.5.2. Generalized Estimating Equations

Houston GEE results indicate that, adjusting for relevant covariates, US-born Hispanics, non-Hispanic Blacks and non-Hispanic Whites experience significantly lower odds of exposure to 100-year flood risks than do Hispanic immigrants (Table 2.4). US-born Hispanics, non-Hispanic Blacks, and non-Hispanic Whites are respectively 67%, 53%, and 75% less likely than

Hispanic immigrants to reside within a 100-year flood zone. Thus, among the comparison groups, non-Hispanic Whites exhibit the lowest likelihood of exposure to flood hazards relative to Hispanic immigrants. The other minority group and SES factor indicate positive relationships with residing within the 100-year flood zone at a statistically non-significant level. Renter-occupancy and proximity to the coast/beach show negative, statistically non-significant associations with the 100-year flood zone. Proximity to river/lake indicates a positive relationship with residence in a 100-year flood zone at a statistically non-significant level. Our results also show that lower levels of home site flood hazard mitigation are significantly associated with greater flood exposure in Houston, adjusting for other variables. A one standard deviation increase in flood mitigation is associated with a 32% decrease in the odds of residing within the 100-year flood zone. Adjusting for other variables, the relationship between having flood insurance for the home's contents (vs. not) and residing in a flood zone approaches statistical significance ( $p=0.057$ ) and is positive; having insurance is thus associated with greater odds of residing within the 100-year flood zone. Lastly, lower levels of risk perception are significantly associated with greater flood exposure; a one standard deviation increase in the risk perception factor is associated with 19% reduction in the likelihood of living in a flood zone.

GEE results for Miami indicate statistically significant relationships for being non-Hispanic White, having high scores on the SES factor, and having contents flood insurance with inhabitancy in the 100-year flood zone (Table 2.4). In Miami, being non-Hispanic White is associated with a 73% greater likelihood of residing in a 100-year flood zone than being Hispanic immigrant. The directionality of the relationships in the GEE indicate that the other racial/ethnic/nativity groups experience lower odds of residential exposure to 100-year flood risks than Hispanic immigrants, although those relationships are statistically non-significant. A

one standard deviation increase in SES is significantly associated with 24% greater odds of residing in the 100-year flood zone. Renter-occupancy and both water-based amenities variables exhibit positive, non-significant relationships with the 100-year flood zone. Higher flood mitigation exhibits a negative relationship with the 100-year flood zone, at a statistically non-significant level. Having NFIP contents insurance (compared to not having it) is significantly associated with a 98% greater odds of residing in the 100-year flood zone. Lastly, higher flood risk perception exhibits a negative relationship with 100-year flood risk, with this relationship being statistically non-significant.

Table 2.4. Generalized Estimating Equations: Pooled Results for Models Predicting 100-Year Flood Zone Exposure

Variable	Houston			Miami		
	Exp(B)	SE	95% CI <sup>1</sup>	Exp(B)	SE	95% CI <sup>1</sup>
US-Born Hispanic	.326	.457	-1.443, -.460**	.783	.521	-1.268, .778
Non-Hispanic Black	.472	.327	-1.395, -.107**	.940	.318	-.686, .562
Non-Hispanic Other Minority	1.365	.319	-.323, .945	.466	.583	-1.921, .395
Non-Hispanic White	.248	.343	-2.069, -.719***	1.725	.164	.223, .867***
SES Factor	1.169	.146	-.131, .442	1.235	.021	.169, .253***
Renter	.793	.182	-.192, .522	1.234	.184	-.183, .540
Proximity to Coast/Beach	.874	.116	-.364, .095	1.089	.057	-.027, .198
Proximity to River/Lake	1.039	.125	-.207, .285	1.044	.126	-.203, .289
Flood Mitigation Composite	.678	.094	-.573, -.205***	.983	.098	-.208, .175
NFIP Contents Insurance	1.527	.222	-.013, .859	1.984	.074	.538, .832***
Risk Perception Factor	.809	.086	-.380, -.044**	.956	.100	-.242, .151

<sup>1</sup>\*\*p<0.05; \*\*\*p<0.01; Notes: Hispanic immigrants are the reference group for the other race/ethnicity/nativity categories. Participant sex was included as a control variable and has a statistically non-significant relationship with flood risk in both MSA's.

## 2.6. Discussion

In terms of the relationship between race/ethnicity/nativity and flood risk, when comparing the analysis results for Houston and Miami, clear differences emerge. In Houston, results generally align with expectations derived from the EJ literature, since socially marginalized Hispanic immigrants experience significantly greater flood risk than non-Hispanic Whites. Our results also indicate that US-born Hispanics and non-Hispanic Blacks exhibit significantly less flood risk than Hispanic immigrants in Houston, which is a novel finding.



However, in Miami, a contradictory pattern emerged in terms of non-Hispanic Whites and 100-year flood risk. In Miami, non-Hispanic Whites exhibited significantly greater odds of exposure to 100-year flood risks than Hispanic immigrants. While US-born Hispanics and non-Hispanic Blacks exhibited lower exposure to 100-year flood risks than Hispanic immigrants in Miami, those results were not statistically significant. The possibility that Hispanic immigrants may be at greater (as in Houston) and lesser (Miami) risk than non-Hispanic Whites has been masked in prior studies, including one which examined Hispanics as a single ethnic group at the census tract level in Houston and Miami (Grineski et al. 2015). In that study, census tracts in Houston with higher proportions of Hispanics were found to have significantly less 100-year flood risk, while the proportion of tract residents who were Hispanic in Miami was associated with statistically non-significant greater flood risk (Grineski et al. 2015). This underscores the importance of disaggregating the Hispanic population into relevant subgroups whenever possible, since doing so allowed us to uncover that it is specifically Hispanic immigrants and not US-born Hispanics that differ from non-Hispanic Whites in terms of their exposure to flood risks.

Higher SES is associated with greater flood exposure in both cities; the association is non-significant in Houston and significant in Miami. In terms of housing tenure, similarities exist between the two MSAs, as the association between renter status and 100-year flood risk is statistically non-significant and positive. The positive associations between higher SES and prevent flood risk found here aligns with other studies in the US and UK where a similar relationship has been found (Grineski et al 2013; Chakraborty et al. 2014; Fielding & Burningham 2005; Montgomery & Chakraborty 2013). While they face increased odds of exposure, people of high SES are not considered to be particularly vulnerable to flooding; for

example, they typically possess a greater ability to mitigate against flood hazards (Collins 2010; Highfield et al. 2014; Peacock et al. 2015; Maantay & Maroko 2009; Lowe et al. 2013; Cutter et al. 2003; Fothergill & Peek 2004; Masozera et al. 2007), thus reducing their potential losses during a flood event.

In terms of water-based amenities, both MSAs share similarities in that none of the associations these variables have with exposure to the 100-year flood zone is statistically significant, and the associations were positive. These positive associations between rating the proximity to a river or lake as a more important consideration when selecting the current home and greater odds of flood risk are expected based on the literature (Montgomery 2014; Kauko 2012; Bin & Kruse 2006; US Army Engineer Institute for Water Resources 2009).

The association between having flood insurance for contents of the home and 100-year flood risk is positive and approaches significance in Houston, while this association is positive and significant in Miami. This association was expected, as residents of flood zones are encouraged to maintain flood insurance (e.g., owners with mortgaged homes are required to maintain flood insurance on structures within 100-year flood zones). The statistical non-significance of the relationship in Houston suggests that NFIP contents insurance may be underutilized there, and that public awareness should be increased about the importance of maintaining flood insurance. Less flood mitigation is associated with greater flood exposure in both MSAs, but the association is significant only in Houston. Practically, this points to a need to increase public awareness about the importance of implementing structural flood mitigation measures at home sites, especially in Houston.

Lower flood risk perceptions are associated with greater flood exposure in both Houston and Miami, but the association is statistically significant only in Houston. These results do not

align with the literature, as most studies indicate that heightened risk perceptions are associated with closer proximity to flood hazards (Kellens et al. 2011; Lindell & Hwang 2008; Ge et al. 2011). Practically, this suggests that residents of flood zones, especially those in Houston, may tend to underestimate flood risks, and that there is a need for better targeted communication regarding flood risks to residents who reside in flood zones.

From a traditional EJ perspective, our results for Houston generally correspond with expectations, while our results for Miami oppose expectations. Similar to our analysis of Houston, previous studies have found that racial/ethnic minorities and those of relatively low SES experience higher vulnerability to environmental hazards in terms of being unable to take protective action, as well as being adversely impacted by and less able to recover from disasters (Bolin 2007; Adams et al. 2013; Baird 2008; Highfield et al. 2014; Montgomery 2014; Peacock et al. 2015). However, in Miami, we found that non-Hispanic Whites and higher SES households were at greater risk to flooding. These results align with those from a previous study of Miami that found significant associations between lower neighborhood-level economic insecurity (or poverty), as well as lower proportions of Blacks relative to Whites, and higher flood risks (Grineski et al. 2015).

Recall that access to water-based amenities and exposure to flooding are often indivisible from one another and thus typically highly correlated. As a result, socially-advantaged groups, such as wealthier and White people, could reside at disproportionately high risk, given that they also are afforded privileged access to amenities, such as the beach. Prior neighborhood-level studies in Miami support that logic, since they have found strong positive relationships for coastal flood risk with high SES, the proportion of non-Hispanic White residents, and area-based measures of amenity values (i.e., mean housing values, the proportion of seasonal/recreational

housing units, public beach access) (Chakraborty et al. 2014). This suggests that the water-based amenities variables we analyzed, which are based on the level of consideration given to these amenities when the household chose to occupy their current home, do not adequately capture the role of coastal amenities in structuring social relationships with flood hazards in the Miami MSA. In contrast to prior studies (Montgomery & Chakraborty 2015; Chakraborty et al. 2014), we employed household-level measures related to the importance of water-based amenities when the householder chose the home, which did not exhibit significant relationships with flood risk in either our bivariate or multivariate analyses. This suggests that relationships between water-based amenities and flood risk in Miami are structured at a coarser scale—indeed, the entire MSA appears to be socio-economically structured by the amenity values associated with proximity to the sandy beaches that line the Atlantic coast—and determined to a lesser degree by preferences for environmental amenities as expressed through household-level decision-making. Thus, a possible avenue for future research is utilizing multi-level modeling in order to develop a better understanding of individual and neighborhood level factors that shape societal patterns of exposure to flood hazards in Miami and elsewhere.

In Miami, socially-advantaged households appear inclined to place themselves at risk to flooding in exchange for residential benefits that come with the risk, under the condition that flood insurance is available to externalize the economic risks of flooding. This is supported by the relationship found between having contents flood insurance and residence in the 100-year flood zone, which indicates that residents of flood zones in the Miami MSA rely on subsidized flood insurance through the NFIP to offset risks. On the other hand, minority groups and those of lower SES in Miami appear to be less exposed to flood hazards due to their financial inability to tap the sought-after amenities that proximity to the coast affords; by extension, our results

suggest that minority and low SES residents of the Miami MSA experience environmental injustice based on their constrained access to coastal amenities (see Montgomery et al 2015, which substantiates this point).

In addition, the demographic composition of the Miami MSA is somewhat unique in comparison to other US MSAs. The Hispanic immigrant population of Miami in particular is highly diverse, being composed of immigrants from many different countries of origin, many of whom have relatively high SES. Because immigration status in Miami is not highly correlated with lower SES, as it is elsewhere in the US, it stands to reason that the pattern found in Miami may differ substantially from other US metro areas.

In contrast to Miami, residential settlement across Houston is far less structured by coastal amenities, despite this MSA being adjacent to the coast. The main economic activities taking place along the coast bounding the Houston MSA are associated with the petrochemical industrial complex, which is among the largest in the world and a major source of air pollution. Such water-based economic activities represent major residential *disamenities*. Put simply, many landscapes at high risk to flooding in Houston have relatively lower water-based amenity value for residents and consequently, they tend to be inhabited by more socially vulnerable people. As was the case in Miami, the two individual-level amenity variables were not statistically significant, suggesting again that relationships between water-based amenities and flood risk are structured at a coarser scale. Thus, the disjuncture between coarse-scale water-based residential amenities and flood risk in the Houston MSA is perhaps the reason why those findings align with traditional EJ expectations.

Additionally, Houston's Hispanic population, as mentioned before, differs greatly from that of Miami. First, the Hispanic immigrant population in Houston is much more homogeneous,

with more than 80% of immigrants here being of Mexican origin. Second, the Hispanic immigrant population in Houston is generally of relatively low SES, as it is elsewhere in the US. It is thus not surprising that results found here are better aligned with findings from the EJ literature.

## 2.7. Conclusion

This chapter examined whether Hispanic immigrants are disproportionately exposed to risks from flood hazards relative to other racial/ethnic groups, adjusting for relevant covariates. In Houston, our analysis indicates that Hispanic immigrant (i.e., foreign-born) status places households at increased flood risk compared to other groups, including Hispanics who are US-born. Flood mitigation and risk perception were found to be significant and negative predictors of flood risk. Factors found to be significant predictors of flood risk in Miami, including non-Hispanic White race/ethnicity, higher SES and NFIP contents insurance, were statistically non-significant in Houston. In Miami, the observed differences suggest that non-Hispanic White and wealthier households experience heightened exposure to flood hazards, but that their risks may be partially offset by high rates of flood insurance coverage.

Our key findings have several important implications. The increased flood risk experienced by Hispanic immigrants in Houston underscores the need for future EJ and hazard vulnerability studies to differentiate more carefully between minority subgroups, particularly within the highly diverse Hispanic population. In this study, nativity status among Hispanics was shown to have an impact on flood risk, but there may be additional factors that amplify vulnerability. For instance, it has been argued that *undocumented* immigrant status (Stough et al. 2010) and even country of origin (Montgomery & Chakraborty 2015) may contribute to the

social vulnerability experienced by certain minority groups. Ultimately, distinguishing between subgroups can help pinpoint the characteristics that place individuals at heightened vulnerability.

Recognizing the differences experienced by different Hispanic subgroups may help in developing targeted interventions for reducing their vulnerability. For instance, communities with Hispanic immigrant populations should make disaster information readily available in Spanish. Given that Hispanic immigrants tend to come from collectivist cultural backgrounds, their familial connections may provide more effective channels of disaster communications than other conduits, such as mass media (Wilson & Tiefenbacher 2012). Familial modes of communication may target specific family members as entry points, for example, children could be provided with bilingual information about flood risks and prevention/recovery resources at school. Public assistance in times of emergency and recovery should also focus on providing aid in a safe space that makes any individual, regardless of immigrant status or cultural differences, comfortable seeking help. Safe spaces can be cultivated through deepened community engagement, culturally-competent approaches, and participatory methods, as well as partnerships among universities, public health agencies and community-based organizations (Burke et al. 2012).

We found that Miami households of higher SES are at disproportionately high 100-year flood risk. Although wealthier people may be exposed to flood hazards in some contexts, from an EJ perspective it is important to recognize that socially privileged groups have greater capacities to prepare for, respond to, and recover from flood events. This suggests that, when examining flood risks from an EJ perspective, a distinction between hazard exposure and social vulnerability should be made, since they may not always be positively correlated.

The divergent results (between the two MSAs) may be due to distinctions in Hispanic population characteristics and the role of water-based amenities in structuring human-flood hazard relationships. Future studies should adopt a comparative approach focused on multiple study sites, as different contexts may be characterized by different types and levels of water-based amenities that selectively attract particular social groups to live amid flood hazards. As our results demonstrate, different contexts may be characterized by divergent social patterns of exposure to flood risks.



### 3. Hispanic Immigrants' Vulnerabilities to Flood and Hurricane Hazards in Two US Metro Areas

#### 3.1. Introduction

A substantial body of research has focused on the vulnerability of racial/ethnic minorities to hazards and disasters. This work has lumped people with diverse characteristics into general groups, such as “Hispanic” or “Latino/a” (Bolin 2007). Today, Hispanic immigrants represent an important group in US society due to their large and increasing population. According to American Community Survey estimates, as of 2013 there were 21 million foreign-born Hispanics in the US, representing 52.5% of the total foreign-born population and 6.6% of the US population. Hispanic immigrants are distinguishable from US-born Hispanics due to their concerns about immigration status as well as cultural and linguistic differences. Treating Hispanics as a homogenous group may mask important differences between foreign-born and US-born Hispanics and lead to erroneous conclusions about their disaster vulnerabilities.

In terms of self-protection, few studies have examined levels of flood/hurricane hazard mitigation, flood insurance coverage, or disaster preparedness based on race/ethnicity, and none have considered levels of self-protection against floods/hurricanes based on immigration status. Thus, we review studies examining relationships between race/ethnicity and self-protection in the context of multiple hazard types.

Racial/ethnic minorities tend to be less likely than Whites to take specific self-protective actions, including structural mitigation for their homes. In a study of Florida single family homeowners, Peacock (2003) found that Hispanic and Black homeowners had lower levels of hurricane shutter usage than respondents from other racial/ethnic backgrounds, adjusting for income and other variables. Racial/ethnic minorities may be less likely than non-Hispanic Whites to plan for emergencies or to feel prepared for emergencies (Burke et al. 2012). For

example, Burke et al. (2012) found that Latino migrant farmworkers in North Carolina were highly underprepared for disaster. While the case of the migrant farmworker subpopulation reflects extreme vulnerability, similar circumstances exist elsewhere. In Los Angeles, 43% of Latino residents maintained disaster supplies as opposed to 57% of non-Latino Whites (Eisenman et al. 2009). Perry et al. (1982) found that Hispanic/Latino residents were less likely to take protective action defined in terms of flood evacuation. In sum, despite the lack of literature focused specifically on Hispanic immigrants, they may be expected to have lower levels of self-protection in the context of multiple hazard types in comparison to other groups.

Hispanic immigrants affected by disasters—especially those without legal US residency status—may also be less able to take advantage of assistance programs. Undocumented foreign-born individuals are denied access to certain kinds of public assistance after disasters (e.g., FEMA cash assistance), but oftentimes even foreign-born legal residents fail to receive help. For example, after the Northridge Earthquake, undocumented foreign-born people were denied government aid, and many legal residents felt uneasy when applying for state assistance; this led to reduced expectations for assistance and increased reluctance among foreign-born populations, regardless of residency and citizenship status, to apply for aid (Loukaitou-Sideris & Kamel 2004). This reluctance may be due to a fear of deportation experienced even among immigrants with legal residency status (Collins 2009, 2010; Messias et al. 2012; Bolin & Stanford 1998). Ultimately, the relatively low socioeconomic status and varied immigration status of Hispanic immigrants means they are likely to be left with unmet post-disaster needs.

Studies comparing risk perceptions between racial/ethnic minorities and non-minorities have revealed the ‘white male effect’ (Kahan et al. 2007), which is that racial/ethnic minorities and women worry more than White Anglos and men about a variety of risks (Peacock et al.

2005; McCright & Dunlap 2013; Olofsson & Rashid 2011; Bourque et al. 2013). Minorities tend to have higher levels of risk perception regarding natural hazards than White Anglos (Peacock et al. 2005; Lindell & Hwang 2008). Foreign-born status has also been associated with heightened perceptions of risk to natural hazards (Adeola 2007).

While risk perceptions among racial/ethnic minority groups are typically amplified, Hispanic immigrants tend to have less knowledge about how to prepare for hazards and disasters (Carter-Pokras et al. 2007). Carter-Pokras et al. (2007) found that while foreign-born Latin Americans had received little risk-related information, many reported a wide range of perceived risks, including those associated with environmental hazards. The lack of accessible information in the US context may contribute to immigrants' lack of knowledge.

The dissemination of information (e.g., regarding evacuation) is of vital importance during times of disaster. Hispanics, and those foreign-born in particular (Wilson & Tiefenbacher 2012), are more likely to get disaster information through their social networks than via mass media (Morrow 1997; Perry & Mushkatel 1986; Perry & Nelson 1991). This puts them at a disadvantage, since mass media provides the most important channel of disaster information in the US. Ultimately, the information dissemination methods predominantly utilized by emergency managers may contribute to a knowledge deficit for Hispanic immigrants.

A related issue is that Hispanic immigrants may experience constrained access to timely information due to language barriers. Language barriers contribute significantly to the inadequacy of the circulation of information about disaster, particularly in communities that consist of multicultural populations (Carter-Pokras et al. 2007). Despite the growing numbers of Hispanics in the US, warnings about disasters and dangers are often broadcast in English only (Arlikatti et al. 2014; Benavides & Arlikatti 2010), which may lead to awareness deficiencies

among non-English speaking ethnic minorities (Aguirre 1988; Senkbeil et al. 2014), ultimately placing groups like monolingual Spanish-speaking Hispanics at distinct risk.

This study highlights particular vulnerabilities of Hispanic immigrants living at risk to flooding and hurricanes in the Houston (Texas) and Miami (Florida) and Metropolitan Statistical Areas (MSAs) by examining their self-protective actions and their perceptions of and knowledge about flood risks, in comparison to both US-born non-Hispanic Whites and US-born Hispanics.

To address research questions 2 and 3 (see Chapter 1), we analyze primary structured survey and semi-structured interview data using a mixed method analysis approach, which enables us to clarify particular factors that place Hispanic immigrants at increased risk to flood and hurricane disasters.

### 3.2. Data & Methods

#### 3.2.1. Study Communities

Houston and Miami, the two largest US Gulf Coast MSAs, face high levels of exposure to flood and hurricane risks and are home to substantial numbers of Hispanic immigrants. Houston-Sugar Land-Baytown (Houston) is the sixth largest MSA in the US with a total population of 5.9 million (2009). Flooding has been a recurring problem in the area and more than US \$112 billion in property assets are covered under the NFIP (FEMA 2010). In 2001, Tropical Storm Allison killed 22 people, damaged thousands of homes, and caused widespread flooding. Houston has since been affected by Hurricanes Rita and Katrina in 2005 and Ike in 2008. Demographically, non-Hispanic Whites comprise about 39% of the Houston MSA population, followed by Hispanics (35%), and non-Hispanic Blacks (17%). About 22% of the population is foreign born and 15% of the population lives in poverty.

With a total population of 5.4 million (2009), Miami-Fort Lauderdale-Pompano Beach (Miami) is the largest MSA in Florida and the seventh largest in the US. A study of coastal flood risk ranked Miami first in asset exposure and fourth in population exposure for cities worldwide (Nicholls et al. 2008). Over US \$212 billion in property assets are covered under the NFIP (FEMA 2010). Because of its location between the Gulf of Mexico and the Atlantic Ocean, Miami is one of the most hurricane-prone metro areas in the world. Hispanics comprise about 41% of the population, followed by non-Hispanic Whites (35%) and non-Hispanic Blacks (20%). Approximately 38% of the population is foreign born, and 16% lives in poverty. Figures 2.1 and 2.2 depict the two study areas, including flood zones and approximate locations of the study participants.

### 3.2.2. Data Collection

Our mixed methods analysis relies on structured survey and interview data pertaining to households living at high risk to flooding. We first completed an Institutional Review Board (IRB)-approved telephone survey of 1,283 randomly selected adult respondents (with nearly complete data) living in the Houston and Miami MSAs from June through July 2012. We then completed follow-up, in-depth semi-structured interviews with a subset of 94 survey respondents between January and May 2013. Survey participants were selected at random using probability-based methods and a two-stage sampling strategy in order to obtain a sample that was socially and spatially representative of Houston and Miami MSAs (see Collins et al 2015a; 2015b for additional details). The survey had a response rate of 33%, which is comparable to that achieved in recent published studies based on random digit dialing surveys (e.g., Mumpower et al. 2013). Studies indicate that similar and even substantially lower survey response rates can yield representative samples (Curtin et al. 2000; Holbrook et al. 2007; Keeter et al. 2006; Visser et al.

1996), and a meta-analysis found that response rates poorly predict nonresponse bias (Groves & Peytcheva 2008). Most socioeconomic and demographic survey items were derived from the American Community Survey instrument (version 2011).

The survey was conducted in English and Spanish. It was written in English, and then subjected to three translation iterations, including a back translation. The telephone interviews were conducted by trained, English-Spanish bilingual interviewers employed by a firm with expertise in survey research with Hispanic populations. Incentives of \$10 in cash were provided to all survey participants. All respondents verbally consented to participate and were 18 years of age or older.

Next, based on the structured survey respondent pool, we drew on a social vulnerability framework to select a diverse sample of follow-up interviewees living in a variety of urban environmental contexts. Using all survey respondents, we constructed a social vulnerability index (SOVI) in each city. We then paired this index with a measure of flood hazard exposure corresponding to each respondent's home site, which was operationalized as the proportion of a 1 km buffer surrounding each respondent's home location that was intersected by the 100-year flood zone (from FEMA Digital Flood Insurance Rate Maps). We then arrayed all respondents into strata based on social vulnerability and quartiles of flood risk. For each MSA, we sampled at the high (top 25%) and low (bottom 25%) flood risks. Respondents not consenting to be interviewed were removed after the strata were created, and the qualifying and consenting survey respondents in each stratum were randomly ranked. They were contacted in that rank order until three semi-structured interviews were completed in each stratum. Additional interviews were conducted with Hispanic residents as part of an oversampling strategy. For this analysis, we used data for follow-up interview participants in the high flood risk strata only.

The semi-structured interview guide was IRB-approved, and it covered themes of risk perceptions, hazard experiences, and hazard mitigation. Interviews were conducted over the phone in Spanish or English, lasting an average of 52 minutes, and they were digitally recorded. Upon completion of the interview, each interviewee was given a \$20 incentive. Interviews were transcribed and those in Spanish were translated by bilingual members of the research team. Each interviewee was given a pseudonym in order to maintain anonymity.

This analysis includes data for 429 surveys and 31 interviews completed with residents who lived within a 100-year or 500-year flood zone. Those individuals were identified using a geographic information system (GIS) to geocode their home addresses and overlay spatial data with FEMA Digital Flood Insurance Rate Maps. Participants were placed at their residential locations using address-based geocoding with ArcGIS 10 and Google Earth. Given the highly urbanized contexts of the two study sites, the address-based geocoding approach provided a suitable degree of locational accuracy for our analysis. For comparison purposes, participants were divided into three groups: Hispanic immigrants (n=117 survey respondents and 15 interviewees), US-born Hispanics (n=24 survey respondents and 4 interviewees), and US-born non-Hispanic Whites (n=288 survey respondents and 12 interviewees). Participants not fitting within those racial/ethnic groups were excluded.

Survey respondents' characteristics varied across the three groups (Table 3.1). As opposed to the US-born non-Hispanic Whites and US-born Hispanics (groups from which none lacked English language proficiency) a majority of Hispanic immigrants lacked English language proficiency. The proportion of renters (as opposed to homeowners) was significantly higher among Hispanic immigrants. Among the three groups, foreign-born Hispanics had the lowest

median household incomes. Detailed information about each interviewee is presented in Table 3.2.



Table 3.1. Characteristics of Survey Respondents by Group

Characteristic	Hispanic Immigrant (n = 117)	US-born Hispanic (n = 24)	US-born non- Hispanic White (n = 288)	<i>p</i> -value
Housing tenure, % renter occupancy <sup>1</sup>	36 <sub>a</sub> <sup>3</sup>	17 <sub>a,b</sub>	10 <sub>b</sub>	<0.00
English language proficiency, % proficient <sup>1</sup>	41 <sub>a</sub>	100 <sub>b</sub>	100 <sub>b</sub>	<0.00
Median household income (2011 US\$) <sup>2</sup>	\$20,000- 30,000 <sub>a</sub>	\$40,000- 50,000 <sub>b</sub>	\$40,000- 50,000 <sub>b</sub>	<0.00

<sup>1</sup>Pearson chi-square was used to test the significance of differences in proportions

<sup>2</sup>Kruskal-Wallis H was used to test the significance of differences in mean ranks; mean values rather than ranks for each of the three groups are reported for descriptive purposes

<sup>3</sup>Differences in subscript letters indicate statistically significant pair-wise differences between groups ( $p < 0.05$ ), based on post-hoc Mann-Whitney U tests. If two groups have the same subscript letter (e.g., a and a), then there is no statistically significant difference between them. If two groups have a different letter, (e.g., a and b) then they are statistically significantly different.

Table 3.2. Characteristics of Interview Participants

Pseudonym	Foreign-born	US Citizen	Hispanic	Gender	Age	Country of Birth	English Proficiency	Flooded	Flood Zone (100 or 500)	Flood Insurance	Household Income (2011 US\$)	Housing Tenure
Aida	Y	N	Y	F	**	El Salvador	N	Y	100	None	20,000 – 29,999	Rent
Albert	N	Y	Y	M	70	Mexico	Y	Y	500	Contents	**	Own
Amanda	Y	Y	Y	F	49	Peru	N	N	100	Home	Under 10,000	Rent
Anahi	Y	N	Y	F	37	Mexico	N	N	500	None	10,000 – 20,000	Rent
Bruce	Y	Y	Y	M	60	Dom. Republic	Y	Y	500	None	Under 10,000	Rent
Cesar	N	Y	Y	M	68	US	Y	N	500	None	**	Own
Daniel	Y	Y	Y	M	81	Colombia	N	N	100	Home	Under 10,000	Rent
Diana	Y	Y	Y	F	78	Colombia	N	N	100	Home & contents	Under 10,000	Own
Dora	Y	N	Y	F	44	Mexico	N	N	100	None	10,000 – 19,999	Rent
Ella	N	Y	N	F	60	US	Y	N	100	None	10,000 – 19,999	Rent
Enrique	Y	Y	Y	M	67	Cuba	N	N	100	**	10,000 – 19,999	Rent
Evelyn	Y	Y	Y	F	76	Colombia	N	Y	100	Home & contents	Under 10,000	Own
Ivan	Y	Y	Y	M	80	Colombia	N	N	100	Home & contents	20,000 – 29,999	Own
Layla	N	Y	N	F	54	US	Y	Y	100	Home	50,000 – 74,999	Own
Lucia	Y	N	Y	F	40	Mexico	N	N	500	None	10,000 – 19,999	Rent
Luz	Y	Y	Y	F	52	Mexico	Y	N	100	Home	75,000 – 99,999	Own
Mario	Y	N	Y	M	60	Mexico	N	Y	100	Home	40,000 – 49,999	Rent
Martha	N	Y	N	F	63	US	Y	Y	100	Home & contents	75,000 – 99,999	Own
Melanie	N	Y	N	F	33	US	Y	N	500	None	50,000 – 74,999	Own
Mika	Y	N	Y	F	31	Mexico	Y	Y	100	None	20,000 – 29,000	Rent
Natalie	N	Y	N	F	67	US	Y	Y	500	None	50,000 – 74,999	Own
Nick	N	Y	N	M	61	US	Y	N	100	Home & contents	40,000 – 49,999	Own
Oscar	N	Y	N	M	59	US	Y	N	500	Contents	150,000 – 249,999	Own
Ruby	N	Y	N	F	90	US	Y	N	100	Home & contents	50,000 – 74,999	Own

Table 3.2. Characteristics of Interview Participants Continued

Samuel	N	Y	Y	M	42	Mexico	Y	Y	100	Home & contents	30,000 – 39,999	Own
Sandra	Y	N	Y	F	47	Mexico	N	Y	100	None	**	Own
Sarah	N	Y	N	F	83	US	Y	Y	100	None	10,000 – 19,999	Own
Susan	N	Y	N	F	83	US	Y	N	100	None	**	Own
Uriel	N	Y	Y	M	51	Venez.	Y	N	100	**	40,000 – 49,999	Rent
Tara	N	Y	N	F	85	US	Y	N	100	**	**	Own
Tom	N	Y	N	M	59	US	Y	N	500	Home	Over 249,999	Own

\*\*No response provided; missing data

### 3.2.3. Quantitative Measures

Data collected from the survey were used to construct analysis variables (in SPSS version 19) for all respondents inhabiting flood zones in both MSAs. See Table 3.3 for detailed descriptions of survey items and response options. Race, ethnicity and nativity were used to define social groups for inclusion and comparison. This variable was constructed by re-coding ethnicity, nativity and race into a single variable with three categories. (1) “Hispanic immigrant” was defined based on “yes” to foreign birth and “yes” to Hispanic ethnicity (any race); (2) “US-born Hispanic” was defined based on “no” to foreign birth and “yes” to Hispanic ethnicity (any race); and (3) “US-born non-Hispanic White” was defined based on “no” to foreign birth, “no” to Hispanic ethnicity, “yes” to White race, and “no” to all non-White races.

The composite variable for flood/hurricane mitigation was based on yes/no responses to four survey items (see Table 3.3). Responses to each were coded as 1 for “yes” and 0 for “no”; then, values for the four items were summed to create a flood/hurricane mitigation measure ranging from 0-4. For the flood insurance (contents) measure, a survey question gauged whether or not the contents of respondents’ homes were insured through the National Flood Insurance Program. “Yes” responses were coded 1, and “no” options 0. The disaster preparedness measure was adapted from existing scales (Faupel et al. 1992; Mulilis & Lippa 1990; Norris et al. 1999),

and based on yes/no responses to eight survey items (see Table 3.3). Responses to each were coded as 1 for “yes” and 0 for “no”, and they were then summed to create a measure ranging from 0-8.

Table 3.3. Quantitative Measures: Variables, Survey Questions, & Coding

Variable	Survey Question	Coding
Race/ Ethnicity/ Nativity	(1) Were you born outside the United States?	0 = not born outside US 1 = born outside US
	(2) Are you of Hispanic, Latino, or Spanish origin?	0 = not of Hispanic origin 1 = Hispanic
	(3) Which of the following best describes your race? (White, Black or African American, American Indian or Alaskan Native, Asian, Pacific Islander, Some other race)	0 = any non-White category 1 = White only
Housing Tenure	Do you rent the home?	0 = owner 1 = renter
English Language Proficiency	How well do you speak English?	1 = very well 2 = well 3 = not well 4 = not at all
Median Household Income (2011 US\$)	What was your total HOUSEHOLD income for the year 2011 before taxes?	1 = <\$10,000 2 = \$10K–19,999 3 = \$20K–29,999 4 = \$30K–39,999 5 = \$40K–49,999 6 = \$50K–74,999 7 = \$75K–99,999 8 = \$100K–149,999 9 = \$150K–249,999 10 = > \$249,999
Flood/Hurricane Mitigation Composite	(1) Home structure, electric components, and HVAC system were built or elevated to protect against flooding	0 = no mitigation actions taken—
	(2) Backflow or check valves and an interior drainage system, including a sump pump with back-up power, were installed to prevent flood waters from backing up into home and to remove any water that enters the home	4 = all mitigation actions taken
	(3) Hurricane shutters were installed	
	(4) Roof was reinforced to protect against hurricane-force winds – for example, by installing hurricane straps or clips to ensure that the roof stays in place	
Flood Insurance (contents)	Are the contents of the home currently covered by the NFIP?	0 = not covered by NFIP 1 = covered by NFIP
Disaster Preparedness Composite	(1) Did research to find out about the types of hazards, emergencies and disasters that may occur in the area of your current home	0 = no preparedness actions taken —
	(2) Developed and practiced an evacuation plan with all household members	8 = all preparedness actions taken
	(3) Sought out an expert for advice on what you might do to protect people in your current home from flooding	
	(4) Learned about your community’s emergency plans, warning signals, evacuation routes, and locations of emergency shelters and medical emergency centers nearest you	
	(5) Trained at least one household members in first aid and CPR	

Table 3.3. Quantitative Measures: Variables, Survey Questions, & Coding Continued

	(6) Learned how to turn off your current home's electrical power at the main switch, and how to turn off the gas, oil, and water supplies at the valves	
	(7) Purchased a fire extinguisher and made sure that members of your household know where it is and how to use it	
	(8) Created and maintained an easy-to-carry emergency preparedness kit for use at home or during an evacuation that is stocked with supplies such as a flashlight, first aid kit and water	
Risk Perception (general)	How much of a problem do you think flooding is in the Metro Area?	1 = "not a problem at all"— 5 = "a very serious problem"
Risk Perception (property)	How concerned are you about the possibility of a flood causing damage to your home or property?	1 = "not concerned at all"— 5 = "extremely concerned"
Risk Perception (health)	How concerned are you about the possibility of a flood causing injuries or health problems to you or to members of the household?	1 = "not concerned at all"— 5 = "extremely concerned"
Risk Perception (livelihood)	How concerned are you about the possibility of a flood preventing your or members of your household from being able to work or causing disruption to daily activities?	1 = "not concerned at all"— 5 = "extremely concerned"

Four Likert-scale type measures were used (see Table 3.3) to assess survey respondents' perceptions regarding the seriousness of flood problems in their community as well as their levels of concern regarding potential flood impacts upon their households. Responses were coded on scales ranging from 1="not a problem at all"/"not concerned at all" to 5="a very serious problem"/"extremely concerned".

#### 3.2.4. Analysis Methods

We conducted statistical analyses with a suite of dependent variables on flood/hurricane mitigation, flood insurance (contents), disaster preparedness, and flood risk perception—as well as income, housing tenure, and English language proficiency—to test for differences between the three groups and answer research question 2. We first characterize differences between the three groups in terms of self-protection and risk perception. To examine relationships between the groups based on our scale dependent variables (e.g., flood/hurricane mitigation composite, disaster preparedness composite, and the four risk perception variables), we employed Kruskal-

Wallis H tests (i.e., one-way analysis of variance on ranks); we also employed post-hoc Mann-Whitney U tests to compare each pair of the groups (i.e., Hispanic immigrant – US-born Hispanic, Hispanic immigrant – US-born non-Hispanic White, US-born Hispanic – US-born non-Hispanic White). To examine relationships between the groups and our binary dependent variable (i.e., flood insurance), we employed a chi-square test; we also employed post-hoc z-tests for proportions to compare each pair of the groups. While more sophisticated multivariate analysis techniques are used by hazards researchers, including the authors of this paper, documenting basic differences between Hispanic immigrants and other groups is warranted since those differences have not been previously examined.

Additionally, given our mixed methods approach, the focus on basic inter-group differences enables triangulation between the quantitative and qualitative analyses. To qualitatively explain differences revealed through the quantitative analysis (and address research question 3), we analyzed the qualitative data using NVivo 10 software. Parent nodes were created by focusing on the parts of the interview that related to: (1) protective actions taken against possible flood and hurricane events and challenges associated with this; and (2) perceptions and knowledge (including sources of information) about their flood risk. These two parent nodes were then broken down into child nodes related to protective actions taken (e.g., having insurance, installing hurricane shutters, elevating the home); barriers to taking protective action (e.g., financial, lack of time, not knowing how to protect oneself); knowledge about flood risks and protective actions/resources (e.g., whether they knew or not that they resided in a flood zone and how they found out about flood risks); and perceptions of flood risks. Using matrix query tool in NVivo 10, we arrayed the coded data by group (i.e., Hispanic immigrant, n=15, US-born Hispanic, n=4, and US-born non-Hispanic White, n=12) for each child node. This

allowed us to systematically identify differences and similarities among the three groups of respondents, while clarifying factors shaping the vulnerability experiences of Hispanics immigrants.

### 3.3. Results

#### 3.3.1. Research Question 2

##### 3.3.1.1. Differences in Self-Protection

Kruskal-Wallis test results shown in Table 3.4 reveal that US-born non-Hispanic Whites took the most flood/hurricane mitigation actions, followed by US-born Hispanics; Hispanic immigrants had the lowest group mean rank for flood/hurricane mitigation. Differences across the groups in the level of flood/hurricane mitigation are statistically significant ( $p=0.015$ ). To illustrate how to interpret the results for the post-hoc Mann-Whitney pair-wise comparisons between groups, we will explain in detail how to do so by referring to the subscript letters denoted in Table 3.4 for flood/hurricane mitigation. Readers can employ the same approach to guide their interpretation of results for the other Mann-Whitney tests. Hispanic immigrants and US born Hispanics both are denoted by the subscript letter of “a”, meaning there is no statistically significant difference between those two groups. Results for the pairwise comparison between Hispanic immigrants and US-born non-Hispanic Whites indicate a statistically significant difference, since Hispanic immigrants are denoted with the subscript letter “a”, while US-born non-Hispanic Whites are denoted with the subscript letter “b”. Thus, post-hoc testing revealed that Hispanic immigrants undertook significantly less mitigation as compared to US-born non-Hispanic Whites, and that the level of mitigation for US-born Hispanics was not statistically significantly different from either Hispanic immigrants or US-born non-Hispanic Whites.



Table 3.4. Comparison of Flood/Hurricane Self-Protection and Risk Perception by Group

Dependent Variable	Hispanic Immigrant (n = 117)	US-born Hispanic (n = 24)	US-born non-Hispanic White (n = 288)	p-value
<b><i>Self-Protection</i></b>				
Flood Mitigation Composite <sup>1</sup>	1.50 <sub>a</sub> <sup>5</sup>	1.83 <sub>a,b</sub>	1.89 <sub>b</sub>	0.02
Flood Insurance: Contents of the home currently covered by NFIP policy, % protected <sup>2</sup>	47 <sub>a</sub>	55 <sub>a,b</sub>	59 <sub>b</sub>	0.11
Disaster Preparedness Composite <sup>1</sup>	4.75 <sub>a</sub>	4.96 <sub>a,b</sub>	5.43 <sub>b</sub>	0.01
<b><i>Risk Perception</i></b>				
How much of a problem do you think flooding is in the Metro Area? <sup>1,3</sup>	4.22 <sub>a</sub>	3.67 <sub>b</sub>	3.36 <sub>b</sub>	<0.00
How concerned are you about the possibility of a flood causing damage to your home or property? <sup>1,4</sup>	3.22 <sub>a</sub>	2.83 <sub>a,b</sub>	2.44 <sub>b</sub>	<0.00
How concerned are you about the possibility of a flood causing injuries or health problems to you or to members of the household? <sup>1,4</sup>	3.31 <sub>a</sub>	2.83 <sub>b</sub>	2.36 <sub>b</sub>	<0.00
How concerned are you about the possibility of a flood preventing your or members of your household from being able to work or causing disruption to daily activities? <sup>1,4</sup>	3.50 <sub>a</sub>	3.04 <sub>a</sub>	2.44 <sub>b</sub>	<0.00

<sup>1</sup>Kruskal-Wallis H was used to test the significance of differences in mean ranks; mean values rather than ranks for each of the three groups are reported for descriptive purposes

<sup>2</sup>Pearson chi-square was used to test the significance of differences in proportions

<sup>3</sup>Scale ranges from 1="not a problem at all" to 5="a very serious problem"

<sup>4</sup>Scale ranges from 1="not being concerned at all" to 5="being extremely concerned"

<sup>5</sup>Differences in subscript letters indicate statistically significant pair-wise differences between groups ( $p < 0.05$ ), based on post-hoc Mann-Whitney U tests. If two groups have the same subscript letter (e.g., a and a), then there is no statistically significant difference between them. If two groups have a different letter, (e.g., a and b) then they are statistically significantly different.

Chi-square results shown in Table 3.4 show that US-born non-Hispanic Whites had the highest rate of flood insurance coverage as a group, followed by US-born Hispanics; Hispanic immigrants had the lowest flood insurance coverage rate. Post-hoc  $z$ -tests for proportions revealed that Hispanic immigrants had a significantly lower rate of flood insurance coverage compared to US-born non-Hispanic Whites ( $p < 0.05$ ), and that the coverage rate for US-born Hispanics was not statistically significantly different from either Hispanic immigrants or US-born non-Hispanic Whites.

In terms of general disaster preparedness, Kruskal-Wallis test results indicate that US-born non-Hispanic Whites had the highest level of preparedness as a group, followed by US-born Hispanics; Hispanic immigrants had the lowest group mean rank for disaster preparedness (Table 3.4). Differences across the groups in terms of level of disaster preparedness are statistically significant ( $p=0.006$ ). Post-hoc Mann-Whitney testing revealed that Hispanic immigrants were significantly less prepared for disasters than US-born non-Hispanic Whites, and that the level of disaster preparedness among US-born Hispanics was not statistically significantly different from either the immigrant group or US-born non-Hispanic Whites.

#### 3.3.1.2. Differences in Risk Perception

Kruskal-Wallis test results also revealed consistent differences in flood risk perception between the racial/ethnic groups (Table 3.4). First, Hispanic immigrants perceived flooding to be a greater general problem in Houston/Miami than US-born Hispanics and non-Hispanic Whites; US-born non-Hispanic Whites perceived flooding to be less of a concern than both the foreign- and US-born Hispanic groups. The same pattern was found for concerns about floods causing damage to property, causing injuries or health problems, and preventing household members from working or disrupting their daily activities. For each risk perception measure, Hispanic immigrants exhibited the greatest concern, followed by US-born Hispanics, with US-born non-Hispanic Whites expressing the least concern. Differences in flood risk perception across the groups were statistically significant for each of the four measures ( $p<0.001$ ).

#### 3.3.2. Research Question 3: Why do differences in self-protection and risk perceptions exist between the three groups?

First, we focus on the main explanatory factors influencing lower levels of self-protection among Hispanic immigrants based on the qualitative data analysis, which include social

disparities in housing tenure, access to resources, and hazard-related knowledge. Second, we report possible explanations for the differences in risk perceptions across the groups based on emergent patterns from our qualitative analysis.

#### 3.3.2.1. Divergent Housing Tenure Arrangements

Renter status, most common among Hispanic immigrants, was a key obstacle to undertaking flood/hurricane hazard mitigation actions and maintaining flood insurance. Among survey respondents, the renter-occupancy rate for Hispanic immigrants was twice that of US-born Hispanics and nearly four times that of US-born non-Hispanic Whites (Table 3.1). Ten of 15 immigrant interview participants were renter-occupants, and seven of those described not being able to undertake mitigation actions at their residences because they were not owners. Mario, an immigrant householder living in Houston, was asked why he had not made home modifications to protect against floods or hurricanes, and he responded:

What happened is that I lived in an apartment. So in an apartment, they don't do anything like that. The apartments I live at are older, and they need a lot of modifications. It is true, the air conditioning units are outside on the floor and not even elevated or anything. A lot of times, that equipment gets wet and...it is a danger. Most of the electrical components are down low—very low—and it should not be like that (translated from Spanish).

US-born Hispanic interview participants also viewed their renter-occupant status as an obstacle to undertaking flood/hurricane mitigation actions. Two of the four interview participants in this group were renter-occupants. Uriel, who resides in Miami, claimed that managers of the property where he lived did not provide adequate structural protections for tenants. When asked if he knew about protective actions taken by the landlord: “Not sure. They don't even have [hurricane] shutters or anything. They don't provide that.” Uriel understood that if he owned his home, he could have undertaken mitigation measures to protect himself and his property. He stated: “I don't own the house [apartment]. I'm pretty sure if I went ahead and bought the house I

would have extra measures”. When asked about his landlord maintaining flood insurance coverage for the complex, Uriel responded: “I guess they have ... some sort of insurance but I haven’t seen anything...so far.” Such lack of knowledge among renter-occupants regarding the maintenance of flood insurance coverage for built structures by landlords emerged as a common theme in interviews with Hispanic immigrants especially.

Compared to both Hispanic groups, members of the US-born non-Hispanic White group were less likely to be renter-occupants, which gave them increased opportunities to protect themselves and their homes from flooding. Only one US-born non-Hispanic White interviewee was a renter-occupant, and she did not discuss housing tenure as being a barrier to taking protective action. Owning their own homes proved to be relatively advantageous for this group in terms of their self-protective decision-making.

#### 3.3.2.2. Inequitable Access to Resources Based on Socioeconomic and Immigration Status

Hispanic immigrant study participants had relatively low socioeconomic status compared to the other two groups, and follow-up interviews indicated that this contributed to their reduced capacities for self-protection. Table 3.1 shows the differences in household income between the three groups. Low socioeconomic status was a barrier made explicit by Hispanic immigrant interviewees. For those without flood insurance, a lack of economic resources was a significant obstacle preventing them from paying for the coverage, with three individuals specifically identifying economic barriers. Lucia, who lacked flood insurance at the time of her interview, said: “At the beginning I had it [flood insurance] here, but then I had to cancel it because it was affecting my finances (translated from Spanish).” Houston immigrant Aida was aware she needed insurance but still did not have it: “I cannot afford to pay for insurance. It may be that I need it, but that’s too bad (translated from Spanish).” Among Hispanic immigrants,

underinsurance was another problem. For example, an individual living in a condo mentioned that her homeowner's insurance policy covered only external areas and if something happened to the home, she would have to pay to fix it. Underinsurance or lack of knowledge about the flood insurance status of their home was a problem more common among Hispanic immigrants than both comparison groups.

Interviews revealed how the low socioeconomic status of Hispanic immigrants also created barriers to self-protection for those seeking to recover from flood/hurricane damage. Seven Hispanic immigrant interviewees suffered property losses due to hurricane or flood events, and all experienced highly constrained access to recovery and self-protection resources. None received help from insurance companies after incurring property damage, which meant they had to cover costs out of pocket or through other means. The jobs typically held by Hispanic immigrants tended to offer few if any benefits (e.g., paid time off and vacation days), and the pay was typically so low that families were forced to live paycheck-to-paycheck. In the case of Mika, her family struggled financially when her husband lost two weeks of work and pay due to a flood/hurricane event. Mika described the situation: "So my husband went two weeks without working. Going two weeks without working is a lot, right? We were lacking money for the following month because we were paying rent. We had to use what we had saved, and we used it all up on that" (translated from Spanish).

In addition to their low socioeconomic status, there is the matter of Hispanic immigrants being prevented from receiving state disaster assistance due to their immigration status. Since many foreign-born individuals are not US citizens, they are denied much of the assistance offered by agencies like FEMA (only short-term and non-cash assistance may be provided for non-citizens with or without legal residency). Among our interviewees, seven of the fifteen

Hispanic immigrants lacked US citizenship. Thus, for a substantial proportion, a lack of entitlement to, or fear of, seeking government assistance in the US context—coupled with the lack of financial means and property ownership—impeded their access to protective resources and constrained their capacities to reduce flood and hurricane risks.

Recognizing the barriers they faced in accessing risk reduction resources, it is not surprising that many interviewees from this group depended heavily on family members for support. Among the seven Hispanic immigrant interviewees who had experienced a flood or hurricane disaster in the US, only two received any state recovery assistance (limited to water/ice in one case and food stamps in the other). Relative to the state aid they received, those two interviewees were assisted substantially more by friends, family, and church. Thus, left without insurance and external aid, our Hispanic immigrant interviewees recovered with help from family and friends. For example, two individuals said that their post-disaster home repairs were done by family and neighbors, since they did not have any other form of aid. Mario said: “The work—to remove all that [damaged carpet]—it was done by all of us—people we know....for example, my brother-in-law” (translated from Spanish). Another two interviewees (in addition to the two who received minimal state assistance) also relied on mutual support among friends, family, and neighbors. In general, those social networks emerged as the primary sources of disaster recovery aid for our Hispanic immigrant interviewees.

US-born Hispanic interviewees were typically better able protect themselves against floods/hurricanes as a result of their generally higher socioeconomic status and US citizenship. The four interviewees in this group did not discuss financial constraints, but instead focused on having limited time to undertake mitigation actions. Uriel worked 60 hour weeks and said he lacked the time to even collect free sandbags from the city. Financial and immigration related

constraints, however, did not appear to strongly influence US-born Hispanics' self-protective decision-making.

The US-born non-Hispanic White interview participants were better able to protect themselves against floods/hurricanes, also largely due to their relatively higher socioeconomic status and US citizenship. An apparent obstacle to self-protection for this group was the perception of not being at high risk of flooding (Table 3.4). Additionally, some US-born non-Hispanic Whites exhibited relatively high levels of knowledge of and confidence in public flood/hurricane protection infrastructure near their homes, even though they resided within flood zones. For example, Houston resident Natalie stated that she was not concerned about the possibility of floods: "I am two blocks from the seawall. And if [Hurricane] Ike didn't destroy it, I can't imagine any hurricane destroying it."

US-born non-Hispanic Whites were also significantly more likely to have state-subsidized flood insurance. Martha, from Houston, said that costs of flood damages to her home were "like a hundred and some odd thousand dollars from insurance" and that the repairs were done right away, of high quality, and 100% covered by her policy. Interviewees from this group who had never experienced flooding also insisted on having flood insurance. Miami resident Oscar said: "we have FEMA flood insurance (both for home and contents) and always have—and probably always will—because our homeowner's insurance will not cover flooding." Oscar had three separate insurance policies. Furthermore, unlike most Hispanic immigrant interviewees, Oscar was knowledgeable about insurance. After being asked why he purchased flood insurance, even though he was not required to as he lived in a 500-year flood zone, Oscar stated: "Homeowner's insurance policy for Florida will cover you for hurricane damage, but if the damage is deemed to be from rising flood waters, the insurance companies are absolved of

any liabilities for damage to your home.” Thus, while non-Hispanic Whites’ enhanced capacities for self-protection stemmed in part from their relatively higher socioeconomic status and access to state resources, they also tended to exhibit greater hazard-specific knowledge.

#### 3.3.2.3. Gaps in Knowledge

Our qualitative analysis indicated a deficit in hazard-specific knowledge among Hispanic immigrants relative to US-born Hispanics and especially non-Hispanic Whites, which also factored into their lower levels of self-protection. All Hispanic immigrant interviewees lacked the in-depth knowledge about available protections against flood/hurricane risks that was demonstrated by many US-born non-Hispanic Whites. For example, while several non-Hispanic Whites (like Oscar) provided detailed descriptions of the protections offered by their multiple insurance policies, a much higher proportion of Hispanic interviewees, both foreign- and US-born, were either uninsured or unsure of what type of insurance they maintained.

The knowledge gap experienced by Hispanic immigrants was amplified by an inability to communicate in English. Less than half of Hispanic immigrant survey participants were proficient in English; in contrast, all US-born Hispanic and non-Hispanic White survey participants were English proficient. Some Hispanic immigrant interviewees reported having received information on unfolding disaster events in Spanish through the radio or television. However, others lacked access to any information in Spanish throughout major disaster events, as was Aida’s experience in Hurricane Ike. Among the seven Hispanic immigrant interviewees who had experienced flood/hurricane damage while in the US, constrained access to recovery assistance was compounded by their English deficiencies and the limited availability of information regarding post-disaster aid in Spanish. Three of those seven interviewees, who were



monolingual Spanish speakers, reported being unaware of any recovery assistance being available.

In contrast to the Hispanic immigrant interviewees, no US-born Hispanics were unaware that they lived within a flood zone, which may be explained by the fact that all were English-language proficient. A different knowledge deficiency, however, emerged for the four interviewees in this group. All US-born Hispanics either lacked knowledge of how to protect against floods/hurricanes or thought that nothing could be done to mitigate flood/hurricane hazards. This general lack of awareness about protections to minimize the risks of flooding/hurricanes distinguished US-born Hispanics from the US-born non-Hispanic White group in particular.

Among the 12 US-born non-Hispanic White interview participants, five were unaware that they were residing at risk to flooding. None lacked English-language proficiency. Of the five individuals who erroneously believed that they were at low flood risk, three were told by their insurance company they did not reside within a flood zone, and technically they did not—these people lived in the 500-year flood zone and were thus not required to maintain flood insurance coverage. Given the lack of awareness displayed by those five interviewees, and the fact that three lived outside of the 100-year flood zone, it is notable that all had flood insurance.

#### 3.3.2.4. Risk Perceptions: Possible Explanations for Observed Differences

Based on our qualitative analysis, all Hispanic immigrants expressed concern about flooding and hurricanes, in terms of property losses as well as impacts on their family members' health, daily lives and livelihoods. In Miami, Amanda, who had not experienced home site flooding, worried about a flood and how this could hurt “her life, her family, and her things” (translated from Spanish). Hispanic immigrants with flood experience, like Houston resident

Mario, voiced concerns about the unaddressed flood protection deficiencies that they had witnessed during previous events. Mario said: “Houston is a city that floods easily. They said that they were going to do something about that, but I don’t know if they are actually doing anything. When a heavy rain falls, there are many areas that flood quickly because they are below sea level. The water that falls recedes very slowly” (translated from Spanish). Others, like Miami resident Ivan, were well aware of the risks of flooding and hurricanes, but were also fatalistic. When asked about his concerns about flooding or hurricanes, Ivan replied: “It’s not that it worries me... I can’t say that it worries me or not because—I don’t want to think about that. If you start thinking about that, you get a little more nervous. It is better just to live in the moment” (translated from Spanish). While Mario acknowledged anxiety about flooding, he tried to ignore it. Despite their concerns, Hispanic immigrant interviewees experienced serious barriers to self-protection and lacked awareness of their self-protection options, which possibly amplified their perceptions of risk.

US-born Hispanics also expressed concern about flooding; however, they primarily emphasized property damage. For example, Albert and Samuel, both from Houston, each expressed some worry about flooding and the damage it could cause to their homes. Similarly, Miami resident Cesar’s greatest concern related to home damage caused by hurricane events. In general, US-born Hispanic interviewees did not express concerns about experiencing bodily harm or livelihood loss due to flooding or hurricanes, which may partially explain the lower perceptions of risk among members of this group relative to their foreign-born counterparts.

The concerns most common among the group of US-born non-Hispanic Whites were primarily property damage and secondarily disruption to daily activities. When asked about what worried him most about flooding and hurricanes, Nick, from Houston, replied “damage to my

home more than any other.” Violet, from Miami, said that she was concerned not only about property damage, but also about having her daily activities disrupted. Lastly, there were those who were concerned about floods, but felt adequately protected. Miami resident Oscar acknowledged that he lived in a hurricane-prone area, but reasoned that he was “not...below sea level.” In sum, the most common worry among non-Hispanic White interviewees was property damage, and there was a much stronger sense of being protected across this group in comparison to the Hispanic immigrant interviewees. This sense of safety based on flood insurance coverage and faith in flood protection infrastructure may explain the lower risk perceptions exhibited by this group compared to the US-born and especially immigrant Hispanic groups.

### 3.4. Conclusion

The Hispanic immigrant population in the US is large, and the US population is Latinizing. Since prior studies have not examined the disaster vulnerabilities of Hispanic immigrants vis-à-vis other groups, our study makes an important contribution. Findings demonstrate that lumping people with heterogeneous characteristics (in this case, US-born and foreign-born Hispanics) conceals important self-protection disparities and risk perception differences. Thus, future studies should distinguish Hispanic immigrants from other social groups. While self-protection disparities between Hispanic immigrants and US-born non-Hispanic Whites were substantial, such disparities were not nearly as stark for US-born Hispanics. The fact that US-born Hispanics may not experience pronounced barriers to self-protection in comparison to US-born non-Hispanic Whites is attributable their US citizenship (which confers them entitlements to protective resources from the state) and English-language proficiency, as well as their higher SES and rate of homeowner-occupancy. We note that our

examination of the US-born Hispanic group was limited by small counts, especially our qualitative analysis; thus, more research is needed to clarify their group-specific vulnerabilities.

Our mixed method findings indicate that multiple, mutually reinforcing factors heightened the flood/hurricane risks experienced by Hispanic immigrants, including their comparatively low SES, high rate of renter-occupancy, low rate of English-language proficiency, and knowledge deficit regarding their exposures and response options to flood/hurricane hazards. Thus, future research on this group should examine their particular vulnerabilities in relation to other groups (including US-born Hispanics and non-Hispanic Whites) using an “intersectionality” lens that seeks to understand their risk disparities and constrained access to protective resources as products of multiple forms of social stratification in which race/ethnicity, class and gender are intertwined (Collins 1990; Crenshaw 1991; McCall 2001). Future work should seek to examine more precisely how multiple dimensions of social difference—including ones not examined here, such as gender and age—are linked and work synergistically to enhance and/or attenuate vulnerability and risk for particular groups.

The disparities in self-protection experienced by Hispanic immigrants indicate that this group would benefit from targeted interventions and assistance efforts. Their high levels of concern about flooding imply latent motivations to reduce risk. Challenges to addressing Hispanic immigrant risk disparities include the fact that many have English-language deficiencies, seek to avoid contact with government agents, and have low incomes. A particularly pernicious obstacle to self-protection in the context of flood/hurricane hazards for Hispanic immigrants is their high rate of renter-occupancy. According to the American Community Survey (2011), only 27% of homes with a foreign-born Latin American or Caribbean householder were “owned free and clear” (i.e., with mortgages paid off), while 55%

were rented. Our findings indicate that renter-occupancy not only imposes barriers to undertaking structural mitigation actions, but that Hispanic immigrants often rent dwellings in 100-year flood zones without receiving any disclosure of risk from their landlords. It is typical under such tenure arrangements for Hispanic immigrants to lack knowledge of their residence within a flood zone, about the insurance status of the building, and about their own need to maintain insurance coverage for their belongings. This is an issue that could be solved by dissemination information about hazards exposure in other languages, such as Spanish, rather than just in English.

At first glance, the fact that Hispanic immigrants exhibit heightened risk perceptions and less hazard-specific knowledge may appear contradictory. However, given their precarious SES, immigration status, and housing tenure arrangements as well as the barriers they face in self-protection, it should come as no surprise that Hispanic immigrants expressed the most concern about flood risks. The risk perception surplus and coincident knowledge deficit we found among Hispanic immigrants was also described by Carter-Pokras et al. (2007), and it suggests that this group may be exceptionally receptive to targeted and culturally-sensitive disaster risk reduction programs. Given that Hispanic immigrants tend to come from collectivist cultural backgrounds, their familial connections and community-based methods of communication (such as through churches or community-based organizations) may provide more effective channels of communication than other conduits, such as mass media (Wilson & Tiefenbacher 2012). In conclusion, a limitation of our study is that findings are specific to Greater Houston and Miami. We hypothesize, however, that they are generalizable to other US contexts. Future studies should examine the social vulnerabilities of Hispanic immigrants elsewhere and in reference to other hazard types. By broadening the range of hazard types, localities, and hypothetical factors

examined, and by seeking to better explain patterns through examination of multiple hypothetical influences, an improved understanding of the disaster vulnerabilities experiences by Hispanic immigrants is possible.

## 4. Summary and Implications

### 4.1. Summary

This thesis has analyzed the disproportionate vulnerability of Hispanic immigrant households to flood hazards relative to other social groups, in terms of their residential exposure to flood risks (Chapter 2), and, among those living within flood zones, in terms of their flood risk perceptions and self-protective actions (Chapter 3). Although flood hazard vulnerability has been a focus of much prior research, the two studies that comprise this thesis are among the first to focus on the vulnerabilities of Hispanic immigrants in particular when compared to other social groups (including US-born Hispanics).

Chapter 2 consists of an examination into the characteristics that place individuals at greater exposure to the 100-year flood zone in the MSA's of Houston, TX and Miami, FL, adjusting for the relevant covariates. Based on the social characteristics of Hispanic immigrants, we hypothesized that this group would share a greater burden of flood exposure compared to US-born Hispanics, non-Hispanic Blacks, non-Hispanic other minorities and non-Hispanic Whites. This study's analysis revealed that our hypothesis was partially correct: Hispanic immigrants experience greater exposure to the 100-year flood zone in Houston, but not in Miami. This suggests the hypothesis that in contexts where water-based amenities weakly structure residential decision-making (perhaps in many areas at risk to inland as opposed to coastal flooding) and where Hispanic immigrants are typically highly socially marginal (in most areas of the US), Hispanic immigrants are likely to experience disproportionate exposure flood risks than more socially advantaged groups (including US-born Hispanics and non-Hispanic Whites).

Chapter 3 described and explained differences between Hispanic immigrants, US-born Hispanics and non-Hispanic Whites in terms of self-protection against flood risks and flood risk

perception, using a mixed method approach. Results revealed that Hispanic immigrants were least protected against flood/hurricane hazards as well as worst prepared for disasters generally, and that they displayed the highest perceptions of flood risks. Lastly, our qualitative analysis indicated that renter status, lower socioeconomic and immigrant status, as well as a lack of hazard-related knowledge (rooted in a lack of access to information) were all factors that help explain why Hispanic immigrants exhibited less self-protection and higher risk perception. On the whole, most findings from this thesis indicate that Hispanic immigrants may exhibit distinct (and typically amplified) flood hazard vulnerabilities relative to other social groups.

#### 4.2. Policy Implications

These findings are important because they demonstrate that Hispanic immigrants are a group that may not only experience greater exposure to hazards (pre-event), but also experience highly constrained capacities to protect themselves (before, during and after events) due to their immigrant and low socioeconomic status, language barriers and a lack of access to information due to cultural barriers. We believe that the flood hazard vulnerabilities experienced by Hispanic immigrants could be reduced in part through targeted interventions. For example, given our findings about the relative lack of knowledge about hazards characterizing Hispanic immigrants (from study 2), we believe this group would benefit from practices that aim at reducing this knowledge gap, since Hispanic immigrants' right-to-know about their risk exposure is being fundamentally violated. One way of better protecting their and others' rights-to-know would be to legally mandate that landlords provide disclosure statements about flood hazards (and the risks associated with this exposure) in English and Spanish to prospective tenants prior to formalizing all rental agreements for properties within 100-year flood zones. Having access to hazards



information in their native language could significantly bridge the knowledge gap among Hispanic immigrants who are not English-language proficient.

Additionally, since our study 1 results (see Chapter 2) indicate that there are some contexts (Houston) in which those who are more exposed to flood risks take less mitigation action (adjusting for the effects of other relevant variables), organizations such as FEMA should see to develop interventions in order to facilitate self-protective actions by those who are highly vulnerable. FEMA, state and local organizations responsible for emergency management and disaster preparedness should take steps in informing vulnerable populations about the risks and options available for protection. Information about the NFIP, tenants' right-to-know, and structural and non-structural protective actions should be made accessible to anyone who is deemed at risk or vulnerable.

In terms of cultural sensitivity that could help reduce the vulnerabilities of Hispanic immigrants, community-based approaches to disaster risk reduction may prove more effective for Hispanic immigrants and other socially vulnerable groups. Familial modes of communication may target specific family members as entry points, for example, children who could be provided information at schools. Improved disaster preparedness among Hispanic immigrants may also be achieved through deepened community engagement, more culturally-competent approaches, participatory methods, as well as partnerships among universities, public health agencies and community-based organizations (Burke et al. 2012). The dissemination of information through other methods (other than mass media) in Spanish as well as in English could potentially reach many more Hispanic immigrants at risk and ensure that more Hispanic immigrant people take actions to protect themselves against potential hazards.

#### 4.3. Directions for Future Research

This thesis has sought to bridge the gap that exists in the EJ and hazards literature in terms of Hispanic immigrants and their vulnerability to flooding. Due to the tendency in EJ and hazards research to treat all Hispanic people as a single, homogenous group, those characteristics that place Hispanic immigrants at higher risk than other minority groups, including other Hispanic groups, are concealed, possibly resulting in underestimation of the actual level of hazard vulnerability this group experiences. For this reason, this thesis has focused on Hispanic immigrants as an independent group from other minorities and it has found that Hispanic immigrants in particular may experience greater exposure (In Houston) to and reduced ability to cope with disasters when compared to other groups (including socially advantaged and other disadvantaged groups). Thus, there is a need for a greater understanding of risks, hazards, and disasters as experienced by Hispanic immigrants. Future research on hazard vulnerability and environmental justice should distinguish between Hispanic subgroups and other minority groups as well, taking into consideration characteristics such as immigration status and cultural and linguistic isolation.

Future research should also seek to make a distinction between different kinds of floodable landscapes in terms of what benefits, if any, are associated with flood hazard exposure. This study was limited by a lack of survey respondents in coastal zones; therefore, the 100-year flood zone variables could not be disaggregated into coastal vs. inland flood zones. However, making distinctions among minority subgroups as well as between different floodable landscapes in terms of associated locational benefits is necessary to determine who is genuinely vulnerable to flood impacts (vs. who simply has a home in a floodable zone), and, in turn, for clarifying practical responses that will successfully reduce vulnerabilities.

## 5. References

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## 6. Vita

Alejandra Maldonado was born in Ciudad Juarez, Mexico and immigrated to El Paso, Texas, where she currently resides, at the age of five. Maldonado started attending classes at the University of Texas at El Paso (UTEP) in the Fall Semester of 2008 after having graduated from Americas High School that same year. While pursuing her double major in History in Sociology, Maldonado worked as a Peer Career Advisor at the University Career Center from January 2010 to August 2013, when she started working as an Undergraduate Research Assistant at the Department of Sociology and Anthropology through a National Science Foundation (NSF) grant under the direction of Drs. Sara Grineski and Tim Collins. Maldonado started work on her Master of Arts in Sociology during the Summer of 2014, and has since been presenting her research on Environmental Justice at national conferences and has published a paper examining the social vulnerabilities of Hispanic immigrants to flood hazards in a peer-reviewed journal. She is currently collaborating in an international research project that examines environmental contamination in the mining community of Mount Isa, Australia. Maldonado will continue pursuing graduate studies and will enroll as a doctoral student during the Fall Semester of 2017.