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Race/ethnicity and worry about the threat of flooding: a mediation analysis of perceived risk versus preparedness

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ABSTRACT

Research has demonstrated that natural disasters, like flooding that are increasing with climate change, can have profound mental health effects. Moreover, these outcomes are not experienced evenly across the population with disadvantaged populations like racial/ethnic minorities and lower socio-economic status individuals being more likely to report psychological diagnoses and symptoms related to floods. However, the mechanisms that could account for the link between social vulnerability and worry about the threat of flooding remain poorly understood. In this analysis, we use a 2022 survey of Houston-area residents to examine how perceived flood risk and subjective flood preparedness relate to racial/ethnic differences in worry about the threat of flooding. We find that both individual-level and area-level race/ethnicity are significantly related to greater worry about the threat of flooding. Further, this is partially mediated by perceived flood risk, but not subjective flood preparedness. This suggests that policies and infrastructure priorities that reduce risk rather than prepare households for flooding would accomplish more in closing the gap in social disparities in mental health outcomes from flooding.

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Worry/anxiety; flood risk; flood preparedness; race/ethnicity; residential segregation; disasters

Introduction

Extant research has examined social vulnerability to climate disasters, demonstrating that marginalized communities are both more likely to be subject to catastrophic flooding and experience greater difficulty in recovering (Chakraborty, Collins, and Grineski 2018; Collins et al. 2019; D. Cox et al. 2002; Finch, Emrich, and Cutter 2010; Lotfata and Ambinakudige 2019; Meyer et al. 2018). As climate change and unplanned urbanization increase the frequency and intensity of extreme weather events, we need to better understand how individuals and communities are affected by climate change. Previous work has demonstrated a myriad of health implications from extreme weather events (Bourque and Cunsolo Willox 2014; Callender et al. 2022; Flores, Collins, Grineski, and Chakraborty 2020; Smiley et al. 2022). The work on flooding specifically has linked flooding to a number of mental health effects, such as PTSD, generalized anxiety, and depression, with enduring mental health effects throughout the long process of flood recovery (Callender et al. 2022; Grineski et al. 2020; Lamond, Joseph, and Proverbs 2015). Moreover, some limited work has demonstrated how these mental health effects disproportionately affect socially vulnerable populations, such as racial/ethnic minority groups (Alderman, Turner, and Tong 2012; Grineski et al. 2020).

Although this work has found important health implications of flooding, comparatively few studies have attempted to unpack the mechanisms that could link flooding to social vulnerabilities and worry about the threat of flooding. Here, we examine two potential explanatory mechanisms through an analysis of flood risk and flood preparedness, which may be two possible explanations for worry about the threat of flooding (Cong and Chen 2022; Flores et al. 2023; Lee and Lee 2019; Wildavsky and Dake 1990). Both disaster preparedness and risk perception involve self-protective behaviors and actions that attempt to mitigate the consequences of flooding (Flores, Collins, Grineski, Griego, et al. 2020; Lin et al. 2020; Rufat et al. 2015). Objectively, racial/ethnic minority communities experience greater risk from flood events and have historically experienced more devastation from natural disasters (Lieberknecht et al. 2021; Lowe, Sampson, et al. 2015; Meyer 2016; Smiley 2020). Thus, we may expect that racial/ethnic minorities experience more worry about the threat of flooding because they are simply more likely to experience it. Racial/ethnic minorities are also more likely to be in a lower socio-economic status position and experience higher rates of material deprivation compared to their White counterparts (Cagney et al. 2016; Smiley 2020). Thus, racial/ethnic minority communities may experience greater worry about the threat of flooding because they are more likely to be in an economically precarious situation where their ability to prepare for a flood event and contend with its effects is limited (Maldonado, Collins, and Grineski 2016; Reininger et al. 2013).

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We will test both of these possibilities in an analysis of worry about the threat of flooding in a study of the Houston area. Specifically, we ask: first, what individual-level and area-level characteristics are associated with worry about the threat of flooding? That is, are racial/ethnic minority individuals and minority clustered areas more likely to experience worry about flooding? And second, what can account for these disparities? Is it due to risk perception, in that people who perceive greater risk experience greater worry about the threat of flooding? Or does it relate to feelings of subjective flood preparedness, that people who feel less prepared to handle a major weather event experience greater worry? We will attempt to adjudicate between these explanations in a quantitative study of Houston, a city that has experienced frequent flood events and natural disasters with increasing intensity in the last several decades, and one that exhibits both racial/ethnic minority disadvantage and social vulnerability.

Literature review and theoretical background

Flood-related psychological outcomes

There has been a recent explosion in interest in how climate disasters like flooding relate to mental health. This work has demonstrated a wide variety of poor mental health outcomes associated with flood events. Specifically, many of these studies have shown important effects of flood events for particular diagnoses, including anxiety, depression, and post-traumatic stress disorder (PTSD), including studies in the Houston area specifically (Flores, Collins, Grineski, and Chakraborty 2020; French et al. 2019; Grineski et al. 2020; Lieberman-Cribbin et al. 2017; Oluyomi et al. 2021; Paranjothy et al. 2011). One such study used a pre- and post-test survey design both before and after Hurricane Harvey, and demonstrated heightened symptoms of PTSD after Harvey, especially for non-White respondents (Grineski et al. 2020). Moreover, these effects tend to be stronger for more challenging flood experiences, such as the depth of flooding or repeat flood events (French et al. 2019; Lieberman-Cribbin et al. 2017). Several longitudinal studies on the health effects of flooding have found important mental health outcomes over time, and have often found enduring effects of these events on mental health, particularly for anxiety, depression, PTSD, and help-seeking behavior (Findlater et al. 2023; Sedighi et al. 2021). Some of these studies even included follow up periods of several years, providing evidence for long term effects of flooding, though some of these studies found that the effects lessened over time (Findlater et al. 2023; Tapsell and Tunstall 2008).

Despite this now robust body of work providing important evidence of mental health outcomes related to disaster and flooding, few studies examine how this may differ by race/ethnicity, particularly in a U.S. context. Because race is a factor in both individual-level factors and area-level social vulnerability that can affect mental health, understanding the ways in which flooding disasters affect an individual's psychological outcomes by race is critical (Nomura et al. 2016; Woodhall-Melnik and Grogan 2019). There is now ample research that has demonstrated important differences by race in the experience of natural disaster, as well as in the recovery process (Flores, Collins, Grineski, Griego, et al. 2020; Lieberknecht et al. 2021; Lieberman-Cribbin et al. 2021; Meyer 2016; Smiley 2020; Smiley et al. 2022). Thus, we might reasonably expect that the mental health effects of disaster and flooding rest disproportionately among racial/ethnic minorities in the U.S. However, few studies to date have empirically tested this.

While the literature on race and negative mental health outcomes related to natural disasters is nascent, some important contributions have been made. For instance, a 2013 study found that there are racial differences in PTSD status, depression, and anxiety following Hurricane Ike in the Houston area (Davidson et al. 2013). Another study on Hurricane Ike, showed that non-Hispanic Black people have higher rates of PTSD related to natural disasters than other racial groups (Lowe, Joshi, et al. 2015). Similarly, a different study examining the case of Hurricane Harvey in Houston found that although severity of exposure was associated with poor mental health outcomes, there were no SES or racial differences in mental health outcomes (Bevilacqua et al. 2020), while another found that minority individuals in the region experienced heightened PTSD symptoms after Harvey (Grineski et al. 2020). First et al. (2021) examined important risk factors that contribute to mental health outcomes among Black and Latino adults after tornado events in Tennessee. Aside from the hazards of exposure itself, they found that barriers to receiving information also adversely affected participants. Although these examples represent key contributions to the literature, there are still several gaps in our understanding of racial differences in worry about the threat of flooding.

One limitation of many of these current studies is that many are limited to specific psychiatric disorders instead of capturing a broader worry or distress about the threat of flooding (Bourque and Cunsolo Willox 2014; Grineski et al. 2020; Saeed and Gargano 2022). The recent literature has called for the utilization of a broader definition of negative mental health outcomes related to natural and climate disasters (Alderman, Turner, and Tong 2012; Woodhall-Melnik and Grogan 2019). In this analysis, we examine worry about the threat of flooding, broadly conceptualized as these negative feelings, including uncertainty, anxiety,

worry, etc., that occur due to flooding disasters, rather than utilizing clinical symptomology. Further, another limitation in the literature is that most studies that focus on flooding disasters typically focus on a specific flood event and study a population in the aftermath of that event. This does not capture how chronic threat from residing in a high-risk flood area can impact mental health (Ali et al. 2017; Bevilacqua et al. 2020; Davidson et al. 2013; Lowe, Joshi, et al. 2015). This paper aims to address these gaps by empirically studying worry or anxious feelings that are related to flood risk and experiences. Another major limitation of the literature is that few studies attempt to tease out the mechanisms by which we may observe this association. In this analysis, we consider two such mechanisms through a study of perceived risk and flood preparedness as mediators in the association between race, social vulnerability, and mental health.

Racial differences in risk perception and disaster preparedness

Individuals' preparedness for disaster involves both self-protective and preventative behaviors. Disaster mitigation involves a wide range of structural protections, while disaster preparedness can involve being aware (or perceiving), learning, and managing the negative consequences of flooding disasters (Cong and Chen 2022; Grineski et al. 2020; Zinda et al. 2023). Access to nonperishable food, water, and transportation are important in disaster preparedness, as well as being aware of shelters, evacuation plans, and alternative housing (K. Cox and Kim 2018; Cutter, Boruff, and Lynn Shirley 2003; Finch, Emrich, and Cutter 2010). A 2010 study found that environmental risk perceptions differ across racial groups, which can affect evacuation rates (Stein, Dueñas-Osorio, and Subramanian 2010). However, perceiving risk should not be confused with what individuals can actually do to prepare for impending natural hazards in that personal resources may limit their ability to prepare or evacuate (Lebel et al. 2015). Instead, individuals' differential perceptions of risk can influence their level of preparedness for impeding disasters (Bolin and Liza 2018; Finch, Emrich, and Cutter 2010; Wildavsky and Dake 1990).

Certain individual characteristics may have an impact on how people perceive and prepare for disasters, particularly race (Cong and Chen 2022; Cutter, Boruff, and Lynn Shirley 2003; Tapsell et al. 2002). Race can be a predictor of social vulnerability to flooding disasters, and race/ethnicity can affect income, housing, and access to knowledge about impending disasters, which can relate to perceptions of risk and preparedness (Cutter, Boruff, and Lynn Shirley 2003; Flores et al. 2023; Maldonado, Collins, and Grineski 2016; Tapsell et al. 2002). For instance, Macias (2016) found racial differences in environmental risk perceptions across racial and ethnic groups. Lachlan et al. (2009) examined risk perceptions across racial groups after Hurricane Katrina and concluded that Black people had the lowest perceptions of risk despite ultimately being the most affected by the disaster. Risk perceptions can also influence how prepared individuals are for disasters. An example of this is socio-economic status (SES). According to U.S. Census figures, more racial minorities live at or below the poverty line than their White counterparts. This economic disparity can negatively affect minorities' material preparedness for floods, such as the ability to implement structural protective measures or purchase flood insurance (Cong and Chen 2022; Cutter, Boruff, and Lynn Shirley 2003; Finch, Emrich, and Cutter 2010; Maldonado, Collins, and Grineski 2016; Reininger et al. 2013).

Furthermore, given the high degree of residential segregation by race, the physical places in which racial/ethnic minorities reside may be less equipped to deal with catastrophic flooding. For example, racial minorities are more likely to reside in areas that have more impervious surfaces and poor infrastructure as a result of redlining and real estate practices that have purposefully sited marginalized groups in areas with inferior infrastructure (Bolin and Liza 2018; K. Cox and Kim 2018; Cutter, Boruff, and Lynn Shirley 2003; Flores et al. 2023). A community-based perspective can provide a deeper understanding of different groups' unique challenges regarding perceptions of risk and disaster preparedness (Cong and Chen 2022; K. Cox and Kim 2018). The social differences found in different communities tend to influence their specific needs during a disaster, which may not be fully understood by administrative officials. This can relate to differential assistance for disaster preparedness across communities (Cong and Chen 2022; D. Cox et al. 2002; Flores, Collins, Grineski, Griego, et al. 2020; Stein, Dueñas-Osorio, and Subramanian 2010). Lack of awareness and preparation for impending disasters can impact at-risk individuals' mental health, particularly worry or anxious feelings (Chen et al. 2020; Lee and Lee 2019; Reininger et al. 2013; Woodhall-Melnik and Grogan 2019).

Conceptual framework and hypotheses

We provide a visual representation of our conceptual framework in Figure 1. Previous work demonstrates that racial/ethnic minorities, as well as lower socioeconomic status individuals, experience both greater mental health symptoms and poorer health outcomes in the wake of natural disaster than their White counterparts (Cagney et al. 2016; Gruebner et al. 2015). This work has included Houston as well (Flores, Collins, Grineski, and Chakraborty 2020; Grineski et al. 2020).

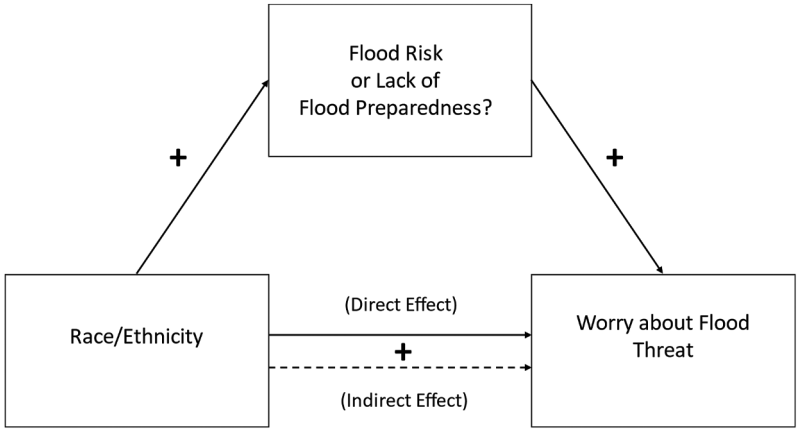

Figure 1. Conceptual model.

However, extant work on the topic has primarily examined worry or anxiety from flooding in the wake of a specific flood event, and only a few studies have examined chronic flood risk and general worry about the threat of flooding. We aim to extend this work to include ongoing flood risk and experiences, and the mental health toll that may produce. Given the robust body of work on social disadvantage in mental health and disasters, we expect to find the same in our sample and hypothesize the following at both the individual and area-level of analysis:

H1: Racial and ethnic minority respondents will be more likely to report greater levels of worry about the threat of flooding.

H2: Individuals living in racial/ethnic minority clustered areas will be more likely to report greater levels of worry about the threat of flooding.

Another goal of this study is to elucidate some of the mechanisms that may relate to this link between race/ethnicity and worry about the threat of flooding. On the one hand, racial/ethnic minority segregated areas are more likely to experience flood risk, and previous work has demonstrated that they are disproportionately affected by extreme weather and experience greater difficulty in recovery (Fitzpatrick and Spialek 2020; Flores, Collins, Grineski, Griego, et al. 2020; Smiley 2020). Thus, one explanation for their disproportionate levels of worry or anxious feelings may stem from the greater risk profile that these individuals and areas experience (Flores, Collins, Grineski, Griego, et al. 2020; Rufat et al. 2015). On the other hand, worry may stem from a feeling of lack of preparedness with regard to natural disasters, which may be greater among disadvantaged populations that have fewer household resources to avoid or protect against the negative effects of natural disasters (Brody, Lee, and Highfield 2017; Maldonado, Collins, and Grineski 2016; Reininger et al. 2013). Thus, we posit two explanations that could help account for this disparity at both the individual and area-level of analysis:

H3: Perceived flood risk will mediate the relationship between race/ethnicity, racial/ethnic clustering, and worry about the threat of flooding.

H4: Perceived flood preparedness will mediate the relationship between race/ethnicity, racial/ethnic clustering, and worry about the threat of flooding.

We will test each of these hypotheses in a series of statistical models using data from the Houston area. First, we detail our data and methodological considerations.

Materials and methods

Data

In order to address these research questions, we combine two data sources. First, for our individual-level data, we use the 2022 Community Perceptions of Flood Mitigation Survey, which was a random telephone survey conducted of adults across the Harris County (Houston), Texas area in March-April of 2022. The 2022 Community Perceptions of Flood Mitigation Survey was designed to examine individual-level experiences with flooding, perceptions of flood risk, opinions of flood mitigation strategies, general community perceptions, and demographic characteristics. To conduct the survey, we contracted with Consumer Research International (CRI), which is a survey research firm based in San Marcos, Texas. A total of 700 responses were collected through a probability-based landline and cell phone sample. Of these, 200 (28.57%) were from random digit landline dials, 401 (57.29%) were from listed cellphone numbers, and 99 (14.14%) were from random digit cellphone dials, with an overall cooperation rate of 11.34%. While this cooperation rate may seem low compared to historical response

rates for telephone surveys, it is reflective of current trends in telephone surveying, which see higher rates of non-response or no answer due to the prevalence of cell phones and marketing fatigue. However, this figure is better or on par with major polling organizations across the U.S., such as Pew and Gallup, which have cooperation rates between 6–7% in recent years (Keeter et al. 2017; Marken 2018). The interviews were conducted in both English (95.14%) and Spanish (4.86%). Ethical approval for this project was provided by our Institutional Review Board (IRB) on 9 February 2022. After dropping values due to missing data, we have a working analytical sample of 640, dropping 8.6% of the original sample. These missing values come from the geographic identifier ($N = 2$ or 0.29%), the dependent variables and mediators ($N = 18$ or 2.6%), basic ascribed demographic characteristics, such as age, race, and sex ($N = 38$ or 5.4%), and the mental health question ($N = 2$ or 0.29%), all described below in detail.

As part of this survey, we also asked respondents to provide a relative geographic location, including their street, the nearest intersecting street, and their ZIP code location. Using this information, we were able to approximate people's geographic location by geocoding to the intersection location or by taking the population weighted centroid of the ZIP code where the intersection data was incomplete, inaccurate, or missing. From these geocoded locations, we were able to link their location to ZIP code-level data from the U.S. Census. Thus, we combine the individual-level survey with ZIP Code tabulation data from the 2017–2021 American Community Survey (ACS) five-year estimates by overlaying the ACS data and attributing it to the point locations for the respondents. We use the 2017–2021 version of the ACS as the ACS is only released at small geographic units of analysis, like the ZIP code, in five-year windows in order to ensure a large enough sample size to be representative.

Dependent variables

In this analysis, we have one primary dependent variable, *worry about the threat of flooding*. This question is specifically worded as, 'How often do you feel worried or anxious about the threat of flooding in your neighborhood?' with the response options of never, rarely, sometimes, and often. Often is coded as 4, indicating that positive coefficients are related to greater worry about the threat of flooding. With a wide distribution in responses across the different response options, and with enough corresponding variation with the two mediator response options (discussed below), we leave this variable with the four-category coding scheme and treat it as ordinal in the models.

Mediators

We also include two explanatory mediator variables that may help account for worry about the threat of flooding, which include *perceived flood risk* and *perceived flood preparedness*. This first question is specifically worded as, 'How likely do you think it is that major flooding that affects your home will occur in the next 10 years?' with the response options of very unlikely, unlikely, neither likely not unlikely, likely, or very likely. Thus, higher values on this measure indicate greater perceived flood risk. The perceived flood preparedness question was worded as, 'How prepared do you feel right now if a natural disaster were to strike the Houston area this week?' with the response options of very prepared, somewhat prepared, somewhat unprepared, very unprepared. Here, higher values indicate a lack of feeling of preparedness. With a wide distribution in responses across the different response options for both variables, we leave these variables with their original five and four-category coding schemes and treat them as continuous when used as independent variables as a mediator and ordinal in the models where they are the dependent variables.

Independent variables

In this analysis, we include two sets of independent variables, measured at the individual respondent level, as well as at the area-level as measured at the ZIP code unit of analysis. First, we include a set of dummy variables for race/ethnicity. These were originally asked as a set of paired questions for race and a separate question for Latino ethnicity. We combined these into one set of dummy variables for: *non-Latino White*, *non-Latino Black*, *Latino*, *and non-Latino Other Race*, with White as the reference group across all models. While the 'other race' category is not particularly useful or instructive given the wide range of included groups, each of these groups (Asian, Native American, Pacific Islander, and multiracial) was numerically too small of a percentage of the sample to be analyzed individually.

We also include several other individual-level characteristics, such as age, gender, marital status, number of children in the household, level of education, employment status, income, foreign born, whether or not the respondent has health insurance, self-rated poor mental health, home ownership, and flood insurance coverage. *Age*, *number of children*, *income*, and the *mental health scale* are all treated as continuous. The mental health scale is a self-assessment of poor mental health, where higher values (5) indicate poorer mental health. This was used to control for whether or not worry about the threat of flooding is the result of generalized anxiety or overall poor mental health. Income was originally asked as a set of several discrete categories and then converted to real numbers to treat it as continuous in the

model by taking the midpoint of each category. Due to the large number of missing values (28%) for this variable, we imputed the values for income for those non-responses using race, employment status, whether or not the household has a personal vehicle, education level, and an item asking about their strategy to pay an unexpected $400 bill.[1] *Female* (1=female, 0=else), *married* (1=married, 0=else), *college educated* (1=bachelor's degree or higher, 0=else), *employed* (1=employed full or part time, 0=else), *foreign born* (1=born outside the US, 0=else), *health insurance* (1=insured through either public or private insurance, 0=else), *home owner* (1=owns home, 0=else), and *flood insurance* (1=has separate flood [not homeowner's or renter's insurance], 0=else) are all re-coded as dichotomous variables.

We also included a set of variables at the ZIP code level of analysis from the ACS. To capture area-level racial/ethnic clustering by race, we use a set of clustering scores measured from the ZIP code-level race variables. Typically, segregation scores, such as the commonly used index of dissimilarity, are measured at a large geographic unit of analysis, such as the metropolitan area or county, to describe how dispersed or clustered groups are across a large area (Massey and Denton 1988). In this case, though, we are interested in how spatially clustered groups are within the Houston area as measured using a small area, in this case the ZIP code. Global measures, like dissimilarity, examine the distribution of groups over a large spatial unit, but knowing how these groups are dispersed over a small unit like the ZIP code as used here would not be particularly informative (Massey and Denton 1988; Yang, Zhao, and Song 2017). A common alternative is to use the racial/ethnic composition in the area, such as the percent of a particular group in a ZIP code. However, these scores have been critiqued for being aspatial in their measurement, despite trying to capture an inherently spatial concept. Recent advances in the literature have begun to consider geographic space more carefully in the construction of small area segregation indices by explicitly incorporating geographic proximity, which are broadly categorized as 'spatial neighbor' measures (Roberto 2018; Reardon and O'Sullivan 2004). Thus, to capture this, in this study we use the ZIP code level percentages of different groups to compute a series of geographic clustering scores measured at the level of the ZIP code. We use the following formula that captures not just the relative size of that group in an area (concentration), but also the numbers of the same group in its adjacent geographic neighbors (clustering):

$$C_i = x_i \sum_{j=1, j \neq i}^{n} w_{ij} x_j$$

where x_i is the variable for feature i, x_j is the variable for feature j, and w_{ij} is the spatial weight between features i and j using a queen contiguity spatial weight matrix (Anderson 2017). This formula reflects the product of the percent of a group in a ZIP code and the average percent (row standardized) in its neighbors (as indicated by a first-order queen contiguity matrix). From this, in theory then, the measure could range from 0 to 10,000, where a score of 10,000 would be possible for an area that was composed of 100% of a certain group and all neighboring areas also had 100% of the same group. However, in practice, no ZIP code in Houston has a score that high, and the range of scores also varies considerably for each group, depending on the size and extent of clustering of that group. While clustering scores have their limitations, as is the case with choosing any one particular method, they tend to be highly correlated with other measures of segregation, such as concentration and centralization, and they represent spatial methods that can contend with the 'checkerboard problem' of other constructs (Lloyd, Shuttleworth, and Wong 2014; Massey and Denton 1988).[2] These small areal unit spatial clustering methods have also been used in similar studies examining area-level consequences of segregation (Anderson 2017; Gibbons et al. 2020; Kim, Clarke, and Dunkle 2022).

For this analysis in particular, we include these scores for three groups: *non-Latino Black clustering*, *Latino clustering*, and *non-Latino Asian clustering*. Due to issues with multicollinearity, we exclude White clustering, and focus instead on the clustering of racial/ethnic minority groups as that is the focus in the literature. Also, while we do not have a separate measure for Asians at the individual-level due to the sample size in the survey, we still include the clustering score at the area level in order to account for Asian clustered areas present throughout Houston. We graphically display these measures in a series of quintile choropleth maps for Black and Latino clustering (which are significant in the models), meaning there is an equal number of ZIP codes per each of the five displayed colors. We also include maps of these two clustering measures with respondents overlaid on top with the dependent variable and two mediating variables displayed as proportional dots. These can be found in Figure 2 for Black clustering and Figure 3 for Latino clustering.

Aside from area-level race, we include two other ZIP code-level measures to assess the socio-demographic characteristics of areas. These include *percent in poverty*, or the percent of the ZIP code population that is living below the federal poverty line, and the *unemployment rate*. Descriptive statistics for all variables used can be found in Table 1.

Methods

We include two sets of models using the two different mediators to test whether or not they can help account

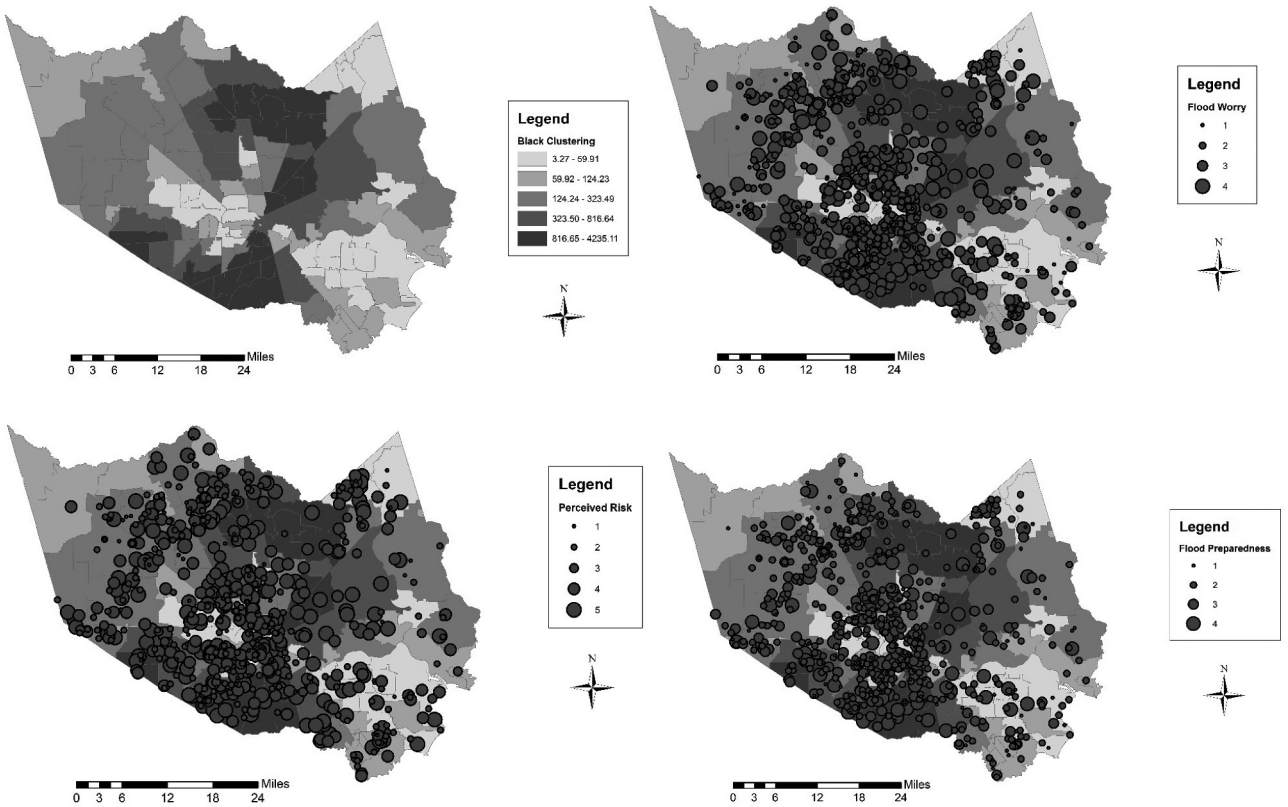

Figure 2. Quintiles of Black clustering over ZIP codes with main variables for individual respondents.

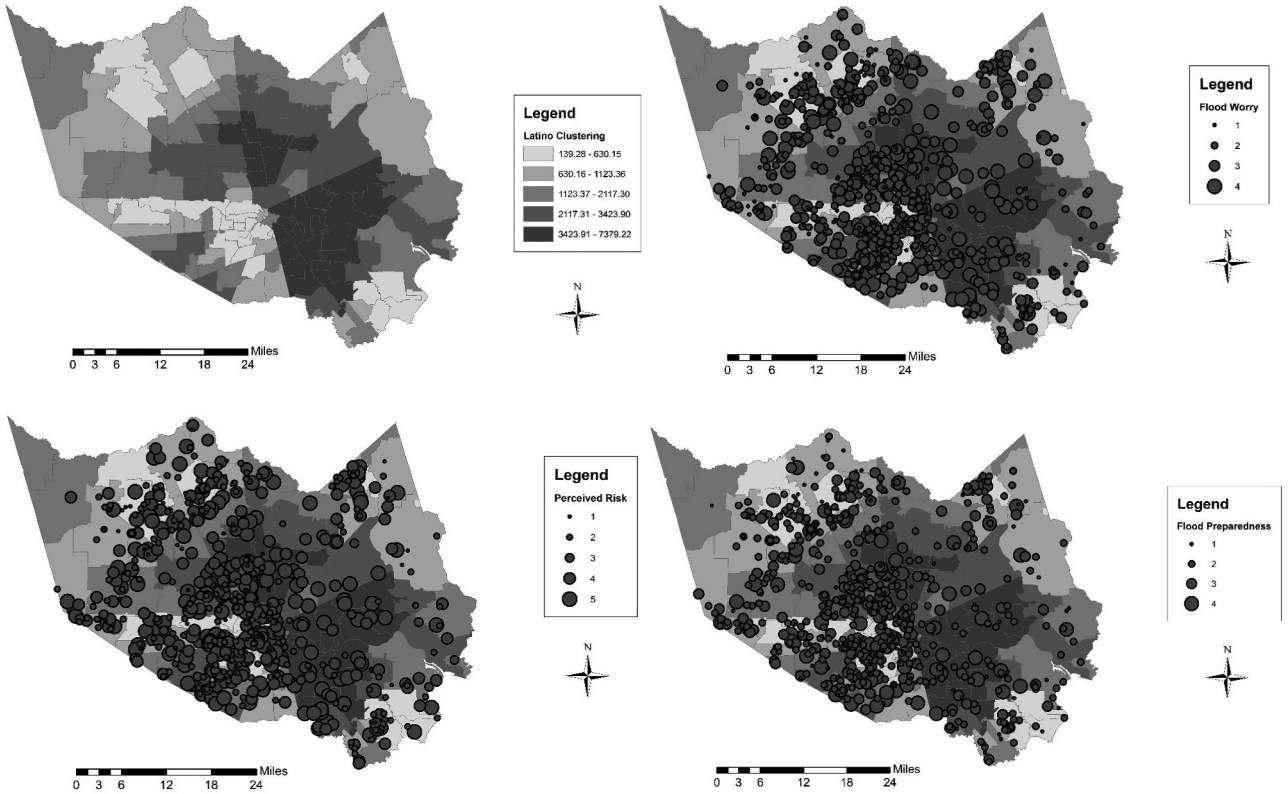

Figure 3. Quintiles of Latino clustering over ZIP codes with main variables for individual respondents.

Table 1. Descriptive statistics for variables used in statistical models.

Dependent Variable and Mediators (Percentages for Ordinal Categories):				
Worry about Threat of Flooding				
1) Never	17.50%			
2) Rarely	28.91%			
3) Sometimes	34.84%			
4) Often	18.75%			
Perceived Flood Risk		Perceived Flood Preparedness		
1) Very Unlikely	10.94%	1) Very Prepared	18.13%	
2) Unlikely	29.53%	2) Somewhat Prepared	49.53%	
3) Neither	3.59%	3) Somewhat Unprepared	20.16%	
4) Likely	29.38%	4) Very Unprepared	12.19%	
5) Very Likely	26.56%			
Variable Name	Mean	SD	Range	Description
Individual-Level Independent Variables				
Race				
White (ref.)	0.54	–	0 to 1	1=White, 0=else
Black	0.17	–	0 to 1	1=Black, 0=else
Latino	0.20	–	0 to 1	1=Latino, 0=else
Other	0.09	–	0 to 1	1=other racial category, 0=else
Age	53.85	17.54	18 to 93	Age in years
Female	0.56	–	0 to 1	1=female, 0=else
Married	0.52	–	0 to 1	1=married, 0=else
# of Children	0.54	1.00	0 to 6	Number of children in household
College Educated	0.53	–	0 to 1	1=bachelor's degree or higher, 0=else
Employed	0.50	–	0 to 1	1=employed full or part time, 0=else
Income	85,768.99	45,931.91	751.99 to 195,000	Income in dollars
Foreign Born	0.14	–	0 to 1	1=born outside U.S., 0=else
Health Insurance	0.89	–	0 to 1	1=insured, 0=else
Mental Health Scale	2.17	1.01	0 to 5	Self-rated mental health scale
Home Owner	0.76	–	0 to 1	1=owns home, 0=else
Flood Insurance	0.47	–	0 to 1	1=has flood insurance, 0=else
Area-Level Variables				
% Black Clustering	399.16	621.07	0 to 4235.11	Clustering measure of percent Black
% Latino Clustering	1659.50	1460.11	0 to 7379.23	Clustering measure of percent Latino
% Asian Clustering	64.61	69.66	0 to 380.57	Clustering measure of percent Asian
% in Poverty	13.74	8.67	0 to 46.5	Percent of population in poverty
Unemployment Rate	6.11	2.72	0 to 18.3	Percent of working population unemployed

$N = 640$. Data come from the 2022 Community Perceptions of Flood Mitigation Survey and the 2017–2021 American Community Survey.

for the link between social characteristics and worry about the threat of flooding. As each of these is measured as an ordinal variable, these are all modeled as cumulative ordered logistic regression models. We tested for the parallel regression assumption across all model specifications using a Brant test and found that none of our models violated this assumption (Long 1997). We also include cluster robust standard errors to account for clustering of our observations in geographic areas, which includes 133 ZIP codes. Although it would have been ideal to model these relationships in a multi-level model, we did not have enough observations per ZIP code to do this effectively with only 4.8 respondents on average per ZIP code. Thus, we account for clustering by area by using robust standard errors as this allows us to relax the assumption of independence of errors within the clusters.

Moreover, we run these in two sets of models in order to examine each of the mediators separately to see how they relate to the outcome and how they change the size of the effect of our social variables. We run these as building models to demonstrate the pathway as proposed in Figure 1. The first model only includes the individual and ZIP code-level social variables with flood worry as the dependent variable. The second includes the individual and ZIP code-level variables with flood risk or flood preparedness as the dependent variable. Finally, the third model includes all variables to see how flood risk or flood preparedness mediate the individual and ZIP code-level social variables. These results can be found in Table 2 for the flood risk models, and Table 3 for the flood preparedness models.

To formally test whether or not perceived flood risk or flood preparedness mediate the relationship between our social variables and worry about the threat of flooding, we rely on the KHB method, which allows for both categorical dependent variables and mediators. The output also provides a decomposition of the direct and indirect effects (Breen, Bernt Karlson, and Holm 2013). These results can be found in Table 4 for the flood risk models, and Table 5 for the flood preparedness models.

Results

First, Table 2 presents the results for the models with perceived flood risk as a mediator. From columns 1 and 2 (without the coefficient for flood risk), we can see that few of our social variables predict worry about the threat of flooding. Indeed, at both the individual-level and the area-level, race/ethnicity appears to be the

Table 2. Coefficients (standard errors) and odds ratios from cumulative ordered logistic regression models of flood worry and flood risk.

	Flood Worry		Perceived Flood Risk		Flood Worry	
	(1)	(2)	(3)	(4)	(5)	(6)
Variable Name	Coeff	OR	Coeff	OR	Coeff	OR
Individual-Level						
Race (Ref. = White)						
Black	0.703**	2.020**	0.514*	1.673*	0.466*	1.594*
	(0.224)	(0.452)	(0.230)	(0.385)	(0.222)	(0.354)
Latino	0.528*	1.696*	0.788**	2.200**	0.118	1.126
	(0.246)	(0.416)	(0.251)	(0.553)	(0.235)	(0.264)
Other Race	0.594*	1.811*	0.770**	2.159**	0.341	1.406
	(0.291)	(0.527)	(0.284)	(0.613)	(0.290)	(0.407)
Age	0.007	1.007	0.001	1.001	0.007	1.007
	(0.006)	(0.006)	(0.005)	(0.005)	(0.006)	(0.006)
Female	0.270	1.310	0.437**	1.548**	0.100	1.105
	(0.142)	(0.187)	(0.158)	(0.245)	(0.149)	(0.164)
Married	0.048	1.049	−0.217	0.805	0.174	1.190
	(0.177)	(0.186)	(0.155)	(0.125)	(0.179)	(0.213)
# of Children	0.071	1.074	−0.031	0.969	0.092	1.096
	(0.077)	(0.082)	(0.090)	(0.087)	(0.081)	(0.089)
College Educated	0.007	1.007	−0.010	0.990	0.008	1.008
	(0.157)	(0.158)	(0.168)	(0.167)	(0.162)	(0.163)
Employed	0.178	1.195	−0.114	0.892	0.280	1.323
	(0.160)	(0.191)	(0.160)	(0.143)	(0.168)	(0.223)
Income	−0.002	0.998	0.001	1.001	−0.003	0.997
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Foreign Born	−0.284	0.753	−0.039	0.962	−0.303	0.738
	(0.218)	(0.164)	(0.238)	(0.229)	(0.219)	(0.161)
Health Insurance	−0.443	0.642	−0.251	0.778	−0.442	0.643
	(0.255)	(0.164)	(0.239)	(0.186)	(0.268)	(0.172)
Mental Health Scale	0.141	1.152	−0.058	0.944	0.203*	1.225*
	(0.088)	(0.101)	(0.069)	(0.065)	(0.093)	(0.113)
Home Owner	−0.218	0.804	−0.498*	0.608*	0.040	1.041
	(0.188)	(0.151)	(0.202)	(0.123)	(0.203)	(0.212)
Flood Insurance	0.452**	1.572**	0.260	1.298	0.362*	1.437*
	(0.168)	(0.264)	(0.171)	(0.221)	(0.170)	(0.245)
ZIP Code-Level						
Black Clustering$_a$	0.544**	1.723**	0.289	1.335	0.474*	1.607*
	(0.198)	(0.341)	(0.160)	(0.214)	(0.212)	(0.341)
Latino Clustering$_a$	0.264***	1.302***	0.171*	1.187*	0.235**	1.265**
	(0.079)	(0.103)	(0.077)	(0.092)	(0.090)	(0.114)
Asian Clustering$_a$	−0.338	0.713	0.789	2.200	−1.108	0.330
	(1.164)	(0.830)	(0.943)	(2.074)	(1.205)	(0.398)
% in Poverty	−0.003	0.997	−0.015	0.986	−0.001	0.999
	(0.015)	(0.015)	(0.014)	(0.014)	(0.015)	(0.015)
Unemployment Rate	−0.100**	0.905**	−0.007	0.993	−0.102**	0.903**
	(0.036)	(0.032)	(0.033)	(0.033)	(0.036)	(0.032)
Mediator						
Perceived Flood Risk					0.695***	2.003***
					(0.068)	(0.136)
Cutpoint Equations						
Cutpoint 1	−0.994	0.370	−2.084***	0.124***	1.015	2.758
	(0.524)	(0.194)	(0.506)	(0.063)	(0.579)	(1.596)
Cutpoint 2	0.524	1.689	−0.279	0.757	2.798***	16.415***
	(0.518)	(0.875)	(0.489)	(0.370)	(0.586)	(9.625)
Cutpoint 3	2.311***	10.085***	−0.120	0.887	4.852***	127.934***
	(0.520)	(5.244)	(0.489)	(0.433)	(0.615)	(78.690)
Cutpoint 4			1.237**	3.446**		
			(0.475)	(1.638)		
Pseudo R^2	0.050		0.052		0.054	

$N = 640$. ZIP code cluster robust standard errors in parentheses. a. Coefficient and standard error multiplied by 1,000 for the ease of interpretation. ***$p < 0.001$, **$p < 0.01$, *$p < 0.05$.

most salient predictor of worry about the threat of flooding. Specifically, being Black, Latino, or some other race, as compared to White, is related to an increase in the odds of experiencing more frequent worry about the threat of flooding. These effect sizes are fairly large as well. Being Black as compared to White is related to an increase in the odds of flood worry by a factor of 2.020, or 102%. This same figure is 1.696 (or 69.6%) for Latinos and 1.811 (or 81.1%) for the other race category. The only other significant coefficient in the model is the variable for flood insurance, which also has a positive association, meaning that none of the socio-economic variables that would indicate household resources appear to be related to this outcome. Moreover, having flood insurance actually increases the odds of worry about the threat of flooding by 57.2%. This may be counterintuitive in that we might expect that flood insurance would ease anxiety about flooding. However, this may be due to greater risk or previous experiences with flooding

Table 3. Coefficients (standard errors) and odds ratios from cumulative ordered logistic regression models of flood worry and flood preparedness.

	Flood Worry		Flood Preparedness		Flood Worry	
	(1)	(2)	(3)	(4)	(5)	(6)
Variable Name	Coeff	OR	Coeff	OR	Coeff	OR
Individual-Level						
Race (Ref. = White)						
Black	0.703**	2.020**	−0.115	0.892	0.693**	2.000**
	(0.224)	(0.452)	(0.238)	(0.212)	(0.224)	(0.448)
Latino	0.528*	1.696*	0.185	1.204	0.519*	1.680*
	(0.246)	(0.416)	(0.246)	(0.296)	(0.246)	(0.414)
Other Race	0.594*	1.811*	0.354	1.425	0.559	1.748
	(0.291)	(0.527)	(0.349)	(0.498)	(0.289)	(0.506)
Age	0.007	1.007	0.005	1.005	0.007	1.007
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Female	0.270	1.310	0.412**	1.510**	0.241	1.272
	(0.142)	(0.187)	(0.157)	(0.237)	(0.142)	(0.180)
Married	0.048	1.049	−0.160	0.852	0.063	1.065
	(0.177)	(0.186)	(0.185)	(0.158)	(0.176)	(0.187)
# of Children	0.071	1.074	0.044	1.045	0.067	1.069
	(0.077)	(0.082)	(0.081)	(0.085)	(0.076)	(0.081)
College Educated	0.007	1.007	−0.169	0.845	0.024	1.024
	(0.157)	(0.158)	(0.169)	(0.143)	(0.157)	(0.160)
Employed	0.178	1.195	0.708***	2.031***	0.133	1.142
	(0.160)	(0.191)	(0.195)	(0.396)	(0.161)	(0.184)
Income	−0.002	0.998	−0.001	0.999	−0.002	0.998
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Foreign Born	−0.284	0.753	0.210	1.234	−0.325	0.723
	(0.218)	(0.164)	(0.234)	(0.289)	(0.215)	(0.155)
Health Insurance	−0.443	0.642	−0.143	0.867	−0.436	0.646
	(0.255)	(0.164)	(0.301)	(0.261)	(0.255)	(0.165)
Mental Health Scale	0.141	1.152	0.373***	1.452***	0.110	1.116
	(0.088)	(0.101)	(0.086)	(0.124)	(0.086)	(0.096)
Home Owner	−0.218	0.804	−0.242	0.785	−0.193	0.824
	(0.188)	(0.151)	(0.228)	(0.179)	(0.186)	(0.154)
Flood Insurance	0.452**	1.572**	−0.343*	0.709*	0.490**	1.632**
	(0.168)	(0.264)	(0.151)	(0.107)	(0.173)	(0.283)
ZIP Code-Level						
Black Clustering$_a$	0.544**	1.723**	0.520**	1.682**	0.482*	1.619*
	(0.198)	(0.341)	(0.163)	(0.273)	(0.203)	(0.329)
Latino Clustering$_a$	0.264***	1.302***	0.112	1.119	0.249**	1.283**
	(0.079)	(0.103)	(0.079)	(0.088)	(0.080)	(0.103)
Asian Clustering$_a$	−0.338	0.713	1.385	3.996	−0.470	0.625
	(1.164)	(0.830)	(1.303)	(5.206)	(1.180)	(0.737)
% in Poverty	−0.003	0.997	−0.019	0.981	−0.001	0.999
	(0.015)	(0.015)	(0.013)	(0.013)	(0.015)	(0.015)
Unemployment Rate	−0.100**	0.905**	−0.065	0.937	−0.091*	0.913*
	(0.036)	(0.032)	(0.043)	(0.040)	(0.037)	(0.034)
Mediator						
Flood Preparedness					0.236*	1.266*
					(0.093)	(0.118)
Cutpoint Equations						
Cutpoint 1	−0.994	0.370	−0.827	0.437	−0.498	0.608
	(0.524)	(0.194)	(0.579)	(0.253)	(0.548)	(0.333)
Cutpoint 2	0.524	1.689	1.633**	5.119**	1.032	2.807
	(0.518)	(0.875)	(0.561)	(2.874)	(0.543)	(1.525)
Cutpoint 3	2.311***	10.085***	2.985***	19.795***	2.830***	16.952***
	(0.520)	(5.244)	(0.585)	(11.575)	(0.551)	(9.335)
Pseudo R^2	0.050		0.052		0.054	

$N = 640$. ZIP code cluster robust standard errors in parentheses. a. Coefficient and standard error multiplied by 1,000 for the ease of interpretation. ***$p < 0.001$, **$p < 0.01$, *$p < 0.05$.

(Brody et al. 2017). Many of the people who have flood insurance are mandated to do so by their mortgage companies because they are located in riskier federally designated flood plains, though many of the individuals in these areas also do not have flood insurance as not all homeowners have mortgages on their properties (Bradt, Kousky, and Wing 2021; Brody et al. 2017). According to recent work, within federally designated flood plains, the flood insurance take-up rate is just over 48%, whereas the take-up rate outside of flood plains is only 2% (Bradt, Kousky, and Wing 2021).

Aside from the individual-level variables, we also see that the racial clustering variables are significant and positive, at least for Black and Latino clustering. These coefficients in the table are all multiplied by 1,000 for ease of interpretation given the large range of the variables. Therefore, a 1,000 unit increase in the Black clustering score is related to an increase in the odds of more frequent worry about the threat of flooding by a factor of 1.723, or 72.3%. This is somewhat smaller for Latino clustering at 1.302, or 30.2%. The only other significant variable here is the

Table 4. Results of the KHB decomposition analysis with perceived flood risk as mediator.

Variable	Coeff	SE	Ratio	Percent
Race Variables				
Black				
Reduced	0.711**	0.235		
Full	0.466*	0.235		
Difference	0.245	0.216	1.526	34.45
Latino				
Reduced	0.523*	0.236		
Full	0.118	0.238		
Difference	0.404	0.218	4.413	77.34
Other				
Reduced	0.741**	0.282		
Full	0.341	0.282		
Difference	0.400	0.218	2.175	54.03
Clustering Variables				
Black Clustering				
Reduced	0.630**	0.206		
Full	0.474*	0.206		
Difference	0.156	0.110	1.328	24.71
Latino Clustering				
Reduced	0.306***	0.086		
Full	0.235**	0.086		
Difference	0.071	0.109	1.300	23.10

$N = 640$. ***$p < 0.001$, **$p < 0.01$, *$p < 0.05$.

Table 5. Results of the KHB decomposition analysis with perceived flood preparedness as mediator.

Variable	Coeff	SE	Ratio	Percent
Race Variables				
Black				
Reduced	0.692**	0.229		
Full	0.693**	0.229		
Difference	−0.001	0.046	1.000	−0.15
Latino				
Reduced	0.546*	0.232		
Full	0.519*	0.232		
Difference	0.027	0.047	1.051	4.87
Other				
Reduced	0.601*	0.275		
Full	0.559*	0.276		
Difference	0.042	0.048	1.076	7.04
Clustering Variables				
Black Clustering				
Reduced	0.534**	0.198		
Full	0.482*	0.200		
Difference	0.052	0.030	1.108	9.76
Latino Clustering				
Reduced	0.261**	0.083		
Full	0.249**	0.083		
Difference	0.011	0.023	1.045	4.37

$N = 640$. ***$p < 0.001$, **$p < 0.01$, *$p < 0.05$.

unemployment rate, which is negatively related to worry about the threat of flooding.

The question then becomes whether or not these social associations, which in this case is essentially a race/ethnicity effect, can be explained away by perceived flood risk or a sense of preparedness. In columns 3 and 4, we include perceived flood risk as the dependent variable. Here, we find a similar pattern. The individual-level race variables are significant and positive, meaning that being Black, Latino, or some other race are all more likely than their White counterparts to report greater perceived risk. These are all sizable effects, especially for Latino and other race. At the ZIP code level, Latino clustering is also significant and positive, meaning that a greater concentration and clustering of the Latino population is related to greater perceived flood risk.

In the final mediating model, in columns 5 and 6, perceived flood risk itself is significant and has a substantial effect size. Each categorical increase in perceived flood risk, on a five-point scale, is related to an increase in frequency of worry about the threat of flooding by a factor of 2.003, or 100.3%. Further, its inclusion appears to attenuate many of the effects from the first model, especially for race/ethnicity. The coefficient for Black is somewhat smaller, and the coefficients for Latino and other race are no longer significant, suggesting partial mediation for Black respondents and perhaps full mediation for Latino and other race respondents. Table 4 includes the decomposition of these effects from the KHB method. From these results, we can see that while none of the reductions in the size of the coefficients are statistically significant (from the rows labeled 'difference'), the percentage reductions are large, suggesting only partial mediation. For the coefficient for Black, the inclusion of perceived flood risk reduces the association with worry about the threat of flooding by 34.45%, and this same figure is 77.34% for Latino respondents and 54.03% for other race respondents. Thus, while the mediation is not complete, in that the difference is not significant, these are fairly large percentage changes, suggesting that perceived flood risk may be one of several potential explanatory variables for understanding the association between race/ethnicity and anxiety about flooding.

We also ran these same analyses for the two clustering scores that were significant in the first model. Both Black and Latino clustering are still significant in the final model, though the size of their effects is somewhat smaller, suggesting partial mediation. Again, from the decomposition of the effects in Table 4, none of these differences are statistically significant. However, they are related to a reduction in the size of the effect by 24.71% for Black clustering and 23.10% for Latino clustering, which are not negligible amounts.

Turning to the results for flood preparedness in Table 3, we can compare and see if flood preparedness provides us with more explanatory power for the first model in columns 1 and 2. However, when examining flood preparedness as a dependent variable in columns 3 and 4, a different set of variables emerge as significant as compared to the flood risk model. None of the individual-level race/ethnicity variables are related to perceived flood preparedness, suggesting that race is unrelated to feelings of flood preparedness. Instead, some other variables are significant, such as gender, employment status, the mental health scale, and flood insurance. Being female, employed, and having poorer self-rated mental health are all related to a greater sense of being unprepared for floods. And,

flood insurance is negative, meaning that flood insurance, while leading to greater feelings of risk as noted above, conversely confers a greater sense of preparedness regarding floods. Finally, the only area-level variable that is significant is the Black clustering score, meaning that the greater the concentration and clustering of the Black population in geographic space is related to a greater sense of being unprepared.

In the last model, we include all variables to test flood preparedness as a mediator. Perceived flood preparedness itself is significant and positive, meaning that feeling unprepared for flooding is related to greater frequency of worry about the threat of flooding. For every one category increase in feelings of unpreparedness about flooding, on a four-point scale, is related to an increase in the odds of worry about the threat of flooding by a factor of 1.266, or 26.6%. Although this association is positive, its inclusion does not appear to attenuate many of the associations in the first model predicting worry about the threat of flooding. The variable for other race is no longer significant in this model, but the coefficients for Black and Latino are only marginally smaller here. The same is the case for Black and Latino clustering. From the formal mediation models in Table 5, we can see that none of the differences are significant, and there are only small reductions in the size of the effects across models (or no reduction in the case of the Black variable). The largest percentage change is for Black clustering at the ZIP code level with a 9.76% reduction in the size of the effect.

Discussion and conclusions

The goal of this study is to examine how social factors, race/ethnicity in particular, relate to the worry and anxious feelings that people have about climate disasters, in this case flooding. Moreover, we aim to examine some of the underlying reasons for why we might observe a link between race/ethnicity and worry about the threat of flooding. We test two arguments. The first is that racial/ethnic minorities may experience greater worry about the threat of flooding because they are more likely to be situated in environments that are more vulnerable to flooding. The environmental justice literature has long demonstrated that minority individuals and minority segregated areas are more vulnerable to extreme weather events and have historically been subject to greater effects from such disasters (Bergstrand et al. 2015; Chakraborty et al. 2021; Collins et al. 2019; Lieberknecht et al. 2021; Lieberman-Cribbin et al. 2021; Smiley 2020; Smiley et al. 2022). An alternative, or perhaps complementary theory, is that racial/ethnic minorities may be more likely to experience such worry about the threat of flooding because they are less prepared to deal with these circumstances (Bolin and Liza 2018; Maldonado, Collins, and Grineski 2016; Reininger et al. 2013; Stein, Dueñas-Osorio, and Subramanian 2010). Racial and ethnic minorities may have fewer personal resources at their disposal to be able to prepare for and contend with the effects of flooding, such as obtaining insurance or making home modifications to protect against flooding (Cagney et al. 2016; Grineski et al. 2020; Johnston, Taylor, and Ryan 2022; Zinda et al. 2023). In this analysis, we test two mediation models to examine how these two possible explanations relate to or may mediate the association between race/ethnicity and worry about the threat of flooding.

Overall, we found that race/ethnicity at both the individual and area levels were highly predictive of worry about the threat of flooding. These results provide support for both Hypothesis 1 and 2. This is in keeping with the limited literature on worry about the threat of flooding and poor mental health outcomes as it relates to race, which has shown both individual and area-level race/ethnicity to be an important factor at least in the U. S. (Davidson et al. 2013; Grineski et al. 2020; Lowe, Joshi, et al. 2015; Lowe, Sampson, et al. 2015). This provides additional evidence of this association. However, in our case, only race is significant, despite the literature on worry about the threat of flooding across the world consistently demonstrating SES to be an important consideration (Finch, Emrich, and Cutter 2010; Lieberman-Cribbin et al. 2021; Meyer 2016). This is not reflected in our results. The sociological literature has long demonstrated important linkages between race, residential segregation, and SES outcomes, which may be hard to disentangle (Massey 2020; Squires and Kubrin 2005). This may not necessarily be so unexpected in Houston, which has a long history of race-based place stratification, residential segregation, and specifically environmental inequalities by race. In the case of Houston specifically (Bullard 2008; Bullard and Wright 2012), as well as other locales (Crowder and Downey 2010; Downey and Hawkins 2008; Pais, Crowder, and Downey 2014), there are a number of environmental justice studies demonstrating race to be a more salient predictor of environmental harms as compared to class factors. Thus, for our Houston sample at least, we do not find an independent effect of SES in the models.

Furthermore, in this analysis, we attempted to adjudicate between different explanations for the association between race/ethnicity and worry about the threat of flooding. In this case, we examine perceived risk and perceived levels of household preparedness. First, for perceived risk we found that race/ethnicity across all groups was associated with higher levels of perceived flood risk, with Black, Latino, and other respondents all reporting higher levels of risk. At the ZIP code-level, only Latino clustering was positively associated with greater risk. Moreover, perceived flood risk was strongly associated with greater worry about the threat of flooding, and this variable at least partially mediated the relationship between race/ethnicity and worry, especially at the

individual-level and less so at the area-level. This provides partial support for Hypothesis 3. These results closely reflect the previous work that has demonstrated that flood risk is not evenly distributed across the population, with more vulnerable groups experiencing greater risk (Bergstrand et al. 2015; Chakraborty et al. 2021; Chakraborty, Collins, and Grineski 2018; Collins et al. 2019; Finch, Emrich, and Cutter 2010; Lieberknecht et al. 2021; Lieberman-Cribbin et al. 2021; Smiley 2020). However, again, this only applied to race/ethnicity and not SES, which is somewhat unexpected given the strong SES findings in the extant literature. This also contributes to the literature by demonstrating perceived flood risk to be a partially mediating factor in our understanding of social characteristics and poor mental health outcomes associated with flooding.

Next, we examine perceived flood preparedness as a mediator, but the results were not as strong here. Individual-level race was not significantly associated with perceived levels of flood preparedness at all for any group. This suggests that there are not significant racial differences in feelings of flood preparedness, which diverges somewhat from the literature (Bolin and Liza 2018; Grineski et al. 2020; Stein, Dueñas-Osorio, and Subramanian 2010; Zinda et al. 2023). However, we ask a fairly basic preparedness question, as opposed to a battery of preparedness questions about the types of preparations taken, in terms of both knowledge of emergency action, as well as the structural mitigation protections that a household may employ (Grineski et al. 2020; Zinda et al. 2023). The research suggests that these may differ in both their racial patterns and in their implications for risk and health. For instance, Zinda et al. (2023) found that while White respondents took more overall flood protection measures, non-White respondents took more high-cost prevention measures. Similarly, Grineski et al. (2020), in a study of the Houston area, asked respondents about a wide variety of both mitigation measures and emergency preparedness actions, but found that mitigation measures, and not preparedness, were associated with fewer adverse events and health effects as result. Furthermore, perceived flood risk does not serve as a mediator between individual or area-level race/ethnicity and worry about the threat of flooding. Only a small portion of the association was explained by perceived flood preparedness. This does not support Hypothesis 4.

This study is, of course, not without its limitations. Chief among these is that all of our key measures are based on self-reported perceptions rather than any objective indicators of worry about the threat of flooding, flood risk, or flood preparedness. While we would argue that perceptions are perhaps what matters most for understanding stressors and the toll that they can have on the mental health of a person, the results must be interpreted with that in mind. Second, the study only includes a random, but non-representative sample of respondents from one county in Texas, and as such, cannot be broadly generalized to the Houston area or all flood risk areas. We pinpointed the Houston area as the largest metropolitan area that deals with frequent flooding, and thus it would not be difficult to recruit participants with enough variation in the responses about flood-related phenomena. However, the obtained sample skews Whiter, older, more educated, and more female, compared to averages from the U.S. Census for Harris County, which limits the generalizability of the findings.[3] Another limitation for this study is the double-barreled form of the question we ask in the survey concerning psychological outcomes from flooding as it includes both worry and anxiety: 'How often do you feel worried or anxious about the threat of flooding in your neighborhood?' While anxiety can be closely linked to poor mental health, we must acknowledge that not all worry is detrimental and can be a benefit to preparedness. Because of the way the question is worded, we are not able to distinguish between negative anxiety or normative worrying. Finally, as a cross sectional survey, none of these findings are causal in nature, and only highlight associations between these different factors.

Despite these mixed findings with regard to the two mediators tested, these results provide some advances to the current literature. First, we focus on worry about the threat of flooding, conceptualized as feelings of worry or anxious thoughts, as opposed to diagnosable disorders. We also examine flood risk and worry about the threat of flooding as a generalized state in the context of a high-risk area using the case of Houston, rather than in reaction to a specific flood event. There is an increasing number of low-lying coastal areas that live with persistent flood risk due to climate change, and we need to understand these health effects in a manner that is de-coupled from a specific traumatic event. Furthermore, with this analysis, we attempt to unpack some of the reasons behind this worry, and here we find that this is largely driven by perceived risk instead of subjective preparedness, which has important implications for interventions. If worry is a function of lack of preparedness, then that would imply that individual-level preparedness measures and education would help alleviate that worry. However, we find that perceived risk plays an important role here. Thus, measures to mitigate the effects of flooding and lower risk profiles would better serve to address worry about the threat of flooding.

Notes

1. We acknowledge that this method of single imputation for income is limited compared to multiple imputation, which allows for less certainty in the precision

of the estimated values by computing several permutations of the same dataset (Rubin 2004). However, for imputation of a single control variable for which we have several related socio-economic variables, single imputation is the most parsimonious approach.

2. As a check on this choice of measure, we ran all of the same models using racial/ethnic composition scores, with percent Black, percent Latino, and percent Asian in the ZIP code. These results are fairly similar to the ones presented here, with only minor differences in the coefficient size, with slightly smaller effect sizes for percent Black in particular (results available upon request). Using these scores presented a problem with multicollinearity, though, with a higher variance inflation factor between percent Black and percent in poverty. Thus, for both the conceptual and empirical reasons laid out here, we decided to present the results with the clustering scores as described.
3. As a check on this limitation, we also ran a version of these analyses using weighted least squares to adjust the models to the proportions of some of these variables that are skewed as compared to Harris County statistics, including race, sex, and education levels (Dickens 1990). These results were not substantively different in their major findings with only minor differences in the coefficients and standard errors, indeed with standard errors that were slightly smaller in most cases as compared to the analysis presented here. Thus, in order to present a simpler version of the analysis, and to allow for the correction on the standard errors for geographic clustering, we present the models with ordered logistic regression models with cluster robust standard errors in lieu of using a weighted approach.

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