Climate Risk Management 27 (2020) 100210

Contents lists available at ScienceDirect

Climate Risk Management

journal homepage: www.elsevier.com/locate/crm

The climate change double whammy: Flood damage and the determinants of flood insurance coverage, the case of post-Katrina New Orleans

Clare Cannon[a,*], Kevin Fox Gotham[b], Katie Lauve-Moon[c], Bradford Powers[d]

[a] Department of Human Ecology, University of California, Davis, One Shields Avenue, 1309 Hart Hall, Davis, CA 95616, United States
[b] Department of Sociology, 220 Newcomb Hall, Tulane University, New Orleans, LA 70118, United States
[c] Department of Social Work, Texas Christian University, Annie Richardson Bass Building 2101, 2800 W Bowie St, Fort Worth, TX 76109, United States
[d] City, Culture, and Community Graduate Program, 220 Newcomb Hall, Tulane University, New Orleans, LA 70118, United States

ARTICLE INFO

Keywords:
Flood hazard
Flood insurance
Global climate change
Coastal cities
Social trust

ABSTRACT

This paper advances scholarly debate on the contradictions of environmental risk management measures by analyzing the determinants of flood insurance coverage among a sample of 403 residents in New Orleans, a city undergoing rapid transformation due to post-Katrina rebuilding efforts and anthropogenic modifications of climate, hydrology, and ecology. The paper focuses on several predictors including subjective flood risk perception, trust in government officials, sociodemographic characteristics, and experience with flood damage. Using binary logistic regression, the results show that the likelihood of having flood insurance coverage is associated with past flood damage and socioeconomic status. Older people (over age 65) are more likely to have flood insurance than younger residents. Race, gender, trust, and perceived flood risk are not statistically significant predictors of flood insurance. We connect our findings to the paradoxes and conflictual dynamics of flood insurance, a major risk mitigation measure. As we point out, in flood-prone cities like New Orleans, flood insurance operates as a double whammy: uninsured or underinsured homes face pervasive risk of both flooding and rising insurance premiums under the conditions of global climate change.

1. Introduction

Flood hazards are a serious threat to human life, community well-being, and property. The number and scope of those affected globally by flood hazards are expected to increase due to intensified real estate development in flood prone areas and increased frequency and destructive of hurricanes due to rising sea-levels and greenhouse gas (GHG) emissions (Das et al., 2013; Government Accountability Office, 2019; Winsemius et al., 2016). Flooding is not just confined to high-risk areas. Rather, according to the Federal Emergency Management Agency (FEMA), floods–that is flash floods, inland flooding, and flooding from seasonal storms–occur across the United States. In fact, 90 percent of weather-related disasters in the U.S. involve some type of flooding. Moreover, 20 percent of all flood claims are filed in low to moderate flood risk areas. In addition, floods account for the highest number of lives lost and most property damages from natural hazards (Kousky, 2010). Consequently, policymakers acknowledge the necessity for flood prevention and protection, and scientists and researchers are currently investigating how and why flooding occurs and who is most negatively

* Corresponding author.
E-mail addresses: cebcannon@ucdavis.edu (C. Cannon), kgotham@tulane.edu (K.F. Gotham), Katie.Lauve@tcu.edu (K. Lauve-Moon).

https://doi.org/10.1016/j.crm.2019.100210
Received 29 July 2019; Received in revised form 12 September 2019; Accepted 17 December 2019
Available online 23 December 2019

affected. To this end, researchers seek to understand how people perceive flood risks and what risk management strategies, specifically flood insurance coverage, governments can implement to reduce the negative consequences of floods (Birkholz et al., 2014; Kellens et al., 2013).

In this paper, we analyze experiential, socioeconomic, and sociodemographic characteristics derived from a survey of New Orleans, Louisiana (United States) residents to predict variation in flood insurance coverage. Understanding why residents have flood insurance coverage is a significant aspect of flood management decision-making and a necessary element for building flood-resilient communities. Knowledge of flood risk perceptions and of flood insurance coverage can inform flood mitigation policy reform and government efforts to reduce the social costs of natural hazards, minimize economic losses to households, and improve management of risks expected to increase due to climate change (Michel-Kerjan and Kousky, 2010). Identifying the major determinants of flood insurance coverage can assist policymakers in formulating policies and land-use practices to increase resiliency of coastal communities over the long term.

Our major goal in this paper is to advance scholarly debate on the contradictions of environmental risk management measures under the conditions of global climate change (Dunlap et al., 2015; Gotham, 2018; 2016a; 2016b; Gotham and Cannon, 2018; Gotham and Faust, 2019; Harvey, 2016; Müller et al., 2017; Nagel et al., 2010; Mileti, 1999; Tierney, 2014). On the one hand, as a critical element of flood risk reduction and mitigation, flood insurance provides homeowners with financial compensation for rebuilding damaged homes (Kousky, 2018; Li and Landry, 2018). On the other hand, federally subsidized flood insurance intensifies flood risk for homeowners and businesses by encouraging settlement in areas where private insurance would normally not write policies (Bagstad et al., 2007). The cacophony of state and local tax incentives, subsidies, deductions, and availability of flood insurance operate in tandem as drivers of real estate development in low-lying riverine and coastal areas, the effect of which reduces the capacity of hydrological systems to store surface water runoff and thereby contribute to increased vulnerability to flooding. These developments act in combination with rapid population growth and annual precipitation associated with a subtropical climate to increase the cost of damages from flooding (Brody et al., 2008; Bagstad et al., 2007). These concerns have motivated researchers to investigate the ways in which various risk reduction measures can generate contradictions and unforeseen consequences, and aggravate rather than alleviate risk and vulnerability to extreme events.

We first describe flood risk management and the evolving challenges faced by the National Flood Insurance Program (NFIP). Next, we engage scholarship on flood insurance risk and discuss the factors affecting flood insurance coverage. We then describe the nature of coastal vulnerability in post-Katrina New Orleans. Next, we explain our sample selection, variable measurement, and data analysis procedures. We then report results based on binary logistic regression analysis of several socioeconomic, experiential, and sociodemographic variables. Finally, we interpret our findings and discuss their policy implications for flood risk management. Today, as disaster losses mount and flood insurance premiums escalate, communities around the United States face a brave new world of increased financial insecurity and increased vulnerability to flood hazard. As we point out, in flood-prone cities like New Orleans, flood insurance operates as a double whammy: uninsured or underinsured homes face pervasive risk of both flooding and rising insurance premiums under the conditions of global climate change.

1.1. Flood risk management and the National Flood Insurance Program (NFIP)

In 1968, the United States Congress established the National Flood Insurance Program (NFIP) to reduce property losses from flood damage and compensate disaster victims. Today, the Department of Homeland Security's (DHS's) Federal Emergency Management Agency (FEMA) administers the program by working with local governments to establish flood insurance rates, regulate floodplain development, and advise the public of potential flood hazards (Knowles and Kunreuther, 2014; Nance, 2015; Government Accountability Office, 2010). The financial management of flood hazards involves (1) funding flood mitigation activities and (2) delivering federal disaster assistance to individuals, private businesses, and communities to assist in rebuilding destroyed property and compensate uninsured victims. Those homeowners with mortgages from federally backed or regulated lenders in a 100-year floodplain, or a Special Flood Hazard Area (SFHA), are federally required to purchase flood insurance. A 100-year flood refers to a probability and that multiple "100-year" floods could occur in a row, as in a 1% annual chance of a flood per year. According to King (2013, p.2), "[f]rom a policymaker's perspective, the fundamental flood management challenge facing the NFIP is finding the best mix of strategies to reduce the nation's long-term exposure to flood losses while ensuring the program's solvency and statutory mandate to provide affordable flood insurance to the general public."

Since 2005, escalating costs of catastrophic flooding combined with increased payouts for flood damage have imperiled the NFIP. In August 2005, Hurricanes Katrina and Rita caused approximately $200 billion in economic losses including $21.9 billion related to insurance claims under the NFIP. Three years later, in 2008, Hurricane Ike caused roughly $2.7 billion in NFIP claims in coastal areas of Texas and Louisiana and further inland, many areas not usually subject to tropical rain events. Also, in 2008, widespread flooding affected more than 11 million people in nine Midwestern states as major rivers in Wisconsin, Nebraska, Missouri, Minnesota, Michigan, Kansas, Iowa, Indiana, and Illinois overflowed their banks and levees (King, 2013). Catastrophic losses from flooding continued again in 2012 with Hurricane Sandy, and again in 2017 with Hurricanes Harvey, Maria, and Irma.

From its inception in 1968 through 2005, the NFIP was self-sufficient, had minimal borrowing authority, and for the most part was able to pay small principal repayments and accompanying interest expenses. However, cumulative debt increased substantially from 2005 to 2016. By 2017, the NFIP was $24.6 billion in debt. In 2017–2018, losses from Hurricanes Harvey, Irma and Maria led the NFIP to borrow $11.9 billion from the U.S. Treasury. After an unprecedented $16 billion cancellation, the NFIP carried $20.5 billion in debt as of December 31, 2017. As designed and implemented, the current program is unable to repay this debt. In FY 2018 alone, the NFIP paid over $375 million of interest expenses (FEMA, NFIP., 2018).

In short, since 2005, devastating U.S. Gulf Coast and Atlantic hurricanes have brought much attention to and scrutiny of flood insurance and political debate rages over the sustainability of the NFIP and other flooding mitigation efforts. The long-term future of the NFIP is uncertain given that Congress has temporarily extended the program 11 times since 2017. Without reauthorization, or extension, the NFIP would lose the ability to borrow money from the Treasury or issue new contracts. Thus, a major challenge facing the NFIP is how to reduce the cost of flooding and maintain the program's fiscal sustainability in the face of the increasing destructiveness of storms and flooding (FEMA, NFIP., 2018).

Scholars and researchers have voiced several criticisms of the NFIP and have challenged the effectiveness of flood insurance as a risk mitigation tool. First, residents who have a federally backed mortgage and live in a floodplain are required to purchase flood insurance. However, these residents often do not purchase the mandatory insurance coverage. Nationally, only 20 percent of residents living in flood zone areas have flood insurance, which raises the possibility of high uninsured flood-related losses (FEMA, 2019). Second, individuals tend to misunderstand flood risk, "thinking that after a 100-year flood occurs, they are safe for another 100 years" (King, 2013, p. 3). Social and behavioral scientists have observed that many individuals living in flood-prone areas often reject low-probability catastrophic events, misunderstand the risk-spreading mechanism of insurance, and overly tend to toward optimism with respect to the possibility of future flood damage to their property (Kunreuther and Slovic, 1978; Botzen et al., 2009; Gray-Scholz et al., 2019). Third, "many at-risk property owners do not think flood insurance is a good investment or opt to finance post-disaster reconstruction with federal-disaster assistance, albeit insurance is generally considered the most effective way to finance post-disaster recovery" (King, 2013, p. 4).

While some critics argue that the benefits of flood insurance are disproportionately enjoyed by wealthy coastal counties and by owners of vacation homes (Holladay and Schwartz, 2010), not all beneficiaries of the NFIP are wealthy, and NFIP also affect primary homes. Moreover, many of those who live in vulnerable flood zones do so out of affordability. For them, their NFIP coverage is indispensable because private flood insurance is either prohibitively expensive or unavailable. In addition, others may be unable to move because of skyrocketing flood insurance rates, which may make it difficult for them to sell. To address policymakers' concerns, a body of research has sought to understand individuals' motivations for purchasing flood insurance (Shao et al., 2017; Browne et al., 2015; Hung, 2009; Kriesel and Landry, 2004).

1.2. Factors affecting flood insurance coverage

The extent to which individuals understand the consequences of flooding, and the degree to which they regard flooding as harmful to their well-being, may relate to their personal lifestyle decisions, willingness to support flood risk reduction policy initiatives, and desire to purchase flood insurance as a flood risk mitigation action. Social science research suggests that socioeconomic and demographic characteristics, such as income, educational attainment, gender, and ethnicity/race, may predict household hazard adjustments (Brody et al., 2017; Lo, 2013; Peacock et al., 2005; Bubeck et al., 2012; Terpstra and Lindell, 2013). Other research has examined the impact of flood risk perceptions, past experience with flooding, hazard proximity (geophysical vulnerability to flooding) on flood insurance purchase (Bubeck et al., 2013; Knowles and Kunreuther, 2014; Kriesel and Landry, 2004).

In a survey of all Gulf Coast counties, Shao et al. (2017) found that that the estimated flood hazard as measured through FEMA flood maps, the strengths and consequences of past flooding events, and perceived flood-related risks significantly influenced an individual's voluntary flood insurance purchase. Flood insurance purchase was also influenced by home ownership, trust in local government, educational attainment, and income. In a study of behavioral bias in the demand for insurance, Browne et al. (2015) found that people tend to prefer insurance for high probability, low consequence risks (HPLC) (i.e., bike theft) over insurance for low probability, high consequence risks (LPHC) like flooding. Incorporating fuzzy set theory into contingent valuation analysis, Hung (2009) found that individuals have difficulty ascertaining whether or not to buy insurance against low-probability, high loss events. Her study suggested that perceived levels of flood risk, experience with flooding, and disposable income are important factors in insurance purchases for individuals.

Previous experience with flooding is another predictor of flood insurance purchase. For the most part, according to Brody and colleagues (2017, p. 764), "the more recent, frequent, and severe the hazard impacts have been, the more likely a household is to take protective action." In their analysis of flood insurance purchases in Georgia from 1978 to 2010, Atreya and colleagues (2015) found that demand for flood insurance is relatively price inelastic and that recent flood events tend to increase purchases temporarily, but this effect fades three years after flooding events.

Other studies have found mixed support regarding the assertion that personal experience with hazards leads to support for risk reduction measures. Howe (2011) and Howe et al. (2013) have noted that the "experience effect" tends to vary according to hazard context, is not necessarily a predictor of risk perceptions or attitudes toward risk reduction measures, and "may have opposite effects on risk perception and hazard adjustment depending on the individual and on the circumstances of the experience" (Howe, 2011, p. 714; Halpern-Felsher et al., 2001). Using U.S. public opinion data on support for an array of adaptation policies, Ray et al. (2017) found that individuals experiencing recent extreme weather events were more likely to support climate change adaptation policy generally. However, the relationship was modest and inconsistent across specific climate change adaptation policies. Moreover, effect of extreme weather activity on opinion diminished over time.

A number of scholars including Laska (1990), Blanchard-Boehm et al. (2001), Browne and Hoyt (2000), Zahran et al. (2006) have found that flood insurance purchases are correlated with flood experience and flood losses. In a longitudinal analysis of household survey data before and after a major flood event in Germany ($N > 7{,}400$), Osberghaus (2017) found a causal relationship of insured flood damage on private flood mitigation and a correlated relationship of mitigation and self-reported flood experience. In addition, Lindell and Hwang (2008) found that though flood experience had an indirect effect on flood insurance purchase, it was mediated by

risk perception. Other studies suggest that there is no one-to-one correspondence between hazard knowledge, risk perception, and adoption of risk reduction (mitigation) measures (Bubeck et al., 2012; for an overview, see Kellens et al., 2013).

Over the years, scholars and researchers have studied the effect of hazard proximity on flood insurance coverage. Scholars recognize that flood insurance coverage does not necessarily relate to objective flood risk measures (base-flood elevation) or geographical proximity to a flood hazard (National Research Council, 2015). Hazard proximity and hazard prone areas tend to vary in the recency, frequency, and severity of the flood events they have experienced, all of these characteristics affect flood risk perception (Lindell and Perry, 2004) and likewise impact decisions to reduce risks (e.g., purchase flood insurance). In their study of the relationship between erosion risk and flood insurance demand, Landry and Jahan-Parvar (2011) found that flood insurance coverage was positively correlated with erosion near shorelines for properties in active erosion zones. Lindell and Hwang (2008) evidence proximity to inland flood as well as coastal hurricane hazards was significantly correlated to flood insurance purchase even after controlling for demographic and household characteristics.

Other research has found that there is no direct relationship between environmental hazard proximity and environmental risk perceptions (see, for example Arlikatti et al., 2006; Zhang et al., 2004). Brody et al. (2017) conclude that "the physical proximity of a respondent to flood hazard areas makes little or no discernible difference in the decision to obtain flood insurance." Hazard proximity can mean different things to different people. Research by Zhang et al., 2010, p. 600) contends that "many people cannot accurately identify their home's location on a risk-area map." Ludy and Kondolf's (2012, p. 1) survey of residents living in a 100-year flood plain "protected" by a levee found that respondents "did not understand the risk of being flooded". Moreover, homeowners living in flood hazard-prone areas can vary in how they interpret the validity of flood information and the credibility of the sources that disseminate risk information, such as authorities, news media, or peers (families, friends, neighbors, or coworkers) (Arlikatti et al., 2007).

Extant scholarship suggests that trust—or lack of trust—in government officials and experts can influence peoples' decisions to engage in risk mitigation behaviors (e.g., purchase flood insurance) (Kellens et al., 2013; Slovic, 2000; Botzen et al., 2015; Whitmarsh, 2008). Early survey research by Slovic et al. (1991) found that if individuals distrust the ability of U.S. government agencies to adequately manage risks of hazardous facilities, they are likely to perceive the risk of hazardous facilities to be high. Terpstra (2011) more recently has found similar effects of trust on individual flood risk perceptions. Terpstra (2011) notes that individuals who trust local government's risk management capability are less likely to undertake protective measures, since they believe that they have a low likelihood of flooding (see also Botzen et al., 2015). Hung (2009) found that trust in public flood protection (levees, dikes, etc.) was negatively related to insurance purchase insurance. Lin et al. (2008) reported that higher levels of trust in crisis management and delivery of flood warnings by government, risk experts, and media increased insurance purchase intentions.

Wachinger et al. (2013) suggest caution in interpreting findings related to trust, risk perceptions, and individual decisions to undertake risk mitigation actions like purchasing insurance. Contextual and situational factors can influence how an individual interprets risk information and uses this information to make decisions regarding insurance purchase. Moreover, trust has different meanings for different people. People can have trust in local authorities but not federal authorities to protect them from hazards. They can also have different views of the protective aspects of risk control structures (levees, dikes). In addition, their experience with hazards can influence levels of trust.

1.3. Coastal vulnerability and the case of post-Katrina New Orleans

During Hurricane Katrina, in August 2005, multiple failures in the levee system maintained by the Army Corp of Engineers flooded 80 percent of New Orleans and damaged over 200,000 homes. The ensuing destruction triggered by the levee collapse killed more than 1,400 Louisiana residents and displaced more than a million others. Since 2007, federal, state, and local governments have worked to construct, repair, and upgrade over 160 miles of levees in response to the tragedy. For instance, the Greater New Orleans Hurricane and Storm Damage Risk Reduction System (HSDRRS) received $14.5 billion in federal and state investments to further elevate levee and floodwall protections, build a new surge barrier, install new pumping stations, and to develop canal closures (Gotham, 2018). Despite these flood protection improvements, flooding remains a constant threat to the area and a major source of worry and insecurity for residents (Gotham, 2018). The threat of flooding is expected to grow as extreme events – seasonal rain and hurricanes – become more frequent and destructive due to global warming and sea level rise (IPCC, 2014).

In short, the New Orleans area is the "canary in the coal mine" when it comes to climate change flood risk in the United States. Scientists view the region as a harbinger of things to come for coastal ecosystems worldwide under the threat of rising sea levels and global climate change (Kent, 2012; Wang et al., 2011). Currently, planners and policy makers debate various policies to reduce coastal flood risk, and major coastal restoration projects and climate change adaptation and mitigation efforts are currently underway (Gotham and Faust, 2019; Peyronnin et al., 2013; Fischbach et al., 2012).

In this paper, we investigate the factors motivating people to buy flood insurance. The U.S. Gulf Coast has some of the lowest flood insurance take-up rates in the country with an estimated 24.9% for all counties along the Gulf Coast. Louisiana coastal counties alone have a take-up rate of 16.18% on average (FEMA, 2018). Orleans Parish, the county of New Orleans, has a slightly larger take-up rate of 20.74% (FEMA, 2018). These concerns underpin the need to examine the linkages among flood risk perceptions, socio-demographic characteristics, and flood insurance coverage more closely.

Based on the extant literature, we test the following hypotheses:

H1: Flood insurance coverage is expected to be positively correlated with age, educational attainment, income, employment status, and homeownership.

H2: Residents with flood insurance coverage are more likely to have lived in a residence damaged by flooding.

H3: Residents with low trust in government officials' ability to protect their household from flooding will be more likely to have flood insurance coverage.

2. Methods and data analysis

In this study, we analyze findings from a survey of New Orleans residents conducted during March to May 2016, consisting of a four-page questionnaire of scaled questions regarding different hazards, flood risk perceptions, and flood insurance coverage. The survey was pretested with 12 residents and professionals living in the region. Incorporating their feedback, we eliminated redundant questions and distilled questions and response categories for clarity. The structured questionnaire contained 18 close-ended questions that asked about perceptions of flood risk, rodent and mosquito disease risk, and individual-level variables including flood insurance coverage, race/ethnicity, gender, age, education, homeownership status, and socioeconomic variables. Respondents were also asked about their previous experiences with storms and flooding, and concerns apropos future threats to safety.

All four authors of this study delivered surveys door to door to 1,944 randomly selected households located in the neighborhoods of Bywater, Gentilly, Lakeshore, Lakeview, Lower Ninth Ward, Upper Ninth Ward, and Uptown. Survey sampling paralleled a network of 72 plots where vegetation and ecological surveys were completed by other research team members funded through a National Science Foundation (NSF) Coupled Natural-Human (CNH) Systems grant. To guarantee a minimum number of respondents per neighborhood for comparative analysis we sampled the same number of households in each neighborhood. In each neighborhood, we distributed a survey to 278 randomly selected addresses.

Recruitment materials and survey questions were printed in English. The adult in a household with the most recent birthday was asked to participate in the study. Respondents were asked to complete the four-page survey and return it to researchers in an enclosed, stamped envelope. Through June 2016, we received 403 returned surveys for a response rate of 20.73%.

To evaluate the predictors of flood insurance coverage, we asked respondents to report whether they had flood insurance, did not have flood insurance, or did not know whether they had flood insurance at their current residence.

Table 1 shows the characteristics and frequency distributions of survey respondents.

We used a binary logistic regression model to determine the impact of flood experience, length of residency, sociodemographic and socioeconomic variables, and social trust in officials on flood insurance coverage. Mathematically, our logistic regression estimates a multiple linear regression function defined as:

$$P(Y) = \frac{e^{b_0+b_1x_1+b_2x_2+\ldots+b_nx_n}}{1 + e^{b_0+b_1x_1+b_2x_2+\ldots b_nx_n}}$$

In this equation, P is the probability of Y occurring; e is the natural logarithm base; b_0 is the interception at y-axis; b_1 is the line gradient; b_n is the regression coefficient of X_n; and X_n are the predictor variables.

In our analysis, the independent variables included whether a residence had been damaged by flood, perception of flood protection for the city and their home, trust in local, state, and federal officials, gender, education level, household income, employment status, housing status (e.g., renter or homeowner), age of respondent, and race. The assumption of linearity and independence of residuals, as assessed by a Durbin-Watson statistic of 1.78, was met. We ran a series of regression models to assess collinearity diagnostics and results showed no issues with multicollinearity in the models. The assumption that the model no unusual points was met ($+-3$); the assumption of no residuals was met ($+-2.6$); there were no leverage values above the accepted threshold value of 0.2; there were no Cook's distance values above 1; and residuals were normally distributed.

More precisely, we ran a series of cumulative-odds binary logistic regression with proportional odds to determine the effect of our independent variables on respondents' flood insurance coverage. This is an appropriate estimation technique given the dependent variable is binary (i.e., flood insurance coverage or not). This analytic technique is appropriate given logistic binary regression does not require assumptions of multivariate normality, linearity and homogeneity of variance for independent variables and equal variance-covariance across groups. One advantage of binary logistic regression over OLS regression is that independent variables can be treated as categorical. Independent variables with categories were specified as such and the models specify the last category of a variable as the referent. Moreover, the logistic regression provides odds ratios, which help elucidate likelihood (Osborn, 2014).

2.1. Survey results

Table 2 presents the parameter estimates of the binary logistic regression model predicting social demographics and length of residency on flood insurance. The chi-square, which indicates goodness-of-fit indicates that the model was a good fit to the observed data, X^2 (403) = 178.778 ($p < 0.001$). There are several statistics that estimate variance for the models that show strength of association between the dependent variable and predictor variables in this analysis. To determine how well the model explains variation in the dependent variable, we calculated Cox and Snell (0.41) and Nagelkerek (0.6) pseudo R^2 measures. Both pseudo R^2 statistics refer to the squared correlation between the observed and predicted values of the outcome variable. Generally, and similar to R^2 in OLS regression, the higher the pseudo R^2, the better the model is specified (see table note for more information on pseudo R^2).

When controlling for all other variables, for those who identified their income as being in the less than $20,000 category there is a decrease in respondents' likelihood to have flood insurance. Similarly respondents in the income categories, $20,000 to $34,999, $35,000 to $49,999, $50,000 to $74,999, had a decreased likelihood of having flood insurance when compared to those who reported income of $200,000 or more. Respondents between the ages of 45 and 74 were significantly more likely than those aged 75 and over

Table 1
Characteristics of Survey Respondents.

Variable (N = 403)	N	%
Dependent variable		
Flood insurance coverage		
Yes	306	75.9
No	93	23.1
Independent variables		
Income		
Less than $20,000	47	11.7
$20,000 to $34,999	30	7.4
$35,000 to $49,999	30	7.4
$50,000 to $74,999	54	13.4
$75,000 to $99,999	42	10.4
$100,000 to $149,999	60	14.9
$150,000 to $199,999	40	9.9
$200,000 or more	84	15.9
Sex		
Female	244	60.5
Male	150	37.2
Age		
18–24	5	1.2
25–34	34	8.4
35–44	59	14.6
45–54	74	18.4
55–64	115	28.5
65–74	77	19.1
75 or older	37	9.2
Racial group		
White	300	74.4
Hispanic/Latino	4	1.0
African America/black	71	17.6
Native American	1	0.2
Asian/Pacific Islander	7	1.7
Other	8	2.0
Educational level		
Less than high school	5	1.2
High school graduate or equivalent	46	11.4
Trade or technical school	32	7.9
College graduate	146	36.2
Graduate degree	168	41.7
Employment Full Time		
Yes	222	55.1
No	179	44.4
Housing status		
Homeowner	326	80.9
Renter	71	17.6
Neighborhood flooded during Hurricane Katrina		
Yes	199	49.4
No	203	50.4
Residence damaged by flood caused by hurricane		
Yes	229	56.8
No	174	43.2
Residence damaged by flood not caused by hurricane		
Yes	86	21.3
No	316	78.4
Perception of flood protection for the city		
About the same as before Hurricane Katrina	94	23.3
Worse now than before Hurricane Katrina	13	3.2
Unsure/Do not Know	52	12.9
Better now than before Hurricane Katrina (reference)	242	60
Perception that levee system will protect home from flooding		
Very unlikely	13	3.2
Unlikely	34	8.4
Unsure/Don't know	115	28.5
Likely	163	40.4
Very likely (Reference)	78	19.4
Perception that levee system will protect the city from flooding		
Very unlikely	11	2.7
Unlikely	79	19.6
Unsure/Don't Know	153	38

(*continued on next page*)

Table 1 (*continued*)

Variable (N = 403)	*N*	%
Likely	131	32.5
Very likely (reference)	29	7.2
Trust in local officials to protect the city from flooding		
Strongly disagree	43	10.7
Disagree	121	30
Neutral/No opinion	105	26.1
Agree	114	28.3
Strongly Agree	18	4.5
Trust in state officials to protect the city from flooding		
Strongly disagree	46	11.4
Disagree	142	35.2
Neutral/No opinion	111	27.5
Agree	91	22.6
Strongly Agree	11	2.7
Trust in federal officials to protect the city from flooding		
Strongly disagree	46	11.4
Disagree	142	35.2
Neutral/No opinion	111	27.5
Agree	91	22.6
Strongly Agree	11	2.7
Trust in Army Corp of Engineers to protect the city from flooding		
Strongly disagree	77	19.1
Disagree	103	25.6
Neutral/No opinion	98	24.3
Agree	106	26.3
Strongly Agree	14	3.5

Table 2
Parameter Estimates of Binary Logistic Regression Model Predicting Effects of Social Demographics and Length of Residency on Flood Insurance, Controlling for Sociodemographic Variables.

Parameter Estimates	*B*	Std. Error	Wald	Exp. (*B*)	95% CI Lower	Upper
Income						
Less than $20,000	−3.513	0.995	12.468	0.03***	0.004	0.21
$20,000 to $34,999	−2.927	1.042	7.889	0.054**	0.007	0.413
$35,000 to $49,999	−2.207	1.011	4.786	0.11*	0.015	0.798
$50,000 to $74,999	−2.598	0.91	8.144	0.074**	0.012	0.443
$75,000 to $99,999	−1.108	0.95	1.36	0.33	0.051	2.126
$100,000 to $149,999	−0.71	0.947	0.562	0.492	0.077	3.145
$150,000 to $199,999	−1.156	0.968	1.425	0.315	0.047	2.1
$200,000 or more (referent)						
Female	0.405	0.402	1.017	1.5	0.682	3.297
Age						
18-24[a]	−16.125	15608.832	0.000	0.000	0.000	–
25–34	0.537	0.879	0.373	1.711	0.306	9.577
35–44	0.779	0.802	0.944	2.180	0.452	10.505
45–54	1.626	0.767	4.488	5.083*	1.129	22.873
55–64	1.196	0.631	3.594	3.306†	0.96	11.377
65–74	2.033	0.698	8.474	7.638**	1.943	30.027
75 or older (reference)						
Racial group						
White	−0.964	1.343	0.515	0.381	0.027	5.302
Hispanic/Latino[a]	35.917	24590.354	0.000	–	0.000	–
African America/black	−1.221	1.366	0.799	0.295	0.02	4.291
Native American[a]	17.783	40192.969	0.000	–	0.000	–
Asian/Pacific Islander	0.584	2.327	0.063	1.793	0.019	171.463
Other (reference group)						
Educational level	0.471	0.208	5.119	1.602*	1.065	2.408
Employment	0.483	0.51	0.898	1.622	0.597	4.407
Renter	−2.956	0.482	37.695	0.052***	0.02	0.134
Neighborhood flooded during Hurricane Katrina	1.4	0.5	7.847	4.055**	1.523	10.8
Constant	−1.227	1.938	0.401	0.293		

† $p < 0.1$
*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$
[a] The sample size was so low that the values computed are uninterpretable.

Table 3
Parameter Estimates of Binary Logistic Regression Model Predicting Effects of Experiential, Perception, and Social Trust Variables on Flood Insurance, Controlling for Sociodemographic Variables.

Parameter Estimates	*B*	Std. Error	Wald	Exp. (*B*)	95% CI Lower	Upper
Residence damaged by flood caused by hurricane	1.051	0.3	12.297	2.86***	1.59	5.146
Residence damaged by flood not caused by hurricane	0.126	0.381	0.11	1.135	0.538	2.393
Perception of flood protection for the city						
About the same as before Hurricane Katrina	0.487	0.424	1.32	1.628	0.709	3.737
Worse now than before Hurricane Katrina	1.796	0.782	5.273	6.024*	1.301	27.895
Unsure/Do not Know	0.308	0.49	0.394	1.361	0.52	3.558
Better now than before Hurricane Katrina (reference)						
Perception that levee system will protect home from flooding						
Very unlikely	0.842	0.962	0.768	2.322	0.353	15.292
Unlikely	-0.943	0.844	1.247	0.39	0.074	2.038
Unsure/Don't know	0.452	0.551	0.671	1.571	0.533	4.629
Likely	0.01	0.491	0.000	1.01	0.386	2.645
Very likely (Reference)						
Perception that levee system will protect the city from flooding						
Very unlikely	-0.482	1.158	0.173	0.617	0.064	5.98
Unlikely	0.334	0.783	0.181	1.396	0.301	6.479
Unsure/Don't Know	0.126	0.697	0.033	1.134	0.289	4.446
Likely	-0.824	0.722	1.301	0.439	0.107	1.807
Very likely (reference)						
Trust in local officials to protect the city from flooding						
Strongly disagree	0.165	1.327	0.015	1.179	0.088	15.887
Disagree	-0.627	1.177	0.284	0.534	0.053	5.369
Neutral/No opinion	0.148	1.172	0.016	1.159	0.117	11.525
Agree	-0.750	1.175	0.407	0.472	0.047	4.728
Strongly Agree (reference)						
Trust in state officials to protect the city from flooding						
Strongly disagree	-0.409	1.158	0.069	0.665	0.031	14.09
Disagree	-0.19	1.41	0.018	0.827	0.052	13.121
Neutral/No opinion	-0.187	1.421	0.017	0.829	0.051	13.444
Agree	0.404	1.427	0.08	1.497	0.091	24.544
Strongly Agree (reference)						
Trust in federal officials to protect the city from flooding						
Strongly disagree	−2.349	0.921	6.509	0.095*	0.016	0.58
Disagree	−1.398	0.828	2.846	0.247†	0.049	1.254
Neutral/No opinion	−1.788	0.835	4.589	0.167*	0.033	0.859
Agree	−1.406	0.838	2.814	0.245†	0.047	1.267
Strongly Agree (reference)						
Trust in Army Corp of Engineers to protect the city from flooding						
Strongly disagree	1.358	1.037	1.713	3.887	0.509	29.687
Disagree	1.307	0.964	1.841	3.696	0.559	24.428
Neutral/No opinion	0.898	0.963	0.87	2.456	0.372	16.221
Agree	0.545	0.952	0.328	1.725	0.267	11.139
Strongly Agree (reference)						
Constant	-0.278	0.979	0.081	0.757		

*p < 0.05, **p < 0.01, ***p < 0.001.
† p < 0.1.
Note: Odds ratios are reported for all logistic regression tables. Odds ratios are estimated to the nearest thousand. The results include pseudo-R^2 even though statisticians disagree over the usefulness of this measure of goodness of fit. Therefore, the low R^2 should not be taken as indicative of incomplete or inaccurate models (see Ramseyer and Rasmusen 2010). One measure of goodness of fit that can be used is the proportioned by chance accuracy rate—that is does the model estimate the model correctly 25% better than chance. These models meet these criteria.

to have flood insurance coverage. Note that the age group 55–64 was statistically significant at $p < 0.1$. Age categories 45–54 and 65–74 were statistically significant at least at the $p < 0.05$ level of significance. The higher the educational level the greater the likelihood that a respondent has flood insurance coverage. Lastly, we found that if a respondent's neighborhood had flooded during Hurricane Katrina, they have an increased likelihood of having flood insurance coverage. Neighborhood flooded in Hurricane Katrina was the most robust predictor of whether or not respondents currently have flood insurance coverage. Sex, racial or ethnic group, and employment were not found to be statistically significant determinants of flood insurance.

Table 3 shows the parameter estimates and overall results of the binary logistic regression model predicting effects of experiences of flooding, perception of flood protection, and social trust on flood insurance, when controlling for the sociodemographic characteristics of respondents (N = 403). The chi-square indicates goodness-of-fit and shows that the model was a good fit to the observed data, X^2 (403) = 59.488 ($p < 0.01$). Our model has a Cox and Snell of 0.141 Nagelkerke R^2 of 0.226.

When controlling for all other variables, for respondents who have lived in a residence damaged by a flood caused by a hurricane there is an increased likelihood that a respondent will have flood insurance when compared to those without such an experience. For

perception variables, respondents who perceive that flood protection for the city is worse now than before Hurricane Katrina have an increased likelihood to have flood insurance. Respondents who expressed this concern are six times more likely than respondents who expressed that flood protection is better now than before Hurricane Katrina to have flood insurance.

Interestingly, respondents who strongly disagree that they can trust federal officials to protect the city from flooding had a decreased likelihood of having flood insurance compared to those that strongly agree that they trust federal officials. Respondents who reported agreeing that they can trust federal officials to protect the city from flooding have a decreased likelihood of having flood insurance compared to those that strongly agree. Those that reported feeling neutral or having no opinion on federal officials also have a decreased likelihood of having flood insurance compared to those that strongly agree. Experience of a residence damaged by flood not cause by a hurricane, perception of the levee system protections, and trust in local and state officials were not statistically significant determinants of flood insurance coverage.

We wish to note that the lack of statistical significance for experience of a residence damaged by flood not caused by a hurricane is curious and interesting. The majority of flood damage insurance claims have historically come from flood damage from nuisance flooding (floods that occur outside of hurricane season which runs from June 1 to November 30). Nuisance flooding—which causes public inconveniences such as repeated road closures, inundated storm drains and compromised infrastructure—has increased on average by about 50 percent over the last 20 years and 100 percent over the last 30 years in the U.S.. Many coastal U.S. cities already face the omnipresence of nuisance flooding. Continued sea level rise is expected to increase the frequency, depth and extent of nuisance floods, with some parts of Louisiana's coast potentially seeing daily flooding by 2100 according to a 2018 report by the National Oceanic and Atmospheric Administration (NOAA) (Sweet et al., 2018). Our findings suggest that residents may not be aware of the damaging impacts of nuisance flooding. Over time, nuisance flooding can degrade drainage and sewer systems, contaminate drinking water supplies, and damage buildings.

3. Discussion

The above findings offer partial support for our stated hypotheses. For hypothesis 1, our findings suggest that only age and income were statistically significant predictors of flood insurance coverage. As expected, older, wealthier homeowners were more likely to have flood insurance coverage, a finding that is consistent with extant literature on flood insurance coverage (Brody et al., 2017). This finding also corroborates environmental justice literature that finds household income to be a predictor of environmental hazard risk perceptions (Eisenman et al., 2007; Finch et al., 2010; Brulle and Pellow, 2006). Given prior research linking home ownership to greater flood risk perception (Burningham et al., 2008; Grothmann and Reusswig, 2006), we find that homeowners are more likely than renters to have flood insurance. We do not find race/ethnicity or gender to be a statistically significant predictor of flood insurance coverage. We did find education to have the expected effect, based on extant literature, of being positively associated with flood insurance coverage.

Additionally, we found support for our second hypothesis that previous experiences of flooding correlate with the likelihood of current flood insurance coverage. Importantly, we found that if a respondents' neighborhood had flooded during Hurricane Katrina, they were four times as likely as someone whose neighborhood had not flooded to have flood insurance. The literature on decision-making concerning risk perception and risk mitigation action suggests that individuals that have experienced a major disaster or traumatic event may underestimate the likelihood of a low-probability event if they have not experienced it and overestimate its likelihood if they have experienced the event (Hertwig et al., 2004; Fox and Hadar, 2006) and overestimate its likelihood (Brilly and Polic, 2005; Ruin et al., 2007; Siegrist and Gutscher, 2006; Viscusi and Zeckhauser, 2006). Researchers explain this behavior as availability bias (Tversky and Kahneman, 1974) and note that individuals who have recently experienced a flood, for example, may find it easier to imagine that a flood in the future will happen and therefore take actions to mitigate the risk.

Scholars and researchers have long known that trust—or lack of trust—in government officials can have a substantial impact on risk perception and risk mitigation action (Wachinger et al., 2013; Atreya et al., 2015; Shao et al., 2017). To test this assertion, we included questions related to experiences of flooding and to perceptions of social trust in officials at local, state, and federal government and the Army Crop of Engineers. We found that those who perceive flood protections to be worse now than before Hurricane Katrina, are significantly more likely to have flood insurance compared to those who perceive flood protections to be better now. Such perceptions point to the importance of reliable and accurate information on the efforts of officials and policymakers to ensure the utmost precautions are taken to protect residents from flooding. This finding gives credence to the importance of studying the protection efforts, themselves, and communicating these results to the public in an accessible way (Kammerbauer and Minnery, 2019). Doing so may reduce perceptions that residents and neighborhoods are not well protected against flooding. This finding also indicates that people are more likely to protect their own interests through flood insurance coverage in light of their perception that local government lacks proper flooding protections.

We believe that the lack of support for race/ethnicity and gender as predictors of flood insurance coverage can be explained by what Wachinger et al. (2013) call the "Risk Perception Paradox" which is the belief that high risk perceptions will lead to risk mitigation behavior. Researchers have found that high risk perceptions do not necessarily translate into behaviors that reduce risks. Across a wide array of risks, involving climate change, disaster events, and hazards, such as volcanoes, earthquakes, and floods, research has found that women and racial and ethnic minorities tend to express higher risk perceptions than men and whites (Bord and O'Connor, 1997; Davidson and Freudenburg, 1996; Finucane et al., 2000; Fothergill, 1996; Fothergill and Peek, 2004; Gotham, 2014; Kellens et al., 2011; Ludy and Kondolf, 2012; Marshall, 2004; Marshall et al., 2006; McCright, 2010; Perry and Lindell, 2008; Senkbeil et al., 2014; Slovic, 2001; Vaughn and Nordenstam, 1991; Vaughn and Seifert, 1992). The intersection of race/ethnicity and gender in risk perception findings has also been noted in the literature but scholars recognize that the relationship between race/

Table 4
States with Severe Repetitive Loss (SRL) Properties.

State	Number of SRL Properties	Total Damages (1978–2015)
Louisiana	7,223	$1.22 billion
Texas	4,889	$0.96 billion
New Jersey	3,246	$0.66 billion
New York	1,802	$0.40 billion
Florida	1,601	$0.37 billion
Missouri	1,526	$0.19 billion

Source: National Resources Defense Council (2017).

ethnicity and gender and risk mitigation behavior can nuanced and complex. While race/ethnicity and gender may not play a direct role in predicting risk mitigation behavior, these factors could act as mediators or amplifiers of the main causal connections between experience, perception, and preparedness to take protective actions.

We can also interpret these findings with respect to the changing nature of flood insurance in post-Katrina New Orleans. The passage of the Biggert-Waters Act in 2012, originally intended to strengthen the future financial solvency and administrative efficiency of the NFIP, has endangered the affordability of flood insurance for many residents. The Act eliminated insurance premium subsidies on severe repetitive loss properties (SRL) and on properties that have incurred flood-related damage that has exceeded the fair market value of the property, among other reforms. SRLs are those properties that NFIP has paid at least two claims of more than $1,000 in a 10-year period since 1978. At 7,223 such properties, Louisiana has considerably more SRLs than any other state with damages adding up to $1.22 billion between 1978 and 2015 (Natural Resource Defense Council (NRDC), 2017) (see Table 4). The Act has also gradually phased in actuarial rates for structures newly mapped into special flood hazard areas and legislated increases in the annual cap on flood insurance premium rate increases from 10% to 20%.

Thus, the Biggert-Waters Act has hit Louisiana especially hard and has exacerbated community uncertainty regarding what parts of New Orleans are at high risk of seeing spikes in the cost of flood insurance. In some neighborhoods, FEMA is asking homeowners to consider elevating their homes in place, a situation that has caused neighborhood disruption as some homeowners cannot afford to raise their home but cannot sell their home because the high cost of flood insurance can deter potential homebuyers. These points dovetail with Elliott's (2017; 2019) observation that flood insurance is not just about guarding against flood damage. Rather, flood insurance is about "values at risk" to the extent that it ensnarls communities in complicated conversations about threat and risk, financial and social values, property loss, and existential security. Because homeownership underpins economic security and wealth creation in the United States, changes to flood insurance are highly consequential for the near- and long-term economic security of individuals and communities.

4. Conclusion

We consider our study as a starting point for investigating relationships among experiential, socioeconomic, and sociodemographic factors in the determination of flood insurance coverage. Our findings must be considered in light of several limitations of the current study. First, the study is cross-sectional, therefore temporal ordering of variables cannot be verified with certainty. Future work using a longitudinal research design could track insurance purchase decisions over time and compare coverage rates across different base flood elevations and land-uses. Such a design could address how and why questions concerning homeowner decisions to purchase flood insurance and then discontinue these policies after a period of time (see Osberghaus, 2017). Second, the study is non-experimental and as such we did not include specific interventions to compare across an experiment and control group. To test causal relations, we need (quasi) experimental and longitudinal designs (Trumbo et al., 2014; Kellens et al., 2013). Third, our survey was restricted to seven neighborhoods in New Orleans and findings therefore are not generalizable to the entire city.

Fourth, the inability for expected demographic characteristics to be statistically significant may be the result of the small sample size of each demographic group and the low response rate (20%). Mail-return surveys tend to have low response rates compared to other kinds of surveys (see Dillman et al., 2014). Other environmental risk survey studies have had higher and lower response rates and research has shown that low response rates do not necessarily bias or weaken the significance of the findings (see for instance Van Duinen et al., 2015; Terpstra and Lindell, 2013). Brody and colleagues (2017, p. 773) suggest that large samples could "provide a sounder basis for proposing and testing multi-stage, multi-equation models that more explicitly model the mediating mechanisms that intervene between exogenous variables such as hazard proximity and house value, on the hand, and the ultimate endogenous variable – flood insurance purchase." Moreover, the addition of other socioeconomic and sociodemographic variables, and individual and context level factors to the models may provide further insights into insurance purchase decisions.

As in other flood prone cities, flood insurance has paradoxical and contradictory effects since it is a policy that both intensifies risk and mitigates risk. On the one hand, flood insurance plays an important role in risk reduction by mitigating economic losses and providing financial support in the event of flooding. These points dovetail with the work of Müller and colleagues (2017) who note, using the example of agriculture insurance in developing countries, that insurance can be an important tool for mitigating the impacts of climate change, but it "needs to be carefully developed with specific local social-ecological contexts and existing risk coping strategies in mind. Otherwise, it is liable to create long-term maladaptive outcomes and undermine the ability of these systems to reduce vulnerability." Like agricultural insurance programs in both developing and developed countries, flood insurance coverage in

the United States shapes land-use decisions and can generate economic, social, and ecological consequences.

In the United States, researchers and scholars have long known that flood insurance can encourage real estate development in flood plains and coastal areas and thereby increase the vulnerability of homeowners and businesses to flood damage (Bagstad et al., 2007). Moreover, the NFIP is the major source of flood insurance in the U.S. but it is in debt by more than $20 billion, having borrowed approximately $40 billion from the government since Hurricane Katrina. Congress designed the Biggert–Waters Flood Insurance Reform Act of 2012 to phase out subsidies in high risk flood areas and raise flood insurance premiums. FEMA requires the majority of homeowners with mortgages living in certain designated areas to purchase flood insurance. There are many neighborhoods across the U.S. that are vulnerable to flooding but where insurance is not mandatory and many residents choose not to enroll there are at times dire consequences. Moreover, rising premiums in many neighborhoods in the United States have spurred mobilizations of residents to challenge what they see as the double whammy of flood insurance: uninsured or underinsured homes face pervasive risk of both flooding and rising insurance premiums under the conditions of global climate change.

Going forward, policy makers will face major flood management challenges in their attempts to shore up the financial sustainability of the NFIP in the context of expected future extreme weather events, sea-level rise, and coastal flooding. While storms and rising sea levels may threaten coastal communities, it could be that rising flood insurance premiums may play a larger role in making some places no longer livable in their current form. Scholars and researchers should probe controversies over climate justice debates pertaining to distributions, procedures, rights, responsibilities and recognition at a subnational scale (Bulkeley et al., 2013; Bulkeley et al., 2014; Broto, 2017). In addition, hurricane damage increasingly exposes the federal government to escalating insurance payouts and budget liabilities (Government Accountability Office, 2019). The Congressional Budget Office (2016) suggests that, over time, the costs associated with hurricane damage will increase faster than the economy will grow. Thus, evolving grassroots and policy understandings of climate change risk will shape and be shaped in part by political debates on the affordability of flood insurance and government definitions of flood risk.

Funding

This work was supported by the National Science Foundation [#1313703]. Declarations of interest: none.

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