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Hazard Experience, Geophysical Vulnerability, and Flood Risk Perceptions in a Postdisaster City, the Case of New Orleans

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This article investigates the determinants of flood risk perceptions in New Orleans, Louisiana (United States), a deltaic coastal city highly vulnerable to seasonal nuisance flooding and hurricane-induced deluges and storm surges. Few studies have investigated the influence of hazard experience, geophysical vulnerability (hazard proximity), and risk perceptions in cities undergoing postdisaster recovery and rebuilding. We use ordinal logistic regression techniques to analyze experiential, geophysical, and sociodemographic variables derived from a survey of 384 residents in seven neighborhoods. We find that residents living in neighborhoods that flooded during Hurricane Katrina exhibit higher levels of perceived risk than those residents living in neighborhoods that did not flood. In addition, findings suggest that flood risk perception is positively associated with female gender, lower income, and direct flood experiences. In conclusion, we discuss the implications of these findings for theoretical and empirical research on environmental risk, flood risk communication strategies, and flood hazards planning.

KEY WORDS: Disaster; flood risk perceptions; hazards; vulnerability

1. INTRODUCTION

Flood hazards are a serious threat to the stability and sustainability of communities around the world. According to the U.N. Office of Disaster Risk Reduction, from 1995 to 2015, more than 157,000 people died as a result of floods and up to 2.3 million people were negatively affected in terms of displacement, injury, and loss of home and property due to flooding.(1) Death tolls from flooding have risen in many parts of the world in the last decade. In 2007, floods killed 3,300 people in India and Bangladesh alone. In 2010, flooding killed 2,100 people in Pakistan and another 1,900 in China, while in 2013 more than 6,500 people died due to floods in India.(1) In March 2011, over 15,000 people died in Japan as a result of the earthquake-induced storm surge. A growing body of literature indicates that the frequency and destructiveness of flood events will increase through the 21st century due to rising greenhouse gas (GHG) concentrations.(2–4) As a result, scientists acknowledge that absolute flood prevention or protection is unattainable, a situation that has motivated researchers and scientists to call for studies to investigate how and why damage from flooding occurs and who is most negatively affected. Relatedly, scientists recognize that more studies are needed to

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understand how people perceive flood risks and what risk management strategies governments can implement to reduce the negative consequences of floods.[5,6]

In this article, we analyze geophysical, experiential, and sociodemographic variables derived from a survey of New Orleans, Louisiana (United States) residents to predict variation in flood risk perception. Understanding public perception of flood risk is an important aspect of flood management decision-making processes and a crucial component of building flood-resilient communities. Just as public risk perceptions play a major role in shaping natural hazards policy, knowledge of flood risk perceptions drives flood mitigation policy reform and government response to flood disaster. Moreover, knowledge about risk perceptions of flood hazards may provide important information about whether the public is likely to support government flood risk reduction regulations and strategies.[7,8] In addition, knowledge of flood risk perceptions is important in that it provides a glimpse into whether, how, and under what conditions people are willing to engage in proactive actions to reduce risks.[9] The assumption is that individual beliefs about hazards are important factors behind individual decision making regarding insurance purchases and the adoption of self-protective measures. Finally, scientists and policymakers have promoted knowledge of flood risk perceptions as a prerequisite to achieve effective risk communication aimed at better mitigation policies.[7,10–13]

In this study, we empirically test theoretical propositions by environmental social scientists on the determinants of flood risk perception, using the post-Katrina context of New Orleans, Louisiana (United States). In 2005, multiple failures in the Army Corps of Engineers' levee system during Hurricane Katrina damaged over 200,000 homes, killed over 1,400 Louisiana residents, and displaced more than a million others. Hurricane Katrina raised the specter of flood risk as the primary climatic threat to the culture and sustainability of New Orleans and the Gulf Coast region. Since 2007, federal, state, and local governments have collaborated to construct, repair, and upgrade over 160 miles of levees in response to the catastrophe. The Greater New Orleans Hurricane and Storm Damage Risk Reduction System (HSDRRS) received $14.5 billion in federal and state investments to raise levee and floodwall elevations, build a massive new surge barrier, install new pumping stations, and construct new canal closure structures. These efforts have been informed by Louisiana's Coastal Protection and Restoration Authority (CPRA), which is tasked to produce a long-term coastal master plan for flood risk reduction and coastal restoration. Despite flood mitigation improvements, flood risk remains a constant threat to the region and will likely increase as floods and storms become more frequent and destructive due to global warming and sea-level rise.[14]

Our analysis addresses risk perceptions in a disaster-devastated city in which city and state governments are implementing a host of new flood risk reduction measures (e.g., rebuilt levee system, higher flood walls, new pumping stations). In existing studies, researchers view people's opinions about hazards as an important basis of knowledge for the development of effective risk reduction policies.[5,10] Scientists have analyzed the determinants of flood risk perceptions in high flood risk cities but we have a dearth of research and information on flood risk perceptions in cities recovering from a major flood disaster. Moreover, while researchers and scholars have studied flood risks facing New Orleans, little attention has focused on residents' attitudes toward flood risk. We address these theoretical and empirical gaps by analyzing the predictors of flood risk perception in a disaster-impacted and flood-prone city. In doing so, our goal is to provide direction to planners and policymakers on how to develop more effective flood risk communication strategies and risk reduction policies.

2. DETERMINANTS OF HAZARD RISK PERCEPTION

Hazard studies have found that age, home ownership, length of residence, income, education, gender, and race and ethnicity tend to be important sociodemographic predictors of risk perceptions. Age has been found to be positively correlated with risk perception of floods and other natural hazards.[15,16] Home ownership has also been related to perceived risks and Burningham *et al.* suggest that owning a property results in higher levels of perceived risk than renting a residence.[17] Other researchers suggests that length of residence may have an effect on flood risk perception though findings have shown this impact to be weak.[17–20] Across different types of hazards, people with lower income and less education tend to have higher perceptions of hazard risk than wealthy and highly educated people.[21] Studies of discrete disaster events—earthquakes, volcanoes, and floods—have found that women tend to have higher perceptions of risk than men.[15,21–25] Studies of climate change risk perception by Brody and colleagues[26] and McCright[27] have found that women are more likely than men to be cognizant of the adverse impacts of global climate change, a result that is consistent with past research on female environmental perception and concern.[28] Researchers have also found race and ethnicity to be correlated with a wide range of risk perceptions, including air pollution, climate change, and nuclear power.[29]

Research on flood risk perception has examined the impact of personal experience with previous flood hazards and sociodemographic variables on perceived personal risk.[5,7,30–33] A central assumption is that risk perceptions arise from the interplay of social-demographic characteristics of individuals, local geophysical conditions (proximity to a hazard), and people's direct experiences with particular hazard events. Researchers note differences between direct personal experience in the form of damage to property or person and indirect or vicarious experience (e.g., hearing or reading about hazards affecting friends, relatives, or neighbors).[16,33,34] Lindell and Perry suggest that the effect of experience depends on how people interpret their experiences and what they have learned from them.[35] The factors that shape risk perceptions are the magnitude of the hazard, the intensity of destruction and damage from the hazard, and the frequency and currency of direct experiences with the hazard.[11]

Similarly, researchers have suggested that there is a spatial dimension to risk and stressed the importance of place and spatial nearness or proximity in shaping peoples' judgments about risk.[15,36–40] Studies by Woods and colleagues on proximity to terrorist targets,[41] Peacock and colleagues on coastal living and hurricane risk,[42] Lindell on proximity to toxic gas and radioactive materials releases,[43] and Brody and colleagues on climate change risk[26] suggest that geographical closeness to a potential hazard affects risk perception. The effect of place and proximity on risk perception, however, is mixed.[44–46] Palm *et al.*[47] and Mileti and Darlington[48] found no association between risk perception and proximity to an earthquake fault line. Using a three-category climate change risk perception item, Carlton and Jacobson found that neither prior experience with hurricanes nor distance of residents from the Florida coast were significant predictors of risk perception.[49]

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

H1: *Residents living in neighborhoods that flooded during Hurricane Katrina—geophysical vulnerability (hazard proximity)—will exhibit higher levels of perceived risk than those living in neighborhoods that did not flood.*

H2: *Direct experiences with floods in terms of property damage will be related to higher levels of flood risk perception.*

H3: *Flood risk perception is expected to be positively related with age, female gender, lower education, home ownership, and long-term residence.*

3. METHODS AND DATA ANALYSIS

This article relies on findings from a survey of New Orleans residents conducted during January to March 2015, consisting of a four-page questionnaire of scaled questions regarding different hazards and flood risk perceptions. We pretested the survey with 12 residents and professionals in the region. Based on feedback, we removed redundant questions and refined unclear questions and response categories. The structured questionnaire contained 18 closed-ended questions dealing with perceptions of flood risk, rodent disease risk, and individual-level variables including education, gender, age, race/ethnicity, homeownership status, and socioeconomic and demographic background. Respondents were also asked questions about their experience with past storms and flooding, and expectations and concerns regarding future threats to safety and security.

Three of the 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 (see Fig. 1). Sampling corresponded to a network of 72 plots where vegetation and ecological (i.e., rodent) surveys were completed by other research team members funded through a National Science Foundation (NSF) Coupled Natural-Human (CNH) Systems grant. We sampled the same number of households in each neighborhood rather than proportioning to population size, to ensure a minimum number of respondents per neighborhood for comparative analysis. In each of the seven neighborhoods, we randomly selected approximately 278 addresses and distributed a survey to each address.

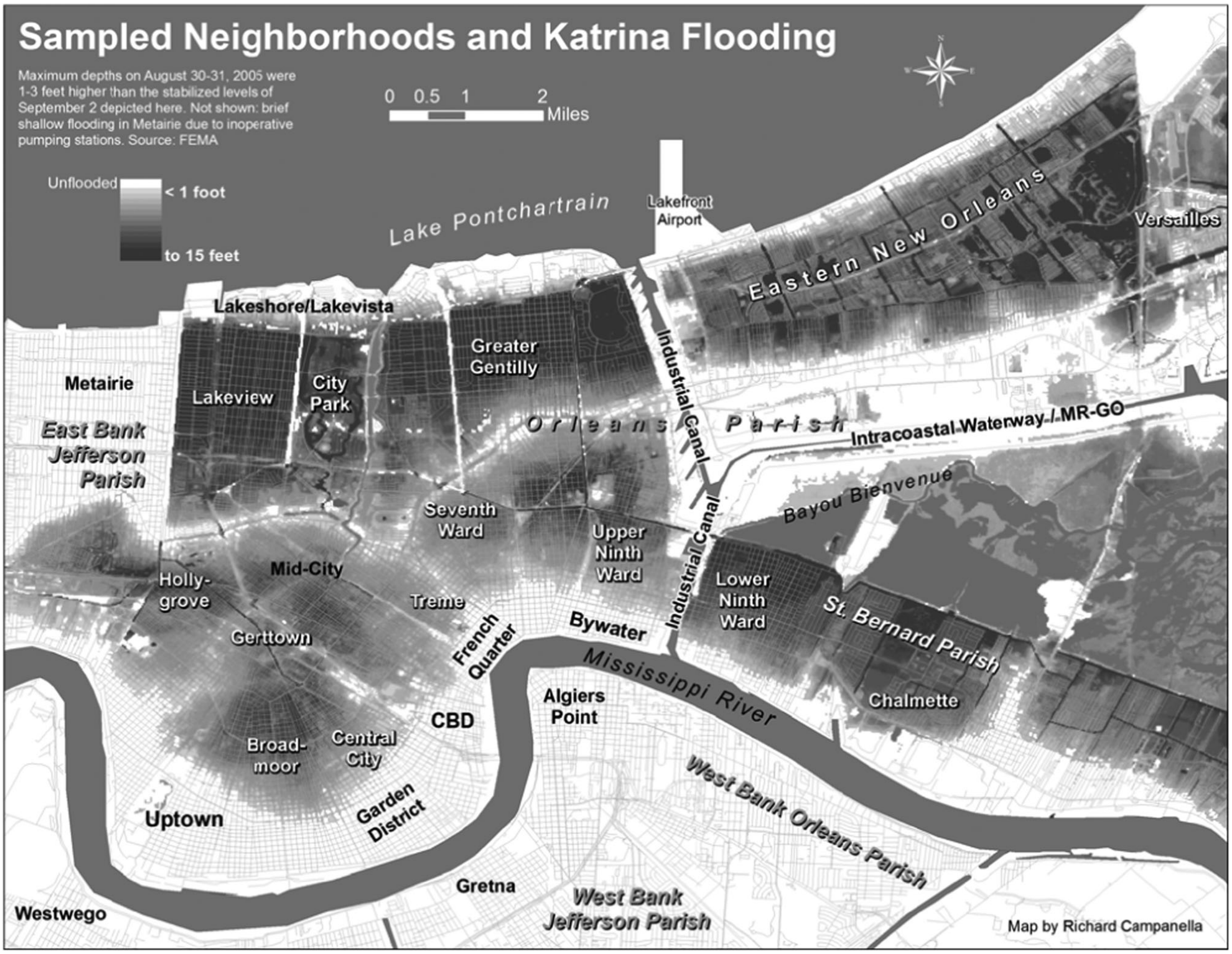

Fig. 1. Map of sampled neighborhoods and Katrina flooding in New Orleans, LA.

Recruitment letters and survey questions were printed in English and the adult in the household with the most recent birthday was asked to participate. Respondents were asked to fill out the four-page survey and return it to the researchers in an enclosed stamped mail envelope. Through June 2015, we received 384 returned surveys for a response rate of about 20%.

To evaluate the predictors of flood risk perceptions among residents living in post-Katrina New Orleans, we asked respondents to rate their level of flood risk For our analysis, we used a single item question—how high or low would you rate your current home's risk of flooding in New Orleans—following a four-point Likert scale. The response categories were no risk (coded as 0), low risk (1), medium risk (2), or high risk (3). We developed our flood risk perception questions based on analysis of previous questionnaires using Likert-scale questions to assess risk attitudes.[19,50,51] Using close-ended Likert-scale questions is consistent with previous studies on seismic hazard perception[52,53] and toxic chemical risk perception.[54,55]

To evaluate the influence of respondents' location and proximity on perception of flood risk, we geocoded each survey by neighborhood—Bywater, Gentilly, Lakeshore, Lakeview, Lower Ninth Ward, Upper Ninth Ward, and Uptown—as shown in Fig. 1. The map shows Katrina-induced flooding by its depth as measured by the Federal Emergency Management Administration (FEMA) on September 2, 2005, four days after the hurricane and levee breaches, and two days after the deluge peaked within the city. The map shows flooding as measured at one-foot increments overlaid with U.S. Census block-groups ($N = 466$) and parish boundaries courtesy of

Environmental Systems Research, Inc. (ESRI). The map shows that the darker the area, the deeper the flood water. Light gray areas reflect lower levels of flooding. FEMA studies, which assess structural damage produced by flooding, have noted that flood water that reaches 24 inches can carry away most automobiles and cause costly damage to property.[56]

We coded the surveys to identify whether respondents lived in a neighborhood that flooded during Hurricane Katrina. Bywater, Lakeshore, and Uptown did not flood whereas Gentilly, Lakeview, Lower Ninth Ward, and Upper Ninth Ward all flooded when Hurricane Katrina breached the levee system in the city. In much of Greater New Orleans, engineers assert that the upgraded HSDRRS provides greater than 100-year flood protection.[14] Nevertheless, areas that flooded during Hurricane Katrina remain vulnerable to future flooding though there is significant uncertainty about the probability of seeing any particular specified level of flooding. Since 2005, other storms have affected the region, including Hurricane Rita (late September 2005), Hurricane Gustav (2008), and Hurricane Isaac (2012). Hurricane Rita caused the Lower Ninth Ward area to flood though every-one living in that neighborhood had been evacuated a few weeks earlier due to flood damage from Hurricane Katrina. The other hurricanes did not cause much physical damage to New Orleans and there was no flooding in the city. Since 2005, the only major flooding in the city has come from Hurricane Katrina.

Geocoding the surveys addresses the question of whether there are location-oriented risk perceptions related to flooding. Geophysical vulnerability is a proximity risk variable that refers to the respondent's physical vulnerability associated with his or her location in a neighborhood that flooded or not during Hurricane Katrina. We measured geophysical vulnerability associated with flooding by calculating whether a respondent is located in a Katrina-flooded neighborhood. Respondents living in a Katrina-flooded neighborhood were assigned a 1; all others were assigned a 0.

Table I shows the characteristics of our survey respondents and presents frequency distributions of the variables. According to the 384 mail surveys we received, 65.8% of respondents have not experienced flooding in their current home; 28.2% have experienced one flood event; 4.4% have experienced two flood events; and 1.6% have experienced three or more flood events in their current home. Our sample

Table I. Characteristics of Survey Respondents

Variable ($N = 384$)	*N*	%
Dependent variable		
How high or low would you rate your current home's risk of flooding in New Orleans?		
No risk	29	7.6
Low risk	221	57.7
Medium risk	92	24.0
High risk	41	10.7
Independent variables		
Flood experience (Q: How many times have you experienced flooding in the house you are living now?)		
Never	252	65.8
Once	108	28.2
Twice	17	4.4
Three times or more	6	1.6
Gender		
Female	203	54.3
Male	171	45.7
Age		
18–24 years old	2	0.5
25–37	62	16.5
38–49	52	13.9
50–64	130	34.7
65 or older	128	34.4
Race/ethnicity		
White	259	71.0
Hispanic or Latino	8	2.2
African American	61	22.2
Native American	1	0.3
Asian	5	1.4
Other	11	2.9
Employment		
Full-time	185	49.5
Not employed	27	7.2
Part-time	46	12.3
Retired	116	31.0
Marital status		
Single, ever married	73	19.3
Married or domestic partnership	202	53.3
Widowed	42	11.1
Divorced	53	14.0
Separated	9	2.4
Household income		
$0–10,000	39	10.9
$10,000–$29,999	50	13.9
$30,000–$49,999	58	16.2
$50,000–$99,999	78	21.7
Over $100,000	134	37.3
Housing status		
Homeowner	301	80.1
Renter	75	19.9
Number of people currently living in household		
One	101	26.8
Two	171	45.4
Three	48	12.7
Four	40	10.6
Five or more	17	4.5

(*Continued*)

Table I (Continued)

Variable ($N = 384$)	N	%
Children under age 18 living at home (yes/no)		
Yes	69	18.5
No	303	81.5
Highest education degree		
Less than high school	13	3.4
High school graduate	51	13.5
Trade/technical/vocational training	31	8.2
College graduate	150	39.7
Postgraduate degree	13	35.2
Length of residence in current home in years		
Less than 5 years	114	30.2
5–10 years	78	20.6
More than 10 years	186	49.2
Length of residence in New Orleans		
Less than 3 years	18	4.8
3–5 years	22	5.9
6–10 years	33	8.8
More than 10 years	303	80.6

has slightly more female (54.3%) than male respondents. Approximately 81% of respondents have lived in New Orleans for more than 10 years and 49.2% have lived in the same home for more than 10 years (as of January to March 2015). Almost two-thirds of the sample, 74.9% of respondents, had a college degree or greater and most respondents, 69.1%, were 50 years and older. A high percentage of respondents had no children in the home (81.5%); 80.1% of respondents were homeowners; 37.3% of respondents had a household income of over $100,000; and 53.3% of respondents were married or in a domestic partnership. Respondents were predominantly white (71%) with about half employed full-time (49.5%) and 31% retired.

We used an ordinal logistic regression model to assess the impact of flood experience, geophysical vulnerability, and sociodemographic factors on flood risk perceptions. The independent variables included residence in a neighborhood that flooded during Hurricane Katrina (geophysical vulnerability), gender, education level, household income, employment status, housing status (e.g., renter or homeowner), experience of flooding in home, age of respondent, race, marital status, number of children and residents in household, number of years in current residence, and number of years living in New Orleans. The assumption of linearity and independence of residuals, as assessed by a Durbin–Watson statistic of 1.780, was met. We ran regression models to determine collinearity diagnostics and results determined no issues with multicollinearity in the model. The assumption that the model exhibited no unusual points was met (±3); the assumption that no residuals exist was met (±2.6); there were no leverage values above the safe value 0.2; there were no Cook's distance values above 1; and residuals were normally distributed.

Specifically, we ran a cumulative-odds ordinal logistic regression with proportional odds to determine the effect of our independent variables on respondents' perception of flood risk. We chose this estimation technique because the dependent variable is ordinal and limited to four ordered categories: no risk, low risk, medium risk, and high risk.[57] Here, the odds ratio is based on the change in the cumulative likelihood of having risk levels for each one-unit change in each independent variable.[58] The probability of interest is thus the cumulative probability (i.e., probability of being less than or equal to a given category) rather than probabilities for discrete categories. This traditional cumulative approach to ordinal logistic regression is the proportional odds model, which assumes that the cut points between the categorical variables are unknown. A major advantage of the proportional odds assumption is that it allows a more parsimonious model than OLS regression, for example, and presentation of output that ensures the ordinal nature of the dependent variable.[59]

4. RESULTS

Table II shows the parameter estimates and overall results of our ordinal logistic regression model predicting flood experience and flood hazard proximity (geophysical vulnerability) on flood risk perception when controlling for the sociodemographic characteristics of respondents. The deviance goodness-of-fit test indicated that the model was a good fit to the observed data, $\chi^2(833) = 512.513$, $p = 0.615$. The Pearson goodness-of-fit test indicated that the model was a good fit to the observed data, $\chi^2(833) = 1{,}030.312$, $p = 1.000$. There are several R-like statistics that can be used to measure the strength of the association between the dependent variable and the predictor variables in our ordinal logistic regression analysis. To assess whether or not we have a good model to explain variation in the dependent variable, we calculated Cox and Snell (0.366) and Nagelkerke (0.410) pseudo R^2 measures. These pseudo R^2 statistics refer to the squared correlation between the observed and predicted values of the dependent variable. Generally speaking, the higher the pseudo R^2 statistics, the better the model fits the data.

Table II. Parameter Estimates of Ordinal Logistic Regression Model Predicting Effects of Experiential and Geophysical Vulnerability Variables on Flood Risk Perception, Controlling for Sociodemographic Variables

Parameter Estimates		B	Std. Error	Wald	Exp. (B)	95% CI Lower	Upper
Threshold	Risk of flooding = 1	−3.03	1.60	3.54	0.05*	−6.18	0.13
	Risk of flooding = 2	1.11	1.59	0.49	3.33	−2.01	4.23
	Risk of flooding = 3	3.10	1.60	3.73	24.42	−0.05	6.24
Experienced flooding in residence		1.42	0.26	30.98	4.25***	2.6	6.95
Neighborhood flooded in Katrina		1.19	0.33	12.82	2.89***	1.60	5.22
Age		−0.31	0.18	2.84	0.54	0.54	1.08
Female		0.63	0.27	5.40	1.94*	1.18	3.21
Marital status							
Married		1.19	0.85	1.95	2.19	0.45	10.67
Separated		−0.28	0.39	0.52	0.75	0.36	1.59
Widowed		−0.14	0.52	0.07	0.87	0.33	2.29
Divorced		−0.06	0.45	0.02	0.83	0.35	1.97
Single (reference)		0a					
Racial group							
Other		0.34	0.75	0.20	1.43	0.33	6.18
Latino/Hispanic		−1.54	0.85	3.28	0.19	0.04	1.03
African American/black		0.30	0.41	0.54	1.72	0.79	3.72
Asian		−1.16	1.11	1.10	0.29	0.04	2.23
White (reference group)		0a					
Education		0.17	0.15	1.40	1.29	0.96	1.72
Income		−0.39	0.15	6.88	0.69**	0.52	0.92
Renter		−0.62	0.39	2.45	0.50	.24	1.10
Employment status							
Retired		0.21	0.40	2.59	1.29	0.62	2.71
Not employed		−0.05	0.51	0.01	0.97	0.37	2.53
Part-time		−0.07	0.42	0.03	0.83	0.38	1.84
Full-time (reference)		0a					
Number of children		0.05	0.46	0.01	1.00	.418	2.40
Number of residents		0.27	0.18	2.32	1.26	0.89	1.78
Years in current residence		−0.43	0.21	4.31	0.59*	0.39	0.86
Years in New Orleans		−0.08	0.19	0.18	0.92	0.65	1.31

*$p<.05$; **$p<.01$; ***$p<.001$.

Our model explained between 36.6% (Cox and Snell R^2) and 41.0% (Nagelkerke R^2) of variance in the dependent variable associated with the predictor (independent) variables.

The final model was statistically significant, predicting the dependent variable over and above the intercept-only model, $\chi^2(22) = 133.798$, $p < 0.001$. When controlling for sociodemographic variables, an increase in the number of times respondents have experienced flooding in their current home was associated with an increase in the odds of being in a higher category of the dependent variable (i.e., responding with a higher level of flood risk). That is, for every one unit increase in perceived risk of flooding, there is a 4.25 (95% CI = 2.6 to 6.95) increase in the odds of the number of times respondents' homes have flooded previously, a statistically significant effect, $\chi^2(1) = 30.98$, $p < 0.001$. Moreover, as the table shows, the odds ratio of being in a higher category of the dependent variable (i.e., responding with a higher level of risk) for respondents living in a neighborhood that flooded as a result of Hurricane Katrina is 2.89 (95% CI = 1.60 to 5.22), a statistically significant effect, $\chi^2(1) = 12.82$, $p < 0.001$. That is, the odds of respondents who live in a Katrina-flooded neighborhood of having higher rates of perceived flood risk is almost three times higher than that of respondents living in an unflooded neighborhood.

Of the sociodemographic variables, income and gender had statistically significant effects on flood risk perception. A decrease in respondents' income was associated with an increase in the odds of being in a higher category of the dependent variable (i.e., responding with a higher level of flood risk), with an odds ratio 0.69 (95% CI = 0.52 to 0.92), Wald $\chi^2(1) = 6.88$, $p < 0.01$. For every one-unit increase in risk perception, female respondents were 1.94 times more likely to respond in a higher category of the dependent variable (i.e., respond with a higher level of flood risk) (95% CI = 1.18 to 3.21), Wald $\chi^2(1) = 5.40$, $p < 0.05$. Finally, a decrease in respondents' reported years in current residence was associated with an increase in the odds of being in a higher category of the dependent variable (i.e., responding with a higher level of flood risk), with an odds ratio of 0.59 (95% CI = 0.39 to 0.86), Wald $\chi^2(1) = 4.31$, $p < 0.05$.

5. DISCUSSION

The above findings offer partial support for our hypotheses. For our first hypothesis, our findings suggest that residents living in neighborhoods that flooded during Hurricane Katrina exhibit higher levels of perceived risk than those living in neighborhoods that did not flood. In addition, our results support our second hypothesis that direct experience with floods in terms of property damage will be related to higher levels of flood risk perception. The ordinal logistic regression analysis provides very strong support for both of these hypotheses, findings that are largely consistent with the extant literature on flood risk perceptions.[11,20,50,60] Several studies have suggested that the effect of place and hazard proximity on risk perceptions depends on past hazard experience or perceived hazard knowledge.[26,42] For Lindell and Hwang,[15] the effects of experience on perceived risk are partial and indirect rather than direct. Others have suggested that flood risk perception is a significant mediating factor between property value and hazard proximity.[40]

Our article provides a replication of empirical findings regarding the influence of past hazard experienced and spatial vulnerability to hazard on risk perception. Our analysis does not show whether past hazard experience would influence the effect of geophysical vulnerability on risk perception. Extant scholarship suggests that proximity and place act as mediators and amplifiers of the main connections between hazard experience and hazard perception. In the study of Terpstra, risk perception was influenced by the feelings associated with previous experience.[61] We believe that living in a Katrina-flooded neighborhood can bring an affective and emotional response, leading to heightened perceptions of flood risk. Residents living in a disaster-impacted city collect, select, and interpret signals about uncertain impacts of traumatic events and hazards. These signals can refer to direct experiences (e.g., witnessing a flood) or indirect experience (e.g., information from others).[31,60] For an overview, see Burns and Slovic.[10] Although Hurricane Katrina is now over a decade old, the direct experience of flooding and omnipresence threat of flooding continue to weigh heavily on residents, especially in the context of continuing blight and devastation in some neighborhoods that struggle to recover and rebuild.

Per our third hypothesis, we found that women and respondents with low incomes were more likely to have higher flood risk perceptions than men and higher income people, a finding that is consistent with past research.[15,22,23,26] Our findings corroborate the broader environmental justice literature that finds gender and household income to be predictive of environmental hazard risks.[23,62–65] According to our survey findings, women and individuals in lower income households were more likely to report higher perceptions of flood risk than men and individuals in higher income households. Recent studies have documented increased hazard risk among socioeconomically disadvantaged groups and researchers have theorized several mechanisms at work linking risk perceptions to social inequality.[62,66–68] Women and low-income people may be at heightened risk of damage from floods because they may not have adequate home insurance policies and therefore struggle to pay for damages in the aftermath of a major flood event. Structural vulnerabilities stemming from socioeconomic disadvantage may also be linked to increased subjective perceptions of environmental risk among disadvantaged individuals. In other words, those who are objectively more likely to be at risk for adverse consequences from environmental hazards may also be more likely to feel at risk due to their socioeconomic position and past experiences with environmental hazards. Socioeconomically disadvantaged individuals living in hazard-prone areas may have heightened sensitivities to risks associated with their low position in the social stratification system and thus may be more likely to report effects than those who enjoy greater insulation from extreme events.

The results for the demographic variables are mixed but offer some useful insight. We did not find race/ethnic status to be an important predictor of flood risk perceptions, a finding that is at odds with much of the literature that suggests race and ethnic categories are strong independent predictors of perceived environmental risks.[29] Our findings do not show a statistically significant effect of homeownership status or household composition on flood risk perceptions. Several studies suggest that owning a property results in higher levels of perceived flood risk than renting a residence.[16,17,69] In contrast, Kellens *et al.* found that home ownership is not a strong predictor of flood risk perception.[50] Our research does not show that owning a home or renting it predicts levels of flood risk perception. Moreover, we expected, based on extant scholarship, that education (highest year of schooling completed) would have a negative effect on risk perception.[50,70,71] We did not find education to be a statistically significant predictor. In addition, for decades, research findings have been inconsistent on the association among hazard risk perception and household composition, for example, the presence or number of children in the household.[42,50,72–74] Our findings reinforce studies by Lindell and Prater[53] on earthquake risk and by Baker[75] and Peacock and colleagues[42] on hurricane risk that did not find that the presence of children had a significant impact on risk perception.

6. CONCLUSION

Understanding hazard risk perceptions in a postdisaster context is important because attitudes and choices about risk shape how individuals, groups, and public- and private-sector organizations adopt risk mitigation practices, how they respond to postdisaster rebuilding activities, and how they plan for future disasters. One recent report of estimates of flood risk in New Orleans found that post-Katrina upgrades to the levee system have improved coastal defenses and achieved significant risk reduction.[76] At the same time, the threat to New Orleans from flooding is increasing due to a combination of sea-level rise and coastal subsidence. The level of Atlantic basin hurricane activity has also risen, with the biggest increases for the strongest storms (with the largest surges), particularly in and around the Gulf of Mexico. These factors all serve to increase the storm surge flood hazard faced by New Orleans, and will significantly raise the risk of flooding in the city through the 21st century.[77,78] Despite much scholarly attention to measuring flood risks facing New Orleans and other coastal cities, little research has investigated local residents' perceptions of flood risk or analyzed the drivers of flood risk perceptions in cities undergoing postdisaster reconstruction.

Our study has been an attempt to address the above lacunae and identify the experiential, geophysical, and sociodemographic predictors of flood risk in a postdisaster context. Like flood risk management in the Netherlands studied by Terpstra and Gutteling,[8] flood risk management in New Orleans is shifting from prevention toward holistic risk management including disaster preparedness, response, and citizen participation in the planning process. Few studies have examined perceptions of risk in this changing risk management policy context or investigated attitudes toward risk communication about flood preparation measures. Our study has been an attempt to understand the linkages among perceptions about flood risk, geophysical vulnerability, and past experiences with flooding. As we have pointed out, flood hazard proximity (geophysical vulnerability) and flood hazard experience interlock to shape flood risk perception. Our study suggests that residents living in neighborhoods that flooded during Hurricane Katrina exhibit higher levels of perceived risk than those residents living in neighborhoods that did not flood. Moreover, peoples' direct experiences with floods in terms of property damage are related to higher levels of flood risk perception. When considering risk communication strategies, our findings that gender and income are negatively related to perceptions of flood risk suggest that public authorities consider tailoring messages that reflect gender and socioeconomic differences.[8,10,33]

Our findings, of course, must be considered in light of the several limitations of this study. First, we used a single measure of risk perception that some researchers might not consider to be optimal. Extant research tends to favor a multivariate measure of risk perception to assess experiential, cognitive, and affective factors together.[7] Second, the study is cross-sectional, so the temporal ordering of the antecedents and response variables cannot be verified with certainty. Cross-sectional designs cannot assess causality, a situation that makes it difficult to determine whether perceived flood risk might have changed after respondents bought their current residence.[15,24] Third, the study is nonexperimental and did not include specific interventions to compare outcomes among those in an experiment group and control group. To test causal relations, (quasi) experimental and longitudinal research designs are needed in addition to cross-sectional surveys.[5,79] Fourth, although geophysical vulnerability and flood experience are significant predictors of flood risk perception, they account for only a small portion of the variation in perceived personal risk. It could also be that the omission of other important causal variables may have biased the regression estimates. Other factors may influence public risk perception, such as hazard information sources (i.e., government agencies, news media, and peers),[35] institutional trust,[80] and risk information dissemination methods.[44,81,82]

In addition, the inconsistent findings of demographic factors may be the result of the small sample size of each demographic group. Moreover, the response rate was low (20%), which could problematize the generalizability of the results. Kung and Chen suggest small sample sizes of various demographic groups may complicate the ability of analysts to undertake comprehensive and integrative analyses of all demographic characteristics.[23] Therefore, for future analyses, we advocate for more balanced samples of demographic characteristics. Other risk perception surveys have had higher and lower response rates and studies over the last two decades have noted that low response rates do not necessarily bias or weaken the significance of the findings. Van Duinen and colleagues reported a response rate of 9% of 1,474 survey requests to evaluate drought risk perception among farmers in the Netherlands.[83] Terpstra and Lindell's survey of flood risk perception in the Netherlands reported response rates of 12.9% for the coastal area and 9.6% for the river area, respectively.[24] While our response rate is higher than these surveys, nonresponse and selection effect issues are of concern. We did not include any token financial incentives in our survey or use follow-up reminders to incentivize participation. Dillman and colleagues have suggested that survey researchers use these two strategies to increase response rates in mail surveys.[84]

Our findings that direct experience and geophysical vulnerability influence risk perceptions imply that people use experiential processing when perceiving risks. Since experiential processing is affective and based on subjective interpretations,[85–87] outreach and communications personnel should consider emotions, metaphors, stories, and images when discussing flood risks.[10,61] Highly technical, tedious, and dull presentations of scientific and analytical facts are less likely to appeal to people who are processing information experientially. Moreover, simply making risk information publicly available may be self-defeating if people distrust the institutions and agencies that are communicating the putative risk. These points resonate with recent climate change risk perception research by Carlton and Jacobson, who contend that the "challenge for communicators is to appeal to experiential processors while maintaining credibility and trustworthiness."[49] It is critical for residents and communities to be aware of flood risks and to be prepared for the next major storm given that climatic models suggest increases in the frequency and destructiveness of coastal flooding.[2–4,88] Risk communications focusing on the potentially controversial, temporally and geographically distant effects of predicted global climate change impacts are less likely to convince people to support flood mitigation policies or adopt individual risk reduction measures. Rather, risk communicators should consider developing risk messages that are salient, resonant, understandable, and directly related to lived circumstances of target audiences.

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