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How about Now? Changes in Risk Perception before and after Hurricane Irma

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Abstract: Risk reduction behaviors are often voluntary and influenced by how at-risk an individual personally feels, known as risk perception. This paper examines how risk perception changed from before and six months after Hurricane Irma, a Category 3 storm that narrowly missed Sarasota County, FL. Both surveys asked about residents' hurricane risk perceptions, evacuation behaviors, mitigation plans, and attitudes about self-efficacy. For each question found in both surveys, the research used *t*-tests ($\alpha = 0.05$) to assess whether significant changes in risk perceptions occurred between responses. The results suggest that Hurricane Irma had a notable impact on risk perception. The changes were most evident in reported levels of self-efficacy as residents were less likely to feel able to sufficiently prepare for or recover from hurricane impacts after Hurricane Irma. Respondents were also more likely to believe individuals are responsible for preparing for hurricane impacts. The findings have implications for public risk communicators, who may find it effective and sustainable to appeal to residents' lowered self-efficacy or sense of responsibility for the dangers of hurricanes while implementing policies and communication strategies.

Keywords: hurricanes; risk perception; resilience; mitigation

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1. Introduction

Hurricanes are frequent, deadly, and costly natural hazards that impact coastal communities. While much of the destructive potential of a hurricane is unavoidable, the devastation can be mitigated through risk-reduction behaviors, such as disaster preparedness and evacuation [1,2]. However, while public institutions can implement mitigation strategies on a larger scale (e.g., city-wide mitigation projects), the decision to perform risk reduction behaviors at the individual level (e.g., installing storm shutters on private homes) is voluntary. Therefore, understanding the complicated process of how people make decisions about hurricane preparation is useful for understanding hurricane impacts and individual disaster preparedness.

Another influential component in hazard-related decision making is one's attitudes and opinions about the risk associated with a disaster, also known as risk perception, which is distinct from individual to individual [1–3]. For example, risk experts often assess the risks associated with a hazard by estimating the probability of death, injury, or estimated damage. In contrast, laypeople understand and interpret risk along various dimensions, such as voluntariness (whether one willingly exposes oneself to a hazard), personal understanding of a hazard, the potential hazard severity, and the number of people potentially affected by a hazard [4–7].

Risk perception is a multi-faceted concept [6]. As such, risk perception research has focused on several different dimensions, such as hazard knowledge [8–10], perceived susceptibility [11,12], self-efficacy [13–15], and community involvement [16].

However, most risk perception studies are static; they only capture risk perception information for a specific time period. Moreover, few studies measure changes in risk perception from before to after a hazard event due to the unpredictable nature of hazards. Research of this nature has been conducted for hazards such as nuclear incidents [17,18], earthquakes [19], volcanoes [20], and wildfires [21], but it is uncommon. Other before and after studies measure changes in risk perception using data proxies, such as property value [22], or by comparing risk perceptions of people with previous hazard experience to those without previous hazard experience [23–25]. Notably, however, no studies appear to examine risk perceptions before and after a hurricane specifically.

This paper addresses these literature gaps by comparing risk perception survey data taken in Sarasota County, FL, shortly before (2016) and shortly after (2018) Hurricane Irma, a major hurricane that made landfall close to Sarasota County in 2017. This research statistically compares twenty-two questions concerning risk knowledge, perceived risk, perceived susceptibility, self-efficacy, and community involvement in both surveys to assess the effects of Hurricane Irma on risk perception in Sarasota County, FL. The analysis tests the null hypothesis that reported that the levels of hurricane knowledge, perceived hurricane risk, perceived susceptibility, self-efficacy, and community involvement after Hurricane Irma showed no significant change from their levels before Hurricane Irma.

2. Background and Literature

2.1. Psychological and Sociological Foundations of Risk Perception

Several theories explore and measure risk perception and its influence on risk reduction behavior (Table 1). Risk perception as a psychological theoretical basis is important for understanding the formation of attitudes and the nature of decision making [5,26–30]. Initially, risk perception research focused on factors most important in determining people's attitudes about a hazard [4–6]. However, these studies do not explain why those factors are important or explore the relationship between risk perception and risk reduction behavior.

As a result, more risk perception research has incorporated psychological and sociological theories that attempt to explain the relationship between risk perception and related behaviors such as mitigation, preparation, and evacuation. Figure 1 shows a visual summary of the psychological and sociological foundations of risk perception). Such theories include the theory of bounded rationality [26,31,32], psychometric paradigm [5,33,34], theory of planned behavior (TPB) [27,35–37], vested interest theory [28,38], social amplification of risk [30,39,40], cultural theory of risk [41], and situational theory of publics [29,32,42–45].

Table 1. Examples of psychological and sociological foundations of risk perception in the hazards literature.

Theory/Paper(s)	Findings
Theory of bounded rationality (TBR) [26,31,32].	Individuals make rational decisions, but those decisions are bounded by the information the individual has access to.
Psychometric paradigm [5,33,34,46].	A consistent and scientifically robust method to measure risk perception, using factors including voluntariness, the immediacy of effect, understanding of risk by those exposed, understanding of risk by science, control over risk, the newness of risk, whether the risk kills many people at once, how common the risk is, and the severity of the consequences of the risk.
Theory of planned behavior (TPB) [27,35–37,47].	There is a distinction between intention and action, and there are three main characteristics that determine one's intention to take a given action: (1) a person's attitudes about that action, (2) how a person believes others would view that action, and (3) their perceived level of control over the outcome of that action, also known as self-efficacy.
Vested interest theory [28,38].	Attempts to predict behavior based on an individual's personal investment in a situation; predictive power of attitudes depends on five factors: (1) one's stake in the outcome of a disaster event, the most important component of vested interest, (2) salience, or the importance of the disaster event to the individual, (3) the perceived certainty of certain outcomes to occur, (4) the immediacy of the disaster outcomes, and (5) self-efficacy.

Table 1. *Cont.*

Theory/Paper(s)	Findings
Social amplification of risk [30,40,48].	Identifies and delineates "information stations," which are any entity that receives information and then potentially amplifies it; information about a risk passing through these stations can be amplified so that, over time, the public's overall risk perception may be significantly heightened.
Cultural theory of risk [41].	One's decision to acknowledge or avoid certain risks is strongly influenced by cultural biases, social norms, and social structures.
The situational theory of publics (STP) [29,32,42–45].	The public is made of many smaller publics that behave differently during a disaster and are categorized by how different groups communicate, interpret, and respond to disaster-related problems.

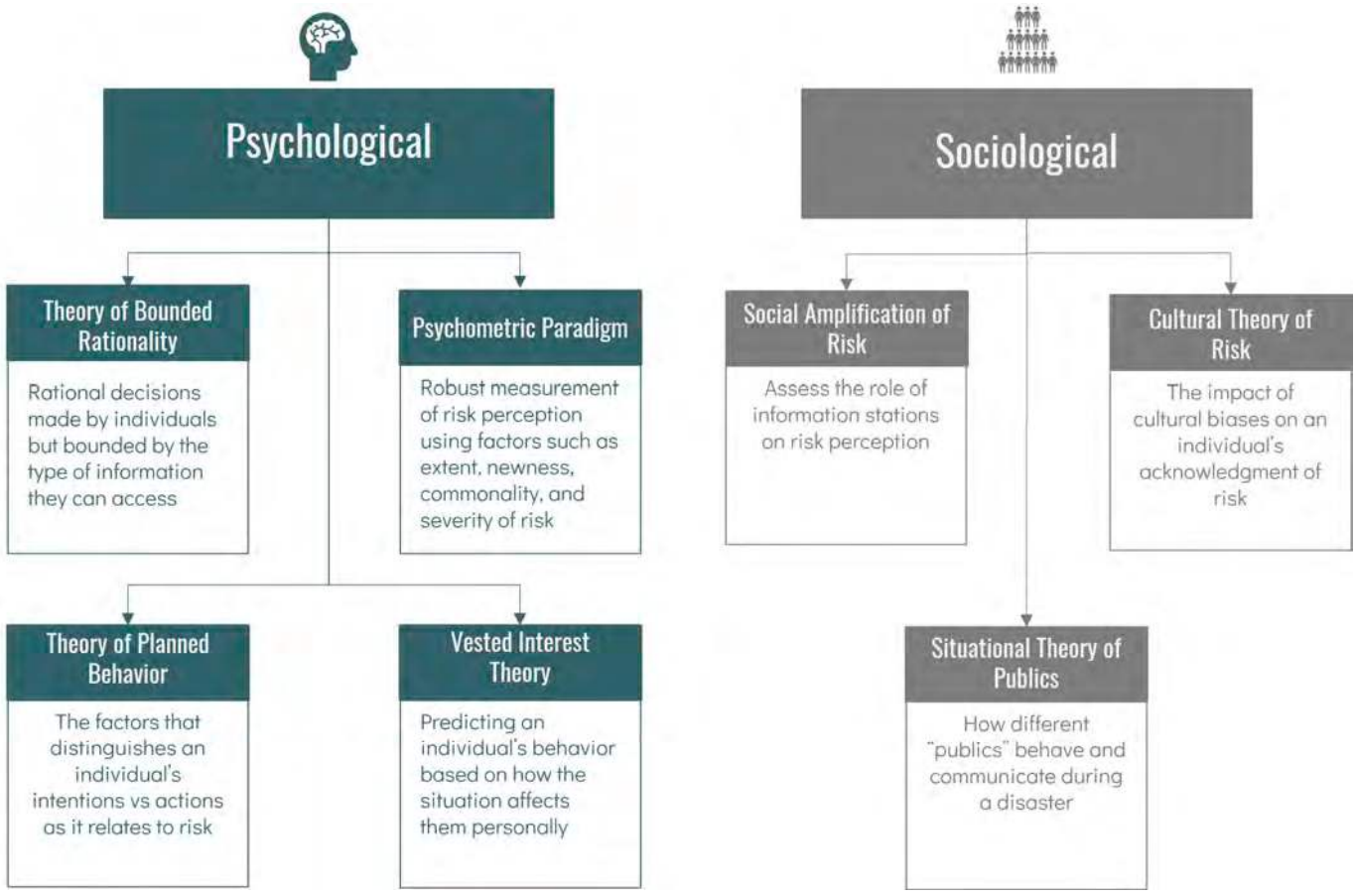

Figure 1. Visual summary of selected psychological and sociological foundations of risk perception in the hazards literature. Psychological theories focus on the rationality of decisions made by individuals, guided by their own personal interest and potential consequences of their actions. Sociological theories of risk perception identify the role that culture and society at large play in an individual's perception of risk.

2.2. Risk Perception Components

Most risk perception studies typically examine risk perception as a whole; however, risk perception is an interplay of several other constructs, such as knowledge of hazards, perceived susceptibility, and self-efficacy. For example, knowledge of hazards (an individual's knowledge and understanding of risk) has been shown to strongly influence risk perceptions; the less known the risk, the less acceptable it is to the individual [6,8,10,49,50].

Risk knowledge is developed from various sources, such as previous experience with hazards, which has been shown to correlate positively with risk knowledge [10]. Typically, the less known the risk, the less acceptable it is to the individual [6,8,50]. However, the

opposite relationship may occur when a hazard is more imminent. For example, the dissemination of information about an imminent hazard has been shown to heighten risk perception [49]. Higher levels of hazard knowledge can also decrease social trust (i.e., a person with high-risk knowledge is less likely to place trust in their peers) [9].

Perceived susceptibility describes one's perception of how likely a hazard event is to occur vis-à-vis the severity of its impacts [51]. Studies have shown that previous experience with hazards is correlated with higher perceived susceptibility [11] and that perceived susceptibility increases with age and decreases with higher income [12].

Self-efficacy describes one's perceived control over the outcome of a situation, similar to the definition used in TPB [27]. Previous studies show that self-efficacy is positively correlated with risk perception (i.e., higher risk perception is associated with higher self-efficacy) [15], males and the young have higher self-efficacy than females or the elderly [13], social capital is positively correlated with self-efficacy [52], physical disabilities lead to lower self-efficacy [14], and self-efficacy is positively correlated with community involvement [16].

2.3. Mitigation and Evacuation Behavior

Previous studies have shown that risk mitigation and evacuation behavior influence risk perception. For example, an interconnected system of hazard warnings heightens risk perception, and risk perception influences mitigation and evacuation behavior, with demographic and socioeconomic factors playing a significant role [1–3,53]. Risk reduction behavior studies focus on what factors contribute to a person's decision to take precautionary action, such as evacuation decisions. Factors contributing to risk reduction decision making include a combination of hazard warnings and demographic factors, risk perception, and perceived mitigation strategy effectiveness [3,53,54].

Mitigation behavior is further enhanced by previous hazard experience, which can increase the likelihood of individuals taking precautionary measures [55], while those who have previously evacuated are likely to do so again in the event of a hazard [56]. In contrast, other research demonstrates that previous hazards experience may lower the likelihood of preparation or evacuation [57,58]. In addition, physical exposure and self-efficacy also influence disaster preparedness decision making [59]. Furthermore, hazard information contributes to risk reduction behavior, as hazard information sources have been shown to affect evacuation likelihood [1]. High-predicted storm surge has also been found to be among the most significant factors in evacuation decision making [2].

Although existing risk perception studies identify and examine different factors that influence risk perception, not all explore how risk perceptions influence risk reduction and evacuation behaviors. While these studies demonstrate how different risk perception factors influence risk reduction behaviors, they do not examine how risk reduction and evacuation behaviors change from before to after an actual disaster event.

2.4. Before and after Studies

Previous research has examined risk perception factors and evacuation behavior [3,8,12,14,16]. However, most studies do not account for temporal changes in risk perception. Although some studies examine risk perception shortly after a disaster [60–62] or changes in risk perception in communities where hazards have occurred previously [23,25], research is limited to comparing pre-disaster risk perceptions to risk perceptions measured within a short period after a disaster.

The paucity of studies in this area is partly because of the unpredictable nature of natural hazard events which makes collecting pre-disaster risk perception data shortly before a disaster difficult. In some studies, proxy data have been used to measure changes in risk perception over time [22,24,63]. For example, property values have been used as a proxy for risk perception, with results showing a reduction in property values after Hurricane Floyd [22]. In cases where risk perception data has been measured in the absence of a disaster event, studies have separated survey respondents by previous hazard experiences to demonstrate how having previous disaster experience influences risk perception [24,63].

However, the correlation between previous disaster experience and perception is inconsistent and has been shown to be both positive [23–25] and negative [58,63].

While before-and-after risk perception data are rare, some research of this nature exists, particularly with manmade disasters. For example, another study examined changes in general risk perception before and after a chemical fire in Odessa, TX, and the opening of a controversial chemical plant in La Porte, TX [64]. That study found that risk perception increased in both towns after their respective "risk events." A longitudinal study of the 2011 Fukushima Daiichi Nuclear Disaster in Switzerland found that even though the disaster had happened far away, public acceptance of nuclear energy decreased after the disaster [17]. Similarly, another study of the Fukushima disaster with subjects near a separate nuclear reactor in China found a similar decrease in public acceptance of nuclear energy [18].

Studies examining changes in risk perceptions after natural disasters also exist for earthquakes [19], volcanoes [20], and wildfires [21]; these studies demonstrated that risk perception increased after these events. However, no studies compare risk perception shortly before and after a hurricane. As such, this research examines the changes in risk perception after a hurricane and provides insight into the peculiarity of such change relative to the type of natural hazard event.

3. Materials and Methods

3.1. Study Area

The study area for this research is Sarasota County, FL, a coastal county along the United States Gulf Coast, an area exposed to hurricanes [65]. The county is also near Tampa and St. Petersburg, communities that are among the most vulnerable cities in the US to flooding [66]. According to the Federal Emergency Management Agency's (FEMA) National Risk Index (NRI), Hillsborough and Pinellas Counties, where Tampa and St Petersburg are located, both have 'very high' hurricane risk index scores (over 99 national percentile), and both rank 'relatively high' in social vulnerability (over 72 national percentile). In addition, Sarasota County has a low average elevation (~42 feet), making it susceptible to flooding and storm surges from hurricanes [67,68].

At the time of the initial survey in 2016, the American Community Survey (ACS) estimated Sarasota County's population was 392,038 with 175,576 households. The median age was 54, and 35% of the population was 65 or over. The median annual household income was $52,796, the unemployment rate was 8.2%, and the poverty rate was 11%. The high school graduation rate was 92.4%, and 32.4% of residents held a bachelor's degree or higher. At the time of the surveys, Sarasota County was one of the top 10 counties with the highest percentage of senior citizens in the nation (33.9% according to the 2014 US Census population estimates). It remains older than the national and Florida average, according to the 2020 Census. According to the NRI, Sarasota County has a 'relatively moderate' social vulnerability score (41.22 national percentile) when compared to other US counties.

As shown in Figure 2, Sarasota County's population is heavily clustered along the coast due to the county's "Urban Service Areas" delineations, within which utilities, storm water management systems, fire protection, sidewalks, and other public infrastructure development and maintenance are prioritized [67,68]. As such, most of the county's population is highly exposed to hurricane hazards.

Hurricane Ian in 2022 is the most recent major hurricane to hit the coast of Florida, making landfall as a Category 4 storm on Cayo Costa island in southwestern Florida. Before Hurricane Irma in 2017 (the focus of this study), the last major hurricane to impact Sarasota County was in 1944 [65]. Shortly after Hurricane Harvey caused widespread damage in Texas, Hurricane Irma became a Category 5 hurricane with a trajectory towards Florida.

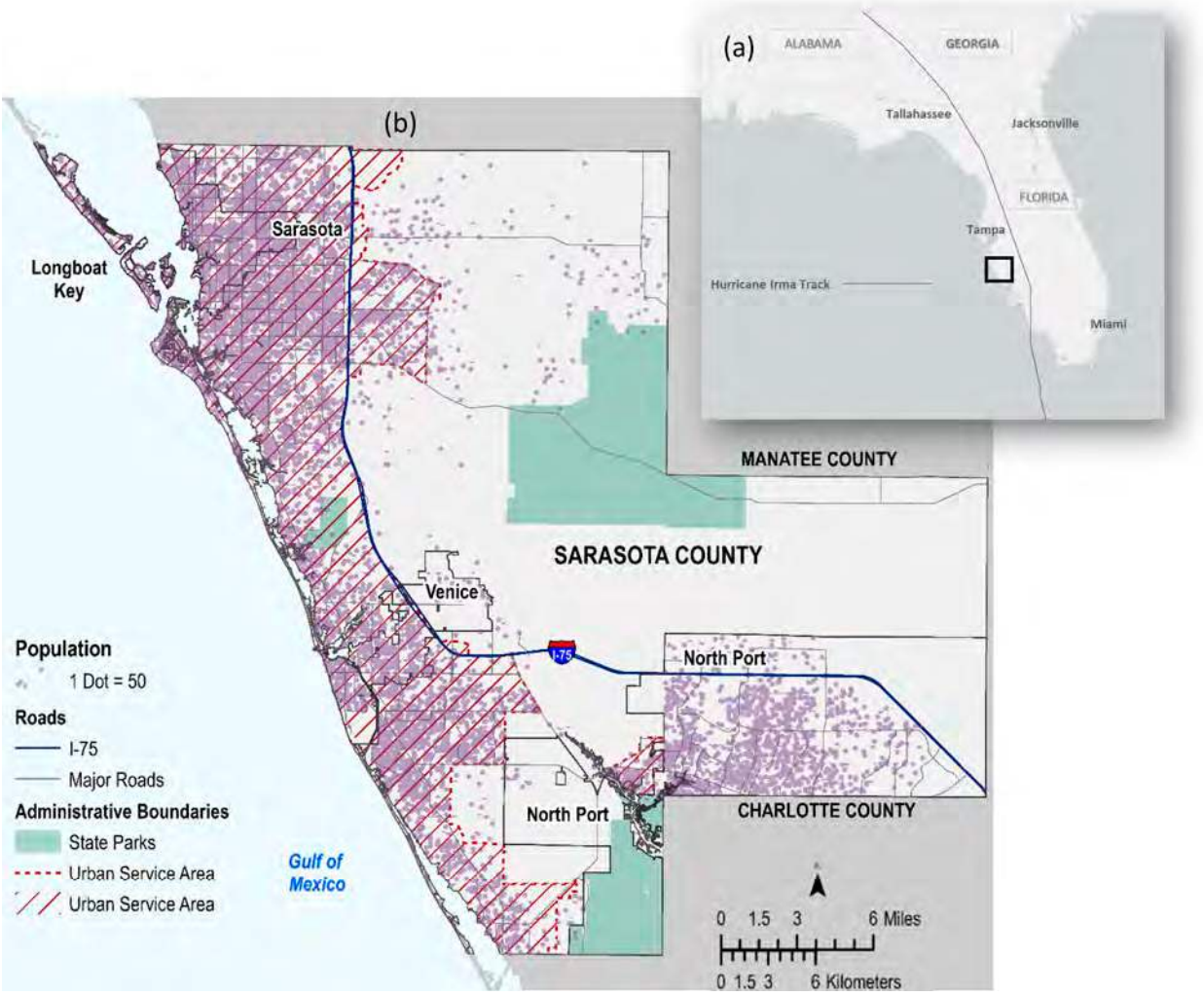

Figure 2. Map of study area. (**a**) shows the location of the study area within Florida (black box), along with Hurricane Irma's storm track. (**b**) depicts the study area of Sarasota County, showing major roads, parks, and municipalities. Data from the Florida Department of Environmental Protection Enterprise GIS ("Florida Department of Environmental Protection") and Sarasota County Enterprise GIS ("Sarasota County Enterprise GIS").

Hurricane Irma led to a large mass evacuation of residents in the affected area [69]. As the storm progressed toward Florida after making landfall over Cuba, Sarasota County officials upgraded a voluntary evacuation order to a mandatory order for residents in the surrounding barrier islands and those living in mobile homes [70]. Irma eventually made landfall in the Florida Keys as a Category 3 hurricane. Initially, one of the possible predicted tracks for Hurricane Irma would have directly hit Sarasota County, but the storm center passed about 35 miles east. As a result, its destruction was less than expected, with damages in Sarasota County estimated at USD 10.5 million [69]. According to the National Weather Service, the maximum sustained wind in Sarasota County fell between 20 and 50 mph.

3.2. Survey Data

To assess changes in risk perception in Sarasota County, this study employed two surveys conducted before and after the hurricane.

First is the 2016 Survey. This survey was conducted in April 2016, about a year and a half before Hurricane Irma occurred. The survey was designed using Qualtrics survey software for deployment online or by phone. The survey was split into seven sections: resi-

dency and demographics and six risk perception sections, including location, knowledge, hurricane risk, susceptibility, self-efficacy, and community involvement. Demographic questions were included because studies have shown that demographic factors influence hazard mitigation strategies and preparedness [39,43,44,71–74].

The risk perception sections inquired about reasons for living in Sarasota County, knowledge of hurricanes, hurricane impacts, mitigation strategies, motivation to implement mitigation strategies, perceived financial resilience, physical susceptibility, knowledge of city and county resources, and community involvement. There were 39 questions in total, some of which were multi-part questions. Most questions were measured on a seven-point Likert scale, while some were fill-in-the-blank, multiple-choice, select-all-that-apply, or yes/no questions.

Participants were recruited using the Qualtrics Online Sample [70]. The sample was constrained to only those who reside in Sarasota County and by age, gender, and race demographic panels that reflected the general demographics of Sarasota County in 2016. In 2016, a sample size of 317 surveys was required to obtain a survey sample with a 95% confidence level and a 5.5% margin of error.

Second is the 2018 Survey. This survey was conducted and completed in April 2018, seven months after Hurricane Irma made landfall. The second survey was designed almost identically to the 2016 survey using Qualtrics survey software, with minor changes. The 2018 survey had the same seven sections and demographic questions as the 2016 survey. However, questions relating to reasons for living in Sarasota County were removed from the location section due to survey length limitations. The risk perception questions also inquired about the same subjects as the 2016 survey, but some were reworded to apply specifically to Hurricane Irma. For example, the question "How much do you feel that preparing for hurricane impacts is your personal responsibility?" on the 2016 survey became "How much do you feel that preparing for Hurricane Irma was your personal responsibility?" on the 2018 survey.

The 2018 survey also included several new questions concerning respondents' actual experiences with Hurricane Irma, such as whether they evacuated, to where they evacuated, whether they were injured or unable to work because of Hurricane Irma, what information sources they used to stay informed in the days leading up to Irma, and what publicly provided services were available after Irma. There were 47 questions in total.

Twenty-two of the forty-seven questions were identical or nearly identical to those on the first survey, not including demographic questions. Of these, 11 were completely identical, and the remaining 11 were re-worded in the 2018 survey to ask about Hurricane Irma specifically.

Responses were collected using a mix of phone and online responses deployed by Qualtrics, where participants were recruited using Qualtrics Online. The sample was constrained to those who live in Sarasota County and by age, gender, race, and income demographic panels that reflected the general demographics of Sarasota County in 2018. At the time of the 2018 survey, a sample size of 317 surveys was required to obtain a survey sample with a 95% confidence level and a 5.5% margin of error.

The academic institution's Internal Review Board (IRB) reviewed and approved this research before data were collected.

3.3. Data Analysis

To examine Hurricane Irma's effect on risk perception levels in Sarasota County, the study implemented a pre-post-test research design to measure the change in mean responses as a result of the storm. A series of t-tests were calculated to determine if there was a statistically significant difference in responses after the storm. Because the 2016 survey was taken before Hurricane Irma and the 2018 survey was taken shortly after, any significant changes in risk perception were potentially the result of Hurricane Irma. The study tests each question individually for significant changes.

The surveys were coded numerically to statistically analyze the resulting survey responses. Most survey questions were ordinal, Likert-scale questions and measured on a scale from 1 to 7, where 1 represents "low" values (e.g., "strongly disagree") and 7 represents "high" values (e.g., "strongly agree"). Conversion to a numerical format allowed them to be treated as continuous variables suitable for statistical analysis.

First, to compare levels of risk perception before and after Hurricane Irma, the study compared the two survey datasets using summary statistics and unpaired *t*-tests. The analytical process involves calculating the summary statistics for each Likert-scale question on both surveys (i.e., mean, variance, and standard deviation). The same process was performed for demographic and socioeconomic items in both surveys to ensure that the samples were sufficiently similar.

Second, each dataset was compared using an unpaired *t*-test with a two-tailed hypothesis. The study used unpaired tests because the two surveys were given to two separate groups of respondents; risk perception changes must be measured for each survey question instead of on a respondent-by-respondent basis. The *t*-test also used a two-tailed hypothesis, as it was unknown whether values were likely to increase or decrease for any given question. *p*-values less than 0.05 ($\alpha \leq 0.05$) indicated a significant change, showing that respondents are either significantly more or less likely to hold their previous risk perceptions after Hurricane Irma.

Finally, the analyses were conducted on specific demographic groups due to differences between the demographic composition of both survey samples. The study repeated the unpaired *t*-tests analysis on subsets of the data representing (1) only those respondents between the ages of 45 and 54, (2) only those respondents who reported having at least one child under 5 years old in their households, and (3) only those respondents who reported having at least one adult over 65 years old in their households.

4. Results

For both the 2016 and 2018 surveys, each received a total of 315 responses. No response rate was provided for the 2016 survey by Qualtrics. For the 2018 survey, the response rate was ~41%. The sample populations were mostly comparable to the reported American Community Survey (ACS) 5-year estimates for their years (2016 ACS 5-year estimates and 2018 ACS 5-year estimates, respectively).

As shown in Table 2, the exception is for the 2018 survey group, which had a higher median age, was less likely to have children under 5 living in their households, and was less likely to have adults over 65 living in their households than the 2016 survey sample. The response rate for the 2018 survey was ~41% (recorded by Qualtrics), but Qualtrics did not provide a response rate for the 2016 survey. For both surveys, all respondents were 18 or older, all age groups were represented in both surveys, and no age group comprised a majority.

Table 2. Survey demographics comparisons with 5-year American Community Survey (ACS) estimates for Sarasota County for both surveys (2016 and 2018).

Demographic Variables	Survey 1—2016		Survey 2—2018	
	Sample Estimates	2016 ACS	Sample Estimates	2018 ACS
Median age	35–44	54.5	45–54	55.5
Households with children under 5 (%)	50.5 (under 5)	9.7 (under 6)	11.1 (under 5)	9.8 (under 6)
Households with adults over 65 (%)	51.10	51.60	27.30	53.30
Minority population (%)	8.25	8.80	10.20	8.80
Female population (%)	54.30	52.30	57.50	52.30
Median income ($1000)	80–90	52.796	80–90	58.644
College graduates (%)	80.60	33.10	72.70	34.70

The *t*-test results for the 22 compared risk perception questions are summarized in Table 3. For clarity, the Table shows both the original 2016 items and the 2018 items reworded for Hurricane Irma. The Table also shows the changes in the average answer choice and the percentage change to illustrate the magnitude of change independent of the units. For example, an increase of 1.0 in answer choices represents a 14.3% increase in that attitude. The item with the largest significant increase was "Do you feel that people like yourself can generally change things in your community if they want to?" (1.23 (17.59%), $p = 0.000$) The largest decrease was "Please indicate how much you agree with the following statements—It is easy for me to prepare for a hurricane" and "Please indicate how much you agree with the following statements—It was easy for me to prepare for Hurricane Irma." (−1.43 (−20.45%), $p = 0.000$). The question with the least amount of change was "How relevant do you feel information about hurricanes and their potential impacts is to you, personally?" (0.18 (2.57%), $p = 0.021$).

As seen in Table 3, nearly all questions show significant increases or decreases. Only "How vulnerable do you feel in terms of hurricane impacts affecting—Your property and/or possessions?" (0.21 (3.00%), $p = 0.059$) showed no significant changes after Hurricane Irma. Questions about knowledge showed increases and decreases in responses for different risk knowledge components, whereas hazard risk questions showed decreased average responses. Questions about perceived hazard susceptibility showed a slight decrease among significant changes, and questions related to self-efficacy all showed decreases. Finally, questions related to community involvement showed both increases and decreases for different questions. The three questions related to community agency (i.e., involvement in community decision making) showed the most significant changes overall, while questions related to hazard susceptibility showed the least change overall.

Table 3. Changes in average responses to questions asked in both surveys.

Question	Change in Average Answer Choice	*p*-Value
Hazard Knowledge		
How well informed are you about the potential impacts of a hurricane hitting Sarasota County?	0.30 (4.29%)	0.000 *
How relevant do you feel information about hurricanes and their potential impacts is to you, personally?	0.18 (2.57%)	0.021 *
How motivated are you to learn more about different mitigation practices (e.g., adding storm shutters to your home) that can help you reduce hurricane impacts?	−0.91 (−13.01%)	0.000 *
Compared to 5 years ago, has your access to information about hurricanes and hurricane impacts improved, decreased, or stayed about the same?	−0.23 (−3.29%)	0.022 *
Hazard Risk		
In the past five years, do you feel the risk from hurricanes in Sarasota County has: [increased, decreased, or stayed about the same?]	−0.31 (−4.43%)	0.009 *
For you personally, are hurricane risks relatively easy to avoid? | How easy/difficult was it for you to avoid the risks associated with Hurricane Irma?	−0.72 (−10.30%)	0.000 *
Hazard Susceptibility		
How vulnerable do you feel in terms of hurricane impacts affecting:—You and your family (i.e., death or injury)	−0.49 (−7.01%)	0.000 *
How vulnerable do you feel in terms of hurricane impacts affecting:—Your property and/or possessions	0.21 (3.00%)	0.059
How susceptible do you feel Sarasota County is to damages from hurricane impacts? | How susceptible or vulnerable did you feel Sarasota County was to damages from Hurricane Irma?	−0.23 (−3.29%)	0.014 *

Table 3. *Cont.*

Question	Change in Average Answer Choice	*p*-Value
Self-Efficacy		
Do you feel that you have the financial capability to recover quickly after a hurricane event? | How capable are you to quickly financially recover (e.g., within 6 months) after Hurricane Irma or another hurricane event?	−0.68 (−9.72%)	0.000 *
How effective implementing preventative measures (e.g., adding storm shutters to your home) be at preventing hurricane damage to your personal property?	−0.21 (−3.00%)	0.036 *
Please indicate how much you agree with the following statements:—I have ample time to prepare for hurricane impacts | Please indicate how much you agree with the following statements:—I had ample time to prepare for Hurricane Irma	−0.21 (−3.00%)	0.024 *
Please indicate how much you agree with the following statements:—It is easy for me to prepare for a hurricane. | Please indicate how much you agree with the following statements:—It was easy for me to prepare for Hurricane Irma	−1.43 (−20.45%)	0.000 *
How likely are you to evacuate during a hurricane? | Did you evacuate in response to Hurricane Irma? [a]	−0.42 (−42%)	0.000 *
Community Involvement		
How involved do you feel in the hurricane preparedness decision-making within your community?	−1.07 (−15.30%)	0.000 *
How much influence do you feel you have in community level decision-making processes?	−1.41 (−20.16%)	0.000 *
Do you feel that people like yourself can generally change things in your community if they want to?	1.23 (17.59%)	0.000 *
How much do you feel that preparing for hurricane impacts is your personal responsibility? | How much do you feel that preparing for Hurricane Irma was your personal responsibility?	0.63 (9.01%)	0.000 *
To what degree do you feel the following organizations are responsible for preparing for hurricane impacts in Sarasota County?—Sarasota County Emergency Management | To what degree do you feel the following organizations are responsible for preparing for Hurricane Irma impacts in Sarasota County?—Sarasota County Emergency Management	−0.55 (−7.87%)	0.000 *
To what degree do you feel the following organizations are responsible for preparing for hurricane impacts in Sarasota County?—City Governments Emergency Management (i.e., City of Sarasota, etc.) | To what degree do you feel the following organizations are responsible for preparing for Hurricane Irma impacts in Sarasota County?—City Governments Emergency Management (i.e., City of Sarasota, etc.)	−0.36 (−5.15%)	0.003 *
To what degree do you feel the following organizations are responsible for preparing for hurricane impacts in Sarasota County?—Florida Division of Emergency Management | To what degree do you feel the following organizations are responsible for preparing for Hurricane Irma impacts in Sarasota County?—Florida Division of Emergency Management	−0.49 (−7.01%)	0.000 *
To what degree do you feel the following organizations are responsible for preparing for hurricane impacts in Sarasota County?—Federal Emergency Management Agency (FEMA) | To what degree do you feel the following organizations are responsible for preparing for Hurricane Irma impacts in Sarasota County?—Federal Emergency Management Agency (FEMA)	−0.89 (−12.73%)	0.000 *

* *p*-value < 0.05; (##.##%) represents the percent change in response; [a] The question about evacuation was recoded to be binary. In the 2016 survey, the question was a Likert-scale question on a scale of 1–7. Any answer between 1–4 (indicating "neutral" or "not likely") was changed to "0", and any answer between 5–7 (indicating "likely") was changed to "1". In the 2018 survey, the question was binary.

As highlighted in Table 2, due to some variation between the survey sample's demographic compositions, specifically the age of respondents, households with children under 5, and households with adults over 65, further validation *t*-tests were run on these three control groups (Table 4).

The control group sample sizes were smaller, resulting in fewer significant changes in risk perception questions. For example, fewer than 100 responses were on each survey from respondents between the ages of 45 and 54. Only eight of the twenty-two changes were significant among this sample. For the same reason, some average answer choice changes of similar magnitudes, both in the control group and the complete set of responses, were

insignificant in the control group. For example, the question "How relevant do you feel information about hurricanes and their potential impacts is to you, personally?" showed a change of 0.18 (2.57%) in the full set of responses ($p = 0.021$) and a change of 0.20 (2.86%) among respondents aged 45–54 but was not significant in this control group ($p = 0.197$) (see Table 4). However, among those changes that were significant, the nature of the changes was the same (i.e., all increases remained increases in the control groups and vice versa).

Table 4. Changes in average responses among control groups.

Question	All	Age 45–54	Children	Adults over 65
Hazard Knowledge				
How well informed are you about the potential impacts of a hurricane hitting Sarasota County?	0.30 * (4.29%)	0.37 * (5.29%)	0.16 (2.29%)	0.30 * (4.29%)
How relevant do you feel information about hurricanes and their potential impacts is to you, personally?	0.18 * (2.57%)	0.20 (2.86%)	0.09 (1.29%)	0.21 * (3.00%)
How motivated are you to learn more about different mitigation practices (e.g., adding storm shutters to your home) that can help you reduce hurricane impacts?	−0.91 * (−13.01%)	−0.56 * (−8.01%)	−0.95 * (−13.59%)	−1.40 * (−20.02%)
Compared to 5 years ago, has your access to information about hurricanes and hurricane impacts improved, decreased, or stayed about the same?	−0.23 * (−3.29%)	0.14 (2%)	−0.84 * (−12.01%)	−0.84 * (−12.01%)
Hazard Risk				
In the past five years, do you feel the risk from hurricanes in Sarasota County has: [increased, decreased, or stayed about the same?]	−0.31 * (−4.43%)	0.01 (0.14%)	−1.50 * (−21.45%)	−1.22 * (−17.45%)
For you personally, are hurricane risks relatively easy to avoid? | How easy/difficult was it for you to avoid the risks associated with Hurricane Irma?	−0.72 * (−10.30%)	−0.73 * (−10.44%)	−1.70 * (−24.31%)	−1.41 * (−20.16%)
Hazard Susceptibility				
How vulnerable do you feel in terms of hurricane impacts affecting:—You and your family (i.e., death or injury)	−0.49 * (−7.01%)	−0.25 (−3.58%)	−0.63 * (−9.01%)	−1.00 * (−14.3%)
How vulnerable do you feel in terms of hurricane impacts affecting:—Your property and/or possessions	0.21 (3%)	0.16 (2.29%)	0.68 * (9.72%)	0.3 (4.29%)
How susceptible do you feel Sarasota County is to damages from hurricane impacts? | How susceptible or vulnerable did you feel Sarasota County was to damages from Hurricane Irma?	−0.23 * (−3.29%)	−0.26 (−3.72%)	−0.3 (−4.29%)	−0.58 * (−8.30%)
Self-Efficacy				
Do you feel that you have the financial capability to recover quickly after a hurricane event? | How capable are you to quickly financially recover (e.g., within 6 months) after Hurricane Irma or another hurricane event?	−0.68 * (−9.72%)	−0.3 (−4.29%)	−1.64 * (−23.45%)	−1.34 * (−19.16%)
How effective implementing preventative measures (e.g., adding storm shutters to your home) be at preventing hurricane damage to your personal property?	−0.21 * (−3.00%)	−0.24 (−3.43%)	−0.27 (−3.86%)	−0.56 * (−8.01%)
Please indicate how much you agree with the following statements:—I have ample time to prepare for hurricane impacts | Please indicate how much you agree with the following statements:—I had ample time to prepare for Hurricane Irma	−0.21 * (−3.00%)	0.03 (0.43%)	−0.65 * (−9.30%)	−0.32 * (−4.58%)
Please indicate how much you agree with the following statements:—It is easy for me to prepare for a hurricane. | Please indicate how much you agree with the following statements:—It was easy for me to prepare for Hurricane Irma	−1.43 * (−20.45%)	−1.04 * (−14.87%)	−2.52 * (−36.04%)	−2.01 * (−28.74%)

Table 4. *Cont.*

Question	All	Age 45–54	Children	Adults over 65
Community Involvement				
How involved do you feel in the hurricane preparedness decision-making within your community?	−1.07 * (−15.30%)	−0.11 (−1.57%)	−2.34 * (−33.46%)	−2.17 * (−31.03%)
How much influence do you feel you have in community level decision-making processes?	−1.41 * (−20.16%)	−0.28 (−4.00%)	−2.40 * (−34.32%)	−2.42 * (−34.61%)
Do you feel that people like yourself can generally change things in your community if they want to?	1.23 * (17.59%)	1.24 * (17.73%)	1.81 * (25.88%)	1.67 * (23.88%)
How much do you feel that preparing for hurricane impacts is your personal responsibility? | How much do you feel that preparing for Hurricane Irma was your personal responsibility?	0.63 * (9.01%)	0.8 * (11.44%)	0.86 * (12.3%)	0.93 * (13.3%)
To what degree do you feel the following organizations are responsible for preparing for hurricane impacts in Sarasota County?—Sarasota County Emergency Management | To what degree do you feel the following organizations are responsible for preparing for Hurricane Irma impacts in Sarasota County?—Sarasota County Emergency Management	−0.55 * (−7.87%)	−0.51 * (−7.29%)	0.42 * (−6.01%)	−0.21 (−3.00%)
To what degree do you feel the following organizations are responsible for preparing for hurricane impacts in Sarasota County?—City Governments Emergency Management (i.e., City of Sarasota, etc.) | To what degree do you feel the following organizations are responsible for preparing for Hurricane Irma impacts in Sarasota County?—City Governments Emergency Management (i.e., City of Sarasota, etc.)	−0.36 * (−5.15%)	−0.2 (−2.86%)	0.12 (1.72%)	0.3 (4.29%)
To what degree do you feel the following organizations are responsible for preparing for hurricane impacts in Sarasota County?—Florida Division of Emergency Management | To what degree do you feel the following organizations are responsible for preparing for Hurricane Irma impacts in Sarasota County?—Florida Division of Emergency Management	−0.49 * (−7.01%)	−0.39 (−5.58%)	−0.44 (−6.30%)	−0.15 (−2.15%)
To what degree do you feel the following organizations are responsible for preparing for hurricane impacts in Sarasota County?—Federal Emergency Management Agency (FEMA) | To what degree do you feel the following organizations are responsible for preparing for Hurricane Irma impacts in Sarasota County?—Federal Emergency Management Agency (FEMA)	−0.89 * (−12.73%)	−0.8 * (−11.44%)	−0.82 * (−11.73%)	−0.86 * (−12.30%)

* *p*-value less than 0.05; (##.##%) represents the percent change in response.

5. Discussion

This study assessed a hurricane event's effect on risk perception levels using a pre-post research approach. The results demonstrate that Hurricane Irma had a notable effect on almost every risk perception component in Sarasota County, Florida. These results allow the rejection of the null hypothesis for nearly every survey question examined, where we hypothesized that reported levels of risk perception factors would show no significant change. However, not all aspects of risk perception increased, indicating that experiencing a disaster event (or the threat of one) does not always result in heightened risk perceptions. The results also highlight that significant change in risk perception occurs when controlling for age, households with children under 5, and households with adults over 65; none of the results ran directly contradictory to the original findings (as shown in Table 4), indicating that changes in risk perceptions were not due to demographic differences in the two samples.

5.1. Post-Disaster Changes in Hazards Knowledge

The statistical analyses for knowledge-related questions illustrate that, generally, respondents felt more informed about the potential impacts of a hurricane directly impacting Sarasota County after Hurricane Irma. Respondents also felt that information about hurricanes was more relevant to them personally after Hurricane Irma. An increase in reported risk knowledge is consistent with previous findings that past experience with hazards is correlated with increased levels of reported knowledge [10].

In contrast, respondents were much less likely to be motivated to learn more about mitigation practices after Hurricane Irma (see Table 3), which is consistent with previous findings which show that self-efficacy correlates positively with information-seeking behavior [47]. Similarly, both reported self-efficacy and motivation to learn more about mitigation practices decreased in this study. While respondents felt that information about hurricanes, in general, was more relevant, they felt less motivated to learn about mitigation practices specifically. This result may occur because while hazard knowledge can increase after a disaster [10], the responses regarding self-efficacy, including those about mitigation and preparation, decreased after Hurricane Irma.

The results also suggest that respondents were less likely to think that access to information about hurricane risks increased in the past 5 years after Hurricane Irma. This result could occur if access to information is related to self-efficacy, which decreased after Hurricane Irma. The statistical analysis for hurricane risk questions also suggests that respondents were less likely to believe hurricanes have increased in frequency in the last 5 years after Hurricane Irma, potentially because of the lack of major hurricanes directly affecting the area in the last 70 years [65].

This finding could also be because of the communication problems experienced during Irma. For example, During Hurricane Irma, county officials used confusing terminology, which only added to residents' struggles in understanding the difference between voluntary and mandatory evacuation areas [75]. This might also be due to the over-evacuation that occurred during Irma across Florida and the traffic problems experienced as a result [76]. Communication gaps must be bridged to build trust between residents and decision makers, and an action plan should be developed with local media to identify the most effective ways to communicate risks during disasters. Bridging this gap can facilitate better communication and ensure that residents receive accurate and timely information during a crisis. Our findings are congruent with a review of the hazards literature [58], which found that individuals often perceive natural hazards as cyclical in nature and feel that, after an unusually severe disaster happens, another is unlikely to occur for an extended period of time. In addition, respondents were less likely to think hurricane risks are easy to avoid after Hurricane Irma, which may indicate that individuals do not regularly consider or plan for such events. This relationship is consistent with similar decreases observed in other questions about self-efficacy, such as decreases in perceived financial resilience and effectiveness of mitigation strategies, as shown in this study.

5.2. Post-Disaster Changes in Hurricane Susceptibility and Risk Reduction Behavior

Respondents were also less likely to feel that they and their families were vulnerable to injury and death after Hurricane Irma, and perceived vulnerability to loss of property demonstrated no significant change. Similarly, respondents were less likely to believe Sarasota County is susceptible to future hurricanes impacting the county after Irma. Our findings contradict established literature that suggests that risk perception is expected to increase after a natural disaster [19–21,23–25].

However, other research suggests that hazards with low frequency or severity may lead to a false sense of security [77]. Hurricane Irma was the first hurricane in several decades to threaten Sarasota County at the time of landfall and caused less damage than expected [69], indicating that Irma was both an uncommon and unexpectedly low-severity event. These factors may account for why perceived susceptibility decreased after Hurricane Irma.

The results also suggest respondents felt an overall decrease in their ability to control outcomes related to Hurricane impacts after Irma, as all the self-efficacy questions showed decreases. Furthermore, although most respondents in the 2016 survey reported being likely to evacuate in the event of a hurricane (81%), most did not during hurricane Irma (39%). This result has important implications when considering vested interest theory; as self-efficacy decreases, so too does the 'vestedness' of an attitude, which decreases the ability to predict behaviors associated with that attitude [38]. Finally, the *t*-test results suggest that after a hurricane, risk perception is a less powerful predictor for mitigation or evacuation behavior. These findings help explain existing "paradoxical" findings that previous experience with a hazard may lead to heightened risk perception but lowered likelihood of undertaking risk reduction or evacuation behaviors [58].

5.3. Post-Disaster Changes in Self-Efficacy and Community Involvement

When considering perceived community involvement, perceptions of community involvement and preparedness responsibilities changed in congruence with self-efficacy; self-efficacy decreased as respondents felt less personally involved and less influential in community disaster preparedness decision making. However, respondents were less likely to feel that government agencies (e.g., Sarasota County or the Federal Emergency Management Agency (FEMA)) are responsible for preparing for impacts from Hurricane Irma and were more likely to feel personally responsible (Table 4).

Two possible interpretations of this finding might be that (1) respondents believe that preparing for impacts is, in principle, their own responsibility (i.e., they ought to prepare on their own) or (2) respondents feel they cannot rely on institutions to prepare for hurricane impacts. While the first interpretation is possible, the second interpretation is more likely considering the respondents' reported knowledge about hurricanes increased; previous studies show that as knowledge increases, social trust decreases [9,78,79].

Changes in perceived community involvement also show that people may not feel involved in community decision making. However, they do feel increased levels of power to enact change in their community (see Table 3). While respondents reported feeling less involved in hurricane preparedness decision making after Hurricane Irma, they were much more likely to feel that people like themselves can generally change things in their communities. This finding demonstrates that feelings about respondents' self-efficacy may be independent of their feelings about others' self-efficacy. These results also underscore the importance of trust, or the lack of trust in authorities, as a primary component that shapes an individual's risk perception after a disaster experience [58].

5.4. Post-Disaster Changes in Risk Perception

Our findings demonstrate that experiencing a disaster can affect overall and individual risk perception components differently. While Hurricane Irma had a notable effect on risk perception in Sarasota County, it would be impossible to say that levels of risk perception as a whole "increased" or "decreased." This is consistent with previous findings, which show that disaster experience has mixed results in relation to risk perception. Some studies show that direct experience positively impacts risk perception [80–82], while others find that it can decrease risk perception [83–86]. This further highlights the existence of the risk perception paradox [58] when conducting research on the impact of disaster experience on risk perception.

Rather than focus on the overall risk perception in our study, it is more accurate to describe how Hurricane Irma changed perceived knowledge, susceptibility, self-efficacy, and community involvement individually, as these components of risk perception changed independently. This study also empirically replicated findings from existing literature in an unprecedented manner, especially regarding literature concerning previous hazard experiences. The statistical analysis results reflect past findings that perceived susceptibility can decrease after a natural hazard, with residents believing that if a particular event did not affect them negatively in the past, it will likely not affect them in the future [75].

Our findings also reflect findings from previous studies that perceived hazard knowledge can increase after a disaster event [10] and that trust in authorities can shape individuals' perception of risk after experiencing a disaster [58].

Understanding the effect of an actual hurricane has on the many components of risk perception separately is crucial for understanding citizens' motivations for risk reduction behaviors such as mitigation and evacuation. For example, if the public is knowledgeable about hurricane risk, it may be more effective to communicate easy and cost-effective mitigation strategies (to account for lowered self-efficacy) to reduce potential hurricane impacts. Acknowledging how and why risk perception change can aid risk communicators to communicate more effectively with their citizens about hurricane risks in ways that are informed by the specific concerns of the population, especially in areas that have recently experienced a hurricane.

6. Conclusions

This study examined the effects of a hurricane on various risk perception components by comparing two surveys, one taken before and one taken after Hurricane Irma made landfall in Sarasota County, FL. The statistical analyses suggest that the various components of risk perception change in different ways independently of one another. For example, the study shows that respondents' feelings of perceived susceptibility decreased after Hurricane Irma, which may occur because Hurricane Irma was less impactful than expected. However, respondents felt increased personal responsibility to prepare for disasters, whereas the perceived responsibility of other entities (e.g., local government) decreased after Hurricane Irma. This result highlights how trust (or lack thereof) in decision-making authorities shapes an individual's risk perceptions after a disaster experience. The different findings highlight the importance of analyzing risk perception at a high level of specificity to accurately understand how risk perceptions change over time. This study contributes to the body of knowledge of risk perception by examining how the many different components of risk perception change in the event of a real-life hurricane, something that has not been directly measured before.

Our findings have important implications for public risk communicators. They may find it effective to appeal to residents' lower self-efficacy or sense of responsibility for hurricane risks by implementing sustainable policies and communication strategies. Additionally, our research highlights the connection between risk perception and sustainability. Past literature has documented the impact of environmental attitudes and perceptions on behavior, the role of psychological theories in shaping attitudes and behavior, and the public's perceptions of climate change and other environmental risks [87–89]. Incorporating sustainable practices requires a shift in risk perception to prioritize the long-term benefits of risk reduction over the short-term gains of limited mitigation behavior.

It should be noted that this study has limitations. First, because the two surveys were cross-sectional, meaning they were comprised of two different sets of respondents, *t*-tests were performed on independent samples. Conducting a longitudinal study on the same set of respondents would allow for a more detailed and rigorous data analysis of the data and would provide information about how pre-disaster risk perception truly translates to (and predicts) actual risk reduction behaviors during disaster events. Repeat respondents would also allow for the use of contingency tables, which are a more statistically sound method of analyzing categorical data, such as Likert-scale data. However, its precision is lowered because the survey responses were not originally continuous values. Furthermore, the difference from one answer choice to another, while internally consistent throughout the survey, is not measured in known units.

Second, future research would also benefit from a more extensive survey sample size and utilizing repeat respondents. Larger sample sizes would allow for more robust statistical analyses, which could also account for the role of housing tenure and flood insurance on mitigation behavior. Using repeat respondents would also make it possible to measure and predict how pre-disaster risk perceptions influence actual risk reduction

behaviors using paired *t*-tests. Such tests would allow analysis on a response-by-response basis and yield more robust results.

Finally, the control groups described in this study were sub-samples from the overall datasets. Ideally, a true experimental control group would consist entirely of an independent group of respondents who had not experienced a hurricane. The changes in risk perception in the 'treatment' group (i.e., the group that experienced the hurricane) could be compared to the changes in the control group (the group that did not experience the hurricane). While future research would benefit from such research design considerations, it should be acknowledged that such conditions can be challenging to find or create.

Despite these limitations, this research advances the understanding of the effect of hurricanes on risk perception and its constituent components by using data from an actual hurricane event. Decision makers can use this understanding to communicate different types of hazard information more effectively in the event of future hurricanes, thereby influencing residents to behave in ways that can reduce the negative impacts of natural hazard events.

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