Spring 2023

A Flood of Information: Assessing the Effectiveness of an Enhanced Flash Flood Warning Social Media Graphic

Christopher John Long

A FLOOD OF INFORMATION: ASSESSING THE EFFECTIVENESS OF AN ENHANCED FLASH FLOOD WARNING SOCIAL MEDIA GRAPHIC

by

Christopher John Long

Bachelor of Science
The Pennsylvania State University, 2021

Submitted in Partial Fulfillment of the Requirements

For the Degree of Master of Science in

Geography

College of Arts and Science

University of South Carolina

2023

Accepted by:

Susan L. Cutter, Director of Thesis

Gregory J. Carbone, Reader

Brett W. Robertson, Reader

Cheryl L. Addy, Interim Vice Provost and Dean of the Graduate School

DEDICATION

The highlight, by far, of my graduate school career was meeting and getting to know the amazing person that is Lilian Hutchens. It is not easy to get up and move 600 miles to a place you have never been before, but she immediately made me feel like I was at home. I used to think that I was an independent person, but now I realized I just hadn't met Lily yet.

Her never-ending support and comforting presence, more than anything, gave me the motivation to complete this project. But more importantly, she makes me excited for the rest of my life. She is the highlight of my every day, and I can't wait to move on from graduate school with her.

To Lily, I dedicate this thesis. These two years have only been the beginning. I'm so excited for what's to come. I love you.

ACKNOWLEDGEMENTS

I would like to express my deepest appreciation to Dr. Susan Cutter for always having her door open and being quick to offer invaluable feedback throughout my entire grad school experience. I also could not have undertaken this project without the support of my two additional committee members Dr. Gregory Carbone and Dr. Brett Robertson.

I am also immensely grateful to the Hazards, Vulnerability, and Resilience Institute (HVRI) crew who were always supportive and there to answer my questions. Especially, I would like to thank Sarah Jackson, my partner in (surveying) crime, who was immensely helpful in providing me support and resources for constructing and implementing the survey I used in this project. Thanks are also owed to members of the Geography 202 team. Dr. April Hiscox, whose office I've spent more time in than maybe my own, Stafford Mullin, and Grant Farmer who have all been incredibly supportive of me personally and professionally in my time here at USC.

Finally, I would be remiss if not mentioning my family, especially my parents and grandparents, and my friends who support from afar. It's comforting to know that I am never more than a phone call away from a familiar voice offering support and motivation.

ABSTRACT

Flash flooding is the most frequent and damaging type of severe weather globally. In the United States, heat is the only weather-related cause of death more frequent than flooding. However, while the number of deaths associated with other types of severe weather has decreased since the 1950s, the number of flash flood-related deaths has remained steady. Therefore, there exists a need to improve flash flood warning communication.

In this project, it is hypothesized that improving the National Weather Service's flash flood warning social media graphic by including areas that commonly flood may increase individuals' perceived storm risk, their intended compliance with the warning message, and intended sharing of the message with others. To test the hypotheses, a new graphic was developed that includes a large map that zooms into the warned area and pinpoints specific intersections and landmarks that are prone to flooding. Additionally, this new graphic removes the population exposure section from the original graphic in lieu of a larger and more zoomed-in inset map. Changes in storm risk perception, intended message compliance, and intended message sharing between the two graphics were collected via a user survey of undergraduate students at the University of South Carolina.

Quantitative survey data indicated that this new graphic does not impact an individual's perception of storm risk, intended message compliance, or intended message

sharing when compared to the original graphic. However, participant comments and investigation into sample subsets revealed that the enhanced graphic may influence some participants' protective action decision-making compared to decisions they would make after viewing the original graphic.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ANOVA .... Analysis of Variance

CIC .... College of Information and Communications

FFW .... Flash Flood Warning

NOAA .... National Oceanic & Atmospheric Administration

NWS .... National Weather Service

RFC .... River Forecast Center

SPSS .... Statistical Package for Social Sciences

WFO .... Weather Forecast Office

USC .... University of South Carolina

CHAPTER 1

INTRODUCTION

No event occurs as frequently and causes as much damage worldwide as flooding (Berz et al., 2001). Flooding is the second most deadly weather hazard in the United States following extreme heat (Figure 1.1). Though flash flood forecasting and communication of the forecasts and warnings have improved in recent years (Erickson et al., 2021), the number of annual deaths associated with flash floods has remained steady since the late 1950s (Ashley & Ashley, 2008; Terti et al., 2017). This starkly contrasts to the decrease in deaths per year associated with most other weather-related hazards.

Figure 1.1 Weather fatalities, 2020.
Source: National Weather Service
(https://www.weather.gov/hazstat/)

In the United States, flash flood watches, warnings, and advisories are issued by the National Oceanic and Atmospheric Administration (NOAA)'s National Weather Service (NWS) (NWS, n.d.-b). Once issued, these warnings are disseminated to the public via multiple channels including traditional private sector media outlets (TV and radio), NOAA Weather Radio, and, increasingly, social media (Barett & Posey, 2019; Endsley et al., 2014; Olson et al., 2019). The primary method that the NWS disseminates flash flood warnings (FFWs) via social media is through an automated graphic (Figure 1.2) posted on a local weather forecast office's Twitter and Facebook accounts.

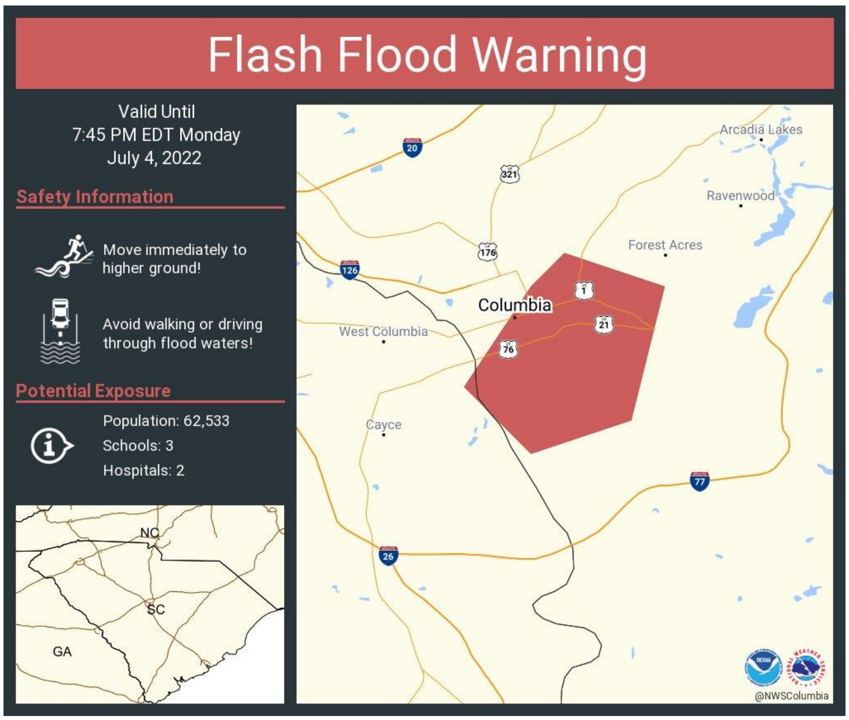

Figure 1.2 Example of an NWS flash flood warning social media graphic. Source: @NWSFlashFlood on Twitter.

The automated FFW graphic is the primary subject of this research project. Since people may receive their warning information on social media, they may rely on the information in the graphic to make protective action decisions. However, the current version of the graphic has room for improvement. To start, the NWS uses the same graphic for flash flood, severe thunderstorm, tornado, snow squall, and dust storm warnings, changing only the headline at the top and the safety information (Fischer et al., 2023). However, flash flood warning protective action decision making is different from the other five types of warnings. In flash floods, as opposed to a tornado (for example), most people are not in danger unless they are located in or driving through a low-lying, flood prone area. Previous research on NWS social media graphics has shown that often an individual's first response to viewing a tornado warning graphic is to determine where they are located in comparison to the warning polygon (Sutton & Fischer, 2021). This is likely still the case for a flash flood warning. However, participants may additionally need information on specific areas to avoid when viewing flash flood warning graphics, especially if they are in transit. Otherwise, they may not worry about the warning since it doesn't directly influence their day.

In this project, the effectiveness of the current flash flood warning graphic is investigated. This study also tests the influence that adding impacted locations (e.g., locations in the warned area known to commonly flood) to the graphic has on individual's perceived risk of the warned storm, their intended message compliance, and their intended sharing of the warning message.

To test the effectiveness of enhancing the social media graphic, I propose three primary research questions (RQs).

1. To what extent does including impacted locations in NWS' flash flood warning social media graphics influence the publics' perceived storm risk?

I hypothesize that including impacted locations in the graphic will increase an individual's perceived risk as including locations familiar to the message recipient may make the warning seem more personalized. This personalization has been shown to increase a person’s likelihood of believing the warning and their perceived risk of the storm (Quarantelli, 1990).

2. To what extent does including impacted locations in NWS’ flash flood warning social media graphics influence the publics’ intended message compliance?

For this question, I hypothesize that a list of impacted locations in the graphic will increase an individual’s intended message compliance. Since most flash flood deaths occur in vehicles (Coles & Hirschboeck, 2020; Gruntfest & Ripps, 2000), FFWs are designed to alert motorists that flash flooding is either ongoing or will begin shortly. However, since FFWs are often issued for a relatively large area (i.e., one or more counties) and flooding only occurs in a few locations, much of the public receiving the message does not need to take any protective action. Adding a list of locations to the warning graphic may be a way to decrease ambiguity over where people should be taking protective action (i.e., avoiding certain roads). This decrease in ambiguity, according to the Protective Action Decision Model (PADM), a theoretical framework used in this study, will cause warning recipients to spend less time seeking and processing information and more time preparing and implementing protective action (Lindell & Perry, 2012).

3. To what extent does including impacted locations in NWS’ flash flood warning social media graphics influence the publics’ intended message sharing?

For this RQ, I hypothesize that including impacted locations in the FFW graphic will increase the publics’ intended message sharing. This RQ investigates ‘milling’, the term that describes most people’s first reaction to a warning message when they will consult with others to try to confirm the warning message in some way (Drabek, 2000;

Quarantelli, 1990; Turner & Killian, 1957, 1972; Wood et al., 2018). Knowling exactly where flooding is or will be occurring, I hypothesize that individuals will be more likely to share the warning information with others they know are in, or near, the locations listed on the graphic.

The remainder of this document is divided into five chapters. Chapter 2, the literature review, analyzes literature from the fields of meteorology, communication, and hazards and disasters to provide a rationale for completing this project. Chapter 3, the methods, reviews the steps taken to develop and test the effectiveness of an enhanced flash flood warning graphic. This required the use of a survey questionnaire. The complete survey can be found in Appendix A. Chapter 4, results, reviews the quantitative results of the survey to answer the three research questions introduced in this chapter. Some results that are not discussed in the results section are listed in Appendix B. More details on the reasoning behind the results are discussed in chapter 5 (the discussion). Finally, the thesis concludes with a short chapter 6 that summarizes the project's findings and provides future research directions.

CHAPTER 2

LITERATURE REVIEW

To rationalize the undertaking of this project, it is pertinent to review past work on related topics and similar projects. This chapter holistically outlines literature from meteorology, communication, and hazards and disaster management which led to the formation of the research questions and the reasoning behind this project.

2.1 FLOOD DEFINITION AND ASSOCIATED DANGERS

Floods can be classified into three types: flash floods, riverine floods, and coastal flooding. Flash floods are defined by the NWS as those that "follow within a few hours of heavy or excessive rain, a dam or levee failure, or a sudden release of water impounded by an ice jam" (French & Holt, 1989, p. 69). In recent years, the NWS has defined a flash flood as occurring within six hours of the triggering event (NWS, 2016). A Riverine flood is "the rise of a river to an elevation such that the river overflows its natural banks causing or threatening damage" (NWS, n.d.-d). Finally, coastal flooding pertains to "flooding which occurs from storms where water is driven onto land from an adjacent body of water" (French & Holt, 1989, p. 70).

Riverine floods are typically forecasted by hydrologists and depend mostly on how much rain has already fallen. Coastal flooding is almost entirely dependent on tides and winds. Flash flood forecasts, on the other hand, require accurate rainfall forecasts and hydrology information (Doswell III et al., 1996). Therefore, flash floods are often tougher to forecast. Since the uncertainties involved in forecasting are often poorly communicated to the public, flash floods ultimately result in more loss of life than riverine and coastal floods (Ashley & Ashley, 2008; Creutin et al., 2013; Terti et al., 2017). Since flash floods are the most hazardous flood type, flash flood communication is the focus of this project.

In the United States, most flash flood related deaths are in vehicles (Gruntfest & Ripps, 2000). Ashely & Ashely (2008) found that 63% of flood-related deaths from 1959-2005 were in vehicles. Ultimately, Ashley & Ashley (2008, p. 814) concluded that "the U.S. population is still largely unaware of the life-threatening powers of floodwater." This was echoed by Drobot et al. (2007) who researched risk factors that caused people to drive into flooded roads. They found that younger drivers, those who don't understand the danger of vehicle flood-related deaths, and those who don't take flash flood warnings seriously are more likely to drive through flood waters. For this reason, one of the primary goals of issuing a flash flood warning is to discourage individuals from unnecessary driving into flooded roadways.

However, recent work by Coles & Hirschboek (2020) reveals that most individuals who drive through flooded roadways trust flash flood warnings and know the consequences of driving through floodwaters but decide to drive through them anyway. This highlights the need for a different approach to flash flood warning communication. Perhaps knowing exact areas to avoid will lead to more avoidance behavior because of flash flood warning issuance.

2.2 FLASH FLOOD WATCHES, ALERTS, AND WARNINGS

In the United States, the National Weather Service (NWS) is the agency responsible for forecasting and warning the public about flash floods. The greater NWS mission is to "provide weather, water, and climate data, forecasts, warnings, and impact-based decision support services for the protection of life and property and enhancement of the national economy" (NWS, n.d.-a, sec. Mission). To achieve this mission, the NWS is divided into several regions and offices. Local weather forecasting and warning issuance, crafted by meteorologists, is done at 122 Weather Forecast Offices (WFOs) spread throughout the country (NWS, n.d.-a). Hydrology and flood information is provided by 13 regional River Forecast Centers (RFCs). While WFOs are delineated by counties (or county-equivalents), RFCs are delineated by river drainage basins. This means that a WFO's forecast area may overlap more than one RFC area of responsibility.

Short-term flash flood alerts are issued by local WFOs. Flash flood watches are issued to indicate current or developing hydrologic conditions that are favorable for flash flooding in and close to the watch area while flash flood warnings are issued when a flash flood is imminent or occurring (NWS, n.d.-b). The NWS currently defines a flash flood as "A rapid and extreme flow of high water into a normally dry area, or a rapid water level rise in a stream or creek above a predetermined flood level, beginning within six hours of the causative event" (NWS, n.d.-b). In addition, the NWS issues areal flood advisories for flooding that develops gradually. These events usually stem from prolonged and persistent moderate to heavy rainfall (NWS, n.d.-c). Since October 1, 2007, flash flood warnings have been polygon based, meaning that warnings are drawn by forecasters independent of geopolitical boundaries (NWS, 2007).

2.3 CRISIS COMMUNICATION AND PERCEPTION OF RISK

Flash flood warnings are messages disseminated in times of crisis. To understand how people make decisions based on these messages we must understand how people react to them. To do so, we delve into crisis communication. Additionally, in today's ever-changing media landscape it is important to review the literature surrounding how new media (e.g., the internet, mobile phones, social media) is affecting crisis communication.

When a warning message, such as a flash flood warning, is issued, there are many social and personal influences that go into people's interpretation of danger and their response to the message. Fritz (1961) identifies several of these influences including people's past experiences with the threat, their present direct perceptions of the physical environment, their perceptions of how others are responding to it, and a comparison of their own information with others. Then, to decide how to respond to the message, people also consider the threat's nature and strength and the potential responses' effectiveness. After weighing all of these, a person may decide to act based on the message.

This is not unlike Karl Weick's (1969) theory of organizing. This four-stage theory is ignited by a change in the environment (i.e., issuance of a warning message). This causes people to enter the enactment phase where they are engaging in sensemaking to understand their new environment. In the example of the issuance of a warning, this is the phase when people use their past experiences and perceptions of how others are responding to the threat. The third stage, selection, is when the person decides how to act. Finally, in the fourth stage, retention, people reflect on their decision and decide if they would act similarly if a similar situation were to occur again (Barett & Posey, 2019).

In the hazards literature, Emergent Norm Theory (ENT) is defined in almost the same way as Weick's theory of organizing. ENT describes "what people do when they are in unfamiliar circumstances to make sense out of and define the uncertain reality in which they find themselves" (Wood et al., 2018, p. 537). However, ENT places a much heavier emphasis on what happens to an individual in the context of interaction with other people (Quarantelli, 1990). Most people first react to a warning message by consulting with others to try to confirm it in some way (Drabek, 2000; Turner & Killian, 1957, 1972; Wood et al., 2018). This act can also be considered ‘milling’ (Turner & Killian, 1957; Wood et al., 2018). Turner and Killian (1957, p. 59) define milling as a restructuring activity in which a person “seeks repeatedly to find out what is going to happen next.” However, “When other people are present in the same ambiguous situation…He [the individual] may now seek cues in the reactions of others to the situation.” (Turner & Killian, 1957, p. 59). The act of milling is found to be the common first response to a warning message (Turner & Killian, 1957; Wood et al., 2018). Then, based on what happens in the milling stage, and an individual’s risk perception and understanding of the warning, the individual may decide to take protective action.

A third theoretical model, the Protective Action Decision Model (PADM) further describes “the way people ‘typically’ make decisions about adopting actions to protect against environmental hazards” (Lindell & Perry, 2012, p. 617). The PADM identifies three predicational processes that are necessary to produce a protective response. These include being exposed to, heeding, and accurately interpreting environmental cues and information from the social environment (typically a warning message) (Figure 2.1). In addition, three core perceptions form the basis of how an individual will respond to an environmental threat: threat perceptions, protective action perceptions, and stakeholder perceptions. These perceptions are mainly guided by an individual’s overall risk perception.

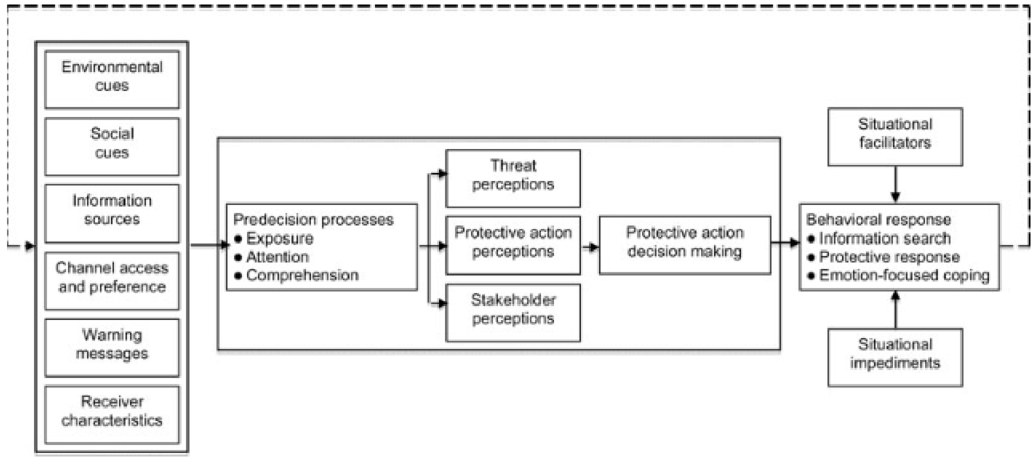

Figure 2.1 The protective action decision model (PADM). Source: Lindell & Perry 2012

2.3.1 RISK PERCEPTION

Also important in determining people's reaction to a warning is their risk perception. Individuals who have a high risk perception will respond more quickly and adaptively to flood warnings (Drabek, 2000). Though experts judge risk on technical estimates of annual fatalities (Slovic, 2000), laypeople consult their affective feelings to make judgements and decisions about risk. This is known as the affect heuristic (Slovic et al., 2002). Since rainfall is an ordinary event, it can be difficult for the public to become concerned even when rainfall becomes life threatening (Doswell III et al., 1996). The unknown and dread risk associated with events also impact people's judgement of risk (Slovic, 2000).

People's past experiences with similar situations also influence one's risk perception (Drobot & Parker, 2007). Kates (1962) defines the "prison of experience" as the idea that individuals who experience an event expect those experiences to repeat and will take similar actions in future scenarios. While this may be known as the 'prison' of experience, Mileti & O'Brien (1992) found that people who have experience with an event are more likely to take warnings for future events more seriously. Equally important in the determinant of risk is the availability heuristic (Tversky & Kahneman, 1973). This is the idea that the ease with which relevant instances come to mind affects risk perception. This extends the "prison of experience" beyond those who have previously had direct experience with an event.

Demographics are another characteristic that may influence someone's risk perception. Younger people and females are found to respond more adaptively (e.g., evacuating if in a flood zone or heeding a warning to not drive into flood waters) to flood warnings than older people and males (Drabek, 2000). Bateman & Edwards (2002, p. 113) found that "women perceive potential flooding to be a greater risk to their homes than men do." They go onto say that this is because women are more socially vulnerable than men and may be more severely impacted by a flood event.

Finally, Fate control (or locus of control) influences a person's risk perception. An individual with an internal locus of control feels as though they have control of their actions and will take measures to protect themselves and their property when a warning is issued. Individuals with an external locus of control (also known as a fatalist) feel as though others (i.e., God) will protect them and they can't influence their own destiny. For this reason, they may be less likely to react to a warning message than an individual with an internal locus of control (Coles & Hirschboeck, 2020; Silver & Braun, 1999).

2.3.2 SOURCE AND CONTENT OF WARNINGS

No matter a person's risk perception, the content, source, and means by which individuals receive a warning message is important. Emergent Norm Theory (ENT) identifies five key contents of warning messages (Wood et al., 2018). Warning should directly specify the hazard, guidance, location, time, and source of the hazard (Mileti & Sorensen, 1990; Wood et al., 2018). The believability of the warning is also dependent on the source of the warning. Specific warnings and those delivered directly by other people are more likely to be believed than general warnings communicated by an impersonal medium (Quarantelli, 1990). However, since governmental warnings (including NWS warnings) are not individualized, trust of the issuing agency is also an important factor in whether people take protective action from a warning (Drobot et al., 2007).

One of the factors that may influence people's trust in the issuing agency and their decision to take protective action based on a warning is the number of warnings issued and the false alarm rate of those warnings. It has been found that a high false alarm rate can lead to low citizen trust of the warning system and government officials (Dow & Cutter, 1998; Downing, 1977). However, most research surrounding the topic has found that false alarm rates don't influence future decision-making from similar warnings (Barnes, 2006; Dow & Cutter, 1998; Trainor et al., 2015). The most issued NWS warning is the severe thunderstorm warning. While this warning has a relatively high false alarm rate, recent work has shown that people believe that the NWS is issuing the right amount of severe thunderstorm warnings (Krocak et al., 2023). While these findings decrease worry in the weather enterprise about the false alarm problem, little work has been done on flood warning false alarm perceptions.

Most people don't receive weather warnings directly from the issuing agency. Instead, the warnings are disseminated through media sources. Traditionally, this was done mainly via television and radio. However, within the past 15 years, this has begun to be done on the internet, over social media, and even though wireless emergency alerts

(WEAs). Still today, traditional media is more trusted than social media (Endsley et al., 2014) and the most common source of information (Sherman-Morris et al., 2020) during crisis events. However, more people are turning to social media to receive crisis-related information (Barett & Posey, 2019) especially after the disaster when people are looking for rapid updates (Stokes & Senkbeil, 2017).

Social media is defined as “a new era of web-enabled applications that are built around user-generated or user-manipulated content, such as wikis, blogs, podcasts, and social networking sites” (Jin et al., 2014, p. 75). Even in 2007, around the dawn of the social media era, Sutton et al. (2008) found that people in crisis events were beginning to rely on internet backchannels (such as blogs and social media posts) instead of traditional media in crisis scenarios. They found that people living in areas that the traditional media didn’t cater to (mainly rural areas) found more in-tune information from informal mediums on the internet than from traditional media outlets. In the years since, social media has exploded in use. We now know that people’s social media usage increases during times of crisis (Jin et al., 2014). Murthy (2018) reported that during disasters individuals are more likely to turn to mobile and social media for information than traditional media sources. One of the reasons that social media has become a go-to for people during times of crisis is because of the two-way communication that can occur via the internet. Social media is a way that people can confirm a warning (during the milling process) and a way that those who are not in the affected area can assist those at risk by crafting individualized messages (Smith et al., 2021). Increasingly, traditional media channels have begun to rely on the information they receive from social media (Simon et al., 2015) further proving how vital social media will be moving forward.

2.4 FLASH FLOOD COMMUNICATION ON SOCIAL MEDIA

Social media is now one of the primary mechanisms that NWS WFOs use to communicate with the public. Olson et al. (2019) studied how communication from official WFO Twitter accounts differs during times of imminent threat and no imminent threat. They find that during times of no threat, offices focus on fostering a community of followers and engaging with other users. During threat times, the Twitter accounts provide information, mostly on current conditions. Through they note that there is not an increase in action items embedded within Tweets during threat times like would be expected (Olson et al., 2019).

One of the primary products Tweeted by WFO Twitter accounts during a threat is the warning graphic (Figure 1.2). The NWS utilizes nearly the same graphic for tornado, flash flood, severe thunderstorm, dust storm, and snow squall warnings, changing only the title at the top of the graphic and the safety information on the graphic's left side. Fischer et al. (2023, p. 31) found that these graphics "may help to provide content that informs participants, regardless of prior hazard experience, about the hazard and its impacts." However, since it has been established that most people who drive into flooded areas both trust flash flood warnings and know the consequences of driving through flood waters, it seems necessary to explore enhancements to the flash flood warning graphic specifically.

Sutton and Fischer (2021), using eye-tracking technology on the tornado warning graphic, found that the graphic's impacts and population exposure sections elicited the most visual attention. In contrast, the header, inset map, and logo were found to have received relatively little visual attention. In addition, using think-aloud surveys, they found that most people's first reaction to seeing a graphic is to try to determine their location relative to the warning area. This provides rationale for this proposed study as the addition of impacted locations allow an individual to compare their location to those listed on the graphic. The individual can then more quickly determine their level of risk from the warned flash flood. Additionally, the inclusion of commonly flooded areas may help individuals decide to avoid those areas when driving or avoid driving altogether until the flooding subsides.

2.5 CHAPTER SUMMARY

Flash floods are one of the most common weather-related killers and many people who drive into flash floods know the risk but decide to do so anyway. New techniques of communicating flash flood warnings to discourage this behavior is therefore necessary. Since social media use increases during times of crisis, such as a flash flood, the study of flash flood warning communication on social media is pertinent.

When people receive a warning message, such as a flash flood warning, many variables go into their perception of the threat and response to the warning. This may include their past experiences with the threat, their overall risk perception, their locus of control, their perceptions of the current threat, and information that they glean in the milling process. For this reason, warning information should include information that helps an individual determine their level of risk and information that triggers the milling process.

The NWS' current set of social media graphics are effective in helping a person determine if they are in a warned area. However, since flash floods typically do not occur throughout the entire warned area, changes to the current graphic are necessary to increase individuals' perception of the risk associated with flash flood warned storms. An increase in risk perception may then lead to individuals taking more protective action such as not driving into flooded areas, which is the most common cause of flood related deaths in the United Sates.

CHAPTER 3

METHODS

To address the research questions proposed in this study, an enhanced flash flood warning social media graphic was designed and then quantitative survey data was collected on individual's reactions to both the original and enhanced graphics. That survey data had to then be processed and collapsed into several variables which were subsequently evaluated to answer the research questions. In this chapter, the methods for designing the enhanced social media graphic, designing, and implementing the survey questionnaire, and collapsing survey items into variables is discussed. The chapter consists of four sections. The first focuses on the development of the enhanced version of the NWS social media graphic. Next, is a short section on data collection techniques. Third, details are provided on the development of the survey questionnaire. Finally, the chapter ends with a section detailing data analysis steps completed to answer the research questions.

3.1 ENHANCED GRAPHIC DEVELOPMENT

To evaluate the effectiveness of adding impacted locations to the NWS' social media graphic, an enhanced social media graphic was developed. This graphic aimed to highlight areas in the warning polygon that commonly flood to warn individuals that those areas will likely flood in this storm. The locations added to the graphic are currently listed on the text version of the NWS-issued warning. However, this text version is rarely viewed by members of the public. On this new enhanced graphic, the locations are labeled using a yellow triangle warning icon with a black exclamation point inside the triangle. Additionally, the name of the point of interest or street intersection known to flood is included next to the yellow warning icon. To accommodate this change to the graphic, the current large map (on the right side of the graphic) is shrunk and moved to the current location of the inset map while the potential exposure information is removed. The enhanced version of the graphic tested in this project can be seen in Figure 3.1.

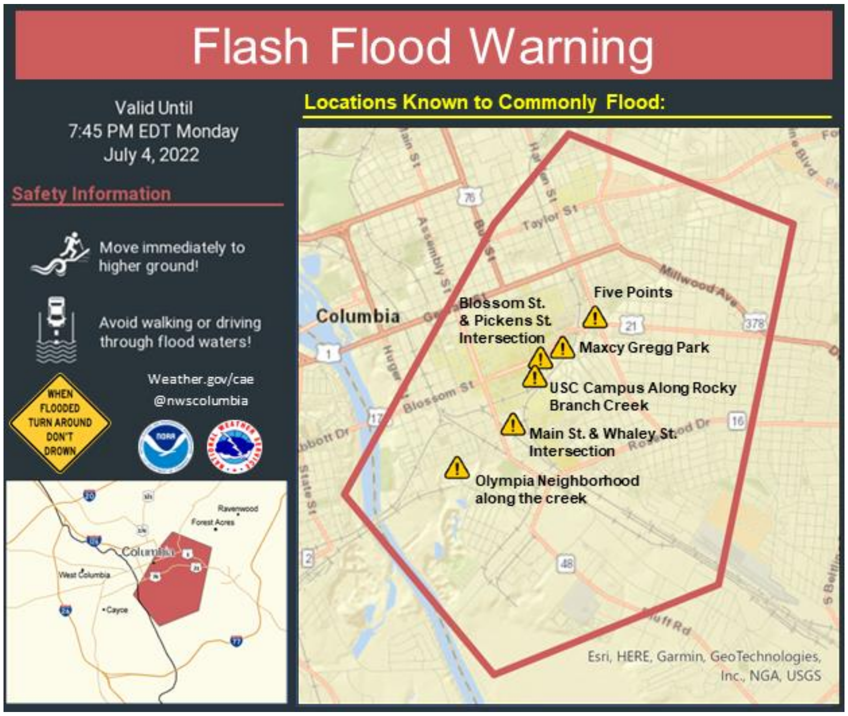

Figure 3.1 Enhanced flash flood warning graphic developed for and tested in this project.

The warning selected to appear on the enhanced graphic was an actual flash flood warning issued by the Columbia, SC NWS office on the evening of July 4, 2022, for Richland and Lexington counties in South Carolina. This warning was issued for flash flooding that occurred along Rocky Branch creek near the campus of the University of South Carolina. This warning was chosen for use in the project because many of the locations that experienced flooding are near USC's campus and are likely to be familiar to the undergraduate students who participated in the survey.

The enhanced graphic was created using ArcGIS Pro and Microsoft PowerPoint. To begin, a shapefile of the warning polygon was downloaded from Iowa State University's Iowa Environmental Mesonet website (2022). This shapefile was added into a blank ArcGIS Pro project with a World Street Map base map. A blank feature class layer was then added to the project so that the locations that commonly experience flooding, from the text version of the warning, could be manually added to the map. Once those locations were manually added and the symbology of the point features was changed to a warning icon, the map was exported from ArcGIS Pro as a PNG image and brought into Microsoft PowerPoint. The rest of the graphic, including the addition of the text names of locations impacted by flooding, was added in PowerPoint. The non-map portion of the graphic was made to look as much like the original NWS graphic as possible.

3.2 DATA COLLECTION

Data for this project was collected by surveying undergraduate students taking introductory courses in the Department of Geography and students enrolled in the College of Information and Communications (CIC) at the University of South Carolina in the fall of 2022. Much early risk perception work has been done on convenience sampled undergraduate students (Slovic, 2000). This project follows that precedent.

Survey responses were collected in SurveyMonkey. Students in geography 202 (weather and climate) and geography 330 (the geography of disasters) were invited to take part in the survey which was emailed to all enrolled students and posted on the course's Blackboard pages. Students were given a small amount of extra course credit for completing the survey. Students in the CIC took the survey via the CIC Research Participant Pool website. This allowed those students to also receive course credit for taking the survey. Therefore, all CIC undergraduate students were eligible to take the survey and were part of this project's population.

3.3 SURVEY QUESTIONNAIRE

The project utilized a self-reported questionnaire to allow for individualized assessment of perceived risk from the sampled undergraduate students. The entire questionnaire can be found in Appendix A. The questionnaire began by asking participants for their consent. Then, the remaining items were divided up into three sections. The first section collected information unrelated to individual's responses to the flash flood warning graphics. This information included participant's demographic information, flash flood experience, evaluation of flash flood risk, locus of control, and social media use. In the second section, the respondents were shown the current flash flood warning graphic (Figure 1.2) that was posted on Twitter and Facebook on July 4, 2022, and asked questions about their perceived risk of the warned storm, intended message compliance, and intended message sharing based on the graphic. For the third section, the respondents were shown the enhanced version of the graphic (Figure 3.1) and asked the same questions about perceived risk, intended message compliance, and intended message sharing based on this new enhanced graphic. Finally, at the end of the survey, students were asked to share any other comments. The questionnaire had 37 questions including question 1 that provided participant consent. The survey used items adapted from prior studies that also researched similar themes (Ash et al., 2014; Barnett

& Breakwell, 2001; Botzen et al., 2009; Bowman et al., 2012; Casteel & Downing, 2016; Kellens et al., 2011; Kox & Thieken, 2017; Liu et al., 2017; Perreault et al., 2014; Ripberger et al., 2015; Sutton & Fischer, 2021). Below each section of the survey is detailed.

3.3.1 SECTION 1 – BACKGROUND AND CONTEXT

In this section, students were asked to answer basic socio-demographic items as well as context questions unrelated to the social media graphics. The first eight items were basic demographic questions (Table A.1).

Next, the students answered seven questions about their past experiences with flash floods (Table A.2). It was expected, based on the literature, that those who have experienced more flash floods would be more likely to take warnings for future events more seriously (Mileti & O'Brien, 1992).

Participants' evaluation of overall flash flood risk was assessed in the next two questions (Table A.3). This data was collected because an individual's risk perception guides their response to an environmental threat (Lindell & Perry, 2012).

Students then answered items that measured their locus of control (Table A.4). This was done because those with a high, or internal, locus of control feel as though they have control over their fate and will be more likely to take protective action when presented with a warning compared to those with a low, or external, locus of control (Coles & Hirschboeck, 2020; Silver & Braun, 1999).

Finally, the first section of the survey ended with questions that measured participants use of Twitter and Facebook (Table A.5). These two websites were chosen because they are the only places that the NWS posts flash flood warning graphics. Items were modified from Bowman et al.'s (2012) social media diet measures. The scale measures one's frequency ("0=never" to "4=every day"), amount ("0=none" to "5=30+ times daily"), and duration ("1 = less than 1 year" to "3= more than 5 years") of social media usage.

3.3.2 SECTION 2 – ORIGINAL WARNING GRAPHIC

In this section, participants were shown the original graphic (Figure 1.2) and asked to answer questions about their response to the warning as if they were located inside the warning polygon. First (Table A.6), participants were asked to answer either yes or no to "Do you feel you understand what the graphic is warning you about?" Then, they proceeded to answer items about their perceived storm risk (Table A.7), intended message compliance (Table A.8), and intended message sharing (Table A.9) based on the information gleamed from the graphic. One of the items in the message compliance section focuses on driving since most flash flood deaths occur when people drive into flood waters (Ashley & Ashley, 2008; Coles & Hirschboeck, 2020; Gruntfest & Ripps, 2000). Finally, the message sharing questions collect data on if participants would enter the milling process after viewing the graphic. The literature highlights the importance of the milling process in decision making. Thus, an individual who plans to either share the message with others or seek out additional information is likely more engaged with the warning and more likely to take protective action (Drabek, 2000; Turner & Killian, 1957; Wood et al., 2018).

3.3.3 SECTION 3 – ENHANCED GRAPHIC ASSESSMENT

In this section, participants were shown the enhanced graphic (Figure 3.1) and asked the same questions as in section 2. Again, first participants were asked (item 31) to answer either yes or no to “Do you feel you understand what the graphic is warning you about?” Then, they proceeded to answer items about their perceived storm risk (Table A.7), intended message compliance (Table A.8), and intended message sharing (Table A.9) due to the graphic. The survey ended with a final open-ended question (Table A.10) that allowed participants to share any comments they had after completing the survey.

3.4 DATA ANALYSIS

To answer the research questions, the survey responses were coded into values, collapsed into variables, and those variables were analyzed using statistical methods. This section details the processes that were utilized to answer the research questions from the survey responses.

3.4.1 COMPOSITE VARIABLE CONSTRUCTION

For data analysis purposes, survey items were collapsed into variables using Microsoft Excel. All socio-demographic variables (age, gender, length of time living in Columbia, class standing, place of residence, and access to a car) were kept as individual variables. All other variables were constructed by coding survey responses and either averaging or summing those responses into composite variables. Coded values can be found in Appendix A.

A few questions throughout the survey were reverse coded to avoid response style bias. Response style bias is when the respondent goes down a list of items and indicates the same response (Scharrer & Ramasubramanian, 2021, p. 113). These items are denoted with an asterisk in Appendix A. For these items, strongly disagree was coded as +2 (instead of -2) while strongly agree was coded as -2 (instead of +2).

Of note, to keep the scores consistent, standard deviations were used to code the feeling thermometer responses (items 26, 27, 32, and 33) onto a -2 to +2 scale. Participants whose feeling thermometer response were within one standard deviation of the mean were coded as 0, participants whose response was within 1-2 standard deviations of the mean were coded as +1 or -1, and participants whose responses were greater than 2 standard deviations from the mean were coded as a -2 or +2. The remaining techniques used to construct the ten composite variables can be found in Table 3.1.

Table 3.1 Composite variable construction.

Composite Variable	Item #s	Scale	Statistic	Range
Flash Flood Experience	9, 10	Yes (1)-No (0)	Summation	0 to 7
	11, 14	True (1)-False (0)		
	12, 13	Yes (1)-No (0) -Unsure (0)		
	15	Correct (1)-Incorrect (0)-Unsure (0)		
Evaluation of Flash Flood Risk	16a-e, 17	5-scale Likert (-2 to +2)	Average	-2 to +2
Fatalism	18a-e	5-scale Likert (-2 to +2)	Average	-2 to +2
Social Media Usage	19, 22	Multiple Choice: 0-3 Scale	Summation	0 to 24
	20, 23	Multiple Choice: 0-5 Scale		
	21, 24	Multiple Choice: 0-4 Scale		
Graphic 1 Perceived Storm Risk	26, 27	0-10 Ranking (Standardized to -2 to +2)	Average	-2 to +2
	28a-d	5-scale Likert (-2 to +2)		
Graphic 1 Message Compliance	29a-f	5-scale Likert (-2 to +2)	Average	-2 to +2
Graphic 1 Message Sharing	30a-f	5-scale Likert (-2 to +2)	Average	-2 to +2
Graphic 2 Perceived Storm Risk	32, 33	0-10 Ranking (Standardized to -2 to +2)	Average	-2 to +2
	34a-d	5-scale Likert (-2 to +2)		
Graphic 2 Message Compliance	35a-f	5-scale Likert (-2 to +2)	Average	-2 to +2
Graphic 2 Message Sharing	36a-f	5-scale Likert (-2 to +2)	Average	-2 to +2

The final composite variables all ranged from -2 to +2 except for flash flood experience and social media usage. A value of -2 represents individuals with a low evaluation of flood risk, a high locus of control, a low perceived storm risk, a low intended message compliance score, and a low intended message sharing score. Conversely, a value of +2 represents individuals with a high evaluation of flood risk, a low locus of control (fatalist), a high perceived storm risk, a high intended message compliance score, and a high intended message sharing score. Individuals with a score of

0 on the flash flood experience variable have had no previous experience with flash floods while an individual who scores a 7 has a high amount of flash flood experience. Finally, the social media use scale is measured on a scale from 0, no social media use, to 24, frequent, daily, and long-term social media use.

3.4.2 COMPARATIVE STATISTICS

To answer the project's three research questions and to use demographic information to explore additional relationships between the variables, comparative statistics were utilized to test for meaningful differences in participants responses after viewing graphic 1 versus graphic 2. All statistical analysis was completed in Statistical Package for Social Sciences (SPSS).

The research questions were answered by completing paired sample t-tests which determines if there was a statistically significant difference in participant responses after viewing the second graphic as compared to the first. As explained by Scharrer & Ramasubramanian (2021, p. 249), "A dependent t test is derived from the sum of the differences between groups and the sum of the differences squared between the groups in addition to the sample size." Research question 1, which investigates if including impacted locations in the enhanced version of the flash flood warning graphic will influence the public's perceived storm risk, was answered by using a paired samples t-test of the graphic 1 and graphic 2 perceived risk composite variables. Research question 2, which investigates if including impacted locations in the enhanced version of the flash flood warning graphic will influence the public's intended message compliance, was tested using a paired samples t-test of the graphic 1 and 2 message compliance composite variables. Finally, Research question 3, which investigates if including impacted locations in the enhanced version of the flash flood warning graphic will influence the public's intended message sharing, was tested using a paired samples t-test of the graphic 1 and 2 message sharing composite variables. Results were considered significant if $p < 0.05$.

While not directly answering the three research questions, additional data analysis was done to evaluate subsets of the population using the socio-demographic, flash flood experience, evaluation of flash flood risk, locus of control, and social media use information collected in section 1 of the survey. In these instances, subsets of the population were tested, again using paired samples t-tests, to see if there were meaningful differences in perceived risk, message compliance, and message sharing as a result of viewing both sample graphics. Additionally, three analysis of variance (ANOVA) tests were conducted to determine if individuals' length of time living in Columbia, their class standing at USC, and their living situation impacted their response to the graphics.

3.5 CHAPTER SUMMARY

This chapter detailed the methods for carrying out the study on the effectiveness of including impacted locations on the NWS flash flood warning social media graphic. The data collection and analysis techniques were described as well as the steps that went into producing the enhanced flash flood warning graphic. The following chapter offers a review of the results produced from the data analysis methods listed in this chapter.

CHAPTER 4

RESULTS

This chapter details the results of the survey deployed in the fall of 2022. Divided into three subsections, this chapter begins by providing basic demographic information as well as information on individual's flash flood experience, perceived risk of flash floods, locus of control, and social media usage. In section two, data is provided from responses to the survey items about perceived risk, intended message compliance, and intended message sharing that followed both graphics. This answers the three research questions. In section three, subsequent data analysis is presented to identify relationships between demographic variables and individual's responses to both graphics.

4.1 SURVEY RESPONSES AND PARTICIPANT DEMOGRAPHIC INFORMATION

In total, there were 100 responses to the survey. Of those 100, 28 responses came from students in the CIC while the remaining 72 came from students taking geography courses. Four of the responses skipped a significant portion of the survey and were subsequently removed leaving 96 usable responses.

Of these 96 completed responses, the demographic information can be seen in Table 4.1. Respondents have an average age of 20.33 (*SD* =1.60) and an age range of 18 to 27. When compared to the total university enrollment, the sample skews towards women, and upperclassman. However, the sample still is representative of the University of South Carolina campus environment (USC Institutional Research, Assessment, and Analytics, 2022).

Table 4.1 Survey participant's demographic information

	Frequency	Percentage
Gender		
Man	36	37.5%
Woman	59	61.5%
Nonbinary	1	1%
Age		
18	10	10.42%
19	16	16.67%
20	31	32.29%
21	26	27.08%
22	7	7.29%
23-27	6	6.25%
Length of Time Living in Columbia		
Less than 1 year	18	18.8%
At least 1 year but less than 2 years	15	15.6%
At least 2 years but less than 5 years	48	50%
More than 5 years	15	15.6%
Class Standing		
First-year	16	16.67%
Second-year	18	18.8%
Third-year	28	29.2%
Fourth-year	32	33.33%
Fifth-year or beyond	2	2.1%
Respondent's Place of Residence		
Live on campus alone	4	4.17%
Live on campus with roommates	21	21.88%
Live off campus alone	13	13.54%
Live off campus with roommates	55	57.29%
Live at home with family	3	3.13%
Do Respondents have Access to a Car?		
Yes	77	80.21%
No	19	19.79%

After answering demographic information items, participants answered items about their flash flood experience, evaluation of flash flood risk, locus of control (fatalism), and their social media usage. The mean flash flood experience score, on a scale from 0 (no experience) to 7 (high experience), was 3.71 (*SD* = 1.33) and ranged from 1 to 6. In other words, the average participant has a moderate amount of flash flood experience. The mean evaluation of flash flood risk score, on a scale from -2 (low risk) to +2 (high risk), was 0.01 (α = 0.87, *SD* = 0.81), indicating that the average participant views flash flooding as neither a high nor low risk, but rather right in between. However, the range from -2 to 1.83 suggests that some participants view flash flooding as carrying nearly no risk while others feel that flash floods are highly risky and hazardous. Fatalism, on a scale from -2 (high/internal locus of control) to +2 (low/external locus of control or fatalist), averaged -0.31 (α = -.12, *SD* = 0.45) meaning the average participant has a slightly internal locus of control. The range of locus of control, -1.6 to 1, indicates that there are no participants who are extremely fatalist and likely all participants believe they have some level of control over their own destiny. Finally, social media usage, measured on a scale from 0 (no social media use) to 24 (frequent, long-term use), averaged 6.05 (*SD* = 4.41) with a range from 0 to 16. The social media usage scores suggest that survey participants either don't use Twitter or Facebook frequently or have not been using them over a long period.

4.2 – RESEARCH QUESTION RESULTS

To answer the research questions, the questionnaire presented both the original and enhanced version of the flash flood warning graphic and asked participants about their perceived storm risk, their intended message compliance, and their intended message sharing after viewing each graphic. Results are presented in Table 4.2. As a reminder, all three variables are measured on a -2 to +2 scale, where -2 represents individuals with low perceived risk of the storm, no intended message compliance, and no intended message sharing. In contrast, +2 represents individuals with a high perceived risk of the storm, high intended message compliance, and high intended message sharing.

Table 4.2 Participant's perceived risk, message compliance, and message sharing scores after viewing graphic 1 (original) and graphic 2 (enhanced).

	Graphic 1 (Original)				Graphic 2 (Enhanced)			
	Mean	α	SD	Range	Mean	α	SD	Range
Perceived Risk	0.16146	0.84	0.624	-2 to 2	0.09375	0.86	0.633	-2 to 1.67
Message Compliance	0.82917	0.82	0.680	-1.83 to 2	0.82118	0.82	0.647	-1.33 to 2
Message Sharing	0.48333	0.74	0.701	-1.67 to 2	0.49826	0.79	0.718	-1.5 to 2

Participants' mean perceived risk, message compliance, and message sharing values changed little after viewing graphic 1 compared to graphic 2. However, there was a slight decrease in perceived storm risk, a slight decrease in intended message compliance, and a slight increase in intended message sharing after viewing graphic 2 compared to graphic 1. Next, the information in Table 3.2 was used to run paired samples t-tests which answered the three research questions.

4.2.1 RESEARCH QUESTION 1: PERCEIVED RISK

Research question 1 asked "to what extent does including impacted locations in NWS' flash flood warning social media graphics influence the public's perceived storm risk?" There was no significant difference in the perceived risk of the storm after viewing graphic 1 (*M* = 0.16146, *SD* = 0.624) compared to graphic 2 (*M* = 0.09375, *SD* = 0.633), *t*(95) = 1.11, *p* = 0.268. This does not support the hypothesis that including impacted locations in the social media graphic would increase an individual's perceived storm risk.

4.2.2 RESEARCH QUESTION 2: MESSSAGE COMPLIANCE

Research question two asked "to what extent does including impacted locations in NWS' flash flood warning social media graphics influence the publics' intended message compliance?" Again, there was no significant difference in intended message compliance after viewing graphic 1 (*M* = 0.82917, *SD* = 0.680) compared to graphic 2 (*M* = 0.82118, *SD* = 0.647), *t*(95) = 0.16, *p* = 0.873. It was hypothesized that including impacted locations in the graphic would increase an individual's intended message compliance. The t-test results do not support this hypothesis.

4.2.3 RESEARCH QUESTION 3: MESSAGE SHARING

Finally, research question three asked "to what extent does including impacted locations in NWS' flash flood warning social media graphics influence the publics' intended message sharing. It was hypothesized that including impacted locations in the flash flood warning graphic would increase message sharing. However, there was no significant difference in the intended message sharing after viewing graphic 1 (*M* = 0.4833, *SD* = 0.701) compared to graphic 2 (*M* = 0.49826, *SD* = 0.718), *t*(95) = -0.299, *p* = 0.765), not supporting the third hypothesis.

4.3 SUBSEQUENT ANALYSIS

While the three research questions can be answered with the three paired samples t-tests described above, additional exploratory analysis was done utilizing the demographic information as well as the flash flood experience, evaluation of flash flood risk, locus of control, and social media use collected in section 1 of the survey.

4.3.1 CORRELATION MATRIX

To begin, a bivariate correlation matrix was produced in SPSS. The matrix (Table 4.3) includes 11 variables: respondents age, flash flood experience (ff experience), evaluation of flash flood risk (eval. of flood risk), fatalism, social media usage (SM usage), and perceived storm risk, message compliance, and message sharing after viewing graphic 1 (G1) and graphic 2 (G2).

Table 4.3 Correlation matrix

Variable	n	M	SD	1	2	3	4	5	6	7	8	9	10	11
1. Age	96	20.33	1.60	—										
2. FF Experience	96	3.71	1.33	.101	—									
3. Eval. of Flood Risk	96	0.01	0.81	-.009	.067	—								
4. Fatalism	96	-0.31	0.45	-.112	.014	.090	—							
5. SM Usage	96	6.05	4.41	.071	.100	.052	.197	—						
6. G1 Perceived Risk	96	0.16	0.62	-.204*	-.046	.529**	.197	.003	—					
7. G1 Message Compliance	96	0.83	0.68	-.139	-.035	.381**	.133	.132	.516**	—				
8. G1 Message Sharing	96	0.48	0.70	-.121	-.084	.263**	.104	.001	.601**	.392**	—			
9. G2 Perceived Risk	96	0.09	0.63	-.033	0.024	.592**	.180	.025	.551**	.356**	.470**	—		
10. G2 Message Compliance	96	0.82	0.65	-.103	-.012	.433**	-.016	.110	.339**	.732**	.406**	.531**	—	
11. G2 Message Sharing	96	0.50	0.72	-.126	.038	.337**	.058	.052	.431**	.311**	.736**	.674**	.558**	—

* $p < 0.05$, **$p < 0.01$

The correlation matrix showed that participants' age significantly and negatively, correlated with graphic 1 perceived storm risk. This means that people with the original graphic perceived storm risk to be lower with older age. However, there was no such correlation with graphic 2 perceived storm risk. Additionally, the correlation matrix revealed a significant positive correlation among all six of the research question variables (G1 & G2 perceived storm risk, G1 & G2 message compliance, and G1 & G2 message sharing).

4.3.2 SAMPLE SUBSET T-TESTS

Next, demographic information was used to divide the sample into subsets. T-tests were run for those subsets of the sample to look for differences in response to graphic 1 versus 2. Few significant results were found. Those that were found to be significant are discussed below. Results of all the sample subset t-tests can be found in Appendix B.

Of all the sample subset t-tests run, the only significant difference ($p<0.05$) between responses to the first and second graphics was among participants in the highest quartile of flash flood experience (n = 27). Of those participants, there was a significant increase in intended message sharing after viewing graphic 2 (M = 0.673, SD = 0.618) compared to graphic 1 (M = 0.51234, SD = 0.515), $t(26) = -2.359$, p = 0.026.

There were a few results that were significant at a $p<0.10$ level. Among those who have lived at least 2 years in Columbia (n = 63), there was an increase in intended message sharing after viewing graphic 2 (M = 0.57937, SD = 0.679) compared to graphic 1 (M = 0.49206, SD = 0.695), $t(62) = -1.731$, p = 0.088. Among participants who scored more than 1 standard deviation above the mean in their evaluation of flash flood risk (*n* = 19), there was an increase in message sharing after viewing graphic 2 (*M* = 0.75439, *SD* = 0.731) compared to graphic 1 (*M* = 0.57895, *SD* = 0.762), *t*(18) = -1.770, *p* = 0.094. Finally, for participants who scored above the mean in locus of control (*n* = 49), there was an decrease in message compliance after viewing graphic 2 (*M* = 0.7483, *SD* = 0.686) compared to graphic 1 (*M* = 0.84694, *SD* = 0.639), *t*(48) = 1.767, *p* = 0.084.

4.3.3 ANALYSIS OF VARIANCE (ANOVA) TESTS

Finally, three analyses of variance (ANOVA) and subsequent post-hoc tests were run to investigate if participant's length of time living in Columbia, their class standing at USC, and where they live during the academic year impacted the other measured variables. For each ANOVA run, the grouping variable was participants response to item 5 (How long have you lived in the Columbia area?), item 6 (What is your class standing?), and item 7 (Where do you live during the academic year?) respectively. The dependent variables selected in the tests were flash flood experience, evaluation of flash flood risk, locus of control, social media usage, graphic 1 perceived risk, graphic 1 message compliance, graphic 1 message sharing, graphic 2 perceived risk, graphic 2 message compliance, and graphic 2 message sharing.

The first ANOVA test that was run using item 5 (length of time living in Columbia) as the grouping variable produced two significant results. There was a significant effect on participant's evaluation of flash flood risk at the $p<.05$ level based on the length of time they have lived in Columbia [$F(3, 92) = 3.078$, $p = 0.031$]. There were no significant results among the three research question variables (perceived risk, message compliance, or message sharing).

The next ANOVA test was run using item 6 (class standing) as the grouping variable and this test produced one significant result. Again, there was no significant results among the three primary variables. The post hoc test revealed no significant differences among social use between participant's specific class standing.

Finally, the third ANOVA test was run using item 7 (where participants live during the academic year) as the grouping variable. There was a significant effect on participant's flash flood experience at the $p<.05$ level based on their living arrangement during the academic year [$F(4, 91) = 2.804$, $p = 0.030$]. The post hoc test revealed that there was a significant difference in participant's flash flood experience between participants that live off campus with roommates and those that live off campus alone. There were no significant results among the three primary variables.

4.4 CHAPTER SUMMARY

This chapter presented the survey results and answered the three research questions introduced in chapter 1. The demographics of the survey participants were found to be representative of the USC campus environment. Additionally, the participants' responses revealed the inclusion of flooded locations on the flash flood warning social media graphic does not have a significant impact on individuals' perceived storm risk, intended message compliance, or intended message sharing behaviors. In the subsequent chapter, the reasoning behind these findings is discussed which may lead to directions for future research.

CHAPTER 5

DISCUSSION

The results from the survey instrument allow for the direct answer to the three research questions. The survey indicates that including impacted locations in the flash flood warning social media graphic does not modify individual's perceived storm risk, intended message compliance, or intended message sharing among students at the University of South Carolina. However, while this may be true among the entire sample, the answers are not as straightforward for some sample subsets. This chapter discusses those sample subsets and is divided into four subsections. The first three discuss each of the three variables (perceived storm risk, message compliance, and message sharing) in depth, including how those variables were impacted by participant's demographic information and the structure of the questionnaire. Finally, the last section discusses how the three variables influence each other and how participant's length of time living in Columbia and living situation impacted their responses to the questionnaire.

5.1 PERCEIVED STORM RISK

The survey results indicate that the enhanced graphic did not increase individual's perceived storm risk as compared to the original graphic. However, there were several correlations between perceived risk and individual's demographics.

To begin, age has a significant negative correlation with perceived storm risk after viewing graphic 1. This means that older individuals had a lower perceived storm risk after viewing graphic 1 than younger participants. This is consistent with previous research on the topic (Drabek, 2000). However, there was no significant correlation between age and perceived storm risk after viewing graphic 2. One reason for the discrepancy between the correlations from graphic 1 to graphic 2 may be the relatively small age range in the surveyed population (ages 18-27). Most previous research surveyed a population with a much larger age range. This could allow for comparison between college-aged students with middle-aged and elderly subsets of the population. For this reason, the current survey's population doesn't allow for a full investigation into the role of age on perceiving risk from flash flood warning social media graphics.

Evaluation of overall flash flood risk also showed a significant positive correlation with perceived storm risk both after viewing graphic 1 and 2. This makes sense, as individuals with a higher risk perception of flash floods will view a warned flash flood as riskier than those who have a lower perception of overall flash flood risk. However, the difference between the two correlations was minimal. This means that the inclusion of impacted areas on the graphic did not influence individual's perceived risk of the warned storm.

Flash flood experience was not found to correlate to individual's perceived storm risk after viewing graphic 1 or 2. This is not consistent with other research as experience with an event (such as a flash flood) has previously been shown to increase individual's perceived risk of future warned events (Drobot & Parker, 2007; Kates, 1962; Mileti & O'Brien, 1992). Part of the reason the results in this project differ from past research may be because of items that were used to quantify individual's flash flood experiences. Items such as "do you know what constitutes a flash flood" (item 9) and "most flash flood deaths occur in vehicles" (item 11) more accurately measure individual's knowledge of and familiarity with flash floods instead of experience. While it was expected that familiarity with flash flooding would increase individual's perception of future flash floods, familiarity is not the same as experiencing a flash flood event. Additionally, participants were not provided the definition of a flash flood before answering item 10 which asked, "have you ever experienced a flash flood event?" Therefore, participants may have been unsure when answering this question. This could have influenced the flash flood experience variable used in the data analysis.

Locus of control had no correlation with individual's perceived storm risk after viewing either graphic. Past research has not explicitly investigated the relationship between locus of control and perceived risk of warned storms. Rather, locus of control and perceived risk typically work in tandem to influence an individual's response to a warning. A deeper investigation into locus of control can be found in section 5.2.

Finally, social media use was not correlated with individual's perceived storm risk after viewing either graphic. Again, previous research has not investigated the relationship between these two variables. However, it was expected that individuals who use social media more frequently may be more familiar with the graphics posted by the NWS. Therefore, their risk perception of the storm may be impacted. However, it's important to note that the social media usage questions only asked about Twitter and Facebook usage. This was chosen because these are the two platforms utilized by the NWS to post flash flood warning graphics. This leads to the possibility that participants who regularly use other social media platforms may have scored low on the social media diet. As an example, one participant commented "I am much more likely to follow friends and acquaintances on something such as Instagram than Twitter because Instagram's platform allows for a better connection between people who share a local area." While this could be viewed as a weakness in the survey questionnaire, it can also be viewed as a weakness in the NWS' communication strategy. Only utilizing Facebook and Twitter for sharing warning messaging means that a share of the online public may not be exposed to warning messages. For an organization that stresses the need for people to have multiple ways to receive warnings, utilizing other social media platforms to communicate warning information would be helpful to achieving that goal.

5.2 MESSAGE COMPLIANCE

Like perceived risk, the rate of intended message sharing among participants in the project's sample did not significantly differ after viewing graphic 1 compared to graphic 2. Among all the tested subsets of the population, the results were similar. However, participant's comments reveal that that the inclusion of flooded locations was not unnoticed. One participant commented, "I would see that graphic [graphic 2] and be sure that my commute does not cross one of the dangerous areas." Another commented, "the second [graphic]…narrowed down specific areas that may be more affected than others and implied that you should avoid them." Finally, a third participant added, "Connecting the danger with known locations in the community makes things seem more severe/important, rather than just some polygon printed onto a sheet of paper by someone in an office far away."

One of the reasons that the t-test results may not reflect the theme of these comments is because of how the participants interpreted their interaction with the flash flood warning. The questionnaire told participants to answer the items as if they were "located within" the warning polygon. While the participants followed this instruction, they may have envisioned themselves either as at home or as commuting during the time that the warning was issued. One participant commented "Personally, I'm not concerned about flash floods if I'm indoors, but that would change if I were driving." While only one participant commented on this, it was likely that others had similar thought processes while answering the survey items. Out of the six items in the message compliance section, only one specifically asked participants if they would change their driving and/or travel plans because of the flash flood warning. The question (items 29d and 35d) asked participants to rate on a strongly disagree (+2) to strongly agree (-2) 5-point Likert scale their response to the statement "I would feel comfortable driving in the Columbia area." Participants average score decreased, albeit non significantly, from graphic 1 to graphic 2 indicating that the inclusion of impacted locations may discourage participants from driving during the time of the warning. The remaining five items asked participants if they would respond to the warning, not providing specifics of what they would be doing in this hypothetical scenario. While it is reasonable to believe that participants may have noted that they should avoid certain areas after viewing the second graphic but indicated that they would not responded differently to the second graphic because they were not planning on going to those impacted areas. Future research could specifically investigate participant's driving intentions after viewing the enhanced graphic.

Participant's evaluation of flash flood risk had a significant positive correlation with message compliance both after viewing graphic 1 and 2. This means that as participant's evaluation of overall flash flood risk increases, their intended message compliance after viewing both graphics increases. This confirms previous research that people with a higher risk perception respond more quickly and adaptively to flood warnings (Drabek, 2000). However, there was little difference in the correlations among graphic 1 versus graphic 2 message compliance with evaluation of flash flood risk.

Message compliance had no significant correlation with age, flash flood experience, locus of control, or social media usage. This is not consistent with past research that finds that younger people (Drabek, 2000), those with more flash flood experience (Drobot & Parker, 2007; Fritz, 1961; Mileti & O'Brien, 1992; Weick, 1969), and those with a higher/internal locus of control (Coles & Hirschboeck, 2020; Silver & Braun, 1999) are more likely to take protective action when a warning is issued. Social media use, again, has not been previously evaluated for its influence on weather warning compliance. However, the use of only Twitter and Facebook could be a reason for the lack of correlation between the two variables.

5.3 MESSAGE SHARING

As with perceived risk and message compliance, intended message sharing did not significantly differ among the entire study sample after viewing graphic 1 versus after viewing graphic 2. However, of the three variables tested, message sharing was the variable most impacted in participant's responses after viewing each graphic when dividing the sample into subsets. Individuals in the highest quartile of flash flood experience were found to significantly increase their intended message sharing after viewing graphic 2 compared to graphic 1. The survey also found that among those who lived in Columbia for at least 2 years, intended message sharing increased after viewing graphic 2 compared to graphic 1. This means that the enhanced version of the graphic had more of an impact on intended message sharing for those who have lived in the Columbia area for an extended period and those who have prior experience with flash flooding.

Participant's comments shed some insight into why message sharing is impacted by length of time living in Columbia. One participant, a fourth-year student living off campus, commented "The reason I chose neutral on the retweeting graphs question is because I genuinely don't know if I follow that many people in the Columbia area who would find the graph useful." This thinking likely impacted many participant's responses to the message sharing items as most undergraduate students only live in Columbia during the academic year. Therefore, they may not know others in the community beyond campus. So, while participants may have indicated that they would not have shared the message in this situation, they are not necessarily skipping the milling process. They may be utilizing other processes to confirm the warning message instead. Additionally, they may have shared the enhanced version of the graphic if it was for a place they were more familiar with, such as their hometown.

The correlation matrix also reveals how intended message sharing was impacted by the individual's evaluation of flash flood risk. There was a higher positive correlation between graphic 2 message sharing and evaluation of flash flood risk compared to graphic 1 message sharing and evaluation of flash flood risk. This indicates that individual's evaluation of overall flash flood risk also played a role in their responses to the message sharing items. The positive correlation between Graphic 1 message sharing and evaluation of flash flood risk reveals that individuals who view flash floods as more risky are more likely to share the current version of the graphic, consistent with past findings (Drabek, 2000). However, the inclusion of impacted locations on graphic 2 may increase the likelihood that they share the warning information as they work through the milling process.

Finally, the survey results indicated that age, flash flood experience, locus of control, and social media usage did not impact individual's intended message sharing behavior. The relationships between these variables have not been studied extensively since message sharing (the milling process) along with flash flood experience, locus of control, age, and social media use together form the basis for how a person perceives a risk. It is not expected that a higher value among any one of these variables will lead to higher values in the other variables. Rather, they all work together to influence individual's perception of the warned risk.

5.4 OTHER INFLUENCES

5.4.1 CORRELATIONS AMONG PRIMARY VARIABLES

While there were few significant correlations between demographic variables and the primary variables, all the primary variables were positively correlated at a significant level to each other. The primary variables in this section refer to six variables: graphic 1 & 2 perceived storm risk, graphic 1 & 2 message compliance, and graphic 1 & 2 message sharing. This means that individuals with a higher perceived storm risk after viewing graphic 1 were more likely to have higher indented message compliance and message sharing scores after viewing graphic 1 and higher perceived storm risk, message compliance, and message sharing scores after viewing graphic 2. This is because all six primary variables have a significant positive correlation with evaluation of overall flash flood risk. So, individuals who view flash floods as highly risky are more likely to score high on the perceived storm risk, intended message compliance and intended message sharing. Therefore, it is not unexpected that all six of the primary variables are positively correlated with each other.

5.4.2 IMPACT DUE TO LENGTH OF TIME LIVING IN COLUMBIA

In the first analysis of variants (ANOVA) test, item 5 was used as the grouping variable to determine if participant's responses to the questionnaire were impacted by the length of time that they have lived in the Columbia area. There was found to be no impact due to length of time living in Columbia on perceived risk, message compliance, and message sharing after viewing graphic 1 or 2. This doesn't mean that length of time living in Columbia had no effect on individual's responses to the questionnaire, however it means that there was no significant difference in the variables measured by the questionnaire between the four groups (one group per answer choice to question 5). As an example, t-testing revealed that those who have lived in Columbia for at least 2 years are more likely to participate in message sharing after viewing graphic 2 than after viewing graphic 1.

The ANOVA also revealed that there was a significant effect on participant's evaluation of overall flash flood risk based on the length of time they have lived in Columbia. While the post-hoc tests did not return any significant results between the four groups, this remains a significant result. Columbia sees multiple flash flood events per year. It is not surprising that length of time living in Columbia may influence an individual's perception of flash flood risk.

5.4.3 IMPACT DUE TO CLASS STANDING

The second ANOVA test assessed differences in questionnaire responses among individuals divided by their class standing at the University of South Carolina (item 6). There was no significant difference in perceived risk, message compliance, or message sharing after viewing either graphic between any of the five class standing groups. Additionally, there was no significant difference among these five groups in flash flood experience, evaluation of flash flood risk, or locus of control. Since there were no significant result when using class standing as the grouping variable, it can be concluded that length of time living in Columbia has more of an impact on individual's evaluation of flash flood risk than class standing. This likely is influenced by first and second-year students who are from Columbia and have lived in the area for a longer period than they have been a student at the university.

5.4.4 IMPACT DUE TO PARTICIPANT'S LIVING SITUATION

The final ANOVA test assessed differences in questionnaire responses among individuals divided by their living situation (item 7). There were no significant differences among individuals with different living situation in perceived risk, message compliance, or message sharing after viewing either graphic 1 or 2.

There was a significant effect on participant's flash flood experience based on their living arrangement. Specifically, the post-hoc test revealed that there was a significant difference in flash flood experience between participants that live off campus with roommates and those that live off campus by themselves. Further examination of the data revealed that participants living alone off campus have a higher flash flood experience score than those living off campus with roommates. This may be because individuals living without roommates are more likely to live close to, or in, a floodplain where house prices and rent are typically lower (Harrison et al., 2001; Shultz & Fridgen, 2001; Zhang & Leonard, 2019). Evidence of this can be found in student comments. One student who lives off campus by themselves commented, “I was actually in the indicated area (lived at YOUNion) when this flood occurred. I was out of town…but got back to see my entire building flooded, including my apartment. We got forced [to] evacuate soon after.” Another participant who also lives off campus alone commented, “The apartment that I live at has a certain area in the parking lot that will flood, and I always avoid parking there.” An additional reason that the presence of roommates may impact flash flood experience is because roommates may share past experiences with each other. Since many of the flash flood experience questions asked about familiarity with flash flood information and public safety campaigns, it is possible that roommates may have discussed these topics with each other, increasing their flash flood experience scores.

5.5 CHAPTER SUMMARY

This chapter discussed how the three research question variables were impacted by participant’s demographics, the structure of the project, and the design of the questionnaire. The variable most impacted by the addition of impacted locations on the social media graphic was intended message sharing. For those who have prior experience with flash flooding and those who have lived in Columbia for a long period of time, the inclusion of impacted locations on the graphic increased intended message sharing as compared to the original graphic. Few sample subsets indicated that their perceived storm severity or intended message compliance would be impacted by the inclusion of impacted locations on the graphic. This was likely because the survey did not specify the exact situation that the participant should imagine themselves in when taking the survey (i.e., at home or on the road driving). The next chapter concludes the thesis and offers future research directions related to findings discussed in this chapter.

CHAPTER 6

CONCLUSION

This project tested the effectiveness of an enhanced version of the National Weather Service's flash flood warning social media graphic. Quantitative results reveal that there was no significant difference in perceived risk, message compliance, or message sharing after participants viewed the enhanced version of the graphic that included points known to commonly flood compared to the original graphic. However, several participant comments suggest that they would take additional protective actions, especially as it pertains to travel decisions, after viewing the enhanced graphic compared to the original.

The project's structure was not without weaknesses. To begin, the survey's population was undergraduate students. While this demographic is more likely than others to utilize social media to gather information during times of crisis, it is not the only demographic that is doing so. Additionally, students may be less familiar with the locations added to the enhanced graphic's map because many of them are not full-time residents of Columbia. Further research is necessary to understand how the inclusion of these impacted locations would impact protective action decision making of non-student, full-time, Columbia residents or full-time residents of other locations.

Another weakness of this project is that all participants viewed both graphics within a few minutes of each other and answered the same items about perceived storm risk, message compliance, and message sharing after viewing each graphic. This may have meant that participants' responses to items after viewing the second graphic were influenced by comparing the second graphic to the first instead of their reaction to the second graphic only. Since the two graphics were similar, participants may have decided to not change their responses from the first graphic to the second. Other similar studies typically use comparison groups (Scharrer & Ramasubramanian, 2021, p. 131) where one graphic is shown to half of the sample and the other graphic to the other half of the sample. This doesn't allow for participants to compare the two graphics and instead measures only how participants would react to the graphic they are shown. While it was hypothesized that the two graphics tested in this project differed enough for there to be significant differences in participants' reactions, the results suggest that they are too similar and should have been tested using comparison groups. Future research could use a similar graphic and this technique, with perhaps some alterations in color schemes and formatting.

Future work could also change some of the items in the flash flood experience and intended message sharing sections. As mentioned in chapter 5, the flash flood experience items more accurately reflect individual's flash flood familiarity. While the flash flood experience score was utilized in the project's data analysis, future research could ask the participants more specific items about their flash flood experiences. It would be expected that participants who have more flash flood experience would be more likely to take protective action when prompted with a warning message than those who only have knowledge of or familiarity with flash floods but no experience.

Additionally, the message compliance items may not have accurately reflected individual's intended action after viewing the graphic. One of the primary goals of a flash flood warning is to discourage people from driving into flooded roadways. For this reason, individuals would have answered the intended message compliance items differently based on whether they intended to drive during the time of the warning. Future work on flash flood warning social media graphics should prompt individuals to answer message compliance questions as if they are located within the warning polygon and are planning to drive during the time of the warning. This would reduce participant uncertainty in how to answer the message compliance items.

It is also important to note that individuals were only able to answer the survey items about the enhanced graphic in this project. Future projects may use think-aloud methods, such as was used by Sutton and Fischer (2021), to explore people's reactions to viewing the enhanced graphic. In these projects, participants are presented with a graphic in a lab setting and they are "audio recorded while they verbally describe the features of the message that they attend to" (Sutton & Fischer, 2021, p. 182). This would allow participants to voice their feelings about the graphic and questions they may have about the message that the graphic is trying to convey. This would be a necessary step before implementing this graphic into NWS operations.

Finally, this project focused only on the flash flood warning graphic. However, the NWS sometimes utilizes similar graphics for other flood-related watches, warnings, and advisories (such as an areal flood advisory or river flood warning). Additional work is required to determine how to best communicate the hazards associated with those watch/warning/advisory products and how to differentiate them from flash flood warnings.

To conclude, the enhanced version of the flash flood warning social media graphic was not found to increase individual's perceived storm risk, message compliance, or message sharing compared to the original graphic. However, as the number of yearly deaths associated with flash floods continues to stay relatively high, the need continues to improve flash flood warning communication. The science behind what causes flash floods is well understood. National Weather Service meteorologists have many tools at their disposal to monitor rivers, streams, and low-lying urban areas to issue timely warnings. However, the link between meteorologists' situational awareness and the public's decision-making process lies in the NWS' communication of the warnings. This communication process must continue to evolve as society increasingly moves towards online information consumption.

REFERENCES

Ash, K. D., Schumann, R. L., & Bowser, G. C. (2014). Tornado Warning Trade-Offs: Evaluating Choices for Visually Communicating Risk. *Weather, Climate, and Society*, *6*(1), 104–118. https://doi.org/10.1175/WCAS-D-13-00021.1

Ashley, S. T., & Ashley, W. S. (2008). Flood Fatalities in the United States. *Journal of Applied Meteorology and Climatology*, *47*(3), 805–818. https://doi.org/10.1175/2007JAMC1611.1

Barett, A. K., & Posey, C. (2019). Organizational Crisis Communication in the Age of Social Media. In K. K. Stephens (Ed.), *New Media in Times of Crisis* (pp. 15–41). Routledge.

Barnes, L. (2006, July). *False Alarms: Warning Project Research Findings & Warning Accuracy Conceptual Model*. WAS*IS. http://www.sip.ucar.edu/wasis/boulder06/ppt/False%20alarms%20-%20Barnes.ppt.

Barnett, J., & Breakwell, G. M. (2001). Risk Perception and Experience: Hazard Personality Profiles and Individual Differences. *Risk Analysis*, *21*(1), 171–178. https://doi.org/10.1111/0272-4332.211099

Bateman, J., & Edwards, B. (2002). Gender and Evacuation: A Closer Look at Why Women Are More Likely to Evacuate for Hurricanes. *Natural Hazards Review*, *3*(3), 107–117. https://doi.org/10.1061/(ASCE)1527-6988(2002)3:3(107)

Berz, G., Kron, W., Loster, T., Rauch, E., Schimetschek, J., Schmieder, J., Siebert, A., Smolka, A., & Wirtz, A. (2001). *World Map of Natural Hazards-A Global View of the Distribution and Intensity of Significant Exposures*. *23*, 443–465. https://doi.org/10.1023/A:1011193724026

Botzen, W. J. W., Aerts, J. C. J. H., & van den Bergh, J. C. J. M. (2009). Dependence of flood risk perceptions on socioeconomic and objective risk factors. *Water Resources Research*, *45*(10). https://doi.org/10.1029/2009WR007743

Bowman, N. D., Westerman, D. K., & Claus, C. J. (2012). How demanding is social media: Understanding social media diets as a function of perceived costs and benefits – A rational actor perspective. *Computers in Human Behavior*, *28*(6), 2298–2305. https://doi.org/10.1016/j.chb.2012.06.037

Casteel, M. A., & Downing, J. R. (2016). Assessing Risk Following a Wireless Emergency Alert: Are 90 Characters Enough? *Journal of Homeland Security and Emergency Management*, *13*(1), 95–112. https://doi.org/10.1515/jhsem-2015-0024

Coles, A. R., & Hirschboeck, K. K. (2020). Driving into Danger: Perception and Communication of Flash-Flood Risk. *Weather, Climate, and Society*, *12*(3), 387–404. https://doi.org/10.1175/WCAS-D-19-0082.1

Creutin, J. D., Borga, M., Gruntfest, E., Lutoff, C., Zoccatelli, D., & Ruin, I. (2013). A space and time framework for analyzing human anticipation of flash floods. *Journal of Hydrology*, *482*, 14–24. https://doi.org/10.1016/j.jhydrol.2012.11.009

Doswell III, C. A., Brooks, H. E., & Maddox, R. A. (1996). Flash Flood Forecasting: An Ingredients-Based Methodology. *Weather and Forecasting*, *11*(4), 560–581. https://doi.org/10.1175/1520-0434(1996)011%3C0560:FFFAIB%3E2.0.CO;2

Dow, K., & Cutter, S. L. (1998). Crying wolf: Repeat responses to hurricane evacuation orders. *Coastal Management*, *26*(4), 237–252. https://doi.org/10.1080/08920759809362356

Downing, T. E. (1977). *Warning for flash floods in Boulder, Colorado*. University of Colorado. http://hdl.handle.net/2027/uiug.30112049689596

Drabek, T. E. (2000). The Social Factors that Constrain Human Responses to Flood Warnings. In D. J. Parker (Ed.), *Floods* (Vol. 1, pp. 361–376). Routledge.

Drobot, S. D., Benight, C., & Gruntfest, E. C. (2007). Risk factors for driving into flooded roads. *Environmental Hazards*, *7*, 227–234. https://doi.org/10.1016/j.envhaz.2007.07.003

Drobot, S., & Parker, D. J. (2007). Advances and challenges in flash flood warnings. *Environmental Hazards*, *7*, 173–178. https://doi.org/10.1016/j.envhaz.2007.09.001

Endsley, T., Wu, Y., & Reep, J. (2014). The Source of the Story: Evaluating the Credibility of Crisis Information Sources. *ISCRAM 2014 Conference Proceedings – 11th International Conference on Information Systems for Crisis Response and Management*.

Erickson, M. J., Albright, B., & Nelson, J. A. (2021). Verifying and redefining the weather prediction center's excessive rainfall outlook forecast product. *Weather and Forecasting*, *36*(1), 325–340. https://doi.org/10.1175/WAF-D-20-0020.1

Fischer, L., Huntsman, D., Orton, G., & Sutton, J. (2023). You Have to Send the Right Message: Examining the Influence of Protective Action Guidance on Message Perception Outcomes across Prior Hazard Warning Experience to Three Hazards.

Weather, Climate, and Society, *1*(aop). https://doi.org/10.1175/WCAS-D-22-0092.1

French, J. G., & Holt, K. W. (1989). Floods. In M. B. Gregg (Ed.), *The Public Health Consequences of Disasters 1989* (pp. 69–78). U.S. Department of Health and Human Services.

Fritz, C. E. (1961). Disaster. In R. K. Merton & R. A. Nisbet (Eds.), *Contemporary Social Problems* (pp. 631–694). Harcourt, Brace & World, INC.

Gruntfest, E., & Ripps, A. (2000). Warning and Mitigation Efforts and Prospects. In Parker D. J. (Ed.), *Floods* (Vol. 1, pp. 377–390). Routledge.

Harrison, D., T. Smersh, G., & Schwartz, A. (2001). Environmental Determinants of Housing Prices: The Impact of Flood Zone Status. *Journal of Real Estate Research*, *21*(1–2), 3–20. https://doi.org/10.1080/10835547.2001.12091045

Iowa Environmental Mesonet. (2022, July 4). *July 4 Flash Flood Warning, Richland County, SC*. Iowa State University. https://mesonet.agron.iastate.edu/vtec/#2022-O-NEW-KCAE-FF-W-0010/USCOMP-N0Q-202207080030

Jin, Y., Fisher Liu, B., & Austin, L. L. (2014). Examining the Role of Social Media in Effective Crisis Management: The Effects of Crisis Origin, Information Form, and Source on Publics' Crisis Responses. *Communication Research*, *41*(1), 74–94. https://doi.org/10.1177/0093650211423918

Kates, R. W. (1962). *Hazard and choice perception in flood plain management.* Chicago. http://hdl.handle.net/2027/uc1.31210023540931

Kellens, W., Zaalberg, R., Neutens, T., Vanneuville, W., & De Maeyer, P. (2011). An Analysis of the Public Perception of Flood Risk on the Belgian Coast. *Risk Analysis*, *31*(7), 1055–1068. https://doi.org/10.1111/j.1539-6924.2010.01571.x

Kox, T., & Thieken, A. H. (2017). To Act or Not To Act? Factors Influencing the General Public's Decision about Whether to Take Protective Action against Severe Weather. *Weather, Climate, and Society*, *9*(2), 299–315. https://doi.org/10.1175/WCAS-D-15-0078.1

Krocak, M., Ernst, S. R., Ripberger, J., Fox, A., Jenkins-Smith, H., & Silva, C. (2023, January 9). A Misunderstood Hazard? Public Understanding of Severe Thunderstorm Warning Criteria and Issuance Rates. *Communicating Risk: Public Perceptions & Interpretations*. 103rd Annual Meeting of the American Meteorological Society, Denver, CO.

Lindell, M. K., & Perry, R. W. (2012). The Protective Action Decision Model: Theoretical Modifications and Additional Evidence. *Risk Analysis*, *32*(4), 616–632. https://doi.org/10.1111/j.1539-6924.2011.01647.x

Liu, B. F., Wood, M. M., Egnoto, M., Bean, H., Sutton, J., Mileti, D., & Madden, S. (2017). Is a picture worth a thousand words? The effects of maps and warning messages on how publics respond to disaster information. *Public Relations Review, 43*(3), 493–506. https://doi.org/10.1016/j.pubrev.2017.04.004

Mileti, D. S., & O'Brien, P. W. (1992). Warnings During Disaster: Normalizing Communicated Risk. *Social Problems*, *39*(1), 40–57. https://doi.org/10.1525/sp.1992.39.1.03x0062j

Mileti, D. S., & Sorensen, J. H. (1990). *Communication of emergency public warnings: A social science perspective and state-of-the-art assessment*. Oakridge National Laboratory. https://www.osti.gov/servlets/purl/6137387

Murthy, D. (2018). *Twitter: Social Communication in the Twitter age*. Policy Press.

NWS. (n.d.-a). *About the NWS*. Retrieved April 5, 2022, from https://www.weather.gov/about/#:~:text=NWS%20Mission,enhancement%20of%20the%20national%20economy.

NWS. (n.d.-b). *Definitions, Thresholds, Criteria for Warnings, Watches and Advisories*.

NWS. (n.d.-c). *Flood Products—What Do They Mean?* Retrieved March 31, 2022, from https://www.weather.gov/bmx/outreach_flw

NWS. (n.d.-d). *National Weather Service Glossary*. National Weather Service. Retrieved February 27, 2023, from https://w1.weather.gov/glossary/

NWS. (2007). *National Weather Service Storm Based Warnings*. National Weather Service.

NWS. (2016, March 10). *South Carolina Severe Weather & Flood Safety Awareness Week: March 6-12, 2016*.

Olson, M. K., Sutton, J., Vos, S. C., Prestley, R., Renshaw, S. L., & Butts, C. T. (2019). Build community before the storm: The National Weather Service's social media engagement. *Journal of Contingencies and Crisis Management*, *27*(4), 359–373. https://doi.org/10.1111/1468-5973.12267

Perreault, M. F., Houston, J. B., & Wilkins, L. (2014). Does Scary Matter?: Testing the Effectiveness of New National Weather Service Tornado Warning Messages. *Communication Studies*, *65*(5), 484–499. https://doi.org/10.1080/10510974.2014.956942

Quarantelli, E. L. (1990). *The Warning Process and Evacuation Behavior: The Research Evidence*. University of Delaware.

Ripberger, J. T., Silva, C. L., Jenkins-Smith, H. C., & James, M. (2015). The Influence of Consequence-Based Messages on Public Responses to Tornado Warnings.

Bulletin of the American Meteorological Society, *96*(4), 577–590. https://doi.org/10.1175/BAMS-D-13-00213.1

Scharrer, E., & Ramasubramanian, S. (2021). *Quantitative Research Methods in Communication: The Power of Numbers for Social Justice*. Routledge.

Sherman-Morris, K., Poe, P. S., Nunley, C., & Morris, J. A. (2020). Perceived Risk, Protective Actions and the Parasocial Relationship With the Local Weathercaster: A Case Study of Hurricane Irma. *Southeastern Geographer*, *60*(1), 23–47.

Shultz, S. D., & Fridgen, P. M. (2001). Floodplains and Housing Values: Implications for Flood Mitigation Projects1. *JAWRA Journal of the American Water Resources Association*, *37*(3), 595–603. https://doi.org/10.1111/j.1752-1688.2001.tb05496.x

Silver, N. C., & Braun, C. C. (1999). Behavior. In M. S. Wogalter, K. DeJoy, & K. R. Laughery (Eds.), *Warnings and Risk Communication* (pp. 239–255). Taylor & Francsis.

Simon, T., Goldberg, A., & Adini, B. (2015). Socializing in emergencies—A review of the use of social media in emergency situations. *International Journal of Information Management*, *35*(5), 609–619. https://doi.org/10.1016/j.ijinfomgt.2015.07.001

Slovic, P. (2000). Perception of Risk. In P. Slovic (Ed.), *The Perception of Risk* (pp. 220–231). Earthscan.

Slovic, P., Finucane, M., Peters, E., & Macgregor, D. G. (2002). Rational actors or rational fools: Implications of the affect heuristic for behavioral economics. *Journal of Socio-Economics*, *31*, 329–342.

Smith, W. R., W. Robertson, B., K. Stephens, K., & Murthy, D. (2021). A different type of disaster response digital volunteer: Looking behind the scenes to reveal coordinating actions of disaster knowledge workers. *Journal of Contingencies and Crisis Management*, *29*(2), 116–130. https://doi.org/10.1111/1468-5973.12352

Stokes, C., & Senkbeil, J. C. (2017). Facebook and Twitter, communication and shelter, and the 2011 Tuscaloosa tornado. *Disasters*, *41*(1), 194–208. https://doi.org/10.1111/disa.12192

Sutton, J., & Fischer, L. M. (2021). Understanding Visual Risk Communication Messages: An Analysis of Visual Attention Allocation and Think-Aloud Responses to Tornado Graphics. *Weather, Climate, and Society*, *13*(1), 173–188. https://doi.org/10.1175/WCAS-D-20-0042.1

Sutton, J., Palen, L., & Shklovski, I. (2008). Backchannels on the Front Lines: Emergent Uses of Social Media in the 2007 Southern California Wildfires. *Proceedings of ISCRAM 2008 – 5th International Conference on Information Systems for Crisis Response and Management*.

Terti, G., Ruin, I., Anquetin, S., & Gourley, J. J. (2017). A Situation-Based Analysis of Flash Flood Fatalities in the United States. *Bulletin of the American Meteorological Society*, *98*(2), 333–345. https://doi.org/10.1175/BAMS-D-15-00276.1

Trainor, J. E., Nagele, D., Philips, B., & Scott, B. (2015). Tornadoes, Social Science, and the False Alarm Effect. *Weather, Climate, and Society*, *7*(4), 333–352. https://doi.org/10.1175/WCAS-D-14-00052.1

Turner, R., & Killian, L. (1957). *Collective Behavior* (1st ed.). Prentice-Hall, INC.

Turner, R., & Killian, L. (1972). *Collective Behavior* (2nd ed.). Prentice-Hall, INC.

Tversky, A., & Kahneman, D. (1973). Availability: A Heuristic for Judging Frequency and Probability. *Cognitive Psychology*, *5*, 207–232. https://doi.org/10.1016/0010-0285(73)90033-9

USC Institutional Research, Assessment, and Analytics. (2022, September). *Enrollment Overview Dashboard*. University of South Carolina. https://sc.edu/about/offices_and_divisions/institutional_research_assessment_and_analytics/uofsc_data_dashboards/enrollment/overview.php

Weick, K. E. (1969). *The Social Psychology of Organizing*. Addison-Wesley.

Wood, M. M., Mileti, D. S., Bean, H., Liu, B. F., Sutton, J., & Madden, S. (2018). Milling and Public Warnings: *Environment and Behavior*. https://doi.org/10.1177/0013916517709561

Zhang, L., & Leonard, T. (2019). Flood Hazards Impact on Neighborhood House Prices. *The Journal of Real Estate Finance and Economics*, *58*(4), 656–674. https://doi.org/10.1007/s11146-018-9664-1

APPENDIX A

SURVEY QUESTIONNAIRE

Table A.1 Survey demographic questions.

Item #	Item	Answer Choices
1	Do you consent to participate in the study?	Yes, No
2	Are you a current student at the University of South Carolina?	Yes, No
3	What is your age?	Open Ended
4	To which gender do you identify?	Women, Man, Nonbinary, Intersex, Prefer not to say, Other (please specify)
5	How long have you lived in the Columbia area (including as a student at UofSC)?	Less than 1 year, At least 1 year but less than 2 years, At least 2 years but less than 5 years, More than 5 years
6	What is your class standing?	First-year, Second-year, Third-year, Fourth-year, Fifth-year or beyond, Non-degree seeking
7	Where do you live during the academic year?	Live off-campus (eg. dorm room) alone, Live off-campus (eg. dorm room) with roommates, Live off-campus (within 20 miles of the university) alone, Live off-campus (within 20 miles of the university) with roommates, Live at home with family, Other (please specify)
8	Do you have a car where you live during the academic year?	Yes, No

Table A.2 Items used to measure flash flood experience with coded responses in parentheses.

Item #	Item	Answer Choices
9	Do you know what constitutes a flash flood?	Yes (1), No (0)
10	Have you ever experienced a flash flood?	Yes (1), No (0)
11	Most flash flood deaths occur in vehicles.	True (1), False (0)
12	Are you familiar with the National Weather Service's public service announcement "Turn around don't drown"?	Yes (1), No (0), Unsure (0)
13	In the past 5 years, have you heard/read any public safety information on how to respond to a flash flood warning?	Yes (1), No (0), Unsure (0)
14	Flash floods only occur near rivers and streams.	True (1), False (0)
15	How many inches of flowing water can cause loss of control and potential stalling of a vehicle?	1 inch (0), 6 inches (1), 1 foot (0), 2 feet (0), Unsure (0)

Table A.3 Items used to measure evaluation of flash flood risk with coded responses in parentheses.

Item #	Item	Answer Choices
16a	I am worried about the danger of flash flooding in the Columbia Area.	5-Point Likert (Strongly Disagree (-2), Disagree (-1), Neither agree nor disagree (0), Agree (1), Disagree (2))
16b	When there is severe weather in my area that could result in flash flooding, I worry I will suffer injury or death.	
16c*	I do **not** worry about flash floods in the Columbia area.	
16d	I am fearful when a flash flood warning is issued in the Columbia area.	
16e*	I am **not** concerned about flash flooding in my area.	
17	What do you feel in the risk of a flash flood occurring in the Columbia area?	No Risk (-2), Slight Risk (-1), Moderate Risk (0), High Risk (1), Extreme Risk (2)

* Items reverse coded

Table A.4 Items used to measure locus of control/fatalism with coded responses in parentheses.

Item #	**Item**	**Answer Choices**
18a	My fate in life is determined mostly by chance.	5-Point Likert (Strongly Disagree (-2), Disagree (-1), Neither agree nor disagree (0), Agree (1), Disagree (2))
18b	Life is unpredictable and I have little control.	
18c	I have to live life by lots of rules, but I don’t get to make them.	
18d*	It is up to me to inform myself independently and in time about imminent severe weather threats.	
18e	When a flash flood threatens me, the outcome is in God’s hands.	

* Items reverse coded

Table A.5 Items used to measure social media use with coded responses in parentheses.

Item #	Item	Answer Choices
19	How often do you use Twitter	Never (0), A few times a month (1), Multiple times a week (2), Every day (3)
20	When using Twitter, how many times a day do you check it?	None (0), 1-5 times a day (1), 6-10 times a day (2), 11-20 times a day (3), 21-30 times a day (4), More than 30 times a day (5)
21	How long have you used Twitter?	Less than 1 year (1), 1 to 3 years (2), 4 to 5 years (3), More than 5 years (4), I don’t use Twitter (0)
22	How often do you use Facebook?	Never (0), A few times a month (1), Multiple times a week (2), Every day (3)
23	When using Facebook, how many times a day do you check it?	None (0), 1-5 times a day (1), 6-10 times a day (2), 11-20 times a day (3), 21-30 times a day (4), More than 30 times a day (5)
24	How long have you used Facebook?	Less than 1 year (1), 1 to 3 years (2), 4 to 5 years (3), More than 5 years (4), I don’t use Facebook (0)

Table A.6 Items 25 and 31.

Item #	Item	Answer Choices
25, 31	Do you feel you understand what the graphic is warning you about?	Yes, No

Table A.7 Items used to measure perceived storm risk with coded responses in parentheses.

Item #	Item	Answer Choices
26, 32	How would you rate your perceived severity of the storm on a scale from 0 (no danger) to 10 (extremely violent, damaging storm)?	0-10 Scale (integers only)
27, 33	How would you rate the risk/danger level to humans associated with the storm on a scale from 0 (no danger) to 10 (extreme danger)?	
28a, 34a	I would feel concerned for my safety.	5-Point Likert (Strongly Disagree (-2), Disagree (-1), Neither agree nor disagree (0), Agree (1), Disagree (2))
28b, 34b	I would feel worried about the danger of flash flooding in the Columbia area.	
28c, 34b	I would feel as though I may suffer injury or death.	
28d, 34c	I would worry that others under the warning may be in danger	

Table A.8 Items used to measure intended message compliance with coded responses in parentheses.

Item #	Item	Answer Choices
29a, 35a	I would comply with the directed action.	5-Point Likert (Strongly Disagree (-2), Disagree (-1), Neither agree nor disagree (0), Agree (1), Disagree (2))
29b, 35b	I feel confident that taking directed action would increase my safety.	
29c, 35c	I would be prepared to respond to the flash flood warning.	
29d*, 35d*	I would feel comfortable driving in the Columbia area.	
29e, 35e	I would feel as though I should avoid areas in Columbia because of this storm.	
29f*, 35e*	I would ignore the message and do nothing.	

* Items reverse coded

Table A.9 Items used to measure intended message sharing with coded responses in parentheses.

Item #	Item	Answer Choices
30a36a	I would tell other people about the flash flood warning.	5-Point Likert (Strongly Disagree (-2), Disagree (-1), Neither agree nor disagree (0), Agree (1), Disagree (2))
30b, 36b	I would retweet/repost the warning graphic.	
30c, 36c	I would share the information with someone in the affected area.	
30d, 36d	I would search for additional information about the flash flood warning.	
30e, 36e	I would look outside at the current conditions before deciding how to react to the warning.	
30f, 36f	I would ask friends/family who are also in the warned area about how they plant to respond before deciding how to respond myself.	

Table A.10 Item 37.

Item #	Item	Answer Choices
37	Do you have any other comments to share?	Open ended

APPENDIX B

SAMPLE SUBSET T-TEST RESULTS

B.1 RESULTS BY GENDER

Table B.1 Average primary variable values and paired sample t-test results subdivided by gender. Graphic 1 represents the original NWS graphic while graphic 2 represents the enhanced graphic. For the paired variables, -2 indicates individuals with a low perceived risk, no intended message compliance, and no intended message sharing. +2 indicates individuals with a high perceived risk, high intended message compliance, and high intended message sharing. P-values are generated from running a paired samples t-test comparing individual's results after viewing graphic 1 compared to graphic 2.

	Women (n = 59)			Men (n = 36)		
	Graphic 1	P-Value	Graphic 2	Graphic 1	P-Value	Graphic 2
Perceived Risk	0.19209	0.851	0.17797	0.08333	0.180	-0.06019
Message Compliance	0.88983	0.860	0.90113	0.70185	0.336	0.66667
Message Sharing	0.57910	0.279	0.63842	0.29352	0.282	0.23611

B.2 RESULTS BY LENGTH OF TIME LIVING IN COLUMBIA

Table B.2 Average primary variable values and paired sample t-test results subdivided by length of time living in Columbia. Graphic 1 represents the original NWS graphic while graphic 2 represents the enhanced graphic. For the paired variables, -2 indicates individuals with a low perceived risk, no intended message compliance, and no intended message sharing. +2 indicates individuals with a high perceived risk, high intended message compliance, and high intended message sharing. P-values are generated from running a paired samples t-test comparing individual's results after viewing graphic 1 compared to graphic 2.

	At least 2 years (n = 63)			Less than 2 years (n = 33)		
	Graphic 1	P-Value	Graphic 2	Graphic 1	P-Value	Graphic 2
Perceived Risk	0.19577	0.936	0.20106	0.09596	0.099*	-0.11111
Message Compliance	0.90899	0.541	0.94444	0.67677	0.338	0.58586
Message Sharing	0.49206	0.088*	0.57937	0.46667	0.252	0.34343
	More than 5 years (n = 15)					
	Graphic 1	P-Value	Graphic 2			
Perceived Risk	0.38888	0.401	0.30000			
Message Compliance	0.96667	0.717	0.92222			
Message Sharing	0.53333	0.199	0.64444			

* $p < 0.10$

B.3 RESULTS BY AMOUNT OF FLASH FLOOD EXPERIENCE

Table B.3 Average primary variable values and paired sample t-test results subdivided by flash flood experience scores. Graphic 1 represents the original NWS graphic while graphic 2 represents the enhanced graphic. The average flash flood experience value, on a 0-7 scale, is 3.71. For the paired variables, -2 indicates individuals with a low perceived risk, no intended message compliance, and no intended message sharing. +2 indicates individuals with a high perceived risk, high intended message compliance, and high intended message sharing. P-values are generated from running a paired samples t-test comparing individual's results after viewing graphic 1 compared to graphic 2.

	Above average FF Experience (>3.71) (n = 54)			Below Average FF Experience (<3.71) (n = 42)		
	Graphic 1	P-Value	Graphic 2	Graphic 1	P-Value	Graphic 2
Perceived Risk	0.01234	0.394	0.06481	0.21032	0.469	0.13095
Message Compliance	0.79321	0.816	0.80864	0.87540	0.619	0.83730
Message Sharing	0.4444	0.095*	0.53704	0.5333	0.343	0.44841
	Highest quartile FF Experience (>=5) (n = 27)			Lowest quartile FF Experience (<=3) (n = 42)		
	Graphic 1	P-Value	Graphic 2	Graphic 1	P-Value	Graphic 2
Perceived Risk	0.11728	0.464	0.18519	0.21032	0.469	0.13095
Message Compliance	0.83333	0.610	0.88272	0.87540	0.619	0.83730
Message Sharing	**0.51234**	**0.026****	**0.67284**	0.53333	0.343	0.44841
	Above 1 SD from FF Experience Mean (>5.04) (n = 10)			Below 1 SD from FF Experience Mean (<2.38) (n = 19)		
	Graphic 1	P-Value	Graphic 2	Graphic 1	P-Value	Graphic 2
Perceived Risk	0.05	0.387	0.18333	0.13158	0.783	0.08772
Message Compliance	0.8	0.678	0.86667	0.95262	0.970	0.95614
Message Sharing	0.5	0.309	0.56667	0.66140	0.283	0.61404

**** p < 0.05** * p < 0.10

B.4 EVALUATION OF FLASH FLOOD RISK

Table B.4 Average primary variable values and paired sample t-test results subdivided by evaluation of flash flood risk scores. Graphic 1 represents the original NWS graphic while graphic 2 represents the enhanced graphic. The average flash flood risk value, on a -2 to +2 scale, is 0.00521. For the paired variables, -2 indicates individuals with a low perceived risk, no intended message compliance, and no intended message sharing. +2 indicates individuals with a high perceived risk, high intended message compliance, and high intended message sharing. P-values are generated from running a paired samples t-test comparing individual's results after viewing graphic 1 compared to graphic 2.

	Above Average Flood Risk (>=0.00521) (n = 50)			Below Average Flood Risk (<0.00521) (n = 46)		
	Graphic 1	P-Value	Graphic 2	Graphic 1	P-Value	Graphic 2
Perceived Risk	0.42000	0.338	0.34667	-0.11957	0.530	-0.18116
Message Compliance	1.00000	0.964	0.99667	0.64348	0.846	0.63043
Message Sharing	0.66000	0.609	0.69667	0.29130	0.902	0.28261
	Highest Quartile Flood Risk (>=0.5) (n = 31)			Lowest Quartile Flood Risk (<=-0.625) (n = 24)		
	Graphic 1	P-Value	Graphic 2	Graphic 1	P-Value	Graphic 2
Perceived Risk	0.43548	0.476	0.36022	-0.2222	0.163	-0.45139
Message Compliance	1.06989	0.740	1.03763	0.54861	0.516	0.47917
Message Sharing	0.56989	0.602	0.62366	0.29444	0.346	0.21528
	Above 1 SD from Flash Flood Risk Mean (>0.82) (n = 19)			Below 1 SD from Flash Flood Risk Mean (<-0.81) (n = 20)		
	Graphic 1	P-Value	Graphic 2	Graphic 1	P-Value	Graphic 2
Perceived Risk	0.44737	0.395	0.53509	-0.291667	0.344	-0.46667
Message Compliance	1.08772	0.493	1.16667	0.51667	0.639	0.45833
Message Sharing	0.57895	0.094*	0.75439	0.23667	0.434	0.15833

* $p < 0.10$

B.5 FATALISM/LOCUS OF CONTROL

Table B.5 Average primary variable values and paired sample t-test results subdivided by locus of control scores. Graphic 1 represents the original NWS graphic while graphic 2 represents the enhanced graphic. The average fatalism value, on a -2 (high locus of control) to +2 (low locus of control/fatalist) scale is 0.31458. For the paired variables, -2 indicates individuals with a low perceived risk, no intended message compliance, and no intended message sharing. +2 indicates individuals with a high perceived risk, high intended message compliance, and high intended message sharing. P-values are generated from running a paired samples t-test comparing individual's results after viewing graphic 1 compared to graphic 2.

	Above Avg Locus of Control (<= -0.31458) (n = 47)			Below Avg Locus of Control (>= -0.31458) (n = 49)		
	Graphic 1	P-Value	Graphic 2	Graphic 1	P-Value	Graphic 2
Perceived Risk	0.09220	0.870	0.07801	0.22789	0.172	0.10884
Message Compliance	0.81064	0.295	0.89716	0.84694	0.084*	0.74830
Message Sharing	0.49787	0.664	0.53191	0.46939	0.958	0.46599
	Highest quartile Locus of Control (<= -0.6) (n = 34)			Lowest quartile Locus of Control (>= 0) (n = 33)		
	Graphic 1	P-Value	Graphic 2	Graphic 1	P-Value	Graphic 2
Perceived Risk	0.02941	0.700	-0.01471	0.30808	0.334	0.19697
Message Compliance	0.77745	0.406	0.86765	0.87879	0.197	0.78283
Message Sharing	0.52157	0.678	0.48039	0.50000	0.364	0.57071
	Above 1 SD from Locus of Control Mean (>0.14) (n = 15)			Below 1 SD from locus of control Mean (<-0.77) (n = 20)		
	Graphic 1	P-Value	Graphic 1	P-Value	Graphic 1	P-Value
Perceived Risk	0.35556	0.954	0.34444	-0.025	0.697	-0.075
Message Compliance	0.97778	0.153	0.77778	0.76333	0.489	0.85833
Message Sharing	0.47778	0.672	0.54444	0.345	0.735	0.38333

* $p < 0.10$

B.6 SOCIAL MEDIA USE

Table B.6 Average primary variable values and paired sample t-test results subdivided by social media use scores. Graphic 1 represents the original NWS graphic while graphic 2 represents the enhanced graphic. The average social media diet score, on a 0 (virtually no social media use) to 24 (frequent, daily, long-term social media use) scale is 6.05. For the paired variables, -2 indicates individuals with a low perceived risk, no intended message compliance, and no intended message sharing. +2 indicates individuals with a high perceived risk, high intended message compliance, and high intended message sharing. P-values are generated from running a paired samples t-test comparing individual's results after viewing graphic 1 compared to graphic 2.

	Above Average SM Use (> 6.05) (n = 39)			Below Average SM Use (<6.05) (n = 57)		
	Graphic 1	P-Value	Graphic 2	Graphic 1	P-Value	Graphic 2
Perceived Risk	0.09402	0.873	0.10684	0.20760	0.161	0.08480
Message Compliance	0.89145	0.966	0.88889	0.78655	0.874	0.77485
Message Sharing	0.41453	0.295	0.49145	0.53041	0.687	0.50292
	Lowest quartile SM Use (<= 3) (n = 27)			Highest Quartile SM Use (>=9) (n = 28)		
	Graphic 1	P-Value	Graphic 2	Graphic 1	P-Value	Graphic 2
Perceived Risk	0.07407	0.630	0.01851	0.18452	0.902	0.17261
Message Compliance	0.67901	0.819	0.70370	0.91071	0.872	0.92262
Message Sharing	0.41605	0.965	0.41975	0.42857	0.178	0.54167
	Above 1 SD from Social Media Use Mean (>10.47) (n = 17)			Below 1 SD from Social Media Use Mean (>1.64)		
	Graphic 1	P-Value	Graphic 2	Graphic 1	P-Value	Graphic 2
Perceived Risk	0.17647	0.583	0.09804	0.06481	0.664	0.12037
Message Compliance	0.93137	0.773	0.96078	0.6111	0.354	0.75
Message Sharing	0.42157	0.307	0.53921	0.31852	0.302	0.41667

* p < 0.10