HOW ABOUT NOW: CHANGES IN RISK PERCEPTION BEFORE AND AFTER A HURRICANE

A Thesis

by

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ABSTRACT

Much of the damage caused by hurricanes is influenced by risk reduction behaviors in affected residents such as evacuation and implementation of mitigation strategies. Risk reduction behaviors are often voluntary and heavily influenced by how at-risk an individual personally feels, a concept known as risk perception. This thesis examines how risk perceptions change before and after a hurricane by comparing data from two surveys conducted in Sarasota County, one before and one 6 months after Hurricane Irma, a category 3 storm that narrowly missed Sarasota County. Both surveys asked almost identical questions about residents' hurricane risk perceptions, evacuation behaviors, mitigation plans, and attitudes about self-efficacy. For each question found in both surveys, unpaired t-tests were conducted on the 2016 and 2018 responses to determine whether significant changes in risk perceptions occurred before and after Hurricane Irma ($\alpha = 0.05$). The results suggest that Hurricane Irma had a notable impact on hurricane risk perception. Changes were most evident in reported levels of self-efficacy -- residents were less likely to feel able to sufficiently prepare for or recover from hurricane impacts after Hurricane Irma. Respondents also were more likely to believe individuals are responsible for preparing for hurricane impacts, as opposed to public or government institutions (e.g., city governments). Residents also reported feeling more informed about the potential impacts of hurricanes after Irma, although they were not more likely to feel at risk of injury or loss of property.

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1. INTRODUCTION

Hurricanes are frequent, deadly, and costly natural disasters that impact highly populated coastal areas in many parts of the world. 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 (Burnside 2007, Brommer 2010). 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 ultimately voluntary. Therefore, understanding the complicated process by which people make decisions about hurricane preparation is useful for understanding hurricane impacts and individual disaster preparedness.

One influential component in hazard-related decision-making is one's personal attitudes and opinions related to the risk associated with a disaster, distinct from expert opinion, also known as risk perception (Grothmann 2006, Burnside 2007, Brommer 2010). While subject experts often assess the risks associated with a hazard in terms of probability of death, injury, or estimated damage, laypeople have been shown to understand and interpret risk along a variety of dimensions such as voluntariness (whether one willingly exposes oneself to a hazard), personal understanding of a hazard, the potential severity of a hazard, and the number of people potentially affected by a hazard (Starr 1969, Fischhoff et al. 1978, Slovic 1987, Slovic 2002).

Risk perception has been studied as early as the 1960s and 70s (Starr 1969, Fischhoff et al. 1978) in close relationship with the field of psychology, as a psychological theoretical basis is important for understanding the formation of attitudes and the nature of decision-making (Simon 1972, Ajzen 1975, Fischhoff et al. 1978, Sivacek and Crano 1982, Grunig 1983, Kasperson et al. 1988). Risk perception is a multi-faceted concept (Slovic 1987); as such, risk perception research has focused on several different dimensions, such as hazard knowledge (Sjöberg and Sjöberg 1991, Siegrist and Cvetkovich 2000, Avvisati et al. 2019), perceived susceptibility (Weinstein et al. 2000, Adelekan and Asiyanbi 2015), self-efficacy (Armaş, Cretu, and Ionescu 2017, Marceron and Rohrbeck 2018, Lemée, Fleury-Bahi, and Navarro 2019), and community involvement (Bachrach and Zautra 1985).

However, most risk perception studies are static, in that they only capture risk perception information for a specific time period. Few studies measure changes in risk perception before and after a hazard event due to the unpredictable nature of hazards. Research of this nature has been conducted for hazards such as nuclear incidents (Visschers 2013, Huang 2013), earthquakes (Russell 1995), volcanoes (Houghton et al. 1999), and wildfires (McGee 2009), but is still uncommon. Some before and after studies measure changes in risk perception using data proxies, such as property value (Bin 2004) or by comparing people with previous hazard experience to those without previous hazard experience. (Anderson 1969, Martin 2016, Demuth 2016). Notably, however, no studies appear to have been conducted measuring risk perception before and after a hurricane specifically.

This thesis aims to rectify this gap in the literature 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 the county in 2017. Independent two-tailed t-tests are used to compare survey responses for twenty-two questions about risk perception in both surveys to measure how each facet of risk perception changed after the hurricane. Understanding these changes can inform decision-makers as to the way citizens consider risks and their relationship with those risks.

The research objective for this thesis is **to assess the effects of Hurricane Irma on risk perception in Sarasota County, FL.** There are five hypotheses associated with this research objective, and they are as follows:

1) Hurricane Knowledge

H_0: Reported levels of hurricane knowledge in Sarasota County after Hurricane Irma show no statistically significant change from their levels before Hurricane Irma.

H_A: Reported levels of hurricane knowledge in Sarasota County show either a significant increase or decrease after Hurricane Irma.

2) Hurricane Risk

H_0: Levels of perceived hurricane risk in Sarasota County after Hurricane Irma show no statistically significant change from their levels before Hurricane Irma.

H_A: Levels of perceived hurricane risk in Sarasota County show either a significant increase or decrease after Hurricane Irma.

3) Perceived Susceptibility

H_0: Levels of perceived susceptibility in Sarasota County after Hurricane Irma show no statistically significant change from their levels before Hurricane Irma.

H_A: Levels of perceived susceptibility in Sarasota County show either a significant increase or decrease after Hurricane Irma.

4) Self-Efficacy

H_0: Reported levels of self-efficacy in Sarasota County after Hurricane Irma show no statistically significant change from their levels before Hurricane Irma.

H_A: Reported levels of self-efficacy in Sarasota County show either a significant increase or decrease after Hurricane Irma.

5) Community Inolvement

H_0: Reported levels of community involvement in Sarasota County after Hurricane Irma show no statistically significant change from their levels before Hurricane Irma.

H_A: Reported levels of community involvement in Sarasota County show either a significant increase or decrease after Hurricane Irma.

Because several different survey questions are compared, these hypotheses are tested for each question. This study contributes to the body of knowledge of risk perception by examining how the many different components of risk perception change both independently and as a whole in the event of a real-life hurricane, something that has not been directly measured before.

This thesis is structured in a journal article format: First, a review of relevant literature is provided. Second, the study area, data used in the study, and the methods used to analyze that data are described. Third, the study findings are presented. Fourth, the study findings and their implications for risk perception before/after studies are discussed and interpreted. Finally, the study is summarized, including a discussion of its limitations and potential future work directions necessary to improve and expand upon the present research.

2. LITERATURE REVIEW

Schools of thought regarding natural hazards and disasters have changed over many decades. Traditionally, natural hazards were studied in terms of their physical parameters, such as a hurricane's wind speed or the magnitude of an earthquake, and proposed mitigation solutions have focused on physical mitigation strategies from an engineering perspective, such as dams and levees to control flooding (Montz et al. 2017). However, natural hazards of equal magnitude may have unequal impacts on human populations (Birkmann 2013). For instance, while a category five hurricane has stronger windspeeds that a category one hurricane, a category one hurricane that makes landfall in a highly-populated area is potentially more devastating than a category five hurricane that does not make landfall. The unequal distribution of impacts challenges research focused only on the physical magnitude of a hazard and prompted a shift to research focused on understating differential human impacts from hazard events.

Human-focused hazards geography was pioneered by Gilbert F. White in his 1945 paper "Human Adjustment to Floods," in which White famously writes "floods are 'acts of God,' but flood losses are largely acts of man" (White 1945, p. 2). White's work was largely focused on a concept known as exposure, the likelihood that a given person or property will be physically affected by a hazard (e.g., the number of people who live within a 100-year floodplain) (Birkmann 2013). However, more recent hazards research accounts for potentially compounding socioeconomic factors (such as age, gender, race, income, education, etc.) that may lead to disproportionate hazard consequences for

certain individuals, a measurement known as vulnerability (Birkmann 2013, Frazier et al. 2014, Montz et al. 2017).

In addition to flooding and hurricanes, modern hazards geography covers hazards such as droughts (Bae et al. 2019), rockfalls (Ovreiu et al. 2019), volcanoes (Houghton 1999), wildfires (McGee 2009), and earthquakes (Kang et al. 2019), and has expanded on the human component of hazards geography by examining human-related concepts like pre-disaster preparedness, early warning systems (Iturrizaga 2019), disaster response, post-disaster assistance (Zhang et al. 2019), and escape routes (Wang 2019). One such human component, important for understanding hazards-related decision-making at the individual and community level, is risk perception.

2.1. Risk Perception

While subject experts often assess hazard risks using probability of death, injury, or damage, laypeople have been shown to understand and interpret risk along dimensions related to voluntariness, personal understanding, control, novelty, and catastrophic potential, among other factors (Starr 1969, Fischhoff et al. 1978, Slovic 1987, Slovic 2002). Laypeople's understanding of risk as different from expert opinion is known as risk perception. Risk perception is a psychometric measurement of thoughts, opinions, and beliefs about the risks associated with a hazard (Slovic 1987), whereas 'real' risk represents real-world measurements of risk likelihood, severity, and potential physical impacts (i.e. exposure), using substantiated modeling methods independent of affected individuals' perceptions and experiences ("Sea, Lake, and Overland Surges from Hurricanes model", "Know Your Zone", Frazier 2014). An individual's perception

of risk does not necessarily reflect 'real' risk (Frewer 1999, Oren et al. 2012), although 'real' risk has been shown to be a factor in perceived risk (Peacock et al. 2005, Wong-Parodi 2018). Risk perception influences individual disaster preparedness (Grothmann 2006) and evacuation behavior (Burnside 2007, Brommer 2010); as such, examining risk perception helps explain individual decision-making behaviors, which can potentially save lives and property.

Table 2.1 Summary of literature - risk perception

Risk Perception	
Paper(s)	**Findings**
Starr 1969, Fischhoff et al. 1978, Slovic 1987, Slovic 2002	Laypeople interpret risk along dimensions related to voluntariness, personal understanding, control, novelty, and catastrophic potential, among other factors
Frewer 1999, Oren et al. 2012	An individual's perception of risk does not necessarily reflect 'real' risk
Peacock et al. 2005, Wong-Parodi 2018	'Real' risk has been shown to be a factor in perceived risk
Grothmann 2006, Burnside 2007, Brommer 2010	Risk perception influences individual disaster preparedness, and evacuation behavior

2.1.1. Psychological and Sociological Foundations of Risk Perception

Risk perception research originated in the field of psychology, where it was studied with respect to general risk events and activities (e.g., nuclear power, driving, handguns, etc.) (Starr 1969, Fischhoff et al. 1978, Slovic 1987). This initial research focused on factors most important in determining people's attitudes about a hazard, such as willingness to expose themselves to the hazard, the degree to which they can control the outcome of the hazard, the potential severity of the consequences of the hazard, and their personal understanding of the hazard (Starr 1969, Fischhoff et al. 1978, Slovic

1987). Slovic (1987) organized several risk perception variables into two main factors; the "dread" factor (comprised of variables such as lack of control, severity of consequences, and "inequitable distribution of risk and benefits") and the "unknown" factor (comprised of variables such as the visibility of the risk, the delay in the realization of its consequences, and the scientific community's understanding of the risk). While such research describes what factors constitute and influence risk perception, they do not explain why those factors are important nor do they explore the relationship between risk perception and risk reduction behavior. Therefore, risk perception research has incorporated several psychological and sociological theories that attempt to explain the relationship between risk perception and related behaviors such as mitigation, preparation, and evacuation.

Many risk perception theories are based on the idea that people make imperfect decisions with the best information available while competing with socioeconomic constraints. The theory of bounded rationality, originally developed by Herbert Simon (1972) to explain economic decision-making, explores the various ways that individuals can be missing important information for decision making and the strategies they use to make decisions without that information. Simon (1972) uses the example of chess, where there are millions of potential strategies; chess players (and by extension any decision-maker faced with limited information) do not attempt to calculate every possible outcome, but instead calculate a few outcomes, one by one, until they reach one with a satisfactory outcome (De Groot 1965). An example of this theory being applied to natural hazards is Botzen and van den Bergh's (2009) study of flood insurance in the

Netherlands, which demonstrated that individuals placed a high value on flood insurance because it reduced uncertainty associated with climate change losses.

However, the theory of bounded rationality does not distinguish between types of information sources, nor does it account for the interpretation, amplification, or distortion of information by individuals. Bounded rationality also does not consider how cultural and social systems influence the mutation of information. In response, several risk perception theories were built upon the theoretical foundations of bounded rationality that aim to understand these more complex, interconnected processes.

One such theory pertaining specifically to risk is called the psychometric paradigm. Developed by Fischhoff et al. (1978), the psychometric paradigm builds upon previous work by Starr (1969) by developing a scientifically and theoretically sound methodology to measure risk perception. In the psychometric paradigm, risk can be measured using nine dimensions based on 1) its perceived benefit to society, 2) its perceived risk of causing death, 3) how acceptable its current level of risk is in society, and 4) its rating along nine dimensions of risk (Fischhoff et al. 1978). The nine dimensions are voluntariness, immediacy of effect, understanding of risk by those exposed, understanding of risk by science, control over risk, 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 (Fischhoff et al. 1978).

The psychometric paradigm is credited as first demonstrating that the differing risk perceptions between laypeople and experts are not due to irrationality, but due to a broader and more complex definition of "risk" used by laypeople (Marris et al. 1997).

The psychometric paradigm has informed the methodologies of many risk perception studies in the intervening years (Sjöberg, Moen, and Rundmo 2004), but does not explain why or how individuals differ in their perceptions of risk (Kraus and Slovic, 1988).

Building on the science of decision-making, Ajzen (1975)'s theory of planned behavior (TPB), makes an important distinction between an individual's intentions and the outcomes of their decisions. TPB focuses on the intention component of behavior, and describes three main characteristics that determine one's intention to take a given action: 1) a person's own attitudes about that action, 2) how a person believes others would view that action, and 3) their own perceived level of control over the outcome of that action, a concept known as self-efficacy (Ajzen 1975). TPB has been applied to hazards research to explain why some individuals do or do not choose to prepare for natural disasters. For example, a study by Najafi et al. (2017) surveyed residents of Tehran, Iran about disaster preparedness and found that disaster preparedness behavior was related both to their intentions and perceived control over disaster outcomes. Another study by Daellenbach (2018) used TPB to categorize survey respondents not only on their disaster preparation behavior but also on their stated reasons for their disaster preparation behavior. Daellenbach (2018) specifically singles out self-efficacy as a factor influencing respondents' intentions regarding disaster preparation (i.e. respondents with higher self-efficacy were more likely to have intentions to prepare for incoming hazards). The results from Paton (2005) illustrate how self-efficacy is related

to bounded rationality, as self-efficacy was found to be associated with information-seeking behavior concerning disaster preparedness.

TPB has also been used by Lindell and Hwang (2008) to develop a model of household hazard response called the Protective Action Decision Model (PADM), which builds on TPB by specifying several different sources of influence on personal attitudes about risk and by dividing the decision making process into several stages of a sequence. They found that gender, age, income, and race all affected the decision making process at different points in the sequence (Lindell and Hwang 2008).

Another theory used to explain human behavior and decision making is known as vested interest theory. Originally developed by Sivacek and Crano (1982), vested interest theory attempts to predict behavior based on an individual's personal investment in a situation. For instance, Sivacek and Crano (1982) found that college-age students' attitudes about raising the legal drinking age were "associated with their age, and, consequently, the degree to which this change would affect them" (Sivacek and Crano 1982). Miller, Adame, and Moore (2013) further develop this theory by outlining five components of vested interest: 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. If any aspect of vested interest is absent, the vestedness for that attitude and the predictability of behaviors associated with that attitude is lessened. Miller, Adame, and Moore (2013) applied vested interest theory to hazards by conducting three studies of risk perception for earthquakes and

tornadoes and were able to derive three of the five components -- certainty, immediacy, and salience -- empirically through exploratory factor analysis. They also found a strong correlation between perceived hazard susceptibility and both self efficacy and certainty, demonstrating that the principles of vested interest theory apply to natural hazards.

The above theories primarily seek to explain the behavior of single individuals. TPB accounts for the attitudes of others in its framework, but it is still primarily concerned with individuals rather than groups. The idea of how risk perception interacts with groups of people and the public is more thoroughly explored by the theory of social amplification of risk (Kasperson et al. 1988, Brenkert-Smith et al. 2012b, Harvatt, Petts, and Chilvers 2013). Kasperson et al. (1988) developed the social amplification of risk to identify and delineate "information stations," which are any entity that receives information and then potentially amplifies it (e.g., a news station, government, local organization, an individual's peer group, or individuals themselves). Kasperson et al. (1988)'s results suggest that 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. This can lead not only to increased risk reduction behavior, but also to secondary effects such as impacts on local businesses, property values, social order, and voting patterns (Kasperson et al. 1988).

Brenkert-Smith et al. (2012b) conducted a study of wildfire risk perception in Colorado through the social amplification of risk lens and found that amplification from formal or expert sources and informal peer-to-peer interactions were associated with heightened risk perception. Harvatt, Petts, and Chilvers (2013)'s study of sea-level rise

risk perceptions, in contrast, found that, in the context of the social amplification of risk, informal peer-to-peer interactions were more important in influencing risk perceptions than information from official or expert sources.

A similar risk perception theory is the cultural theory of risk. Originally developed by Douglas and Wildavsky (1983), cultural theory proposes that one's decision to acknowledge or avoid certain risks are strongly influenced by cultural biases, social norms, and social structures. However, neither the social amplification of risk or cultural theory account for the role of society and the public in influencing risk perception.

One theory that addresses the role of society and the public is the the situational theory of publics (STP) created by Grunig (1983), which challenges the notion of a single "public." Grunig (1983) instead proposes that the public is made of many smaller publics that behave differently during a disaster event. Publics are categorized by how different groups communicate, interpret, and respond to disaster-related problems. As an example of STP in hazards research, Major (1998) conducted a study of earthquake risk perception in the New Madrid fault zone in the midwestern United States. Major (1998) employed STP as the study framework by separating respondents into several publics during analysis and found it to be useful for explaining "a number of cognitive variables in the risk assessment process." More recently, STP was applied to hazards research by Liu et al. (2019), who combined it with the social-mediated crisis communication model (SMCC) to study how publics communicate during tornados. They found STP to a useful predictor of commucation behavior during tornados (Liu et al. 2019).

Publics are sometimes tied to demographic characteristics such as gender, race, age, and income (Hamilton 1992, Illia, Lurati, and Casalaz 2013), many of which have also been shown to influence risk perception; Botzen et al. (2009), for example, found that older ages and higher levels of education lead to lower risk perceptions. These studies typically examine risk perception as a whole, but risk perception is comprised of several components that may be studied individually or together.

Table 2.1.1 - Summary of literature - psychological and sociological foundations of risk perception

Psychological and Sociological Foundations of Risk Perception	
Paper(s)	**Findings**
De Groot 1965, Simon 1972, Botzen and van den Bergh 2009	Theory of Bounded Rationality - individuals make rational decisions, but those decisions are bounded by the information the individual has
Fischhoff et al. 1978, Kraus and Slovic, 1988, Marris et al. 1997, Sjöberg, Moen, and Rundmo 2004	Psychometric paradigm - a consistent and scientifically robust method to measure risk perception, using factors including voluntariness, immediacy of effect, understanding of risk by those exposed, understanding of risk by science, control over risk, 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
Ajzen 1975, Paton 2005, Lindell and Hwang 2008, Najafi et al. 2017, Daellenbach 2018	Theory of planned behavior - there is a distinction between intention and acton, and there are three main characteristics that determine one's intention to take a given action: 1) a person's own attitudes about that action, 2) how a person believes others would view that action, and 3) their own perceived level of control over the outcome of that action, also known as self-efficacy
Sivacek and Crano 1982, Miller, Adame, and Moore 2013	Vested interest theory - attempts to predict behavior based on an individual's personal investment in a situation; predictive power of attitudes depend 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
Kasperson et al. 1988, Brenkert-Smith et al. 2012b, Harvatt, Petts, and Chilvers 2013	Social amplification of risk - 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

Paper(s)	Findings
Douglas and Wildavsky 1983	Cultural theory of risk - one's decision to acknowledge or avoid certain risks are strongly influenced by cultural biases, social norms, and social structures.
Grunig 1983, Hamilton 1992, Major 1998, Botzen et al. 2009, Illia, Lurati, and Casalaz 2013, Liu et al. 2019	Situational theory of pulics - the public is made of many smaller publics that behave differently during a disaster event, and are categorized by how different groups communicate, interpret, and respond to disaster-related problems.

2.1.2. Components of Risk Perception

Risk perception is a complex and dynamic concept with several interconnected components. One such component is knowledge about risk. For this research, knowledge is distinct from one's personal experience. Instead, knowledge describes one's understanding of a hypothetical risk, such as the likelihood of a volcanic eruption or earthquake (Perry, Lindell, and Greene 1982).

An individual's knowledge and understanding of a risk have been shown to strongly influence risk perceptions; the less known about a risk, the less acceptable it is to the individual (Slovic 1987, Botzen et al. 2009). For example, Sjöberg and Sjöberg (1991) found that among nuclear power plant employees, long-term employees (who were more familiar with safety procedures and had more knowledge of the plant's risks) were more satisfied with their plant's safety measures than temporary workers, who were less familiar with safety procedures and had less knowledge of the plant's risks. However, the opposite relationship may occur in situations where a hazard is more imminent. For example, Perry, Lindell, and Greene (1982) surveyed residents' risk

perceptions near Mt. St. Helens volcano in Washington, USA and found that hazard information dissemination potentially affected residents only when a volcanic eruption was imminent, heightening their risk perception.

More complex relationships between knowledge, risk perception, and other factors have also been explored. For example, Siegrist and Cvetkovich (2000) conducted a psychological study of students at Western Washington University and found that when hazard knowledge was low, subjects had increased levels of social trust (i.e. when a person has low knowledge about a hazard, that person is more likely to place trust in his or her peers). Additionally, research has also been conducted on hazard knowledge itself, independent of risk perception or mitigation behavior. Avvisati et al. (2019) conducted surveys about several hazards in southern Italy and found that previous experience with a hazard was positively correlated with risk knowledge.

Perceived susceptibility is another important risk perception factor. Perceived susceptibility describes one's perception of how likely a hazard event is to occur and the potential severity of its impacts (Wisner 2013). Drawing from the psychometric paradigm, this includes attitudes related to the "perceived risk," "chronic-catastrophic," and "severity of consequences" dimensions of risk (Fischhoff et al. 1978).

Perceived susceptibility has been studied under many different names. For example, Weinstein et al. (2000) conducted surveys of residents of communities that both had and had not been impacted by tornadoes, where perceived susceptibility was described using "perceived vulnerability". They found that among communities that had been recently impacted by tornadoes, optimistic biases (i.e. the perception that a hazard

event is unlikely to occur) were lower (Weinstein et al. 2000). In contrast, Adelekan and Asiyanbi (2015) found that in Lagos, Nigeria, perceived vulnerability to flooding impacts was high overall across all age groups, but steadily increased with age up until age 55, after which point it decreased. Adelekan and Asiyanbi (2015) also found that perceived vulnerability decreased with higher incomes.

Another component of risk perception is self-efficacy. Self-efficacy is defined as one's perceived control over the outcome of a situation, similar to the definition used in TPB (Ajzen 1975). The relationship between self-efficacy and risk perception has been studied in the context of natural hazards extensively. For example, Marceron and Rohrbeck (2018) conducted a nationwide survey and found that people with physical disabilities had lowered self-efficacy and heightened risk perception of natural and manmade disasters. Likewise, Lemée, Fleury-Bahi, and Navarro (2019) conducted a study of adults in France and found that self-efficacy was positively correlated with risk perception (i.e. higher risk perception is associated with higher self-efficacy), although they did not demonstrate a link directly between self-efficacy and mitigation behavior (which they refer to as "active coping").

Studies have also examined the influence of other risk perception factors on self-efficacy. A survey of residents in Bucharest, Romania by Armaş, Cretu, and Ionescu (2017) found that gender and age affect self-efficacy, as men and the young were found to have higher levels of self-efficacy than females or elderly respondents. Babcicky and Seebauer (2016) also studied factors influencing self-efficacy, namely social capital, and found that among flood-prone households in Austria, social capital increased self-

efficacy and decreased risk perception. Similar to social capital, community involvement is an aspect of self-efficacy that has been studied in the context of hazards. For example, Bachrach and Zautra (1985) studied residents of Phoenix, AZ living near a proposed hazardous waste facility and found that self-efficacy was correlated positively with community involvement.

Existing risk perception research studies extensively identify and examine the many different factors that influence risk perception; however, not all examine risk perception as a factor in risk reduction and evacuation behaviors.

Table 2.1.2 Summary of literature - components of risk perception

Components of Risk Perception	
Paper(s)	**Findings**
Perry, Lindell, and Greene 1982, Slovic 1987, Sjöberg and Sjöberg 1991, Botzen et al. 2009, Avvisati et al. 2019	Knowledge - An individual's knowledge and understanding of a risk have been shown to strongly influence risk perceptions; the less known about a risk, the less acceptable it is to the individual. Previous experience increases hazard knowledge
Weinstein et al. 2000, Wisner 2013, Adelekan and Asiyanbi 2015	Perceived susceptibility - one's perception of how likely a hazard event is to occur and the potential severity of its impacts. May increase with previous hazard experience, and may decrease with higher income
Ajzen 1975, Bachrach and Zautra 1985, Babcicky and Seebauer 2016, Armaş, Cretu, and Ionescu 2017, Marceron and Rohrbeck 2018, Lemée, Fleury-Bahi, and Navarro 2019	Self-efficacy - one's perceived control over disaster outcomes. Shown to be negatively correlated with perceived susceptibility, positively correlated with community involvement

2.2. Risk Reduction and Evacuation Behaviors

Risk perception influences certain risk mitigation and avoidance behaviors, including evacuation (Burnside 2007, Brommer 2010). Risk reduction behavior studies focus on what factors contribute to a person's decision to take precautionary action or

evacuate (or not). A literature review by Dash (2007) concerning these factors proposed that an interconnected system of hazard warnings, heightened risk perception, and demographic and socioeconomic factors affect one's likelihood to evacuate. Similarly, Grothmann (2006) found that not only is risk perception a factor in mitigation behavior for flooding, but so is one's perception of the effectiveness of such mitigation efforts.

Previous hazard experience has been shown to influence risk reduction behaviors; Bubeck (2012)'s metastudy found that previous experience with hazards is among the most important indicators of mitigation behavior (including evacuation), more so even than risk perception. In addition to previous hazard experience, previous experience with evacuation is another potential factor; Meyer (2018) found in a study of residents in southeastern Louisiana that those who had previously evacuated from hurricanes were likely to do so again if ordered, and vice versa.

Physical exposure can also influence risk reduction behavior, even when risk perceptions do not match 'real risk.' Wong-Parodi (2018) surveyed individuals impacted by Hurricane Matthew in 2016 and found that greater exposure to risk (as opposed to an individual's perception of that risk) increased risk reduction behaviors. They also found that increased mental health and self-efficacy led to more risk-appropriate mitigation behavior (i.e. taking precautionary action if and only if they are in an evacuation zone) (Wong-Parodi 2018).

Other demographic and information access factors also contribute to risk reduction behaviors. For example, gender has been shown to influence risk reduction behavior; Bateman (2002) examined gendered evacuation behavior and found that while

women were more likely to evacuate than men, this is partly because they had higher risk perception on average; among men and women with equal levels of risk perception, men were more likely to evacuate. Information sources also influence risk reduction and evacuation behavior. Burnside (2007) conducted a survey of New Orleans residents and found that their sources of hurricane information affected their likelihood to evacuate, with particular emphasis on how the inclusion of visual images in hurricane information increased evacuation likelihood. Regarding information and hazard knowledge, a survey by Brommer (2010) found that among hurricane characteristics, a high predicted storm surge was the most important factor in respondents' decision to evacuate. Conversely, a survey specifically of tourists in Florida by Matyas (2011) found that previous experience with hurricanes led to *lower* reported likelihood of evacuation. Similarly, Wachinger (2013) found that heightened risk perception does not always correlate positively with a heightened likelihood of evacuation.

While these studies demonstrate how different factors of risk perception influence risk reduction behaviors, they do not examine how attitudes about risk reduction and evacuation behaviors change before and after an actual disaster event.

Table 2.2 Summary of literature - risk reduction and evacuation behaviors

Risk Reduction and Evacuation Behaviors	
Paper(s)	**Findings**
Grothmann 2006, Dash 2007, Burnside 2007, Brommer 2010	An interconnected system of hazard warnings, heightened risk perception, and demographic and socioeconomic factors affect one's likelihood to evacuate, and risk perception influences mitigation and evacuation behavior
Maytas 2011, Bubeck 2012, Wachinger 2013, Meyer 2018	Previous experience with hazards - among the most important indicators of mitigation behavior (including evacuation), although the relationship has been found to be both positive and negative depending on the study

Paper(s)	Findings
Wong-Parodi 2018	Physical exposure - greater exposure to risk (as opposed to an individual's perception of that risk) increases risk reduction behaviors
Bateman 2002	Gendered evacuation behavior - women are more likely to evacuate than men
Burnside 2007, Brommer 2010	Information sources - information with visual components make evacuation more likely, high predicted storm surge leading factor leading hurricane factor in evacuation decision-making

2.3. Before and After Studies

Previous research has examined many different aspects of risk perception and evacuation behavior, but most describe these phenomena at a single point in time and do not account for temporal changes (Bachrach and Zautra 1985, Sjöberg and Sjöberg 1991, Grothmann 2006, Adelekan and Asiyanbi 2015, Marceron and Rohrbeck 2018). Some studies examine changes in components of risk perception in communities where hazards have occurred previously (Anderson 1969, Demuth 2016), but they do not compare pre-disaster risk perceptions to risk perceptions measured shortly after a disaster.

It is possible, although uncommon, to measure changes in risk perception before and after a disaster event occurs. However, due to the unpredictable nature of natural disasters, it is difficult to collect baseline or pre-disaster risk perception data shortly before such disasters occur. Proxy data, or data used to study a phenomenon for which direct information or measurements do not exist, has been used to measure changes in risk perception over time (Bin 2004, Peacock et al. 2005, Martin 2016). For instance,

Bin (2004) examined property values as a proxy for risk perception and found that they decreased in the study area after Hurricane Floyd. Where data about risk perceptions as measured using surveys is unavailable, a proxy may be used.

In cases where risk perception data has been measured without a recent disaster, separating survey respondents by their previous hazard experiences has been used as proxy data to demonstrate how having previous disaster experience influences risk perception (Peacock et al. 2005, Martin 2016) However, the correlation between previous disaster experience and perception is inconsistent and has been shown to be both positive (Anderson 1969, Martin 2016, Demuth 2016) and occasionally negative (Peacock et al. 2005, Wachinger 2013).

Even though before-and-after data is rare, some research of this nature exists. Rogers (1997) examined changes in general risk perception in Odessa, TX and La Porte, TX before and after a chemical fire in Odessa and the opening of a controversial chemical plant in La Porte. Rogers (1997) found that risk perception increased in both towns after their respective "risk events". Changes in risk perception before and after manmade disasters (such as nuclear incidents) have also been studied. Visschers (2013) conducted a longitudinal study of the Fukushima Daiichi Nuclear Disaster in 2011 in Switzerland and found that even though the disaster had happened far away, public acceptance of nuclear energy decreased after the disaster. Huang (2013) also studied the Fukushima incident with subjects near another nuclear reactor in China and found a similar decrease in public acceptance of nuclear energy.

Changes in risk perceptions before and after natural disasters other than hurricanes have also been studied, such as earthquakes (Russell 1995), volcanoes (Houghton et al. 1999), and wildfires (McGee 2009), and these studies demonstrated that risk perception increased after these events. However, no studies appear to exist comparing risk perception using survey data collected shortly before and shortly after a hurricane. As such, there is a need for such a study to understand exactly how hurricanes change affected residents' risk perceptions.

Table 2.3 Summary of literature - before and after studies

Before and After Studies	
Paper(s)	**Findings**
Bin 2004, Peacock et al. 2005, Martin 2016	Proxy data, or data used to study a phenomenon for which direct information or measurements do not exist, has been used to measure changes in risk perception over time
Anderson 1969, Peacock et al. 2005, Martin 2016, Martin 2016, Demuth 2016	Separating survey respondents by their previous hazard experiences has been used as proxy data to demonstrate how having previous disaster experience influences risk perception, although the correlation between previous disaster experience and perception is inconsistent and has been shown to be both positive and occasionally negative
Russell 1995, Rogers 1997, Houghton et al. 1999, McGee 2009, Visschers 2013, Huang 2013	Before and after studies have been conducted for other hazards including fires, earthquakes, wildfires, and nuclear meltdowns, and generally show increases in perceived susceptibility after the disaster, but none of these studies examine hurricanes

3. METHODS

3.1. Study Area

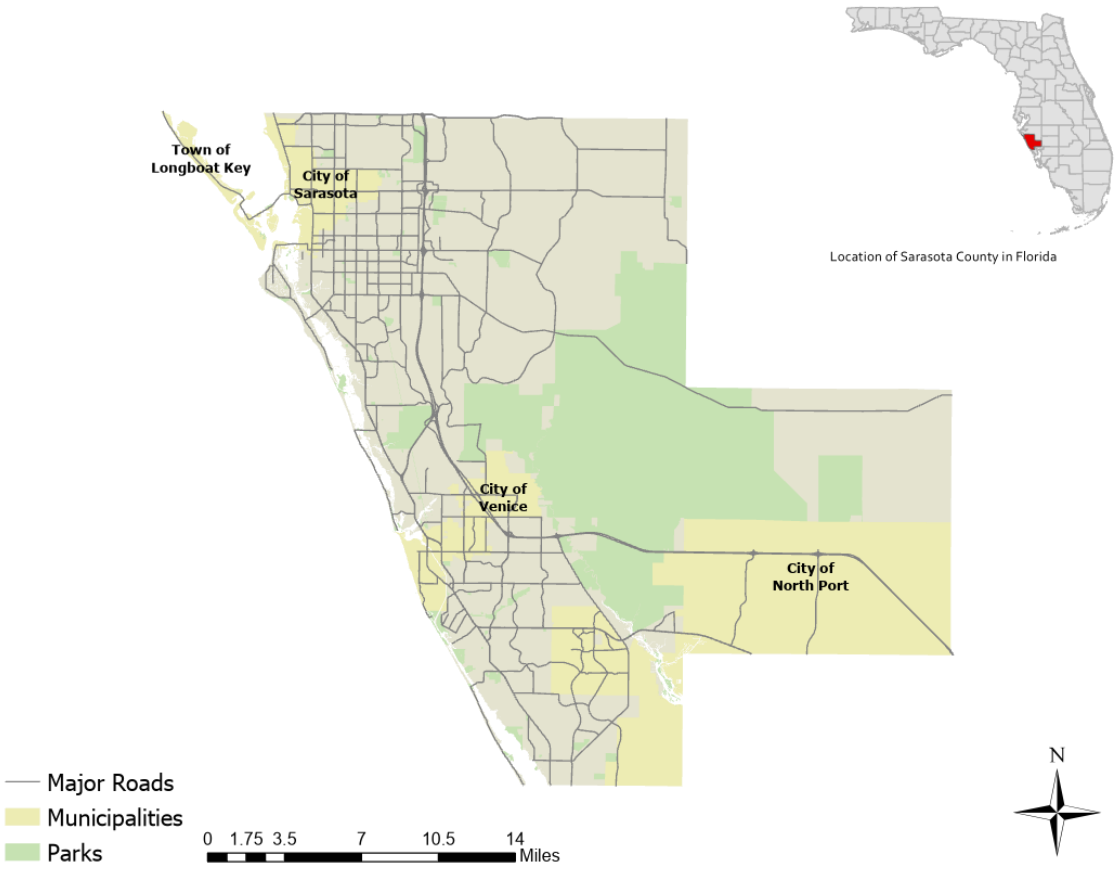

Figure 3.1: Map of Sarasota County showing major roads, parks, and municipalities. Data from the Florida Department of Environmental Protection Enterprise GIS (https://floridadep.gov/otis/enterprise-application-services/gis) and Sarasota County Enterprise GIS (https://data-sarco.opendata.arcgis.com/)

Sarasota County, Florida served as the study area for this research due to its location along the west coast of the Florida peninsula (an area exposed to hurricanes (Howe 2011)) and its proximity to the Tampa Bay area, including the cities of Tampa and St. Petersburg, which are among the most vulnerable cities in the U.S. to flooding (Kulp & Strauss 2017). Sarasota County also has an average elevation of about 42 feet

above sea level, making it susceptible to flooding and storm surge from hurricanes (Sarasota County, 2015; Sarasota County Department of Planning, 2016).

At the time of the initial survey in 2016, Sarasota County's population had grown ~10% (~1% per year) over the previous decade. In 2016, the American Community Survey (ACS) estimated the population of the county was 392,038 with 175,576 households. The median age for the county was 54 years old, and 35% of the population were aged 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.

The population is also heavily clustered along the coast due the county's "Urban Service Areas" delineations, within which utilities (e.g., water and sewage), stormwater management systems, fire protection, sidewalks, and other public infrastructure development and maintenance are prioritized (Sarasota County, 2015; Sarasota County Department of Planning, 2016). As such, most of the county is highly exposed to hurricane hazards.

Before Hurricane Irma in 2017, the last major hurricane to impact Sarasota County was in 1944, more than 70 years earlier (Howe 2011). Shortly after Hurricane Harvey caused widespread damage in Texas, Hurricane Irma became a category 5 hurricane with a trajectory towards Florida. This led to the largest mass evacuation in the history of the United States (Rodriguez 2018). Irma eventually made landfall in Florida as a Category 3 hurricane in the Florida Keys. Initially, one of the possible predicted tracks for Hurricane Irma would have directly hit Sarasota County, but the storm ended

up passing about 35 miles east. Its destruction was less than expected, with damages in Sarasota County estimated at $10.5 million, mostly as a result of “damage, debris removal, staff overtime pay, equipment and fuel” (Rodriguez 2018).

3.2. Survey Data

To gather temporal risk perception data for Sarasota County, FL, data from two surveys were utilized. The first survey was conducted in April of 2016 by Thompson and Dezzani (under review), about a year and a half before Hurricane Irma occurred. Responses were gathered from a mix of online and phone responses deployed by Qualtrics. The survey was split into seven sections: residency 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 can influence hazard mitigation strategies and preparedness (Major 1999, Lindell & Whitney 2000, Tierney et al. 2001, Kim & Grunig 2011, Brenkert-Smith et al. 2012a, Illia et al. 2013, Kellens et al. 2013).

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 asked for attitudes and opinions on a seven-point Likert scale, while some were of other formats including fill-in-the-blank, multiple-choice, select all that apply, or yes/no.

The second survey was conducted in April 2018, seven months after Hurricane Irma made landfall. Responses were also collected using a mix of phone and online responses deployed by Qualtrics. The second survey was formatted almost identically to the 2016 survey, with some minor changes. The 2018 survey had the same seven sections demographic questions from the first survey, but 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 hurricane risk knowledge, perceived susceptibility, likely risk reduction behavior, motivation to implement mitigation strategies, perceived financial resilience, physical susceptibility, knowledge of city and county resources, and community involvement, but were re-worded to apply specifically to risk perceptions and behaviors in response 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, some of which were multi-part questions.

Twenty-two of the 47 questions were identical or nearly identical to those on the first survey, not including demographic questions (Table 4.2). Of these, 11 were completely identical and the remaining 11 were reworded in the 2018 survey to ask about Hurricane Irma specifically.

3.3. Statistical Analyses

To examine what effect, if any, Hurricane Irma had on levels of risk perception in Sarasota County, the two risk perception surveys were compared statistically. Because the first survey was taken shortly before Hurricane Irma and the second survey was taken shortly after, any significant changes in the responses were potentially the result of Hurricane Irma. Multiple variables were involved in the analysis, so each variable was tested for significant changes individually.

3.3.1. Data Formatting

To perform statistical analysis on the surveys, the data were formatted in a numerical format. Most survey questions were categorical or ordinal, but conversion to a numerical format allowed them to be treated as continuous variables suitable for statistical analysis. All Likert-scale questions were measured on a scale from 1 to 7, where 1 represents “low” values (e.g. “strongly disagree”, “very unlikely”, etc.) and 7 represents “high” values (e.g. “strongly agree”, “very likely”, etc.).

The surveys were not completely identical, so only questions that appeared on both surveys were compared. While most questions on both surveys had exactly the

same wording, some questions were slightly reworded on the second survey to pertain specifically to Hurricane Irma. This distinction between questions worded exactly the same and questions that were reworded to pertain to Hurricane Irma was maintained in the statistical analyses and subsequent findings and their interpretations. Twenty-two questions were compared in total.

3.3.2. Comparison of Responses Before and After Hurricane Irma

To compare levels of risk perception before and after Hurricane Irma, the two survey datasets were compared using summary statistics and a series of t-tests. First, summary statistics for each Likert-scale question on both surveys were calculated, including mean, median, mode, variance, and standard deviation, using Microsoft Excel. This process was also done for all the demographic questions to ensure that the samples were sufficiently similar. For any demographic variables that were notably different between the two surveys, the analysis process was repeated, controlling for these variables.

Second, each dataset was compared using an unpaired t-test with a two-tailed hypothesis calculated using an online tool on the website socscistatstics.com (Stangroom n.d.). Unpaired tests were used because the two surveys were given to two separate groups of respondents. As a result, the changes in risk perception must be measured in terms of changes in the entire set of responses for each question, instead of on a respondent-by-respondent basis. A two-tailed hypothesis was used because it was unknown whether values were likely to increase or decrease for any given question, thus

it was important to test for effects in both directions for each survey question. A p-value of less than 0.05 ($\alpha \leq 0.05$) indicated a significant change, meaning that whatever opinion or attitude was being measured, respondents were either significantly more or significantly less likely to hold that opinion or attitude after Hurricane Irma.

To control for differences in the demographic composition of the survey respondents, these t-tests were also repeated 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. This was done to ensure that differences in risk perceptions were due to the impacts of Hurricane Irma, and not due to demographic differences in the data.

4. RESULTS

4.1. Respondent Demographics

The first survey, taken in 2016, received 315 responses. Compared to Sarasota County's reported 2016 ACS 5-year estimates, the survey sample's demographics were mostly representative of the population, with some exceptions (Table 4.1). The second survey, taken in 2018, also received 315 responses and respondent demographics were mostly comparable to the reported Sarasota County's reported 2018 ACS 5-year estimates, with some notable exceptions (Table 4.1). The response rate for the 2018 survey was 41% (recorded by Qualtrics), but Qualtrics did not provide a response rate for the 2016 survey.

Table 4.4.1: Survey demographics comparisons with 5-year American Community Survey (ACS) estimates for Sarasota County for both surveys (2016 and 2018)

	Survey 1 - 2016		*Survey 2 - 2018*	
Demographic Variable	**Sample Estimates**	**2016 ACS 5-year estimates**	**Sample Estimates**	**2018 ACS 5-year estimates**
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%

	Survey 1 - 2016		*Survey 2 - 2018*	
Demographic Variable	**Sample Estimates**	**2016 ACS 5-year estimates**	**Sample Estimates**	**2018 ACS 5-year estimates**
Median income	$80,000-$90,000	$52,796	$80,000-$90,000	$58,644
Full-time employment	95.20%	45.4% (part-time and full time)	78.10%	46.2% (part time and full time)
College graduates	80.60%	33.10%	72.70%	34.70%

For both surveys, all respondents were 18 or older, but the median age for the 2018 survey was older overall (Table 4.1). All age groups were represented in both surveys and no age group comprised a majority. Respondents from the 2018 survey were less likely to have children in their households than the respondents from the 2016 survey (11.11% versus 50.5%, respectively) and were less likely to have adults over 65 in their households (27.3% versus 51.1%, respectively). The percentages of racial minorities were similar between both surveys, which were similar to the county's reported percentages. Roughly half of the respondents were women in both surveys, which reflected numbers reported by the ACS. Both sets of survey respondents had similar median incomes, and both were much higher than the numbers reported by the ACS ($80,000-$90,000 versus ~$50,000). Respondents to the 2018 survey were slightly less likely to work full time than those in the 2016 survey (78.10% versus 95.20%, respectively), although both percentages were higher than the ACS average of around 45%. A sizable majority of both sets of respondents were college graduates, at much higher percentages than the ACS average (~75% versus ~34%, respectively).

4.2. Risk Perception T-Tests

The t-test results for the 22 compared risk perception questions are summarized in Table 4.2. For reworded questions on the second survey that pertain to Hurricane Irma, both wordings of the question are included. The question 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, p =0.000). The question with 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, 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, p=0.021). The only question that was not significant was “How vulnerable do you feel in terms of hurricane impacts affecting: - Your property and/or possessions?” (0.21, p = 0.059). Questions about knowledge showed both increases and decreases depending on the question and hazard risk questions showed decreased average responses. Questions about perceived hazard susceptibility showed little change and a slight decrease among significant changes. Questions related to self-efficacy 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

greatest changes overall, while questions related to hazard susceptibility showed the least amount of change overall.

Table 4.4.2: 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***
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***

Question	Change in Average Answer Choice	p-value
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?**	-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***

Question	Change in Average Answer Choice	p-value
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 less than 0.05
**The question about evacuation was binary. In the 2016 survey, the question was a Likert-scale question on a scale of 1-7. Any answers 1-4 (indicating "neutral" or "not likely") were changed to "0" and any answers 5-7 (indicating "likely") were changed to "1". The question was binary on the 2018 survey.

Due to substantial variation between the survey sample demographic compositions, specifically the age of respondents, households with children under 5, and households with adults over 65 (Table 4.1), validation t-tests were conducted on three control groups (Table 4.3). The first control group was respondents aged 45-54, as the median age according to the ACS survey is around 55 (Table 4.1). The second control group was households with children under 5, as there was a 39.4% difference between the two surveys in such households. Similarly, the third control group was households with adults over 65, as there was a 23.8% difference in such households.

Table 4.3: Changes in average responses among control groups

Question	All responses	Age 45-54	Households with Children	Households with 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%)**

Question	All responses	Age 45-54	Households with Children	Households with adults over 65
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 (2.00%)	**-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 (3.00%)	0.16 (2.29%)	**0.68* (9.72%)**	0.30 (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%)	-0.30 (-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%)**	-0.30 (-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%)**

Question	All responses	Age 45-54	Households with Children	Households with adults over 65
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%)**
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* (12.30%)**	**0.93* (13.30%)**
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%)**	-0.20 (-2.86%)	0.12 (1.72%)	0.30 (4.29%)

Question	All responses	Age 45-54	Households with Children	Households with adults over 65
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%)**
* indicates significant changes in responses (p<=0.05)				

Due to the smaller sample size of each of the control groups, fewer of the changes were considered significant. For example, there were fewer than 100 responses on each survey from respondents between the ages of 45 and 54, and as such only eight of the twenty-two changes were significant among this smaller sample. Furthermore, some changes that were of very similar magnitudes both in the control group and in the full set of responses were nonetheless not significant in a control group for the same reason. 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 in the full set of responses (p=0.021), and a change 0.20 among respondents aged 45-54, but was not significant in this control group (p= 0.197). 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).

5. DISCUSSION

This study assessed the effect of an actual hurricane event on levels of risk perception. The results of the statistical comparison of risk perception over time demonstrate that Hurricane Irma had a notable effect on almost every aspect of risk perception, allowing the rejection of the null hypothesis for nearly every survey question examined (where H_0 hypothesized that reported levels of risk perception in Sarasota County after Hurricane Irma would show no significant change from their levels before Hurricane Irma). Significant changes were also mostly maintained when controlling for age, households with children under 5, and households with adults over 65. While the smaller sample size in these control variables changed the significance of some variables, none of the results ran directly contradictory to the original findings, meaning that changes in risk perceptions were not due to demographic differences in the two samples. However, not all aspects of risk perception increased, indicating that experiencing a disaster event (or the threat of one) does not always equate with heightened risk perception when risk perception is examined with a granular approach.

Of the 22 risk perception questions compared, all but one significantly changed in average answer, indicating that Hurricane Irma significantly impacted risk perception both as a whole, and in individual risk perception factors measured by the surveys, including hurricane knowledge, opinions about hurricane risk, perceived susceptibility, self-efficacy, and community involvement.

The statistical analysis results for knowledge-related questions illustrate that, on average, respondents felt more informed about the potential impacts of a hurricane

directly impacting Sarasota County after Hurricane Irma. Respondents also felt information about hurricanes was more relevant to them personally after Hurricane Irma. An increase in reported risk knowledge is consistent with findings by Avvisati (2019), who found that previous experience with hazards was correlated with increased levels of reported knowledge.

In contrast, respondents were much less likely to be motivated to learn more about mitigation practices after Hurricane Irma (Table 4.2). This finding is consistent with previous findings by Paton (2005), where self-efficacy was shown to positively correlate with information-seeking behavior. Similarly, both reported self-efficacy and motivation to learn more about mitigation practices decreased in this study. While respondents felt information about hurricanes was more relevant to them, they felt less motivated to learn about mitigation practices specifically, not about hurricanes in general. This may occur because while hazard knowledge has been shown to increase after a disaster (Avvisati 2019), questions about self-efficacy, including those about mitigation and preparation, showed decreases in our findings. Our results also suggest that respondents were less likely to think that access to information about hurricanes and hurricane risks has increased in the past 5 years after Hurricane Irma. This makes sense if access to information (as distinct from feeling informed about hurricane impacts) is considered to be related to self-efficacy, which also decreased.

The statistical analysis for hurricane risk questions also suggests that respondents were less likely to believe hurricanes have increased in frequency in the last five years after Hurricane Irma, which could occur due to the lack of major hurricanes directly

affecting the area in the last 70 years (Howe 2011). Our findings are congruent with a review of hazards literature by Wachinger (2013) that states that individuals often perceive natural hazards as cyclical in nature, and often feel that, after an unusually severe disaster happens, another is unlikely to occur for a long period of time. Interestingly, respondents were also 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, including those about preparation and mitigation.

For feelings of susceptibility, the statistical analysis indicates that perceived vulnerability to any hurricane impacts did not increase after a major hurricane event and people generally felt lower levels of susceptibility (Table 4.2). Respondents were 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. Respondents were also less likely to believe that Sarasota County is susceptible to future hurricanes impacting the county after Irma. While our findings contradict established literature that suggests that risk perception is expected to increase after a natural disaster (Anderson 1969, Russell 1995, Houghton et al. 1999, McGee 2009, Martin 2016, Demuth 2016), other research has suggested that risk perception may sometimes decrease instead (Peacock et al. 2005, Wachinger 2013), as hazards with low frequency or low severity may lead to a false sense of security (Wachinger 2013). Hurricane Irma was the first hurricane in several decades to threaten Sarasota County at the time of landfall (Howe 2011) and caused much less damage than initially expected in

the county (Rodriguez 2018), indicating that Irma was both an uncommon and unexpectedly low-severity event.

Furthermore, although most respondents in the first survey reported being likely to evacuate in the event of a hurricane (81%), in the event of Irma most did not (39%). All the self-efficacy questions showed similar decreases, suggesting that respondents felt an overall decrease in their ability to control outcomes related to hurricane impacts after Hurricane Irma. This 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 (Miller, Adame, and Moore 2013). In this case, the results suggest that after a hurricane, risk perception would be 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 to undertake risk reduction or evacuation behaviors (Wachinger 2013).

When considering perceived community involvement, the results demonstrate that 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. Despite lowered feelings of involvement and self-efficacy, however, respondents were less likely to feel government agencies (e.g., Sarasota County, or the Federal Emergency Management Agency (FEMA)) are responsible for preparing for impacts from Hurricane Irma and more likely to feel personally responsible (Table 4.2).

The inverse relationship of these findings suggests that, after a major disaster event, respondents are more likely to believe preparing for impacts is their own responsibility, not the responsibility of institutions. 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 themselves and not need the help of institutions) or 2) respondents do not feel they can *rely* on institutions to prepare for hurricane impacts (i.e. they do not trust institutions to prepare for hurricane impacts).

While the first interpretation is possible, the second interpretation is more likely, especially when considering that reported knowledge about hurricanes increased; previous studies have demonstrated that as knowledge increases, social trust decreases (Earle & Cvetkovic 1995, Siegrist and Cvetkovic 2000, Bronfman, Vázquez, and Dorantes 2009).

Changes in perceived community involvement also show that people may not feel involved in community decision making but do feel increased levels of power to enact change in their community (Table 4.2). 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 if they wanted. The finding that respondents showed an increase rather than a decrease when asked about people *like* themselves serves to demonstrate that feelings about respondents' own self-efficacies may be independent of their feelings about others'.

Overall, the study findings demonstrate that experiencing a disaster can affect both overall risk perceptions 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." Rather, it is more accurate and useful to describe how Hurricane Irma changed perceived knowledge, perceived susceptibility, self-efficacy, and community involvement, as these components of risk perception have been shown by the present research to have changed independently.

Studies like this are important for risk perception research because no longitudinal study of hurricane risk perception before and after a hurricane had been conducted before this study. This study empirically replicated findings from existing literature in an unprecedented manner, especially regarding literature concerning previous hazard experience. For instance, the statistical analysis results reflect Wachinger (2013)'s finding that perceived susceptibility can decrease after a hurricane and Avvisati (2019)'s finding that perceived hazard knowledge can increase after a disaster event.

This research also synthesizes findings about changes in several different aspects of risk perception and describe how they relate and/or differ in the wake of a disaster. Understanding the effect 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. This understanding allows risk communicators such as local, state, and federal governments to more effectively

communicate with their citizens about hurricane risks in a way that is 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 the various components of a population's risk perception by comparing two risk perception surveys, one taken before and one taken after Hurricane Irma in Sarasota County, FL. The statistical analyses suggest that the various components of risk perception change in different ways independently of one another. Perceived knowledge increased, perceived susceptibility decreased slightly, self-efficacy decreased, personal community involvement decreased, potential community involvement of others increased, and perceived personal responsibility for disaster preparation increased. These different findings highlight the importance of analyzing risk perception at a high level of specificity to accurately understand how risk perceptions change over time.

It should be noted, however, that this study does have limitations. Because these two surveys were comprised of two different sets of respondents, the t-tests were performed on independent samples. Conducting a study on the same set of respondents would allow for a more detailed and rigorous 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. Additionally, the statistical analyses were conducted on Likert-scale data, which is categorical data. Because the data are not continuous values, its precision is relatively low. Furthermore, the difference from one answer choice to another, while internally consistent throughout the survey, is ordinal in nature; increases and decreases described in the results do not have known units.

Additionally, the control groups described in this thesis were sub-samples from the overall data set. Ideally, a true experimental control group would consist of an entirely independent group of respondents, similar in demographics, that had not experienced a hurricane at all. 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). Future research would benefit from such research design considerations.

Despite these limitations, this research is important because it advances 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 hazard information more effectively in the event of future hurricanes. Future research would benefit from a larger survey sample size and utilizing repeat respondents. Larger sample sizes would allow for more robust statistical analysis. Utilizing repeat respondents would also make it possible to measure and predict how pre-disaster risk perceptions influence actual risk reduction behaviors. Furthermore, repeat respondents would allow for the use of contingency tables, which are a more statistically sound method of analyzing categorical data such as Likert scale data than t-tests. Additionally, repeat respondents would allow for paired t-tests to be conducted instead of unpaired t-tests, which would allow analysis on a response-by-response basis and yield more robust results.

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