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Walden University

College of Management and Technology

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Teresa Simmons

has been found to be complete and satisfactory in all respects,
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Review Committee
Dr. Robert DeYoung, Committee Chairperson,
Applied Management and Decision Sciences Faculty

Dr. Jean Gordon, Committee Member,
Applied Management and Decision Sciences Faculty

Dr. David Bouvin, University Reviewer
Applied Management and Decision Sciences Faculty

Chief Academic Officer
Eric Riedel, Ph.D.

Walden University
2016

Abstract

A Qualitative Examination of the Perception of Risk in Warnings for Severe Weather

by

Teresa Simmons

MS, California State University, 2004

BS, Metropolitan State University of Denver, 1994

Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Philosophy

Management

Walden University

November 2016

Abstract

In the past decade, weather disasters have claimed thousands of lives and resulted in billions of dollars in damages. Awareness of a storm threats can occur hours or days in advance, but disaster assessments indicate many people do not heed storm warnings. This problem is old. Despite 50 years of research, and new technologies and training to improve responsiveness, the basic issue–understanding how people interpret and respond to weather warnings–persists. An exploratory study that incorporated human behavior theories and communication models not traditionally associated with severe weather analysis was conducted to learn how weather risks are perceived by nonscientists. Emergency management personnel, a group consisting of emergency managers, support staff and law enforcement telecommunicators from two Midwestern states, were asked to read tornado warnings issued for storms that occurred in 2013 and 2014. Individuals were then interviewed to learn (a) how they perceived the risk and (b) their response to information conveyed by the warnings. Data analyses software was used to examine perceptions of severity, susceptibility, and response efficacy. Findings indicated that perceptions of risk and response depend upon relationships: trust in the source of the message, job responsibly, knowledge of risk, personal experience, and the type of threat perceived. Benchmarks, that did not previously exist, were established for perceptions of severity, susceptibility, and response efficacy to severe weather warnings. This study is one step in the process of positive social change to improve the warning process and save lives. The tangible impact of positive social change will be demonstrated by warnings that increase public responsiveness and result in fewer weather-related fatalities.

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Chapter 1: Introduction to the Study

This study was developed to understand how humans perceive risk and how they determine an appropriate response to severe weather warnings. According to the National Oceanic and Atmospheric Administration (NOAA), previous research indicated human response to weather warnings was problematic and that more research was needed to comprehend how people perceived risks associated with storm warnings (NOAA, 2016). This study was undertaken as a primary step to document risk perception benchmarks for severe weather. In Chapter 1, I define the problem and how it came to be known as problematic. I also describe the purpose of the study and present the study's foundational theories, assumptions and scope of the research, limitations to the study, the research questions, and the significance of the study.

Severe weather is common across the United States and each year the lives of millions of Americans are disrupted by the effects of catastrophic flooding, hurricanes, tornados, and winter weather (Morrow, 2009). Annual estimates indicate that damage costs associated with weather related disasters can climb into the billions of dollars, while the human toll can mean hundreds of people killed or injured (Smith & Katz, 2013). People can be alerted to weather risks when watchers and warnings are issued. Watches identify geographic areas of a weather threat and warnings are issued when severe weather is occurring or imminent (NOAA, 2013b).

Significant weather events are documented in StormData, a monthly publication of the National Climatic Data Center (NCDC, 2015). StormData statistics are compiled from National Weather Service (NWS) storm reports, newspaper clippings, and insurance and power company data, as well as information provided by county emergency managers, the Federal Emergency Management Agency (FEMA), and first responders in the hours or days following a weather

event. Figure 1 provides an example of tornado damage tracks and population density. Damage cost estimates come from aggregated storm reports, while fatality and injury statistics come from local health departments and FEMA.

The numbers of injuries are frequently inaccurate. Injured people transported to medical facilities outside the local community may not be counted when statistics are compiled, and people with lesser injuries may not seek care for themselves until days after the event (Joplin Globe, 2011). It is often difficult to gather injury statistics due to patient privacy rules and regulations imposed by the Health Insurance Portability and Accountability Act of 1996 (HIPAA). The severity of damage, the recovery costs, and the number of injuries and fatalities determine whether a community is eligible to receive state or federal disaster assistance. When more people are affected, disaster assistance and recovery costs grow (Smith & Katz, 2013; Weiss & Weidman, 2013). However, it is unclear how many of the costs could be reduced.

The warning process has been defined as an interdependent system of forecast, dissemination, and response (McLuckie, 1974). While technological improvements have been made to address storm predictability and improve the dissemination of weather warnings, few studies have been conducted to understand behaviors associated with human response to severe weather warnings (NOAA, 2016). Case studies are commonly favored by forecasters and researchers who investigate storms that produce death, injury, or significant damage. Case studies have been used to determine whether storm effects could be reduced, deaths prevented, or the warning process improved, but without an understanding of how individuals perceive a weather risk or determine a response, improvement efforts to the warning process may be ineffective.

Effective warnings provide seamless connections between forecasters and the intended recipients of severe weather warnings (McLuckie, 1974), but little is known about how humans understand warning information or perceive the risks associated with a storm (NOAA, 2016). Learning how humans perceive severe weather risks is necessary to fully comprehend the knowledge gap between the hazardous conditions that scientific experts discern and what the general public recognizes as a threat.

This study was developed to evaluate how information contained in severe weather warnings affect nonscientists perceptions of risk and response and to establish a baseline for future research into human responsiveness to weather warnings. Positive social change may be possible when meteorologists, emergency managers, broadcasters, educators, and researchers seeking ways to improve severe weather forecasts, warnings, and public response understand how scientific information is perceived by nonscientists and how words in a warning affect the response which is taken. Long-term results could include fewer injuries and deaths from severe weather.

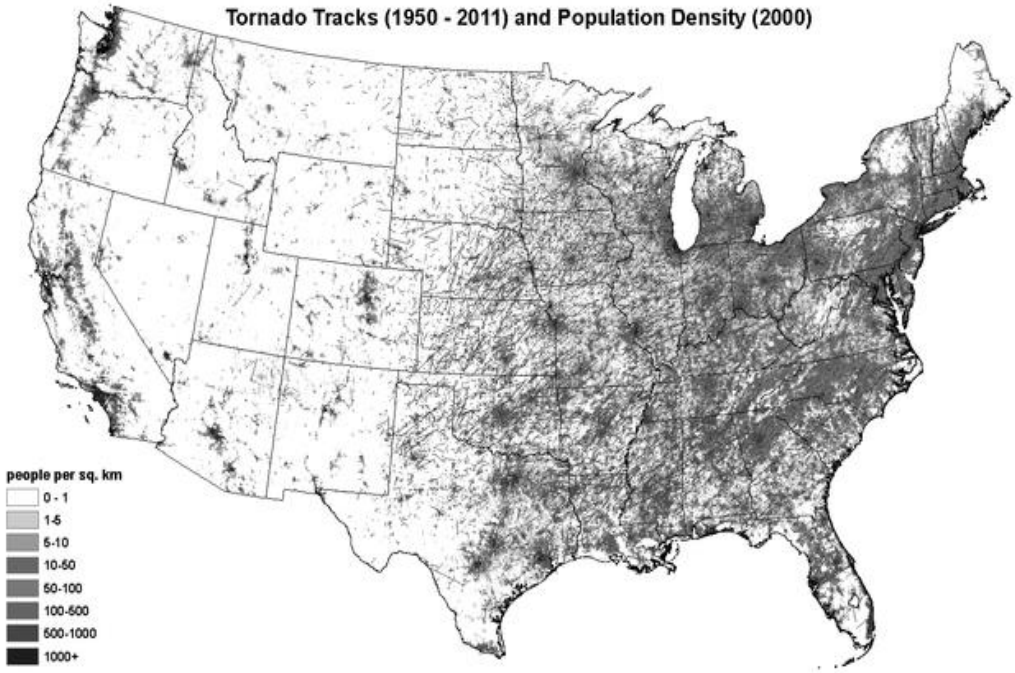

Figure 1. Tornado tracks (1950–2011) and population density (2000). *U.S. map depicting tornado tracks and population density* by National Weather Service Storm Prediction Center, n.d. (http://www.spc.noaa.gov/wcm/).

Background of the Study

In 2011, over 550 people died from injuries sustained in tornados and thunderstorms (NOAA, 2011b; NOAA, 2011c) that ravaged parts of Alabama, Georgia, Mississippi, Missouri, Tennessee, and Virginia (see Figure 2).

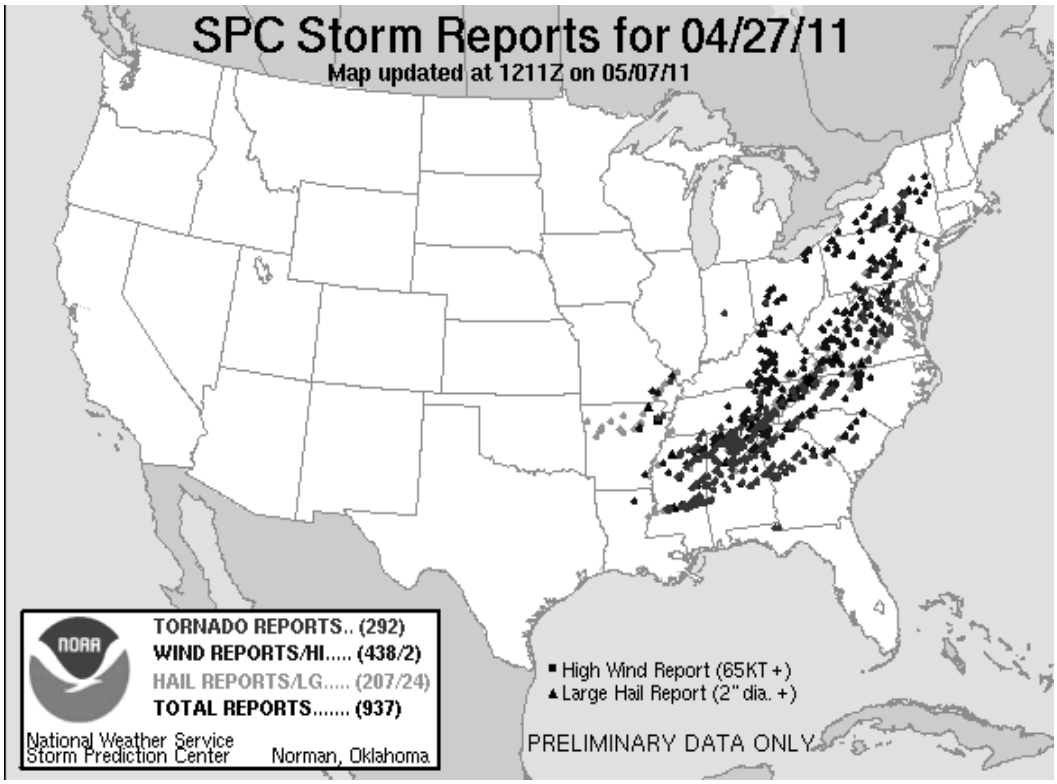

Figure 2. Tornado, wind, and hail occurrences reported during the tornado outbreak of April 27, 2011. *SPC storm reports for 04/27/11*, by the National Weather Service Storm Prediction Center, 2011 (http://www.spc.noaa.gov/exper/archive/event.php?date=20110527).

In the weeks and months following these storms, scientists, engineers, and emergency management experts documented the strength of the storms, the damage produced, the timeliness and availability of warnings, and public response (NOAA, 2011b; NOAA, 2011c). The investigators also examined the structural integrity of buildings, crisis communication, and emergency response, yet the assessments did not provide a comprehensive picture of the public response. The storm assessments were focused upon the adequacy of warnings and sheltering options (NOAA, 2011c) and not on the people at risk, their understanding of the threat, or their reasons for heeding or disregarding the warning.

On May 22, 2011 a significant portion of the central United States was impacted by tornados, large hail, and high wind (see Figure 3). Many communities were devastated by these storms (NOAA, 2011b).

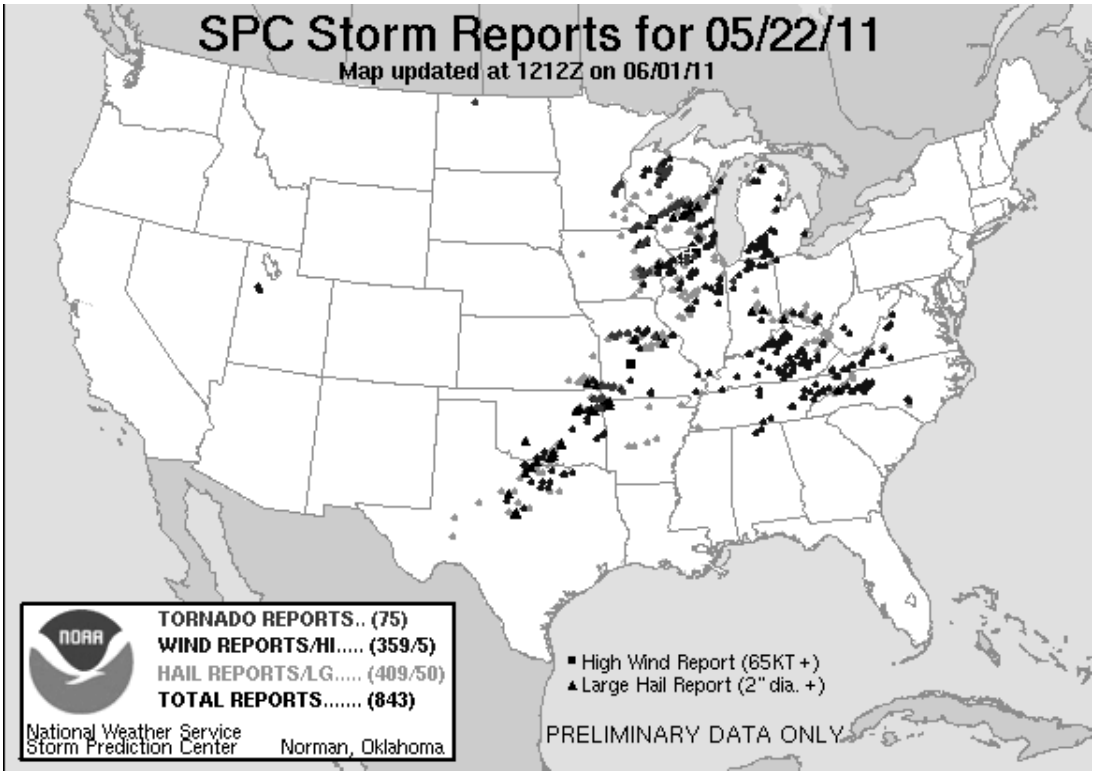

Figure 3. Reports of tornados, high wind, and large hail that occurred May 22, 2011, the day of the Joplin tornado. Note: All data are considered preliminary. *SPC storm reports for 05/2/11*, by National Weather Service Storm Prediction Center, 2011, (http://www.spc.noaa.gov/exper/archive/event.php?date=20110522).

The community of Joplin, Missouri, was alerted to a tornado several minutes before the storm struck the city, but in spite of what appeared to be a successful warning many people died or were seriously injured. Some residents did not hear the warning, some individuals were unable to take cover, and some shelters did not withstand the storm. According to the damage assessment findings, several residents received multiple warnings before they responded, yet

many who heard the initial warning did not seek any shelter (NOAA, 2011b; Paul & Stimers, 2012).

On June 29, 2012, a line of severe thunderstorms, known as a derecho, roared across 11 states, producing widespread damage and power outages in areas already suffering from a prolonged heat wave (see Figure 4). Thirteen deaths were attributed to the derecho, and another 34 deaths were due to heat-related illnesses during the power outages (NOAA, 2013a). After the storm, an investigation conducted by meteorologists, sociologists, and emergency response experts evaluated storm warning responses to better understand how the public perceived the risks associated with the derecho. The assessment team spent weeks interviewing emergency managers, members of the broadcast media, and the general public. Many respondents to the assessment interviews and the focus groups indicated that they were expecting thunderstorms, but not hurricane force winds accompanying the storms, nor subsequent effects of widespread power outages in the midst of a heat wave (NOAA, 2013a).

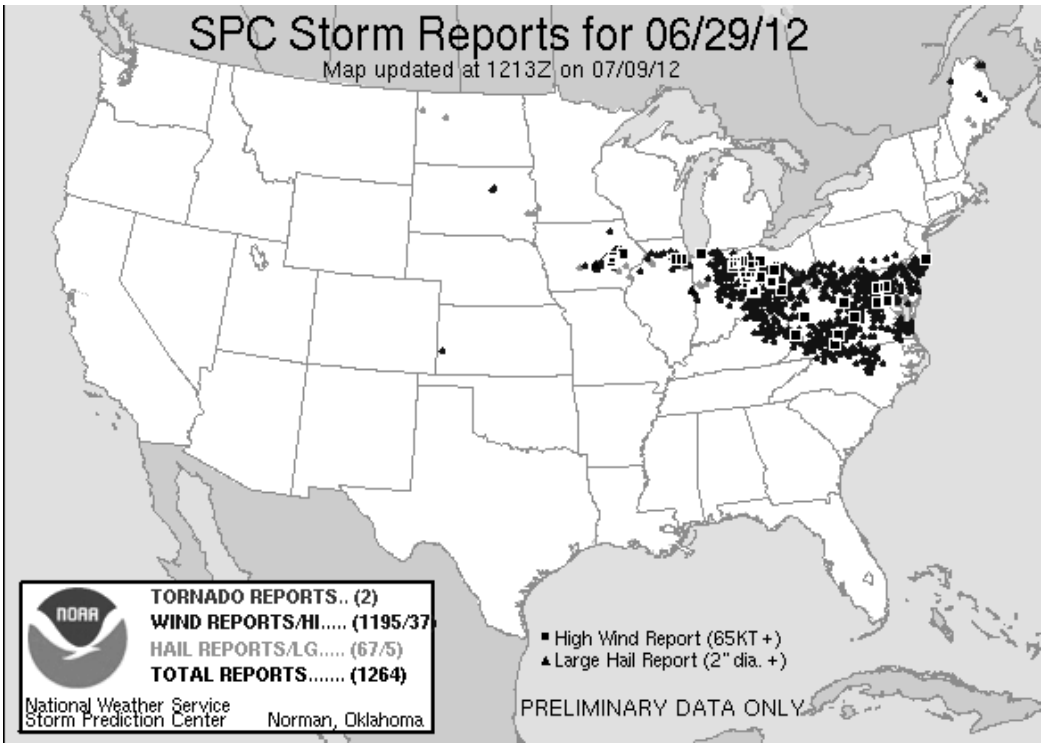

Figure 4. Tornado, wind, and hail reports along the track of the June 29, 2012 derecho. *SPC filtered storm reports for 06/29/12*, by the National Weather Service Storm Prediction Center, 2012 (http://www.spc.noaa.gov/exper/archive/event.php?date=20120629).

The interrelationships of extremes within the environment, human perception of threat, and recognition that communities are vulnerable have caused people to seek ways to protect themselves and their communities from natural hazards (Fleischhauer et al., 2012; Smith & Katz, 2013). Hazard awareness and warning systems can mitigate risk and reduce vulnerability. Post disaster analysis indicates that more should be done to reduce death and damage, yet these assessments do not provide a comprehensive picture of what the public understands about a potential threat (Fleischhauer et al., 2012; Ripberger et al., 2015). Real-time confirmation of storm damage along with post storm analysis can document the strength of a storm and the validity of a warning. Investigations that focus on the timeliness and accuracy of warnings, the structural integrity of sheltering options, and the capability of forecasters to use technology to

detect threats and disseminate warnings can be used to train forecasters and state and local agencies in their response to disasters (Blair & Leighton, 2014; Drabek & Evans, 2007). However, a limited understanding of how individuals comprehend warnings or perceive risk may leave communities vulnerable when appropriate actions are not taken (Kanno, Furuta, & Chou, 2012; Morrow, 2009). This study was undertaken to explore how individuals' perceive weather risks and to determine which actions demonstrate an appropriate response to a severe weather warning.

Problem Statement

Severe weather and damaging winds can destroy property, injure or kill people, and devastate the physical and social infrastructures of a community. In the United States, the NWS is mandated to provide warnings for hazardous weather conditions. Each year hundreds of NWS warnings alert people to severe weather and hydrologic threats. In spite of these warnings, findings from after-action reviews, storm assessments, and disaster surveys indicate that even when advance notice is provided many people do not heed warnings (NOAA, 2011b; NOAA, 2011c; NOAA, 2013a; NOAA, 2014). Crisis communication experts say that more needs to be known about human response (Sheppard, Janoske, & Liu, 2013). Explicit knowledge of warning response has been documented for generations (Fritz & Williams, 1957; McLuckie, 1974) but not tacit knowledge, which can be challenging to capture, hard to formalize, and difficult to communicate (Polanyi, 1966). The weather warning process has been studied and improved, but social scientists assert more must be done to insure that information conveyed by scientists is understood by the people for whom the warning is intended (Demuth et al., 2007; Fischhoff, Brewer, & Downs, 2011). The problem is that little research has been conducted to discover how

recipients of severe weather warnings perceive weather risks or the efficacy of a response (NOAA, 2016). It is challenging for researchers to conduct real time research in the midst of a storm (Wild, 2004) or to find proxy groups to provide subjective insight into risk perception and response after a weather event.

Determining ways to uncover tacit knowledge, known by individuals, and making this knowledge explicit is the strength of knowledge management. Knowledge management (KM) is a multidisciplinary approach for capturing data, subjective information, or expert knowledge so it can be used by others (Koenig, 2012). According to Koenig (2012), explicit knowledge can be expressed in formal language which can be packaged, stored, or codified. Tacit knowledge is held within an individual and generally transmitted through face-to-face communication, by watching, or learning-by-helping interactions (Linn-hsing & Lin, 2015; Vygotsky, 1962). KM suggests that nothing is totally new. Much of what has previously been learned, including information emanating from other groups, may be useful in other settings (Senge, 2006). New knowledge is created or developed when insight is applied and old problems are viewed from different vantage points (Koenig, 2012).

A systems thinking approach explores different perspectives to consider the whole system when solving problems (Ackoff, 1967; Senge, 2006). The interconnections in relationships among systems and subsystems are such that a change in one area can result in an unexpected change elsewhere. According to chaos theory (Lorenz, 1963), a perfect weather forecast is not possible. Yet people are expected to respond appropriately when warning information is provided. In situations where actions are required, individuals resort to internalized knowledge (Argyris & Schön, 1974); how people internalize knowledge of weather

threats and turn it into actionable behaviors is not known. Lessons from systems theory indicate that informational deficiencies may be due not to a lack of information, but to an "overabundance of irrelevant information" (Ackoff, 1967, p. B-147). It is important to discover what aspects of information are relevant to human perception of weather-related risk when considering behavioral outcomes.

In this study risk perception is investigated. There are multiple components to risk, including hazard, probability, consequence, threat, and so on (Risk, 2016); as a concept, risk can be quantifiable and predictable. Meanwhile, qualitative aspects of risk (or risk perception) apply to relationships that underlie the behaviors, actions, and decisions associated with risk (Brown, 2014). Perception is a conscious recognition and interpretation of stimuli that help one to understand, learn, know, or be motivated (Mosby, 2012). Risk perception can be influenced by an individual's past experience and by age, gender, and culture; but perception of risk usually refers to the judgment an individual will use to assess the severity of a direct or indirect threat and the probability that it will occur (Keller et al., 2012; Wachinger et al., 2013).

This study has implications for positive social change. By uncovering tacit knowledge of how people perceive risk, how they determine an effective response, and then codifying this knowledge so it is useful to others a new benchmark is established. This information becomes one step in the process improving the warning process and saving lives.

Purpose of the Study

The purpose of the study was to investigate warnings issued for severe storms and determine whether they contain sufficient information for decision-making purposes. The human response component of crisis communication has been documented for over 50 years (Sheppard,

Janoske, & Liu, 2012). While it is common for articles to suggest that more research is needed, follow-up studies do not address the basic issue of how individuals interpret and respond to severe weather warnings.

Real-time problems are often difficult to research rigorously because diagnostic techniques may be unavailable (Argyris & Schön, 1974) and research is not usually conducted during emergency situations (Wild, 2004). This applies during severe weather situations because processes in the environment are not controllable and it would be difficult to observe how people react when they assess and respond to the threat. In an attempt to overcome the research barriers, copies of weather warnings that were issued for past events were randomly selected and evaluated. During actual severe weather situations, warnings are disseminated via an internal messaging system used by government agencies, the media, law enforcement, and subscription services. Individuals working in these organizations redistribute warning information within their agencies and with the general public. The focus of the study was to explore the perceptions that these secondary disseminators of warning information interpreted from the warning messages.

The NWS is the primary source of weather warnings. Secondary disseminators serve in positions of trust and are considered local experts for emergency communication messaging. They include members of law enforcement, county or city dispatchers, or emergency managers at the county, state, or national level. In this study, *emergency management personnel* (EMP) refers to a subgroup of secondary disseminators.

Research Questions

The most reliable forecast in a severe weather event is accurate and timely, but it is up to people in the path of a storm to respond appropriately when warnings are issued. If the warning

serves the purpose for which it is intended, individuals or groups must comprehend the threat and understand which protective actions are needed. In 1974 McLuckie provided the NWS with a sociological perspective on warnings and human response, but whether this perspective continues to be understood is unclear. If this advice were fully implemented, why do storm assessment and damage surveys continue to identify communication and response as problematic? According to Griffin et al. (1999), humans need to confirm health threat. This assertion has been applied to crisis communication studies; and although it is widely cited within the weather enterprise, no studies were found to indicate that it was examined in a severe weather context. It is unclear whether a confirmation process is necessary for severe weather warnings or if confirmation needs change when warning recipients trust the source of the message.

Although there are many questions about warnings and human responses to them, this study concentrated on severe weather warnings and the perceptions of EMP who convey warnings to others. The study was guided by three questions.

- RQ_1. How does a VTEC-encoded warning affect EMP's perception of risk toward a severe weather threat?
- RQ_2. How does information in a VTEC-encoded warning affect EMP's perception of an effective response?
- RQ_3. How does a VTEC-encoded warning affect EMP's perception of efficacy?

Theoretical Foundation

Five theories provide a foundation for this study; Habermas' theory of communicative action (1998), Parson's structure of social action (1997), Mehrabian's communication model

(1966), the risk information seeking and processing model (Griffin et al., 1999), and the extended parallel process model (Witte, 1992). Other relevant models including the heuristic-systematic model of information processing (Chaiken & Maheswaran, 1994), foundational aspects of the health belief model (Hochbaum, 1958), and perception of risk research that identifies trust as a needed component for decision-making (Slovic, 1987) are discussed in later chapters.

The theory of communicative action claims that there must be understanding before the speech act is considered successful (Bohman, 2014). A listener must validate the ethical orientation of the speaker and his or her right to make a request before the listener responds (Habermas, 1998). The actions taken by the listener should be in context to the message. Speakers and hearers of a message understand the meaning of a sentence when they know under what conditions it is true (Habermas, 1998). In a severe weather situation, the recipient must assess the intent of the warning, evaluate whether the conditions are valid, and determine whether the communicator has the authority to request a response.

The theory of social action suggests that socialized members of society rely upon the guidance of norms or internalized expectations for behavior (Parsons, 1997). According to Parsons (1997), societal needs are independent parts of an integrated system of biology, personality, and culture. If the social system is to survive, the social elements must work together to balance and benefit society (Parsons, 1997). A community can develop an emergency response plan, but the success of the plan depends on the ability of individuals to understand and respond appropriately to messages that are intended to serve the public good. The meaning of a message can be misunderstood. Meaning is distinct from words (Mehrabian, 1966) and words

used in a warning may be interpreted in a number of ways. The prior experience of the listener, body language of a speaker, or the context of the situation can alter the meaning of a message (Mehrabian, 1966; Mehrabian & Reed, 1968; Mehrabian & Wiener, 1967).

Determining whether warnings contain credible information and enhance personal understanding of threat and risk are important considerations in this study. The most frequently cited studies on this concept are outdated (Griffin et al., 1999; Mileti & Sorenson, 1990; Witte, 1992) and except for health behavioral research or psychology studies little current research exists. Risk information seeking and processing behaviors (RISP) are believed useful for interpreting the credibility of a warning (Griffin et al., 1999), while the extended parallel process model (EPPM) investigations are focused on warning content and whether the message contains sufficient information to convey the seriousness of the threat (Witte, 1992). EPPM suggests that a message recipient must comprehend the threat, determine whether he or she will actually experience the threat, decide whether the information provided is adequate, and assess whether he or she has the ability to take protective action (Witte, 1992). RISP and EPPM are both based upon health behavioral models and, although they are frequently cited in crisis communication studies, it is not clear whether they are applicable to severe weather situations. For a broadened perspective, seminal research that investigates public perception and warning response is useful (Ajzen, 1991; Gruntfest, 1987; McLuckie, 1974).

Nature of the Study

This study was developed to discover how VTEC-encoded warnings affect EMP's perception of risk toward severe weather threats and to understand how information in VTEC products corresponds to appropriate response actions. The concept of risk can be quantifiable and

predictable; it can be defined as hazard, the probability of a future event, a consequence, or a threat (Bourque et al., 2012; Hartley & Phelps, 2012; Slovic & Peters, 2006). However, risk perception refers to individual judgment used to assess the severity of a threat and the possibility that it will occur (Bourque et al., 2012; Slovic, 1987). Perception of risk applies to relationships that underlie personal behaviors, actions, and decisions associated with risk. Past experience, age, gender, and culture can influence how risk is perceived. Individuals and groups can also perceive risk differently and this perception gap is one reason why real-world problems can become difficult to research (Kanno, Furuta & Chou, 2012).

Knowledge management provides an integrated approach for the research. KM suggests that knowing and doing are affected by valuation and understanding of meanings (Polanyi, 1966). Social theories state that the cooperative processes of behavior and systems of action can help social groups to survive (Dynes, 2006; Mead, 1934; Parsons, 1977). Theories of crisis communication state that there is a need to confirm a threat (Griffin et al., 1999; Mileti & Sorenson, 1990; Shepard, Janoske, & Liu, 2012). Communication theories claim that a message recipient must evaluate the ethical intent of a message sender and his or her right to make a request before the message recipient can undertake an action (Bohman, 2014; Habermas, 1998).

In this study, EMP were interviewed to evaluate their perceptions of risk and efficacy toward VTEC-encoded warnings issued by government meteorologists. The purpose was to investigate whether severe weather warnings contained sufficient information to affect human decision-making processes in assessing a threat and for choosing an appropriate protective response. Determining how EMP perceive risk from information provided in weather warnings and statements was crucial because these individuals are a first link in the warning chain from

the forecaster to the general public. At this first connection point, the EMP receives warning information from meteorologists and redistributes the information to other nonscientists. If EMPs who relay the message to others do not perceive a risk, the information they do share may be distorted by personal interpretation and the intent of the warning may be inappropriately conveyed to those who are vulnerable.

I bypassed the primary data collection stage by focusing on open-access, non-proprietary data from NOAA. Secondary analysis of storm assessments and surveys reduced costs associated with data collection in regard to time and expense of conducting additional field studies, and this supported an underlying function of KM in the reuse of data. In the United States, NOAA is the federal agency responsible for monitoring climate and the environment. The NWS, a sub agency of NOAA, is mandated by congress as the sole provider of warnings in the public-private weather enterprise. VTEC warnings are archived according to NOAA protocols; therefore, the authenticity and reliability of data is documented. However, it is unknown whether storm surveys or disaster assessments are biased by selective survival or selective deposits of information in the written record. Data completeness may need to be examined through future research.

Background data were contained in public domain documents and official records. These data include published reports of storms occurring within the continental United States, historical documents, and data from storm surveys, disaster assessments, and hazardous weather outlooks that alert the public to severe weather potential several days before storms occur. Also included are statements, watches and warnings issued for severe storms and transcriptions of EMP interviews. VTEC products were favored for the study, because the warnings conform to a

standardized format, they are archived, and can be retrieved. Every VTEC warning contains codes that trigger audio products and alarms on NOAA All Hazards Radio (NWR). VTEC-encoded warnings and statements also provide storm-specific information to disseminators (i.e. broadcast media, emergency managers, and law enforcement). Secondary dissemination of weather warnings was not included in the study.

When information is communicated effectively the information received is the same as what the communicator intended to convey (Habermas, 1998). Inaccurate information has a potential to affect the response. A person, or people in the community, must understand that a threat exists, believe that they may be susceptible to the threat, recognize that they can survive if protective actions are taken, and then engage in the necessary protective measures.

Definitions

Terms relevant to this study are commonly used within Emergency Management and National Weather Service operational settings. Most terms identify Federal Agency abbreviations and weather characteristics or represent functional responsibilities. The definition of terms is contained in Appendix A.

Assumptions

In the early 1970s, sociologist Benjamin McLuckie completed an extensive study for the NWS concerning warnings and disaster response. This was the standard for forecaster training until the 1990s. McLuckie (1974) noted that people have set patterns for coping with a threat, that some behavior patterns are subtle, that individuals respond in a variety of ways, and that their responses may vary over time. According to McLuckie, “Good warnings should stimulate people to action” (McLuckie, 1974, p. 79); to do this, the effects of a hazard must translate into

the terms and experiences that people comprehend. Before McLuckie similar statements were voiced following the 1955 Yuba City flood (Stiles, 1957), in studies of human behavior during disasters (Fritz & Williams, 1957), and by researchers investigating warning systems for hurricanes, nuclear attack, and dam failure (Mack & Barker, 1961; Moore, et al, 1963).

Since 1974, when McLuckie's research was presented to the NWS, new technologies have been developed, weather radar detection capabilities have been improved, and warning templates have been created to help forecasters rapidly construct and disseminate information in standardized formats. The American Red Cross and the NWS have developed educational materials that describe storms and identify protective actions, and communities have created emergency response plans. Yet, after each weather disaster, sociologists insist that the warning process should be improved (Mileti & Sorenson, 1990; NOAA, 2013a; NOAA, 2014).

Scope and Delimitations

Many organizations and individuals provide weather information. According to Public Laws 100-695 and 102-567, the NWS is mandated as the sole provider of severe weather warnings. Since 2012, severe weather watches, warnings, and advisories have been distributed with valid time event code (VTEC) headers that allow weather providers and vendors to track and decode the information contained within the statement. VTEC allows for quicker dissemination of severe weather warnings and helps standardized weather products (NOAA, 2012, June). Dissemination of VTEC-encoded products occurs through public-private partnerships comprising the National Weather Service, broadcast organizations, law enforcement, and emergency management agencies.

This study was developed to examine how individuals perceive risk from standardized wording in VTEC-encoded warnings. Weather warnings are created with software and standardized templates to reduce variation in warning messages. The study was confined to VTEC products because these watches, warnings, and advisories are archived and retrievable. Audio products that play on NWR, on the other hand, are perishable. A weather radio product drops out of the broadcast cycle when a warning expires, or is replaced by another warning or follow-up statement. Media broadcasts are not consistent across a warning locale due to multiple broadcast markets and the priorities that station managers allocate to storm coverage. Outdoor warning systems and sirens are also unsuitable for this study. Siren activation policies are not consistent among the communities using sirens, and records of siren activation may not exist. Sirens may not provide information about a particular threat and they may fail to work if the community experiences a power failure (Plotnick, Hiltz, & Burns, 2012).

Weather forecasters create VTEC-encoded warnings to alert people to significant weather phenomena when a hazardous weather situation or hydrologic event occurs, is imminent, or has a very high probability of occurring. There are several elements in these warnings: an event tracking number, a statement that describes the threat, a time stamp to indicate the time period during which the warning is in effect, latitude and longitude coordinates to identify the geographical area within the warning, and a call-to-action statement that includes possible protective actions to mitigate or lessen the risk. Special coding within the warning activates NWR and emergency broadcast networks. A text copy of the emergency message is transmitted to dispatch centers and subscriber services. An audio alarm and computer-generated voice

convey the warning on weather radio: text and graphical products are transmitted in a format that allows television stations to scroll the warning message and display the warned area on a map.

Although triggers in a VTEC warning header activate Federal emergency communication systems, these warnings do not automatically activate outdoor warnings or sirens. Communities within the confines of the warning area determine whether sirens will be activated based upon pre-established protocols and the particular threat the warning poses. Broadcasters who disseminate information to locations within or close to the warned area determine what level of coverage and priority they will dedicate to covering the storm.

Severe storms can produce significant damage or loss of life, but due to the nature of storm development, warning operations, and crisis response, it is not feasible to study warnings or response during the lifecycles of storms or in the midst of a potential disaster. In considering whether warnings and statements contained sufficient information for decision making purposes, I confined the study to warnings from storms that occurred during 2013–2014 and examined what perceptions of risk and response these warnings provided to key stakeholders. Secondary dissemination modes of communication were excluded since the potential for variability is increased when messages are moved through the communication chain. Disseminators' who relay warnings to others may alter information that is provided in a warning or follow-up statement to meet the needs of specific users, or they may adapt the message to fit a particular viewing or listening area.

Key stakeholders are a first link in the warning dissemination process. These stakeholders are not involved in the creation of the warning, but they are directly involved in the distribution of warning information. Key stakeholders include members of the broadcast media, emergency

managers, dispatchers, and law enforcement officials. Broadcasters play a major role in the dissemination process, but they are excluded from this study. A broadcaster's perception of risk may be influenced by station policies that determine how severe weather warnings are broadcast and the level of attention that station managers are prepared to dedicate to live coverage. The remaining members of the stakeholder group are classified as EMP. It is assumed EMP are primary stakeholders who conform to federal or state emergency management criteria for disseminating severe weather information.

Limitations

Weather is an uncontrollable process. To overcome this limitation, data for the study included historic data from severe weather events, published documents, and supplementary data relevant to storms during the 2013–2014 severe weather seasons. There were several challenges. To maintain credibility, avoid conflicts of interest, and ensure that only nonproprietary data were used, I retrieved storm surveys and disaster assessments from public access portions of government-owned websites. These web pages listed warnings and statements issued by 290 weather offices for all types of weather events across the United States and its territories. I used a random number generator to preselect data and reduce the number of variables such as storm type and the years warnings were issued, as well as to identify offices from which the warnings would be selected. The random number generator was used again to identify specific warnings and follow-up statements for the study from the total warnings issued by each selected office.

A cost efficient method to obtain data from an official web page, rather than a formal data certification process which could take months, satisfied my needs and eliminated the release of non-proprietary information. However, it introduced a potential grey area as to whether

documents were true representations of actual warnings and statements issued by the NWS. I addressed this possibility by inviting weather warning experts to serve as members of my control group, asking these experts the same interview questions as study participants, and then asking the experts additional questions concerning the authenticity of the selected warnings. Another potential conflict arose during the study, since a NWS demonstration project for Impact Based Warnings (IBW) fell within the randomly selected warning time period. The IBW demonstration was designed to improve the communication of threat through enhanced wording and coded event tags appended to warnings. Although IBW was not the focus of this study I was concerned that the demonstration project could affect the responses of study participants. To assess the IBW impact, I analyzed the responses of participants to determine the frequency of comments referring to event tags or IBW enhanced wording in the warnings.

Significance of the Study

For more than 50 years scientists, engineers, and sociologists have investigated how people respond to natural and manmade disasters. Those studies related to the civil defense system practices and protocols provide a foundation for current emergency management beliefs and practices (Drabek & Evans, 2007; Nehnevajsa, 1964; Stiles, 1957). Mileti and Sorenson (1990) estimated that in the United States public warnings are issued at least once a day for hazards like earthquakes, chemical spills, dam failures, nuclear emergencies, or weather. Warnings for weather events are issued when severe weather is possible or when a threat to life or property is significant. Such storms include tornados, hurricanes, thunderstorms, blizzards, and winter storms, but whether a specific storm is actually classified as severe depends upon the weather phenomena and the damage produced.

A warning decision is based upon a forecaster's belief that specific threat characteristics exist, but the process for warning is a collaborative venture that depends on forecasts, dissemination, and response (McLuckie, 1974). Meteorologists detect storm threats and identify locations to be impacted by the storm; dispatchers and broadcasters assist in the dissemination of the warning, and emergency managers' plan and prepare communities to respond to warning threats. The warning process works well when all groups work cooperatively, but occasionally the people for whom these plans are created do not respond as planned.

Critical elements of disaster preparedness and emergency response planning are practicing for a disaster and ensuring that threats are communicated (Fischhoff, Brewer, & Downs, 2011). In the United States, severe weather awareness campaigns acquaint the public to environmental threats such as lightning, tsunami, winter storms, flooding, and tornados. Educational materials developed for each campaign describe the weather hazards and protective measures one can take at home or within the community. Schools, hospitals, and businesses conduct drills to practice their emergency response plans, but it is not known how families or individuals develop and practice their own plans.

Awareness campaigns are well intended, but educational materials are often not suitable because of a mismatch between the information presented and audience reading levels, values, and prior knowledge (Morrow, 2009). Whether people hear, understand, believe, personalize, respond, or attempt to confirm the basis for the warning depends upon numerous sender, receiver, and process factors (Mileti & Sorenson, 1990; Stein et al., 2011): when an individual does not comprehend the information a warning provides or when he or she chooses to act in a

manner that is counterproductive to his or her personal safety the personal and community preparedness planning can be jeopardized.

Significance to Practice

Disaster assessments, storm surveys, and prior research identify that human response is a factor for warning success. Studies of warning response have examined human behavior in regard to fires in buildings, industrial safety, civil defense, and health related emergencies (Drabek & Evans, 2007; Fritz & Williams, 1957; Kuligowski, 2013), but less is known about human responsiveness to weather related emergencies. This is likely due to researchers' inability to control the meteorological conditions that result in severe weather (Mileti & Sorenson, 1990). In the 1970s, however, sociologist and disaster specialist Benjamin McLuckie provided weather forecasters with a better understanding of human response to warnings. In the intervening years researchers' have learned much about the development and origins of storms, the climatological patterns that identify the times of day and year when storms are most likely to develop, and the geographical areas where storms occur. Technological improvements to radar enhance weather forecasters' abilities to detect weather threats and StormReady designations mean that some communities are prepared to respond (NOAA, 2013b). Yet people still die in weather-related catastrophes (NOAA, 2011b; NOAA, 2011c; NOAA, 2013a).

According to Mileti and Sorenson (1990), people rarely get too much emergency information in an official warning; rather they are information hungry. To be motivated to respond, people must understand the risk and not be overwhelmed (Sandman, 1987). It is unknown whether warnings and statements for severe storms provide sufficient information to help humans perceive a risk, assess the severity of a storm, determine personal susceptibility, and

comprehend preventative actions. If characteristics that improve responsiveness to severe weather warnings are identified, it may be possible to create warnings, statements, and training programs that convey meaning to people in the path of a storm. Warnings and statements that identify a threat and clearly communicate the potential risks could increase the usefulness of warnings and preparedness plans (Blair & Leighton, 2014). The tangible impact of positive social change would be warnings that increase public responsiveness and result in fewer weather-related fatalities. This study is one small step toward that goal.

Significance to Theory

Before an individual acts or reacts, he or she must perceive a cue, interpret the situation, and make a decision about what action they will take (Kuligowski, 2013). In regards to weather related warnings, how people experiencing a crisis are sensitized to respond to warnings, their perception of risk before or after the storm, the level of trust that must be present for a warning to be believed, or the amount of risk one must sense before a behavioral change is made remains undocumented (Morrow, 2009; Schumacher et al., 2010; Stein et al., 2011). Real-time problems are often difficult to research rigorously because diagnostic techniques may be unavailable (Argyris & Schön, 1974); therefore, research in natural disaster tends to be opportunistic with most research conducted after an event has occurred.

Weather warning improvement efforts commonly address forecast accuracy and longer lead times; other studies have examined warning communication and public response (Morss, Demuth, & Lazo, 2008; Sherman-Morris & Brown, 2012; Uscher-Pines et al., 2012). However, little is known about the impact of warning information after a warning is issued, particularly in how the public interprets, filters, shares, or perceives the message (Schumacher et al., 2010). The

warning process is thwarted when individuals' do not comprehend what the words in a warning mean or when the response actions that are chosen are counterproductive to personal safety. McLuckie's (1974) sociological perspective of warnings and human response provided a foundation for forecaster training over 40 years ago, but his advice appears to be forgotten since recent storm assessment and damage surveys identify warning communication, risk perception and response as problematic (NOAA, 2014, 2013, 2011).

During severe weather events, the best warnings are timely and accurate. For a warning to serve its intended purpose, people in the path of a storm must comprehend the threat and have sufficient time to respond effectively. Understanding of how the public perceives weather risk and responds to weather threats is limited. The purpose of this research is to explore the gap between warning and response. The study was developed to generalize from a sampling of weather warnings and statements and evaluate whether an inference can be made that these documents provide sufficient information for message recipients to accurately perceive risk and make an informed decision about the response that is most appropriate for the weather threat.

Significance to Social Change

Positive social change refers to the ability to apply knowledge to create a positive impact on an organization, a community, or the global environment (Walden, 2013). The actions taken to improve or protect the lives of others are dependent upon the needs and desires of the social group and the abilities of those individuals attempting to create the impact. Positive social change can be difficult to achieve. However, successful outcomes can happen on a number of levels within social groups, neighborhoods, organizations, or nations.

In the United States, weather watches, storm warnings, and advisories provide a foundation for critical safety decisions to protect individuals and society. Public-private partnerships among government agencies, media partners, civic groups, and emergency management agencies create a resource capable of alerting thousands of people to the weather and environmental hazards that threaten lives, property, and livelihoods. Yet, in spite of timely warnings, broad means of dissemination, and the development of plans to diminish vulnerability, many individuals do not take adequate action to protect themselves from hazardous weather.

In the past decade, weather-related disasters have claimed thousands of lives and produced billions of dollars in damages (NCDC, 2015; O'Brien et al., 2012; Smith & Katz, 2013). Disaster assessments conducted weeks and months after severe storms occurred have traditionally focused on warnings, technologies, and the structural integrity of buildings impacted by the storms. Current warnings follow basic templates developed from social science research completed a generation ago, but whether the assumptions that paved the way for this warning framework remain valid has not been researched. Product warning designs have had great success in alerting people to dangers, but research such as this has not been applied to severe weather warnings (O'Brien et al., 2012).

Training and technology upgrades have improved storm detection capabilities. However, disaster surveys and post storm assessments indicate communication and response to warnings can be problematic (O'Sullivan et al., 2012) and, in spite of what appear to be timely and accurate warnings, people still die (NOAA, 2011b; NOAA, 2011c; NOAA, 2013a). It is unclear how people interpret the information that a severe weather warning provides. It appears that societal trust in risk communication and governance has declined and that new perspectives and

strategies are needed to achieve social change (Bostrom, 2014). In order to address these concerns, this research was developed to achieve the following: build upon risk communication research done in other fields of study (Elstad et al., 2012; Sheeran, Harris, & Epton, 2014; Zhang et al., 2013); evaluate characteristics in warning text associated with perceived severity, perceived susceptibility, efficacy of a response, and self-efficacy; and discern whether warnings that use standardized warning templates contain sufficient information for decision-making.

The purpose of a severe weather warning is to alert people to potential weather threats so that protective actions can be taken. Unfortunately, many people do not understand warning information and fail to respond appropriately when a warning is issued. In the study I examined how hazardous information is communicated and perceived by secondary disseminators of warning information. Identifying effective communication methods that have the potential to save lives during severe weather outbreaks could be a step toward positive social change. Positive social change will be realized when this knowledge is used by meteorologists, emergency managers, broadcasters, educators, and researchers who are attempting to improve severe weather forecasts, warnings, and public response. Long-term results could include fewer injuries and deaths attributed to severe weather.

Summary and Transition

In the United States, thousands of people are alerted to weather and environmental hazards by NWS watches, warnings, and advisories. The NWS has a major role in detecting the threat, disseminating warning messages, and documenting storm impacts. New technologies, training, and research have strengthened the warning process, and public-private partnerships have improved dissemination, education, and emergency response protocols for alerting

vulnerable populations to threatening environmental conditions. Although advance notice is provided, problems arise when people do not heed warnings (NOAA, 2011b; NOAA, 2011c; NOAA, 2013a).

During weather events, people in the path of a storm may not perceive risk, may not know what actions will provide protection from the threat, and may not understand how a course of action (not to mention inaction) can affect their chances of survival. One must have sufficient information to make a decision. Information sufficiency, or the perceived amount of information needed to deal with a hazard, requires knowledge about risk and adequate understanding to make a confident decision (Kahlor et al., 2003). Perception of risk is defined by how an individual processes information and his or her responses to the threat (Slovic, 1987). Previous research identified perception of risk with the need to seek additional information (Demuth et al., 2007; Mileti & Sorenson, 1990; Quoetone et al., 2001) and the effectiveness of warning sirens (Plotnick, Hiltz, & Burns, 2012), but no studies were found that investigated this claim in regards to severe weather warnings or warning response. According to Morrow (2009), focusing on risk is one of the least effective means for changing human behavior. To create lasting change the information process must provide the means for researchers to engage the public, understand how the hazard is appraised, and identify the characteristics that explain perceived differences in risk perception (Cummings, Berube, & Lavelle, 2013; Morrow, 2009). Research findings from natural disaster studies indicate that not enough is known about public perception of vulnerability, public willingness to evacuate, those situations that cause hazard information to be believable, or whether government or media advisories are a significant source of information (Bourque et al., 2012; West & Orr, 2007).

The human response component of crisis communication has been documented in publications for over 50 years (Sheppard, Janoske, & Liu, 2012), and while each report indicates that more research is needed, follow-up studies fail to address the basic issue of how individuals interpret and respond to a warning for severe weather. Argyris and Schön (1974) observed that real-time problems are difficult to research rigorously because diagnostic techniques may be unavailable and research is not usually conducted during emergency situations (Wild, 2004). Weather is an uncontrollable process that fits the real-time characterization.

Crisis situations are normally times of response, not research. Due to these observational constraints, this study focused on severe weather warnings from previous weather events and the risks perceived by EMP reading these warnings. The purpose of the study was to determine whether severe weather warnings contained sufficient information for decision-making purposes. The study was limited to VTEC-encoded storm warnings because these documents are standardized and archived. Other alerting methods were not included. Audio warning products triggered on NOAA weather radio are perishable, and siren policies that govern the activation of outdoor warning systems are not consistent among communities.

Chapter 2 contains a review of literature relevant to the study. Multiple post-storm assessments identify communication as a contributor to problems during severe weather events; assessment findings indicate that research is needed to understand why this is so (NOAA, 2011b; NOAA, 2011c; NOAA, 2013a). Findings from studies in a variety of disciplines were applied to gain a broader perspective of challenges to communication. For example, it has been noted that special populations have different needs, risks, and communication preferences for understanding a potential threat (Binder et al., 2012; Fischhoff, Brewer, & Downs, 2011; Werg,

Grothmann, &Schmidt, 2013). Findings from other studies assert that: four elements of perception are necessary for communicating risk and choosing a response (Witte, 1992); that there is a human tendency to gather additional information before taking action (Morrow, 2009; Griffin, Neuwirth, Dunwoody, & Giese, 2004); and that trust in the information source helps to bridge communication gaps (Bonkiewicz & Ruback, 2012; Gray et al., 2012; Love, Mackert, & Silk, 2013).

Other studies in Chapter 2 include an investigation of tornado warnings and fatalities in Joplin Missouri (Paul & Stimers, 2012); investigations related to the perception of risk (Bourque et al., 2012; Lachlan & Spence, 2014); seminal studies in risk perception (Slovic, 1987; Slovic & Weber, 2002); and the role of personal efficacy during nuclear emergencies, earthquakes, volcanoes, and tornados (Drabek & Evans, 2007; Flynn, 1979; Nehnevajsa, 1964). During warning situations, accurate and authoritative communication is important because language that describes risk reveals and shapes the assumptions of those responding to a threat (Habermas, 1998; McLuckie, 1974). Other communication theories include Habermas's theory of communicative action (1998), Parson's structure of social action (1997), and Mehrabian's communication models (Mehrabian 1966; Mehrabian & Reed, 1968; Mehrabian & Wiener, 1967).

Chapter 2: Literature Review

Introduction

During severe weather events, wind and water can destroy property, produce death and injury, and devastate the physical and social infrastructures of communities. In the United States, weather warnings are provided through public-private partnerships between government and private agencies. The forecast and warning mandate of the enterprise serves two needs: 1) the need to protect people and their property from weather-related incidents and 2) the need to provide forecasts and warnings that contribute to the economic well-being of the nation (NOAA, 2011a). Hundreds of warnings are issued each year for severe weather and hydrologic threats. The problem is that, even with advance notice, many people do not heed these warnings (NOAA, 2011b; NOAA, 2013a; NOAA, 2014).

Knowing that a threat exists and alerting others to the threat is crucial to public safety (Lachlan & Spence, 2014; Sandman, 1998), but more than 70% of Americans are either unsure of whether—or are unaware that—their communities have systems to alert them to public safety concerns (Sutherland, 2012). Theoretically and empirically, warnings depend on the ability of the public to respond to threats like war and natural disaster. Community preparedness programs rely upon emergency alerting protocols and common dissemination systems to alert the public to potential threats. Individuals can identify and prepare for some hazards, but preparing a community plans become increasingly difficult as groups and organizations with a variety of needs attempt to keep their communities safe. This has led to multiagency imperatives to reorganize resources, agencies, and policies to create an “all-hazards” preparedness program (Drabek & Evans, 2007; Mileti & Sorenson, 1990). The purpose of this research was to explore

the gap between warning and response. The study was developed to generalize from a sampling of weather warnings and statements and evaluate whether an inference can be made that severe weather warnings provide sufficient information for message recipients to perceive risk and make an informed decision about the response that is most appropriate for responding to the threat.

Literature Search Strategy

Communication of risk and response has been studied in many disciplines (Lachlan & Spence, 2014; Sheppard, Janoske, & Liu, 2012, May; TASA, 2012), but an exhaustive search of ProQuest, Google Scholar, and Thoreau databases indicates that few studies have attempted to uncover the perception of risk that people have toward weather or environmental hazards (Keller et al., 2012). Information cited in weather-related studies comes from research conducted generations ago (Fritz & Williams, 1957; Moore et al., 1963: Stiles, 1957) and from crisis communication studies in the 1990s (Mileti & Sorenson, 1990). Current research in environmental issues is overwhelmingly related to European flood risks (Fleischhauer et al., 2012; Lara, Sauri, Ribas & Pavon, 2010; Uhlemann, Thieken & Merz, 2013) and no studies were found that investigate how people perceive weather risks or the efficacy of their response to severe weather warnings.

Perception of risk refers to the judgment that an individual will use to assess the severity of the threat and the probability that it will occur (Bourque et al., 2012; Slovic, 1987). Perception of risk underlies many behavioral theories, like the health belief model (Hochbaum, 1958), and crisis communication models such as heuristic-systematic processing, affect heuristics, and risk perception, trust and affect (Chaiken & Maheswaran, 1994; Slovic & Peters, 2006, December).

In the following sections, I review aspects of human response, communication, risk, crisis communication and trust, decision making, and communication models that consider why people may decline to take protective action.

Theoretical Foundation

This study is based on several theories: Habermas's theory of communicative action (1998), Parson's structure of social action (1997), Mehrabian's communication model (1966), the risk information seeking and processing model (Griffin et al., 1999), and the extended parallel process model (Witte, 1992). Other relevant models include the heuristic-systematic model of information processing (Chaiken & Maheswaran, 1994), foundational aspects of the health belief model (Hochbaum, 1958), and perception of risk research which identifies trust as a needed component for decision-making (Slovic, 1987).

The theory of communicative action claims that there must be understanding before a speech act is considered successful (Bohman, 2014). A listener must validate the ethical orientation of the speaker and his or her right to make a request before an action is taken by the listener (Habermas, 1998). Speakers and hearers of a message understand the meaning of a sentence when they know under what conditions it is true. In a severe weather situation, the message recipient must assess the intent of the warning, evaluate whether the conditions are valid, and determine whether the communicator has the authority to request a response. In spite of the considerations of intent, validity, and authority, messages can be misunderstood. The words used in a warning may be interpreted in a number of ways: a listener's prior experience, the speaker's body language, and the style tone and context of the situation can alter the meaning of a message (Mehrabian, 1966; Mehrabian, & Reed, 1968; Mehrabian & Wiener, 1967).

The theory of social action suggests that members of societies rely upon the guidance of norms and internalized expectations to guide the behaviors of individuals' and collective actions of the group. Action is a process. Socialized members of groups must voluntarily work together to balance and benefit society for the social system to survive (Parsons, 1997). While communities' can develop emergency response plans, the success of these plans depends on the ability of individuals to understand that threats exist and their wiliness to respond appropriately to messages that are intended to serve the public good.

Determining whether warnings contain credible information and contribute to an individual's personal understanding of threat and risk are important considerations in this study. The most frequently cited studies that have explored these concepts are outdated (Griffin et al., 1999; Mileti & Sorenson, 1990; Witte, 1992) and little current research exists. RISP behaviors are deemed useful when interpreting warning credibility (Griffin et al., 1999). Investigations of EPPM focus on warning content and sufficiency of information. EPPM suggests that warning content must convey the seriousness of the threat and that a message recipient must comprehend the risk. The message recipient must also determine whether he or she will be affected by the threat, judge whether the information provided is adequate for decision-making, decide whether protective actions are possible, and then choose a response (Witte, 1992). RISP and EPPM are both based upon health behavioral models and, although they are frequently cited in crisis communication studies, it is not clear whether these are applicable to severe weather situations. Seminal research that investigates public perception and warning response (Ajzen, 1991; Gruntfest, 1987; McLuckie, 1974) provide a better foundation for my study.

Justification of References

The very nature of knowledge management is to use previous knowledge to drive improvement. A practical application of knowledge management is to consider seminal resources and supplement this knowledge with current research.

Sources for this study may appear dated; however, their inclusion is considered relevant for the following reasons. Works related to health behavior (Hochbaum, 1958), civil defense (Mack & Baker, 1961; Nehnevajsa, 1964), and disaster response (Fritz & Williams, 1957; Moore et al., 1963; Stiles, 1957) provide the basis for crisis communication, social science research into environmental hazards (Flynn, 1979), and warning calls to action (McLuckie, 1974), while severe weather and flood warning templates and practices (Morss et al., 2008; Quoetone et al., 2001) help establish a need for change in the warning process. Failure to include resources such as these would cause the document to be less credible within my profession.

Research in the field of meteorology is opportunistic. Studies that are conducted after weather or hydrologic events mainly focus on those events that produce widespread destruction. This is because it is impractical to research every storm that produces damage and impossible to conduct research during a weather episode when the intensity of the storm and location cannot be assured or controlled. Conducting research during crisis situations is difficult (Wild, 2004) and case studies are the predominate method of research in the field of operational meteorology. Case study research provides much information for understanding atmospheric processes, but these findings are less relevant to quantitative or qualitative studies of human response and perception of risk.

Studies which examine perception of risk for natural hazards are limited and much of the available research corresponds to European flood and flash flood events and flood mitigation efforts. Alerting people to flooding does require crisis communication; however, the time perspective for preparation, mitigation, and locations impacted can be significantly different from the time to warn and respond to severe weather threats. For example, there is a sense of urgency during a tornado warning as the storm can develop quickly and the damage can appear to be random with one house in the path of the storm destroyed and the home next door left untouched. Conversely, flood events are normally preceded by rain and it can take hours or days for a river to respond to the runoff. In these instances you are less prone to be concerned with a flood if you do not live by the river.

Works by researchers like Dynes (2006), Drabek and Evans (2008), and Mileti and Sorenson (1990), continue to be cited by the Federal Emergency Management Agency (FEMA) and Homeland Security disaster response, risk mitigation, flood management, and weather researcher communities. These sources create a foundation for emergency management training and communication methods and provide a comprehensive picture of current disaster protocols. This study examines warnings for severe weather and the perception risk these warnings convey to EMP. Knowing how to communicate with EMP in their own “language” is important for understanding how they perceive risk.

Studies that examine human vulnerabilities toward natural disaster are also opportunistic and tied to weather events like hurricanes (Eisenman et al., 2007), flood risk communication (Faulkner et al., 2007; Knocke & Kolivras, 2007; Morrow, 2009), and water inundation (Fischer et al., 1995). These studies are valuable because they provide the perspectives of researchers

outside the field of meteorology. Other seminal studies by authors Chaiken and Maheswaran (1994), Griffin, Dunwoody, and Neuwirth (1999), Sandman (1987), Slovic (1987), Slovic and Peters (2006), and Tiedens and Linton (2001) provide a foundation for risk perception and risk communication.

Argyris and Schön (1974) asserted that scholars in a single profession such as biology, physics, or engineering may fail to grasp the complexity and interconnectedness of a problem, and may rely upon perspectives that support their own limited view. To gain a systems perspective of the interrelatedness of the problem this study incorporates human behavior theories and communication models not traditionally associated with severe weather analysis.

Literature Review

In the early 1970s Dr. Benjamin F. McLuckie, a sociologist with an interest in disaster warnings and human response, investigated the information communicated in a variety of warnings and the actions that were taken by the public to respond to these warnings. McLuckie's linkages between the physical and sociological sciences and training protocols were understood by weather forecasters from the 1970s through 1990. Since 1990, training, tools, and skill building activities for forecasters have focused on warning decision making (NOAA, 2013c; Quoetone et al. 2001). Even so, new generations of social scientists proclaim a need for improved warnings (Demuth et al., 2007; Paul & Stimers, 2012; Uscher-Pines, Chandra, Acosta & Kellermann, 2012, June). In spite of these warning improvement efforts, recent findings following severe weather events indicate that many warnings go unheeded (Joplin Globe, 2011; NOAA, 2013a; Paul, & Stimers, 2012). Severe weather communication is designed to alert people to potential hazards and call attention to protective actions that can be taken.

Human Response

Learning how humans perceive the information contained in severe weather warnings is the focus of this study. Warning products are the initial mode of notification that weather forecasters use to activate weather radio alarms, to interrupt commercial radio and television broadcasts, and alert emergency managers, law enforcement dispatchers, and broadcasters who disseminate the weather information to others. Significant effort has focused on improving forecast technology and forecaster training, but knowledge of public response to warnings is the result of civil defense studies conducted generations ago (Fritz & Williams, 1957), as well as from grey literature (e.g. technical reports) outside scholarly publication routes (Uhlemann, Thieken, & Merz, 2013) and health behavioral studies (Brady, 2012).

Each human has different priorities, values, and needs, yet human behaviors and traits fall into observable patterns that can be perceived and systematically studied (Mead, 1934; Morrow, 2009). Crisis management researchers have pondered human response to threat or risk in regards to healthcare (Binder et al., 2012; Elstad et al., 2012; Fischhoff, Brewer, & Downs, 2011), law enforcement, terrorism, and finance (Ansari, 2012; Bonkiewicz & Ruback, 2012; Sadiq & Graham, 2014). Research to examine how humans understand and respond to natural hazards and flooding exist (Buchecker et al., 2013; Uhlemann, Thieken & Merz, 2013), but studies that relate human behavior to severe weather are difficult to find. Mead (1934) and Parsons (1997) assert that any action taken by a human is the result of a behavioral or decision-making process. This implies that basic human response behaviors to threat may apply to individuals facing a weather-related threat.

Before an individual acts or reacts, the person must perceive a cue, interpret the situation, and make a decision about what action will be taken (Kuligowski, 2013). Morrow (2009), Schumacher et al. (2010), and Stein et al. (2011) have asserted that, in regards to weather, how people experiencing a crisis are sensitized to respond to future warnings, how they perceive risk before or after the storm, the level of trust that is present, believability of the warning, and the amount of risk one must sense before a behavioral change need to be documented. According to Argyris and Schön (1974), real time problems are often difficult to research rigorously, because diagnostic techniques may be unavailable and, for this reason, research in natural disaster tends to be opportunistic with most research conducted after an event has occurred.

Systematic studies of human behavior in disasters began in the 1950s (Fritz & Williams, 1957). By the 1960s and 1970s research of human response to natural disasters in the United States, Italy, and Japan (McLuckie, 1974) established a basis for state and federal emergency management curricula and formal disaster planning efforts. How humans respond to natural disaster intrigues social scientists (Convello, von Winterfeld, & Slovic, 1986; Feldman & Ingram, 2009; Kuligowski, 2013): but, according to Morrow (2009), most social science research is fragmentary and only available within a respective discipline. What set McLuckie's (1974) disaster research apart from his peers was his willingness to examine disaster messaging components, debunk myths and stereotypes, and present information about human behavior in a way that blended the physical sciences with social science. In regards to natural disasters, much of what is known about how humans respond is learned after the disaster. Prior to a disaster, people may believe they know what their response will be, but during crisis situations, an actual response may be quite different (NOAA, 2014). By documenting what occurred before, during,

and after a natural disaster, a researcher can gain a historical and cultural perspective of the event, detect weaknesses in disaster planning efforts, and identify potential areas of improvement (Morrow, 2009).

According to McLuckie (1974), knowing that a danger exists is an insufficient disaster message because people are reluctant to act upon threats that are not perceived to be immediate or personal. Knowledge does not change behavior (Marynissen & Ladkin, 2012), but according to McLuckie (1974), information about a danger is helpful to people. Providing call-to-action statements within a warning was a way to personalize information and leave people better equipped to identify and respond to a threat when interrelationships among the disaster threats, the physical impacts, and potential social disruptions were stated in the warning (McLuckie, 1974). In recognizing that danger is imminent people are more willing to take action to protect themselves and others (Fritz & Williams, 1957; Lachlan & Spence, 2014; Morrow, 2009).

Humans are social beings with internalized expectations and norms. On the cultural level, there are systems of action that help social groups survive (Parsons, 1997). People tend to behave how they believe others would like them to behave (Bonkiewicz & Ruback, 2012; Zhang, Pavur, York, & Amos, 2013) and their behaviors are generally cooperative and adaptive. People will engage in actions to protect themselves and others, will flee the situation, or will fight to gain control of the threat (Fritz & Williams, 1957; Parsons, 1997; Morrow, 2009). According to Fritz and Williams (1957), in some disasters officials have withheld warnings to alleviate human panic, but the urge to flee or fight is not the same as panic (McLuckie, 1974, Parsons, 1997).

Panic is an extremely rare phenomenon in which acute fear is coupled with flight (Dynes, 2006). According to Bonkiewicz and Ruback (2012), social networks and social norms shape

individual and group behaviors and people with connections to groups tend to behave rationally. In disaster situations, much of what is perceived as panic is uncoordinated activity and social disorganization when individuals and groups attempt to render aid and cope with what has occurred (Fritz & Williams, 1957; McLuckie, 1974). Individuals tend to respond to family and friends first, and then turn their attention to others in need. During actual disasters, people act with reference to others, try to stay alive by holding onto things and people, and shielding themselves and others from flying or falling objects (Fritz & Williams, 1957). After the impact people attempt to regain self-control and assist family members, neighbors, and friends (Bonkiewicz & Ruback, 2012; Fritz & Williams, 1957).

A natural disaster is an example of an outside threat that can unite a community. McLuckie (1974) asserted that people tend to unite against a common enemy with solidarity. During a disaster neighbors become the true first responders: they provide for rescue, administer first aid, and transport victims to hospitals (Bonkiewicz & Ruback, 2012; McLuckie, 1974; Uscher-Pines et al., 2012). Although a single location may be impacted, the effects of a disaster and human response to it can extend beyond the immediate geographical area. People in the stricken community and others with connections to people or organizations within the disaster area can be affected by the physical and social impacts (Fritz & Williams, 1957). Many individuals want to be sure their friends and families are safe (Bonkiewicz & Ruback, 2012; McGee & Gow, 2012) and, as news of the disaster spreads into outlying communities, there is a tendency for people to move toward the disaster area rather than flee (Fritz & Williams, 1957; McLuckie, 1974). Convergent behaviors can bring outsiders into the stricken community, which places additional people at risk, impedes rescue efforts, reduces situational awareness, and

overwhelming existing modes of communication (McLuckie, 1974; Mileti & Sorenson, 1990; Morrow, 2009).

Humans find it difficult to think and respond in stressful situations (Hartley & Phelps, 2012; Morrow, 2009), when the capacity for processing information is limited. With low stress, the average human brain can process and hold about seven messages, but with high-stress intellectual processes are diminished as brain processing ability drops to about three messages (Morrow, 2009). During high stress situations complicated messages may be misunderstood. Fernandes et al. (2014) observed that threat and unpleasant emotional stimuli are distractive to informational processing. When so much needs to be done, taking time to coordinate may seem like a wasteful use of time (Fritz & Williams, 1957; McLuckie, 1974). However, the complexity of the situation calls for clear communication and coordination.

Seminal research (Fritz & Williams, 1957; McLuckie, 1974) and disaster response research (Bonkiewicz & Ruback, 2012) indicate that it is crucial for information in disaster warnings and follow-up messages to be clear and consistent, especially when secondary or concurrent threats are possible (i.e. storm surge associated with a hurricane, a bridge collapse during a flooding event, gas leaks in storm-damaged homes, or power outages for days after a weather event). According to Bonkiewicz and Ruback (2012), citizens seek information from credible sources. Differences in how a risk is perceived can lead to disagreements between technical experts and the general public who are expected to respond (Slovic, 1987). Elstad et al. (2012), O'Sullivan et al. (2012), and Rød, Botan, and Holen (2012) have asserted that conflicting information, distrust, worry, or anxiety can cause people to be less responsive to disaster messages. Individual perceptions and social ties strengthen or weaken community

responsiveness, which caused Bonkiewicz and Ruback (2012) to insist that disasters should be viewed as physically destructive incidents and social events. Humans are guided by perception in the actions that they choose (Slovic, 1987), but the influence of communication and community cohesion need to be better understood (Bonkiewicz & Ruback, 2012).

Communication

Descriptions of risk and the manner in which issues are communicated determine how risk is perceived or evaluated. The ability to communicate defines the culture within a social system. In a communication process, one human conveys intangible information to another (Bohman, 2014; Polanyi, 1966) symbolically through actions, gestures, or utterances. Mead (1934) and Parsons (1977) asserted that information is transmitted when a person's experience and attitude are shared with others. Members of the group must agree and determine how the verbal and non-verbal symbols and meanings are understood, but this happens only when the speakers and listeners have heard the terms and shared the circumstances in which the terms are used (Polanyi, 1966). Words and symbols can have a variety of meanings and interpretations. The use of a term like radiation can convey different meanings, even to those familiar with the term; to the atmospheric researcher, it could refer to the radiant energy emitted by the sun, to the engineer it could refer to nuclear energy, and to a cancer patient or physician it could refer to chemotherapy (Dupigny-Giroux, 2010).

To discover the meaning or intent a person wishes to convey, one must analyze the symbol and the manner in which it is used. A shared understanding of the symbol allows the message to be received as it was intended. For example, a flag can provide a visual image of the wind blowing, it can communicate success or defeat, and it can represent local or national

identity. Knowing the conditions under which the symbol is used increases understanding. From the observer's perspective, one may see that an action has been taken and deduce meaning, but it is only in knowing the intention accompanying the symbolic action that one can adequately comprehend the action, describe it to others, and execute a specific plan (Habermas, 1998).

Communication calls attention to the message and the speaker. A gesture or utterance of one organism causes another organism to adjust its response and reflect its attitudes back to other members of the group (Habermas, 1998; Mead, 1934). This rudimentary language does not become communication until the symbol (i.e. vocal gesture or verbal utterance) calls forth a response in others. Sequences of utterances, and utterance expansions, "indicate understanding and knowledge" (Paul, 2014, p.17). The acquired content of communication applies to what the speaker conveys, and also to the "hearer's beliefs about how she is related to the speaker's context" (Weber, 2013, p. 206). The speaker may verbalize a belief. The hearer may understand the sentence and come to believe and to share the utterance because he or she trusts the speaker (Weber, 2013).

Humans interpret material object, language, and events as information. It is only by interpreting this information meaningfully that the information becomes communication (Soukup, 2013). Communication can alert others to danger; provide guidance by demonstrating what to do to react to the danger, and employ social control by establishing the norms under which the community will operate (Habermas, 1998; Mead, 1934). Numerous sender/receiver factors that determine the frequency and communication channels through which a message is transmitted can impact response to the message and to the social cues surrounding the message (McGee & Gow, 2012). Communication, whether it is verbal or non-verbal, can bring solidarity

to a group or drive individuals apart. For example, a message thath alerts members of a group to a fire that is spreading beyond the confines of the fire pit can be a means of summoning help to fight the fire or a notification to flee.

Society, culture, and social order are shaped through a group's use of language, its means of communication, and practices that can be observed and imitated. Group influence expands beyond social and geographical confines when the symbols, utterances, and ideas used within the group are shared through print media or communication modes that allow speech or visual images to be seen and heard (Bandura, 1986; Mead, 1934). Communication technologies allow for greater mobility of knowledge (Soukup, 2014). The convergence of audio-visual and computer networks create mechanisms for ideas, messages, and behaviors to spread rapidly, but speed is not the same as effectiveness (McGee & Gow, 2012). The ability to transfer information to others outside a group's physical confines can alert a greater number of individuals to potential hazards, and improve communication during a crisis; however, technological advances cannot ensure that the people receiving the messages comprehend the risk.

Risk

Risk is defined differently across disciplines. The overall consensus is that risk equates to hazard x exposure x probability (Morrow, 2009). Risk, as a concept, refers to a hazard, a probability, a consequence, a potential adversity, or a threat (Slovic & Weber, 2002) and the probability that future negative effects may result (Bourque, et al., 2013). People attempting to communicate or comprehend risk may find it difficult to grasp that different understandings exist. The terms and concepts for risk reflect subjectivity and a means for humans to cope with danger and uncertainty. Although dangers may be real, "real risk" does not exist (Slovic &

Weber, 2002, p. 4), mainly because one cannot gain sufficient knowledge to recognize all future dangers or comprehend the consequences of our decisions (Luhman, 1993). Statistical probabilities can be associated with certain risks, but even in high probability situations, the public may not be prepared for these dangers. The difficulty of assessing real risk has caused social scientists to examine risk perception as a predictor of preparedness for a variety of natural, technological, and human-made hazards (Bourque et al., 2013; Zhang et al., 2013). The concept of risk and the disaster threshold for risk depend on whether one is a decision-maker or someone affected by decisions (Luhman, 1993 Stein et al., 2011).

Response decisions are shaped by how risks are perceived. Because there is little distinction between risk and danger, both terms are frequently used interchangeably. According to Luhman (1993), every evaluation of risk remains bounded by time and context. The past and present response determines how the risk is interpreted and any future losses "can be attributed to the decision made" (Luhman, 1993, p. 101). The type of decision or loss does not matter, nor does the degree of probability or improbability that a consequence will occur (Luhman, 1993). This contrasts with Sheeran, Harris, and Epton's (2014) observation that intention and behavioral outcomes are positively influenced when risk appraisals are combined with perception of severity, and affected to a greater degree when efficacy is enhanced and response costs are reduced. Still, there is no guarantee that rational decisions are possible. Increased information does not necessarily improve a decision maker's knowledge or attitude toward a response (Luhman, 1993; Sheeran, Harris, & Epton, 2014). The general public interprets risk information differently than do experts (Marynissen & Ladkin, 2012), and any attempt to influence someone to accept risk and respond in a certain manner may cause the individual to become increasingly

entrenched in his or her original opinion (Bourque et al., 2012; Luhman, 1993; Slovic & Weber, 2002).

The concept of risk has multiple meanings. Handmer and James (2007) suggest there is a tendency to categorize risk as an all-encompassing problem to be overcome, but risk is abstract and layered. Risk can be an intuitive feeling related to an individual's instinctive reaction to a danger, risk can be analyzed logically with reason and scientific deliberation, risk can refer to a choice in which multiple outcomes are possible, or risk can refer to the probability of a future event (Bourque et al., 2012; Hartley & Phelps, 2012; Slovic & Peters, 2006). Fear and anger associated with feelings of risk work differently. Fear increases the perception of risk, since fear can be identified with feelings of uncertainty and situational control (Hartley & Phelps, 2012; Morrow, 2009; Witte, 1992). Feelings of anxiety may linger after the initial threat has dissipated (Hartley & Phillips, 2012). Meanwhile, anger dampens the feeling of risk, since anger "arises from appraisals of certainty and individual control" (Slovic & Peters, 2006). Analysis of risk focuses narrowly on the probability that an event will occur and the magnitude of the consequences (Fleischhauer et al., 2012).

Response decisions are shaped by an individual's analysis of risk. Decisions are usually made during periods of uncertainty, when the full extent of the threat may be unknown. The specific goodness or badness of a decision is experienced as a feeling state, or affect, that helps guide a judgment (Slovic & Peters, 2006). The psychological, social, and cultural processes that shape human perception toward risk depend upon the individual involved and the level of satisfaction he or she has with the information provided (Elstad et al., 2012). Big gaps between the knowledge a person has about a risk and the amount of knowledge they perceive to be

sufficient can impact evacuation behaviors and decisions (Lazo et al., 2009; Morrow, 2009; Zhang et al., 2013); and, because decision-making about anything is complex, the differences in the perception of risk often lead to disagreements between technical experts and the general public (Slovic, 1987).

Science cannot prove that risk exists and cannot guarantee safety (Fleischhauer et al., 2012). When experts judge risk, their responses correlate to probabilities based upon statistical data and estimates of casualties; meanwhile, a lay person's judgment of risk is related to possibilities such as hazard characteristics and catastrophic potential (Fleischhauer et al., 2012; Jenkin, 2006). The major emphasis of risk communication literature is to build trust and convey the message that those in authority have the technology and expertise to resolve an issue (Handmer & James, 2007). However, people rely on personal knowledge and experience when interpreting their individual levels of safety (Bourque et al., 2012; Lazo et al., 2009; Zhang et al., 2013). Experience and its influence on response are difficult to define and measure since affective judgments of safety can be misleading (Bourque et al., 2012). According to Jenkin (2006), keeping people safe is not sufficient; people must also feel safe.

If feelings about an action are favorable the risk is perceived to be low and the benefit high (Slovic & Peters, 2006). A frightening experience may carry a disproportionate amount of weight, while a previous experience in which the threat was minimal may diminish perception of risk (Hartley & Phelps, 2012). Gender, race, and ethnicity can affect how risk is perceived (Bourque et al., 2012; Morrow, 2009), but it is unclear how differences related to socioeconomic status (i.e. education or income) influence results (Bourque et al., 2012). Individuals find it easier to comprehend the concept of risk when cues are present in their environments (Mileti &

Sorenson, 1990). Cue-based factors that influence perception of risk can include the following: a higher number of reports from official sources, media coverage, audio alarms, or changes in the physical environment; cues related to the consistency and uniformity of information; social cues consistent with the situation, such as the evacuation of neighbors; the presence of loved ones also at risk; and the appearance of more extreme cues such as a threatening sky, dense smoke, or rising water (Kuligowski, 2013; Stein et al., 2011; West & Orr, 2007). An individual's level of confidence that risk is real rises as the number of cues increase or when the disaster approaches (Bonkiewicz & Ruback, 2012; National Institute of Health, n. d.). Hearing about a risk from multiple sources can amplify the message and elicit greater belief that the information is accurate (Elstad et al., 2012).

Risk preparation can be affected by time, statistics, social measures, or the hazard itself (Handmer & James 2007). These factors also affect the response actions which are taken. The amount of time required for an action to be accomplished and the feeling of pressure to make a decision can negatively affect response. Aspects of the risk message can alter an individual's judgment and trust. When risk is uncertain, an individual may turn to family and friends for guidance (Gray et al., 2012). Meanwhile, a person who defines the situation optimistically may believe nothing will happen or that they have more time in which to act (Kuligowski, 2013; Morrow, 2009). Confidence in warning accuracy can drop when forecast lead time is too long (Lazo, Morss, & Demuth, 2009), and human responsiveness may change when new or conflicting threat information is presented (Morss et al., 2008).

Communicators may assume that amplification of the risk message can alter perception and lead to the desired behavioral response, but additional risk information may interfere with

the reflective judgment needed to choose an action (Bourque et al., 2012; Morrow, 2009). Each time updated information is received, an individual must reevaluate the situation and begin a new behavioral process (Kuligowski, 2013). People tend to rely heavily on the first evidence they receive rather than updated, or more relevant, information (Morrow, 2009). This type of tenaciousness reduces the amount of time an individual has for responding to the threat.

An individual's belief that a mitigating action is possible is defined by the physical attributes of a potential hazard and influenced by other aspects of risk. The process of weighing potential losses against potential gains affects interpretation and perception (Dynes, 2006; Handmer & James, 2007; Morrow, 2009). Rather than making a decision based upon a final outcome, an individual may choose between the value of the gain or the loss (Elstad et al., 2012). An individual who fears the event or perceives that a lack of control will exist may feel dread: feelings of dread risk increase when the catastrophic potential is high, when fatal consequences are possible, and when there is an unequal distribution of risk and benefit in the actions available (Jenkin, 2006; Morrow, 2009). Dread arises because the risk is perceived as dangerous, uncontrollable, and involuntary (Buchecker et al., 2013). Proximity risk varies, and is dependent upon whether the person perceives himself or herself to be located in an area of high risk, medium risk, or low-risk for the potential hazard; meanwhile, an individual's self-efficacy is improved if he or she has previously experienced a similar threat, or has the training to respond to this threat (Kuligowski, 2013; Stein et al., 2011).

Ultimately, one does not accept risk; one "accepts the consequences" the risk provides (Morrow, 2009, p. 20). Some individuals will always take precautions while others will not seek protection under any circumstances (i.e. a motorcyclist's decision toward wearing a helmet).

According to Morrow (2009), individuals evaluate threats (or risk) in a variety of ways depending upon the nature of the threat and whether the exposure is voluntary, familiar, or changing over time. Study findings appear to indicate that the decision-making process for risk involves perceiving the situation, considering courses of action, calculating what is in one's best interest, and choosing a course of action (Stein et al., 2011). However, an accurate perception of risk does not ensure that people will take action to prevent, mitigate, or protect themselves in hazardous situations.

Decision Making

Decision making is the process of weighing a risk against the benefits or costs of taking an action. Several alternatives are often possible, and benefits and drawbacks for each alternative must be weighed. In chaotic situations, circumstances beyond an individual's experience or control can happen (French & Niculae, 2004). Humans experiencing a potential crisis are decision makers, whether they choose to take precautionary measures or choose to take no preventative action.

It is commonly assumed that people are engaged in calculating and acting in their own self-interest, but self-protective behaviors are strongly dependent upon the level of risk that an individual perceives (Stein et al., 2011). Making a decision can be a complicated process. In most instances, several courses of action are possible, and each alternative can contain various attributes that must be considered individually (Morrow, 2009). Economists study how and why people make decisions (Morrow, 2009), but there is a general lack of data about the decisions people make to respond to a weather-related warning, about evacuation behaviors, or about the

triggers that influence people to leave one location for another (Dynes, 2006; Faulkner et al., 2007).

Even though data about evacuation behaviors are missing, predictions about evacuation can be made when assumptions about risk perception are simplified (Kuligowski, 2013). Actions generally stem from three factors: 1) factors that influence what the individual perceives as a cue 2) factors that influence the interpretation of the situation and risk and 3) factors that influence the decision (Kuligowski, 2013). When one is attempting to decide which actions should be taken, the cues that are perceived, the interpretation of the situation, and risk assessment based on these cues is more significant than actions based upon stimulus and response alone.

People are more likely to choose the actions that they believe to be useful or that will provide the greatest benefit. For example, a person with pets may choose to remain at home and not evacuate if no sheltering option exists for his or her pets (Barstow IL Fire Chief, personal communication April 24, 2008). Knowing that a pet is safe can provide peace of mind, and some emergency responders have taken on the role of caregivers to pets to ensure the human owners will leave high-risk locations (Barstow IL Fire Chief, personal communication April 24, 2008). Alternatively, a pet owner may not want to be separated from a pet when he or she depends on the pet for comfort and companionship. In a disruptive situation, the need for companionship may be more important to the pet owner than the possibility that he or she may suffer consequences from the hazard.

People are generally more concerned about the seriousness of a risk than the type of risk, and they are reluctant to act on information for dangers not perceived as immediate or personal (Fritz & Williams, 1957; Stein et al., 2011). An individual weighs the potential outcomes of

certain actions against the probability that a threat will occur by giving the potential impact of a rare event more weight than an event that is perceived to be more likely (Jenkin, 2006; Morrow, 2009). This may be due to his or her perceived lack of control, the catastrophic potential, and an increased possibility of fatal consequences from the rare event (Stein et al., 2011). The pros and cons of risk can cause some individuals to believe that the cost of compliance is outweighed by the benefit of non-compliance. Other factors can affect a decision-making process, and the choice of a response action can depend on whether the risk affects only adults or is a risk for children, too (Morrow, 2009). Ultimately, people want to know whether a risk will or will not occur, but that type of reassurance may not be available due to the nature of the threat, the limitations of technology, and the probability that a hazard may only pose a threat part of the time (Mileti & Sorenson, 1990). Finding effective ways to transfer knowledge of risk to others who need the information is the focus of crisis communication messaging and response plans.

Crisis Communication and Trust

Researchers have examined aspects of crisis communication in regard to message components, dissemination, salient belief, and behavioral response (Becker et al., 2013; Kuligowski, 2013; Morrow, 2009). Perception of threat varies among groups, subgroups, and cultures, and this can impact the abilities and means of groups to respond to a crisis. Communities with people of different ages, various cultural backgrounds, infirmities, or physical limitation often face other risks and have distinct communication needs: their preferences and understanding of threat may be significantly different than communities of able-bodied adults (Binder, Borne, Johnsdotter, & Essen, 2012; Fischhoff, Brewer, & Downs, 2011; Werg, Grothmann, & Schmidt, 2013). In creating a common language of concepts and meanings, the

sender must present the message clearly and with enough detail to radiate its integrity and authority (Wild, 2004); the receiver must decide to listen, ask questions to clarify, and trust the presenter; the delivery method must suit the needs and circumstances of the sender and receiver; and the content must connect with beliefs already held by the receiver (Schein, 2013; Senge, 2006).

People perceive what is happening around them through their human senses and cognitive abilities. People can be aware of what is happening around the globe, but neither human perception nor modern communication can ensure that humans comprehend their vulnerability to current or future threats. An example of this social vulnerability occurred in Dallas Texas when the city prepared for spring thunderstorms and experienced torrential rain and flooding instead of the tornadic activity city managers had anticipated (Calianese et al., 2002). Updated information was available, but from the emergency managers' perspective, the city was prepared for the thunderstorm threat, not hail and flash flooding. The city remained vulnerable to the hail and flooding due to the inflexibility of crisis managers who were locked-in on an outcome that did not materialize (Calianese et al., 2002). Feelings of vulnerability can increase when trust is limited, or when access to information or knowledge is limited (Wild, 2004). Limited information and knowledge may also affect perception and human response.

How people perceive risk is generally misunderstood. When there is a need to alert others to a potential threat or hazardous event, this lack of understanding can be problematic (Lazo, Morss, & Demuth, 2009; Morrow, 2009). A risk is an intangible concept of probability and effect that is interpreted differently by individuals in different situations (Marynissen & Ladkin, 2012). This level of complexity makes it difficult to adequately warn large populations that

cannot directly perceive the danger of disaster (Fritz & Williams, 1957). Humans can become insensitive to numerical risk strategies that focus on hazard potential. Quantitative assessments linked to these types of risk may fail to trigger the emotions or feelings that a person needs (Marynissen & Ladkin, 2012), and various cognitive biases cause people to endorse whatever position reinforces their connection to others (Kahan, Jenkins-Smith & Braman, 2011).

People are generally more willing to believe information from people they know and are more willing to follow instructions when the basis for the message makes sense (Mileti & Sorenson, 1990; Kuligowski, 2013). Trust in the source of information is crucial but most research on trust has been conducted in samples, not emergency situations (Wild, 2004). According to Wachinger et al. (2013), trust is defined as externalized faith in individuals, authorities, and experts. Friends and family are generally considered trustworthy, while government agencies and media have diminished credibility (West & Orr, 2007). Trust is crucial during urgent moments, because it affects the perception of risk and governs the behaviors one will take to respond to a crisis (Khan, 2012; Morrow, 2009; Wild, 2004).

Trust indicates that an individual recognizes their vulnerability and has chosen to believe that the other person, group, or organization will recognize and protect the individual's best interests (Wild, 2004). Trust is given to relatively few important people in an individual's life and granting this authority to others is an act of submission for the individual. The amount of trust an individual has in others to provide protection affects his or her perception of the probability and severity of a threat (Scolobig, De Marchi, & Borga, 2012) and that individuals' risk judgment and sense of personal control and susceptibility to harm (Kahlor et al., 2003). A

lack of trust in the crisis message communicated, or toward the source of the message, can cause people to seek additional information before taking action (Love, Mackert, & Silk, 2013).

Problems with trust arise when information is not consistent among information sources, when warning information changes from one message to the next, or when specific details are missing. Crisis communication that lacks specificity about the risk, about what is being done, and about what is expected of the audience increases anxiety without increasing awareness (Jenkin, 2006). Information that is confusing, inappropriate, ineffective, or contrary to previous reports can delay a response (Morss et al., 2008). When confusion exists an individual may either seek more information or ignore the initial message (Uscher-Pines et al., 2012). Crisis communication that describes the risk and identifies vulnerabilities can eliminate confusion and reduce the information receivers need to seek additional information. However, true communication takes place only when authority and trust in the source of information is justified.

Trust is the intention to accept vulnerability (Wild, 2004). This implies that a certain amount of risk is present and an individual must make a choice about whether to believe that the other will behave in a manner to protect the individual's interests. The level of trust depends on the situation. Rules, behaviors, and precedents that govern everyday behaviors drive routine trust, while urgent trust is needed when an uncertain situation poses a serious threat to one's own life or the collective interests of others (Wild, 2004). According to Wild (2004, p. 2), there is no need to trust someone "whose actions have no impact on the trustor."

Communicating accurately and with authority instills trust and can convince people to take action during warning situations (Bonkiewicz & Ruback, 2012). The language that describes

risk reveals information about the threat and shapes the assumptions and perceptions of those who respond to the threat (Habermas, 1998; McLuckie, 1974; Mehrabian & Reed, 1968). Vague descriptions of the hazard, or a lack of clarity in defining the specific area of risk, increase feelings of uncertainty for nonscientists (Bonkiewicz & Ruback, 2012; Mileti & Sorenson, 1990), and uncertainty can delay a response. During warning situations people are reluctant to act when dangers are not perceived to be immediate or personal (Fritz & Williams, 1957; Stein et al., 2011). Feeling unsure about what will happen can increase a person's worry, fear, or sadness, while feeling angry about a situation can increase an individual's confidence, certainty, or disbelief that a threat will actually occur (Tiedens & Linton, 2001). Reasons for disbelief may include a lack of past experience, inability to adopt new frames of reference, willingness to believe reassuring communication and disregard communication predicting disaster, or reluctance to abandon property (Fritz & Williams, 1957).

The perception of risk, whether it is perceived to be unlikely or real, shapes an individual's response to severe weather events (Stein et al., 2011). The intended recipient of a warning needs usable information to make decisions about the seriousness of a threat and to determine an appropriate response. Other challenges exist. Communication often contains symbolic language used within a social group. In warning situations, many social groups may be impacted and the language used in the warning may not be universally accepted or understood. Signs and symbols that convey threat may present barriers for understanding risk and increase uncertainty when there is no common culture (Faulkner et al., 2007). Too much information can be confusing. Yet, important information can be lost when crisis communication messaging is overly simplified.

A warning is considered to be effective when the recipient of the disaster message has a sufficient amount of information to make a decision (Morrow, 2009). Ineffective warnings may cause confusion, be ignored, or cause message recipients to seek additional information. Receiving the message from multiple sources can help people to confirm the warning message (Mileti & Sorenson, 1990), so long as the sources do not impart conflicting information. Consistent information helps remove doubt. For example, during the May 3, 1999, outbreak of tornados in Oklahoma, forecasters personalized the threat and used clear concise wording to indicate its certainty. The certainty of the message was relayed by broadcasters who included images of the storm and storm damage. As the general public became aware of the devastation via news broadcasts they became more attuned to the seriousness of the situation and went to great lengths to heed warnings (Quoetone et al. 2001).

In any disaster, citizens make decisions regarding the probability that a threat will occur and whether a specific locale will be safe. However, these conclusions can vary. Some communication experts believe the role of the scientist is to be a non-persuasive communicator who provides a few necessary facts about risk and options (Fischhoff, Brewer, & Downs, 2011; Morrow, 2009), but this suggests that the public has knowledge of threat and risk. The activities of hearing the warning, understanding the content, believing that a warning is credible and accurate, personalizing the warning to oneself, and confirming that the warning is true and that others are taking heed help an individual make the decision to take protective action.

Decision Support

Humans experiencing a potential crisis are decision makers whether they choose to take precautionary measures or not. It is unclear how much information is needed for an individual to

make a decision, because determinations about vulnerability to threat and assessments of whether they are at risk are based on personal criteria (Faulkner et al., 2007; Mileti & Sorenson, 1990; Morrow, 2009). A person may fail to recognize danger if he or she has no experience with the threat. Individuals are generally adaptive and take action to protect themselves and others once they recognize danger; however, this does not mean that the actions are effective or that they have unlimited choices of action (Fritz & Williams, 1957).

Effective communication should be "more than a transmission of information" (Fischhoff, Brewer, & Downs, 2011, p. 696). When decision makers are trying to understand what they need to do, more information does not equate to better information (Mileti & Sorenson, 1990; Morrow, 2009). It is also difficult to understand information that is loaded with jargon. According to Feldman and Ingram (2009), a bridge must be built to span the gap between scientific communication and the needs of society. Professional and social group rely upon their own culture, language, and norms to communicate. However, words that are commonly understood in one profession or social group may be interpreted differently in others. For example, members of the public and scientists interpret words like probability and uncertainty differently. The public may translate uncertainty as unreliability, while a scientist is conveying precision (Feldman & Ingram, 2009). In this case, a weather forecaster may be certain that the conditions for a tornado are present, but may be less certain about when and where a tornado will develop.

Feldman and Ingram (2009) insist that a crisis can cause attention to be riveted to a potential threat, but that crisis information communicated by scientists can be confusing. When uncertainty is presented in a warning or statement, the amount of confusion is increased

(Faulkner et al., 2007). An element of the uncertainty is always present in weather forecasts and warnings because the weather is uncontrollable. Predictions of an uncontrollable process are never perfect, due to interactions within airmass boundaries and within the storms themselves (Cintineo & Stensrud, 2013). This creates a challenge for the scientist who wishes to be precise in describing and warning for conditions that have the potential to be deadly.

French and Niculae (2004) asserted that when a forecaster is providing information to support the decisions of others he or she should express confidence in what is known, knowable, complex, or chaotic in regards to the event. Acknowledging unknowns and uncertainties help to build credibility, but too much information can be mind-numbing to those faced with a decision (Morrow, 2009). Confidence is the expectation of not being disappointed; yet, confidence in a weather forecast or warning decreases when forecast lead time increases (Lazo, Morss, & Demuth, 2009). The ability to judge time is impaired in high-stress situations: too much lead time can cause the message recipient to believe the original warning was a false alarm, or lead to inertia when recipients of the message believe there is plenty of time to evacuate to safer surroundings (Mileti & Sorenson, 1990; Morrow, 2009). Simple, clear messages that describe the risk, explain the probability and severity of the risk, and identify actions that can reduce the either the risk or losses from the risk can increase the confidence of a decision-maker.

When an individual lacks confidence in a message, he or she will tend to seek other information, such as confirmatory reports from environmental cues, peers, broadcast media like radio or television, sirens, etc. before responding to a warning (Mileti & Sorenson, 1990; Sherman-Morris & Brown, 2012). People in the role of caregiver (i.e. parents, teachers, healthcare workers, etc.), people who realize they are personally vulnerable, and individuals who

have previous experience with the type of threat are generally more responsive to a warning (Bonkiewicz & Ruback, 2012; Mileti & Sorenson, 1990; Morrow, 2009). According to Mileti and Sorenson (1990), most people will not blindly follow recommendations unless they understand the basis of the warning. Confidence in the warning increases when information that confirms the threat is consistent. Study findings indicate that hearing actual reports of damage occurring with a storm are most important to a decision-makers' interpretation of the threat and their ultimate decision of whether to seek shelter (Paul & Stimers, 2012; Sherman-Morris & Brown, 2012; Uscher-Pines et al., 2012). When the experts lack credibility the only rational response is disbelief in the message (Jenkin, 2006).

The goal of a risk communication message such as a severe weather warning or severe weather statement is for individuals, groups, and organizations to make decisions, plan for hazardous events, and take appropriate actions to keep themselves and others safe. To communicate risk and convey hazard information in a useful manner one may need to consider a variety of communication models that have the potential to help individuals make decisions.

Communication and Understanding

Much of what is learned comes through human interaction. A primary form of learning and sensemaking is the language through which one generation transmits cultural knowledge, content, and learning to another (Liddicoat, 2014). Culture teaches individuals what and how to think, how to solve problems, and how to use language. Yet, language and the words that are used can convey different meanings within various culture groups. Meaning is distinct from words (Mehrabian & Reed, 1968), and different meanings can create impediments to communication. The Mehrabian Communication Model indicates that 55 percent of effective

spoken communication is conveyed through facial expression; 38 percent of communication is paralinguistic (i.e. meaning conveyed through the way words are said); and only 7 percent of meaning is derived from the words that are used (Mehrabian & Wiener, 1967). When an individual is unsure what certain words mean, or when he or she lacks trust in the person speaking, more attention is paid to the non-verbal signals of voice tone and body language. When one is unable to hear the tone or see the body language, it is easier to misunderstand words.

Great care must be taken in written communication since it lacks the language of expression (Mehrabian & Wiener, 1967). When warning processes begin with encoded messaging that must be read and then interpreted, individuals who are unable to read and those who are unfamiliar with the language used in the text or the context may face obstacles. Human factors research suggests that, when alerting people to a threat, a simple, well-written text or graphical image can convey sufficient information for most individuals to comprehend (TASA, 2012). Icons and labeling have universal appeal in communicating danger information to people in a non-verbal way (e.g. no smoking or the narrowing of traffic lanes), since signs and images can transcend language barriers and communicate the actions that are preferred. While graphical depictions can improve an individual's understanding that a danger is present, written messages are more effective when the information is personalized to help people identify and respond to the threat (Dynes, 2006; Mileti & Sorenson, 1990; Morrow, 2009).

A threat can exist whether its presence is known or unknown (Hochbaum, 1958; Witte, 1992). Threat messages that convey a relationship between the threat, the physical impact, and the potential social disruption help ensure that the information contained in the message is

understood (Fritz & Williams, 1957; McLuckie, 1974), but warning messages should also serve as an impetus for action (Morrow, 2009; Stein et al., 2011). Witte (1992) says multiple components are necessary to convey a threat, create an appeal for action, and provide sufficient information for the message recipient to understand the message and believe a response is possible. The message recipient must comprehend the severity of the threat, perceive that he or she is susceptible to the threat, understand that there are things that can be done to reduce susceptibility, and believe that he or she can perform the recommended response (Severtson, 2013; Witte, 1992). Communication and comprehension require a delicate balance. Messages with too much fear and too little efficacy will fail to provoke the desired response (Hong, 2011).

Risk Communication Models

Historically, risk communication research has tended to resort to case studies and best practices, rather than investigating how humans receiving the threat information are impacted by the message or their response behaviors (Schumacher et al., 2010; Sheppard, Janoske, & Liu, 2012). Health care models have long been used to predict or explain an individual's behaviors, intentions, and attitudes toward risk and compliance with medical regimens, smoking, diet and physical activity (Glanz, Rimer, & Viswanath, 2008). Recently, heath care models have been adapted for use in crisis management, emergency management, and terrorism response studies to help officials construct better methods for alerting the public to the risks that environmental hazards, terrorism, and natural disasters can pose; to improve public response; and to develop explicit communication for the response phase after an event has occurred (Mileti & Sorenson, 1990; Morrow, 2009; Sheppard, Janoske, & Liu, 2012).

The health belief model (HBM) implies that an individual's belief that a threat exists, combined with the belief that an action to mitigate the risk will be effective, can predict how likely it is that an individual will adopt a protective behavior (Hochbaum, 1958). Components of the HBM are applied to a variety of health-related behaviors, from screening for disease, immunizations, chronic illness, and health maintenance activities (Updefraff et al., 2015). However, HBM has limitations. It does not take into account the personal attitudes and beliefs of the individuals facing the threat or the environmental or economic factors that may prohibit the recommended actions. Furthermore, HBM assumes that all individuals have equal access to information and decision-making cues. HBM could be used to examine perceptions and influence if it considered how perceived knowledge about susceptibility and severity influence people to take protective actions. However, fear may be a better predictor of predicting health-related behavior (Glanz, Rimer, & Viswanath, 2008).

The theory of planned behavior (TPB) focuses on behavioral intent. Intentions are influenced by a person's attitude toward a behavior, the social and subjective norms that cause the individual to believe that peers and people of importance will approve or disapprove of the behavior, and the amount of control that the individual perceives is needed for the situation (Ajzen, 1991). Behavior is a function of an individual's personal estimate of risk and the potential harm that he or she would face if the behavior were not performed (Sheppard, Janoske, & Liu, 2012). An individual who feels in control may be more likely to prepare for risks. Perception of control helps predict an individual's behavioral intention and actual behavior: communication that helps an individual feel in control may improve the ability to respond to a threat (Sheppard, Janoske, & Liu, 2012). TPB assumes that behavior is developed through linear

decision-making processes; it does not consider circumstances that could result in a modified decision when new information is available or the environment changes. TPB does not consider emotional variables like threats, fear, or past experience.

Social cognitive theory (SCT) (aka social learning theory), considers how a person's past experiences influence, reinforce, and shape behaviors. According to SCT learning is dynamic and reciprocal; it has a social context since an individual's internal and external behaviors can be reinforced through skills, expectations, and the behaviors modeled by others in the social environment (Bandura, 1986). SCT has been widely applied in areas of human functioning, organizational behavior, classroom learning and achievement, and physical and mental health. However, there are limitations to this theory. SCT automatically assumes that a person will change when their environment changes; it focuses on the processes of learning and knowledge acquisition and fails to consider other emotions or motivation that could influence behavior.

The heuristic-systematic model of information processing (HSM) is a communication model that attempts to explain how people receive and process persuasive messages (Chaiken & Maheswaran, 1994). Heuristics also explain how a person uses his or her previous experiences to analyze risk and make decisions (Sheppard, Janoske, & Liu, 2012). HSM suggests a person attempts to seek and validate information when he or she is motivated to find relevant facts. Heuristic rules are normally applied early in a decision-making process when people rely on gut feelings and are less motivated to resort to the systematic processing rules of analysis. Attitudes formed through a heuristic process tend to be less predictive of future behavior, less stable, and less resistant to counter-arguments. This may be because attitude judgments are influenced less by the caliber of the argument than by the credibility of the source, the opinions of others, and

the length of the message (Chaiken & Maheswaran, 1994). HSM has been used to evaluate risk judgment, such that systematic processing of information is related to greater motivation and heuristic processing is related to the sufficiency of information (Trumbo, 1999). Both aspects would indicate self-efficacy; however, heuristic processing is associated with a person's judgment that the event has less risk (Trumbo, 1999).

The risk information seeking and processing model (RISP) blends elements from the theory of planned behavior (TPB) and the heuristic-systematic model of information processing (HSM) to identify the gap between an individual's perception of current knowledge and the amount of knowledge that is believed necessary for the person to make an effective decision (Griffin, Dunwoody, & Neuwirth, 1999). This gap is influenced by the perceived characteristics of the hazard, the familiarity with the threat, and the level of dread the individual feels toward the hazard (Sheppard, Janoske, & Liu, 2012).

Summary

In disaster situations, there is a growing trend for people to not respond appropriately to the threat (NOAA, 2014; Paul & Stimers, 2012). Technologies have been developed to detect severe weather, to standardize warnings and statements, and to increase forecaster skill. Yet, even with advance notice, many people do not heed severe weather warnings (NOAA, 2011b; NOAA, 2011c; NOAA, 2013a). Social scientists, concerned with this trend, see a need for the social sciences and physical sciences to unite (Paul & Stimers, 2012; Uscher-Pines, Chandra, Acosta, & Kellermann, 2012, June 29); however, it neither social science nor the physical sciences are drawing upon seminal research from earlier generations that had successfully achieved these objectives.

Disasters are confined by space and time. During disasters members of society are exposed to danger, and undergo loss. The social structure of the community is disrupted and damage to infrastructure can make it difficult for the society to function (Fritz & Williams, 1957). Informational messages that only warn about a danger are insufficient disaster messages, because people are reluctant to act upon threats that are not perceived as immediate or personal (McLuckie, 1974). A warning that stresses the interrelationships among the disaster agent, the physical impact, and the potential social disruption can help people to better identify and respond to the threat (McLuckie, 1974).

For over 50 years scientists, engineers, and sociologists assessing damage and investigating the after-effects of severe weather have recommended that improvements be made in communicating warnings and response planning. Yet a comprehensive picture of what the public understands about a potential threat does not exist, and few studies document how a weather related crisis can sensitize people to respond to future warnings, their perception of threat before or after the storm, or the level of trust that is needed before a warning is believed (Keller et al., 2012).

Trust is crucial to effective risk communication. When risk is uncertain information from a credible source helps improve trust (Bonkiewicz & Ruback, 2012; Gray et al., 2012; Sutherland, 2012). However, the most effective warnings that address the public's need for knowledge, contain specific information about the disaster, and identify actions that can mitigate the threat or provide protection (Bonkiewicz & Ruback, 2012; Lachlan & Spence, 2014). Whether an individual actually takes protective action depends on their perception of risk (Gray

et al., 2012; Slovic & Peters, 2006). People respond differently to crisis information and, when risk is uncertain, perception can change

Uncertain risks are characterized by probability and possibility. People assess risk by personal knowledge and rules-of-thumb. While an expert may assess a risk with statistical and technical means, a non-expert may be influenced by "values, attitudes, social influences or cultural identity" (Fleischhauer et al., 2012, p. 2792). Non-experts rate risks from historic events as more likely and those that have recently affected them as being less likely to occur in the near future (Fleischhauer et al., 2012). Perception of susceptibility helps determine a person's choice of activity, the amount of effort he or she will expend, and how long he or she will sustain the effort under stressful conditions (Severtson, 2013). Being aware that a hazard exists is an insufficient message. The type of response that is taken depends upon an individual's perceptions of risk and susceptibility, their previous experience, and their level of trust in information they receive (Khan, 2012). The methods to uncover these drivers of response are described in Chapter 3.

Chapter 3: Research Method

The purpose of this exploratory study was to examine how information contained in a severe weather warning affected recipients' perceptions of risk and response toward a severe weather threat. In the United States, cost estimates for hurricanes, tornados, flooding and winter weather can surpass billions of dollars while the human toll can be hundreds of people killed or injured (Smith & Katz, 2013). Weather watches and warnings are designed to alert people to weather-related threats before the storms strike. The problem is that many people do not heed these warnings (NOAA, 2011b; NOAA, 2011c; NOAA, 2013a).

Perception and human response have been identified as problematic in research findings after significant storms have occurred (NOAA, 2011b; NOAA, 2013a; NOAA, 2014). Yet, most improvement efforts after severe weather episodes are focused on training and technology (Knocke & Kolivras, 2007). In spite of years of research, how humans perceive risks conveyed by storm warnings or decide to respond remains unknown (NOAA, 2016) and the implication for positive social change comes through the exploration of this gap. In Chapter 3, several elements are addressed: the research design and rational for the study, the role of the researcher, and the methodology.

Research Design and Rationale

According to findings from crisis communication research in other fields of study, humans have a need to confirm threat (Griffin et al., 1999; Mileti & Sorenson, 1990; Sutherland, 2012). Although these finding are generalized within the weather enterprise, only ancillary evidence exists to indicate a confirmation process is needed during severe weather warnings. Human factors analysis of the process to create weather forecasts and warnings have focused on

forecasters and their ability to manage technology and create warnings that convey information about a weather-related threat; however, the general public is ultimately responsible for taking protective action once a warning is issued (Quoetone et al., 2001) and less is known about public responsiveness.

Weather warning improvements have focused on increasing forecast accuracy and providing longer lead times, while other efforts have examined warning communication (Morss, Demuth, & Lazo, 2008; Sherman-Morris & Brown, 2012; Uscher-Pines et al, 2012). Still, little is known about the impact of warning information after a warning is issued, particularly in how the public receives, filters, shares, or perceives the message (Schumacher et al, 2010). The warning process is thwarted when individuals do not comprehend what warnings mean or when they chose actions that are counterproductive to personal safety. McLuckie's (1974) sociological perspective of warnings and human response provided a foundation for forecaster training over 40 years ago. This advice was incorporated into the warning process, so it is unclear why service assessments (NOAA, 2014, 2013, 2011) and damage surveys continue to identify communication and response as problematic.

How the public perceives a warning and responds to a weather-related threat needs to be understood (NOAA, 2016). The purpose of this research was to explore the gap between warning and response. In this qualitative study, severe weather warnings were evaluated by individuals familiar with crisis communication messaging to determine whether the documents contained wording that conveyed perceived severity, perceived susceptibility, self-efficacy, and response efficacy. Previous research indicated that these components were important contributors to human understanding and behavioral response (Witte, 1992).

In this study, a subgroup of key stakeholders evaluated wording in VTEC-encoded warnings to determine whether sufficient information was present for people receiving the warning to perceive a weather risk, to identify people or locations susceptible to the risk, and to comprehend what actions could improve personal or public safety.

Although there are many unanswered questions in regard to warnings and human response, this study was narrowed to focus on one portion of the warning dissemination process by examining previously issued severe weather warnings and the perceptions held by EMP who convey warning information to others. In the study, I attempted to answer three questions.

- RQ_1. How does a VTEC-encoded warning affect EMP's perception of risk toward a severe weather threat?
- RQ_2. How does information in a VTEC-encoded warning affect EMP's perception of an effective response?
- RQ_3. How does a VTEC-encoded warning affect EMP's perception of efficacy?

The aim of science is to produce knowledge and achieve understanding by explaining some aspect of the world around us (Singleton & Straits, 2010). Scientific disciplines differ when it comes to the objects of study, relevant processes, concepts, and jargon. Limited interactions among the disciplines can result in "stovepipes" that keep scientific communities isolated or working at cross purposes from researchers in other disciplines who are investigating similar problems (Feldman & Ingra, 2009).

The science of weather prediction is rooted in the natural sciences of physics, atmospheric chemistry, and mathematics, yet meteorology, as both a natural science and a social

science, provides opportunities for linking the physical processes of the natural environment to human behaviors and response. Within weather research communities', qualitative and quantitative research are most commonly conducted via case studies or surveys. Social scientists who participate in storm assessments and disaster surveys assert that the perception of risk must be understood before the problem of response can be addressed (Keller et al., 2012). For this reason, a different research approach is warranted.

Role of the Researcher

My role as the researcher in this study was that of observer-participant conducting free-response interviews with EMP, recording, transcribing, and coding these responses, and then analyzing these data. As a government employee, I am expected to maintain professional relationships with EMP because of the public-private working relationships established among my work group and other organizations within the weather research and disaster preparedness communities. I routinely interact with EMP due to my work, and during training activities, at conferences, or when responding to weather or hazardous events unrelated to this study.

The goal of each interview was to gain an understanding of EMP's perspective toward the information contained in severe weather warnings and statements issued by my agency, but not my work group. Interviews provided a two-way exchange of knowledge in which direct feedback from the respondent became an opportunity to gain more detailed or free flowing information than that gained by surveys (Buchecker et al., 2013). The audio of each interview was recorded, transcribed, and analyzed. Audio recording and transcription of the interviews provided a control mechanism to reduce fallibilities of intuition, recollection, or selective

attention (Kvale & Brinkmann, 2009; Ten Have, 2004). In coding the responses, I planned to document a previously non-existent benchmark.

I evaluated the effectiveness of VTEC warning messages by documenting how EMP perceived the risk conveyed by the warning and their perception of an effective response to the threat. EMP are a first link in the warning chain from a weather forecaster to the general public. They receive warning information in a standardized format, and then share this information with others. EMP become communication experts due to the nature of their work with emergency communication protocols and, although they are not scientists, they are assumed to have greater familiarity with severe weather warnings and emergency response than the general public. By documenting the perceived risks that communication experts discern from information in VTEC-encoded warnings, I hoped to identify the areas within warnings where scientific information is misunderstood by nonscientists and eventually use information discovered through the open interview process to develop a closed question instrument to be used in future research.

Interviews offered greater flexibility than questionnaires when it came to the types of questions asked and the format used. Open-ended questions allowed participants to explain their thoughts and concerns and interviews provided me with a wealth of information for this study and future research. Audio recording and transcription of the interviews provided a control mechanism to reduce fallibilities of intuition, recollection, and selective attention (Kvale & Brinkmann, 2009; Ten Have, 2004). A simple evaluation strategy was developed to ensure that recipients understood the intended message and the use of a single researcher helped maintain a standardized style of interviewing (Irvine, Drew, & Sainsbury, 2012).

Methodology

The purpose of this study was to explore tacit information about risk and response (Approval No. 10-06-15-0060458). Individuals with specialized areas of knowledge in risk and response were invited to participate in an interview process designed to capture perceptions of the individuals. NVivo 11 was used for data analysis and a work journal was used to capture observations, ideas and insights during and after the study. Before interviews were conducted, potential participants were provided with an invitation and informed consent document that described the interview process, the purpose of the interview, the proposed time commitment for the study, the participant's right to withdraw from the study, and the debriefing procedures.

In the study individuals from a variety of workgroups were provided with warnings for a severe weather event and then asked a series of interview questions to determine whether the message contained four parameters associated with the perception of risk. The interview questions, which were developed by the researcher and a panel of experts (see Appendix C), were used to standardize the interview process and to explore whether the warning messages contained wording that indicated the severity of the storm, that provided clues to identify people or locations susceptible to storm risk, and whether response efficacy and self-efficacy were possible.

The structural portion of the interview consisted of simple questions to begin an inductive conversation. A deductive approach could have masked key utterances and limited further inquiry. In an inductive approach, the evaluator becomes immersed in text for the purpose of crystallizing core understanding intuitively. All interviews were audio recorded, transcribed and analyzed. The audio recordings served as a control on limitations and fallibilities of intuition and

recollection and provided some guarantee that analytic conclusions would not arise due to selective attention or recall. A combination of letters and numbers assigned to each interview were used to mask an interviewee's identity and protect his or her privacy. Names and other pieces of identity information were not attached to the data

Each interview took approximately 20–30 minutes and was followed by the debriefing process. I thanked each participant, discussed the purpose of the study, and asked if there were questions or concerns about the interview or the study. The debriefing process provided a means of triangulation for interview participants to provide feedback on the interview, voice concerns, make observations, or validate perspectives. Information gained during the debriefings also identified opportunities for future research.

Participant Selection Logic

This qualitative study was developed to determine how information in a warning for severe weather affected EMP's perceptions of risk and response. EMP serve as a first link in the warning chain from weather forecaster to the general public. They receive warning information in a standardized format and share this information with others. EMP are considered communication experts due to the nature of their work with emergency communication protocols. It was assumed that these individuals would have greater familiarity with severe weather warnings and emergency response than the general public, but would have a different perspective than the scientists who create the warnings. Measuring the perception of risk that communication experts had toward VTEC-encoded warnings provided an opportunity to identify areas within warnings where scientific information is not effectively conveyed to nonscientists.

EMP are considered partners in the public-private relationship to share warning and disaster information. EMP routinely work with the general public and they are better situated to receive feedback from nonscientists than the forecasters who use technology to identify weather threats and create warnings. When scientists share information with nonscientists the opportunity for miscommunication is high. The opportunity for miscommunication is even greater when message recipients have different perceptions of risk, when warning messages are relayed through a variety of sources, and when messages lack visual or auditory cues. By capturing the perception of risk that EMP had toward threat information conveyed in a VTEC-encoded warning the perspectives of people who are the first link in the warning chain was documented. This helped shed light on how people in a particular setting come to understand, act, and manage themselves during severe weather situations; and this information, when compared and contrasted with the perceptions of weather and water experts, was used to document a benchmark that did not previously exist.

The target population of EMP came from two stakeholder groups: emergency managers for counties in three Midwestern states and telecommunicator dispatchers in these communities. The combined group of emergency managers and telecommunicator dispatchers was known as EMP. It is customary for EMP to receive weather warnings and statements in standardized formats; their jobs require that they convey this information to others. The general public was excluded because information received by the public can be filtered by the information provider. They were also excluded because members of the public receive warnings and statements in a variety of formats (i.e. radio, television, the internet, graphical display, telephone alerting protocols, etc.), it was also assumed that some members of the public would not have the ability

to comprehend text warnings due to language barriers, vision impairment, or physical, emotional, or educational difficulties.

A plan was developed to recruit individuals in emergency management and support positions, conduct a minimum of 20 interviews, and interview until saturation. Saturation occurred when interviews produced essentially the same data; stopping the interview process at saturation reduced redundancy. Non-proprietary contact information was found via an internet search for county emergency managers in Iowa, Illinois, and Missouri. Determining who to contact was challenging since the titles used to identify individuals who develop or implement county or state emergency response plans and the offices where they worked were different in each community. Position titles used by the individuals recruited for this study included county emergency manager, emergency management coordinator, ESDA coordinator (Emergency Service and Disaster Assessment), EMA (Emergency Management Agency), and IPEM (Illinois Professional Emergency Manager). Additional designations could exist elsewhere across the United States.

The recruitment was planned to begin by emails inviting potential participants to take part in the study. The email invitation was designed to serve as a consent form. It briefly described the background for the study, the procedures that would be used, the time commitment for participation, sample questions, the potential risks and benefits of participation, and information on the right to withdraw from the study. People seeking more information were invited to contact me or the Walden University representative whose contact information was included on the form. Individuals interested in participating were asked to acknowledge their consent to the study by email or by signing a copy of the form and mailing it to me.

Instrumentation

I undertook an exhaustive investigation to find an instrument suitable for this study. This included numerous searches of the Mental Measurements Yearbook, Health and Psychosocial Instruments, and PsycTESTS databases. Because no previous instruments were suitable for the study it became necessary to consult with a panel of experts and develop relevant interview questions through an iterative collaborative process. Within the weather enterprise, qualitative and quantitative research is often conducted via case studies or surveys. Social scientists participating in storm assessments and disaster surveys insist that additional research into risk perception is needed and that different approaches are warranted.

Qualitative research is not linear and cannot be entirely planned out before a researcher enters the field (Keyton, 2006). Little-standardized instrumentation exists for exploring the ordinary with a different focus or when searching for a holistic view of culture and context (Shaw, 1999). In these situations the researcher becomes the main instrument in the study. Interviews are appropriate research tools when the underlying problems are not readily apparent, when insider perspectives are needed, when formative evaluation is aimed at improving the program or practice, when a situation permits intensive inquiry without posing serious ethical obstacles, when resources exist to search for counterevidence, and when there are sufficient customer and end-user agreements on the methodological strategy (Shaw, 1999, pp 14–15). Questions about validity may exist due to the small sample and limited participation. This has implications on whether it is possible to generalize the findings to other settings.

This study applied a semi structured interview for several reasons. First, the semi-structured approach allowed me to oversee all aspects of the data collection process; second, the

conversational nature of the interview helped establish rapport between the interviewer and respondents; third, the interview provided a means to address communication problems as they arose; fourth, an interview allowed neutral probing questions to be asked; and finally, the structure helped to ensure that all questions were recorded and answered (Irvine, Drew, & Sainsbury, 2012).

The structural portion of the interview consisted of simple questions to begin an inductive conversation. A deductive approach could have masked key utterances and limited further inquiry. In inductive approaches, the evaluator becomes immersed in text for the purpose of crystallizing core assumptions and intuitions (Shaw, 1999). The inductive approach used in this study was an evaluative attempt to understand how EMP perceive risk and efficacy in VTEC products and uncover how that knowledge came to be known.

An interview is a social production of knowledge between the interviewer and interviewee (Kvale & Brinkmann, 2009). While a standardized interview can reduce interviewer error, it may result in reduced validity if a respondent's misinterpretation of questions is uncorrected or ignored (Irvine et al., 2012; Singleton & Straits, 2010). In this study, it was important for EMP to comprehend the questions asked. I asked clarifying questions to obtain fresh insights and perspectives. Expanded responses to interview questions helped me to identify areas within a warning that increased, diminished, or rendered no effect upon the interviewee's perception of risk or perception of efficacy.

Expert Panel: Selection and Background

Within the weather enterprise qualitative and quantitative research has been most commonly conducted via case studies or surveys. Social scientist participants of storm

assessments and disaster surveys have asserted that additional studies into the perception of risk are needed. An exhaustive investigation was undertaken of the Mental Measurements Yearbook, Health and Psychosocial Instruments, and PsycTESTS databases to find a suitable instrument the study but when no previous instruments were found, it became necessary to try a different approach. I began this alternate process by contacting a meteorologist involved with an experimental project to improve NWS warnings. Through this contact, I was introduced to Expert 1. A chance encounter with a social scientist at a conference led to more introductions and referrals to other experts in the social science, risk communication, and disaster preparedness fields. Two experts failed to respond to my initial inquiries and two others agreed to review the proposed interview questions. These experts challenged me to develop a broader perspective toward risk and response by critiquing the proposed interview questions, asking probing questions about the study, offering suggestions, and recommending subject matter experts to review subsequent revisions. Four subject matter experts were eventually identified to form an expert panel. Questions that were developed with the help of these experts are located in Appendix C.

- Expert 1 is a professor at Arizona State University (ASU) with over 30 years of experience in risk perception, environmental sciences, modeling decision sciences, and information technologies. Before ASU, he was a senior scientist at the University of North Carolina (UNC), served as director of disaster and environmental programs at the Renaissance Computing Institute, and was senior modeling advisor to the U.S. Environmental Protection Agency. Prior to working at UNC, he directed the research and

application of advanced information technologies in problem solving and decision support at the North Carolina Supercomputing Center.

- Expert 2 is an organizational psychologist and management consultant who specializes in mediation services, communication, and cultural conflict management. She is a member of a community emergency response team (CERT) in Florida, where she works closely with EMP. Her academic interests incorporate education, disaster and humanitarian relief, and sustainable action with her experience in pre-disaster planning and disaster management, law enforcement in democratic environments, and decision assessments.
- Expert 3 is the meteorologist-in-charge (MIC) of a weather forecast office in the mid-South, with responsibilities for ensuring the citizens of west Tennessee and portions of Missouri, Arkansas, and Mississippi receive timely and accurate weather warnings, forecasts, and climate information. This expert maintains close working relationships with NWS partners, including the emergency management community and the media. He has conducted extensive research in severe weather communications and preparedness within the emergency management community and is a frequent presenter at professional conferences.
- Expert 4 is a warning coordination meteorologist (WCM) at a weather forecast office in the mid-South. He served as lead investigator for NOAA's 2011 tornado service assessments and has worked as a WCM at weather forecast offices at Fort Worth Texas, and Memphis Tennessee, and as an MIC at Phoenix Arizona. He is a risk management expert with extensive research and understanding in the steps that citizens can take to protect themselves in the face of a natural disaster.

Procedures for Recruitment, Participation, and Data Collection

Background data for the study came from public domain documents, official weather records, and published reports of storms occurring within the continental United States, as well as historical documentation in storm surveys and disaster assessments, hazardous weather outlooks alerting the public to the potential for severe weather several days ahead of the event, special weather statements, severe weather statements, and watches and warnings issued for these storms. Data for the study included randomly selected severe weather warnings and the transcribed interviews from 20 EMP.

The plan was to initially recruit five to seven county emergency managers within in a 36-county warning area that covers portions of Iowa, Illinois, and Missouri, to supplement this population with telecommunicators, dispatchers and emergency management support staff, and to conduct individual interviews with each participant. It was predetermined that additional emergency managers could be invited to participate if the initial recruitment efforts resulted in too few participants

To obtain interviews I planned to travel to the counties where emergency manager participants worked. The data collection time period depended upon my ability to schedule multiple interviews for a single location on the same day. The data collection process was expected to take 3 to 6 weeks. However, problems in the recruitment of participants and the scheduling of interviews caused the data collection process to be delayed several weeks.

I conducted a single interview with each participant and used audio recordings to serve as documentation of the interview process and data collection method. An alias was assigned to mask the identity of participants, and an aggregate of responses provided a composite picture of

the study. It was predetermined that the interview process would be paused or stopped by the interviewer if it appeared that the interview was causing a participant distress. Study participants could also withdraw from the study for any reason at any stage of the research. Each interview was followed by a debriefing process that provided interview participants an opportunity for feedback and discuss concerns, to make observations, or ask further questions about the purpose and design of the study. During debriefing, study participants were also told they would receive a 1 to 2 page summary of the study when all research was complete.

Recordings from each interview were transcribed, and copies of electronic data were stored in password protected files. Paper copies of transcriptions and informed consent documents were stored in a locked file cabinet and electronic versions of transcriptions and computer files were backed up onto a mobile hard drive stored at a secure off-site location**.**

Data Analysis Plan

Data collected consisted of transcribed interviews with EMP. Two tape recorders were used during the interview process. I provided recorders, microphones, spare batteries, and power cords. Each interview was numbered, interview data was transcribed, aliases were assigned to participants, and the code used for assigning interview numbers and aliases was maintained in secure files in my office. Backup copies were stored in a secure, off-site location. Public domain voice recognition software was used to create interview transcriptions. Each transcription was reviewed as needed to ensure that the audio recording and transcribed data were consistent and complete. Digital recordings and transcriptions were stored in a password protected files with backup copies stored off site. Study participants were asked if they wanted to receive a copy of

the informed consent document that they signed prior to the study; a second copy of this document is maintained in a secured file.

NVivo 11 was used for data management and analysis. Computer documents are maintained in password protected files that are routinely backed up. Transcriptions and informed consent documents are stored in a locked file cabinet. Electronic versions of transcriptions and computer files are backed up onto a mobile hard drive and stored in a secure, off-site location. By using NVivo and transcriptions of the interview responses I attempted to answer to three research question.

RQ 1**,** How does a VTEC-encoded warning affect EMP's perception of risk toward a severe weather threat?, was addressed by participant responses to interview questions 1–8. Responses to interview questions 1–3 addressed a participant's level of experience with severe weather warnings. Interview questions 4–8 were developed to assess warning comprehension and perception of risk (i.e. how serious is the threat, when will it occur, who is vulnerable, and what protective actions are needed).

In RQ 2, How does information in a VTEC-encoded warning affect EMP's perception of an effective response?, I was investigating perceptions that EMP had toward information they received in severe weather warnings. Transcribed data were analyzed to recognize how EMP understood information contained in a severe weather warning, their perception of an effective response to the perceived threat, and to uncover how that knowledge came to be known. Interview questions 4 and 7 examined participant perception of susceptibility and severity and whether a protective action was needed. Questions 5, 6, and 8 were asked to examine preconceptions that inspire a response. Questions 9 and10 were designed to examine trust in the

information source. Question 11a, 11b, and 14 were asked to examine a participant's perception of vulnerability. Questions 11c and 11d were developed to examine the potential effectiveness of a response, while interview questions 15 and 16 addressed the quality and sufficiency of information.

In RQ 3, How does a VTEC-encoded warning affect EMP's perception of efficacy?, I wanted to investigate the perception of efficacy that EMP have toward the wording used in severe weather warnings to understand how EMP determined whether a response was needed, whether they believed they would take protective action themselves, and uncover how that knowledge came to be known. Questions 2 and 3 were developed to examine the participants' basis for decision-making. I asked questions 3, 11 a–e, and 12 to examine participant response efficacy and the perceived actions that the public would take. Questions 2 and 13 were asked to examine self-efficacy and the perception of personal responsiveness to a warning.

Data analysis was conducted via computer at my office. By using NVivo 11 qualitative data were conveniently stored and retrieved from document files with a computer program. Search features of the program helped locate words, passages, or themes associated with a data code, and made comparison of data from multiple sources or among code labels possible.

The study also included a stop data collection procedure. If a need had arisen for reasons such as conflict of interest, re-assessment of risks and benefits, or breached confidentiality the interview could have been paused and resumed at a later time, or else considered invalid and eliminated from the study.

Issues of Trustworthiness

Credibility

The credibility of VTEC-encoded severe weather warnings was evaluated to gauge whether words or cues in these products had the ability to convey information, inspire a protective response, alter the perception of risk, or a combination of these. Findings from previous studies indicated that perceived severity, perceived susceptibility, and efficacy were necessary elements for perceiving risk and choosing a response (Hochbaum, 1958; Witte, 1992). In those studies perceived severity was related to understanding that a threat was serious; a belief about the chances of experiencing the threat was indication of perceived susceptibility; belief that a response would prevent or mitigate a threat demonstrated response-efficacy; and an individual's belief in their ability to take protective action was tied to self-efficacy (Severtson, 2013; Witte, 1992).

A quasi-comparative correlational study was used to evaluate the credibility of weather warnings, advisories, and statements by considering the risk an individual perceived from reading a VTEC-encoded warning. I conducted and audio recorded interviews, used voice recognition software to transcribe the interviews, and used NVivo 11 to assist with the management and analysis of data. During analysis, I looked for relationships among the perspectives held by dispatchers and emergency managers. The variables included work setting, age, gender, and experience including: severe weather experience, time in the career field, and position including supervisory status, shift lead, or staff member. The interview debriefing process provided a means of triangulation for interview participants to provide feedback on the interview, voice concerns, make observations, and validate perspectives. Carefully questioning

the meanings during the interview process and member-checking of responses from one respondent to another provided a means of validation-in-situ (Kvale & Brinkmann, 2009). Triangulation and validation also enhanced the credibility of findings.

Transferability

EMP serve as a first link in the warning chain from a weather forecaster to the general public. EMP receive warning information in a standardized format, and then share this information with others. They become communication experts due to the nature of their work with emergency communication protocols. They have greater familiarity with severe weather warnings and emergency response than the general public, but they are not scientists. By documenting the risk that communication experts perceived from information in VTEC-encoded warnings I attempted to turn tacit knowledge, which is knowledge held by the individual, into explicit knowledge that could be captured, codified, and used by others. This was done through the transcription of interviews into documents which could be analyzed. A preliminary goal of the research was to identify areas within a warning where information was not adequately conveyed to nonscientists. Information discovered through the open interview process helped establish a benchmark for future research and may lead to the development of a closed question instrument.

Dependability

To determine dependability, the qualitative counterpart to reliability, I used a control group consisting of warning coordination meteorologists (WCM), a science and operations officer (SOO), a senior weather forecaster, and a hydrologist to establish the validity of content in the warning messages used in the study.

Control group participants were scientists with expertise in severe weather warnings; this expertise includes knowledge of warning criteria, warning composition and dissemination, and storm verification. These government employees were invited to participate as members of the control group via an invitation consent form sent by email. Interviews were conducted at neutral community locations during the scientists' off-duty hours. Each interview consisted of the same questions that were asked of EMP. Control group interviews included an additional question to establish the authenticity of the warnings used in the study as VTEC warnings for severe weather events, and that the warnings conformed to established standards and policies for warnings.

It was assumed that individuals in the control group might have different perceptions toward warning information than others in the study because of their scientific backgrounds and severe weather experience. It was also assumed that members of the control group would comprehend the weather risk and the response that the warning intended to convey. I used the perceptions of the control group to compare and contrast these with responses from EMP. It was my belief that scientific knowledge was effectively transferred when EMP and control group participants provided similar responses. Consistency among the responses was presumed to be an estimate of reliability toward the perception of risk.

Confirmability

I used NVivo 11 to manage and analyze data. Knowledge assets, such as the transcribed interviews from this study, add value to an organization when they can be reused. It was assumed that confirmability of the study would exist if the knowledge objects created by the study could be found, modified, or reused for other research.

Ethical Procedures

Ethical issues that may surface during data collection can include informed consent procedures, confidentiality, deception, or covert activities. To eliminate these matters, all research steps were subject to institutional review and conformed to established guidelines for working with human subjects. All participation in the study was voluntary. The informed consent document provided to each potential participant listed the purpose of the research, the proposed time commitment if they chose to participate in the study, and their right to withdraw from the study before the study was complete. To participate in the study volunteers needed to sign an informed consent document before the interview. The study approval specified that I would consult with dissertation committee members to determine whether to replace a participant or proceed without a replacement if a participant decided to withdraw before the study was complete. I secured all signed informed consent documents in locked files. To ensure anonymity, each participant was assigned an alias and an aggregate of responses provided a composite picture of the study. The research plan specified that all accumulated data were to be archived and retained in a secure storage location for 5 years and removed from storage and destroyed at the end of this archive period.

No agreements were required to gain access to participants. Contact information for emergency manager participants was found via an internet search of public access web pages for 36 counties in the Midwestern United States. Emails were sent to potential participants; individuals interested in the study either responded with a statement of consent or chose not to respond. Once a consent document was received, I contacted the potential participant to set up an interview time and location. Supplemental participants were obtained through a snowball

sampling. Emergency managers became chain referral intermediaries when they shared copies of the invitation/consent document with their support staff and law enforcement dispatcher/telecommunicators. Interested individuals contacted me via email to affirm their consent to participate.

In the interview debriefing process, I asked participants to evaluate the interview from their perspective. The research plan specified that if even one person perceived the event negatively, this event would be reported to the IRB. The research plan also required that unanticipated problems with the potential to affect the risk-benefit analysis, confidentiality, or subjects' willingness to continue in a project be reported to the IRB. These could include challenges to implementing the IRB-approved research design or updates in the research literature that changed the risk-benefit relationship.

The target population consisted of EMP. Five to seven county emergency managers were recruited from county emergency management offices in the Midwestern United States. Contact information for county officials is public domain information and was listed in phone books and on state and county websites. Each emergency manager was sent a letter of invitation that served as an informed consent document by email or surface mail to the emergency manager work address. The invitation/consent document included a proposed time commitment and indicated that a participant had a right to refuse to answer any question or to withdraw from the study. I scheduled interviews with only those individuals who consented to the study. A snowball sampling of law enforcement dispatchers and emergency management staff who were known to the emergency managers was used to augment the target population. An emergency manager became a chain referral intermediary for me to contact other potential participants. An intended

outcome of the study was to establish a baseline for future research by documenting EMP's perception of risk and efficacy toward weather warnings. Individuals who were not county emergency management staff or law enforcement employees were excluded from the study.

The informed consent document included a proposed time commitment and indicated that a participant had a right to refuse to answer any question, withdraw from the study, stop participation, or any combination of these for any reason. Risks for participating in this study were minimal. It was possible that, during an interview about storm warnings, the interview might elicit emotions about a participant's job or past experience with storms. Although, there were no direct benefits to study participants, an indirect benefit of the study may be realized when researchers and forecasters who want to understand how warning information is perceived by nonscientists use this information to improve future warnings.

To protect the identities of subjects, people, and institutions mentioned in interviews I used a combination of letters and numbers to identify each interview and assigned aliases to mask each interviewee's identity. Names and other pieces of identity information were not attached to the data. Future reports, publications, or presentations may use data from this study, but no personal identifying information will be used in these results. Responses may be combined and reported in aggregate to avoid the possibility of deductive disclosure.

All electronic files, recordings, observation notes, and interview transcripts have been stored in physically secure locations with password-protected files and locked file drawers. Data are intended to be kept for a period of at least 5 years, as required by Walden University, then removed from the secure storage locations and destroyed at the end of the archival period.

To avoid conflicts of interest, interviews were conducted at neutral public locations within the county of each emergency manager or within the home county of control group participants. Study participants received no compensation or reimbursement for their responses to the study. After the study is complete, I will provide participants with a one- to two- page summary.

Summary

In Chapter 3, the methodology, research design, target population, sampling, data collection and analysis procedures described how research would be conducted in this exploratory study to examine how people who receive a severe weather warning perceive the risk and an effective response. This study was designed to explore severe weather warnings and document EMP perceptions. There are three stages in a warning process; a forecast, dissemination, and a response. In the forecasting stage, potential threats are detected. In the dissemination stage, an alert is provided; in the response stage, an individual makes a decision about the protective action they will take. Training and technology have helped to improve the first two stages, but the third stage relies upon the perceptions of individuals to assess their risk and determine an appropriate response.

According to researchers (NOAA, 2016) it is unclear how people interpret information in a severe weather warning, how they perceive risk, and how they determine an effective response. I was challenged to find a proxy group to provide subjective insight into the problem. Narrowing the scope to investigate the first link in the dissemination chain of a severe weather warning provided an opportunity to examine how warning information from scientists was interpreted by nonscientists. The perceptions that EMP gleaned from VTEC-encoded weather warnings

provided me with data to document how individuals who are experienced disseminators of crisis communication messaging perceive weather threats, the risks associated with storms, and the response decisions that are needed. VTEC-encoded warnings were chosen for the study because these documents are archived and retrievable. They are transmitted via secure messaging circuits, they trigger audio products and alarms on NWR and commercial broadcast networks, and they provide information to disseminators who share or customize the information for others.

Human response to warnings is associated with the phenomenon of risk information sufficiency (Mileti & Sorenson, 1990; Shepard, Janoske, & Liu, 2012). Information sufficiency contains two variables: knowledge about risk, and the level of understanding needed for one to make a confident decision (Kahlor et al., 2003). Knowledge of risk may be related to perceived severity and perceived susceptibility, while the level of understanding may be related to response efficacy and self-efficacy (Kahlor, 2003).

Three research questions were developed to explore the perceptions of risk and response conveyed through information provided in severe weather warnings. The process to investigate the research questions is documented in Chapter 4. Chapter 4 also contains details of the study, including the locations of interviews, the number of participants, participant demographics, data collection procedures, data analysis, credibility, dependability, consistency, and the transferability of the study.

Chapter 4: Results

The purpose of this qualitative exploratory study was to examine how information contained in a severe weather warning affected an individual's perception of risk toward a severe weather threat and his or her perception of an effective response. The topic of risk is addressed in the fields of finance and medical practice, but across the sciences research on risk is fragmentary, with different scientific disciplines applying various paradigms, hypotheses, and terms to explain cultural attitudes and perspectives toward risk (Brady, 2012; Elstad et al., 2012; Morrow, 2009).

Studies in public health, fire, and earthquake response indicate that focusing on risk is one of the least effective means for changing behavior (Prati et al., 2013). Findings from studies associated with natural disasters state that not enough is known about public perception of vulnerability, public willingness to evacuate, the situations that cause hazard information to be believable, or whether government and media advisories are a significant source of information (Bourque et al., 2012; West & Orr, 2007).

The process of deciding whether to respond can be complex; humans must understand a threat exists, believe that they may experience this hazard, believe the threat can be survived if protective actions are taken, and then take these protective measures (Eisenman et al., 2007; Morrow, 2009; Wild, 2004). Although there are many unanswered questions about warnings and human response, I narrowed this study to examine VTEC-encoded severe weather warnings and the perceptions held by the EMP who convey warning information to others. The study explored three research questions.

- RQ_1. How does a VTEC-encoded warning affect EMP's perception of risk toward a severe weather threat?

- RQ_2. How does information in a VTEC-encoded warning affect EMP's perception of an effective response?
- RQ_3. How does a VTEC-encoded warning affect EMP's perception of efficacy?

Research Setting

EMP from 36 Midwestern counties in the central United States were invited to participate in this study. All participants were adults with relevant emergency management knowledge. Due to the nature of their work with emergency communication protocols, EMP disseminate of all types of hazardous information and develop expertise. It was assumed that EMP would have greater familiarity with severe weather warnings and emergency response protocols than the general public.

Emergency managers from 10 counties agreed to participate in the research. These managers shared invitation consent forms with their support staffs and individuals interested in the research, and invited these individuals to contact me. Due to scheduling and travel constraints, interviews were conducted at neutral public locations in eight communities with 20 EMP. Public library study rooms were frequently chosen as interview locations because they were removed from a workplace setting, they were easily accessible to participants, and they provided a quiet setting for tape recording interviews. Alternative interview locations included conference rooms at courthouses, civic centers, and county planning offices. In rural communities, these types of public access rooms were available to clubs and community groups for a variety of meetings and activities.

Research was conducted in counties that were part rural and part urbanized, but significant differences in these communities likely influenced the responses of interview

participants. One area was highly urbanized with many businesses alongside single and multifamily residential locations. In five communities, river recreation and barge transportation were significant; in two counties, communication was a concern due to the lack of cellular service. Several communities had travel and tourism concerns for events ranging from large university gatherings, regional sporting events, community celebrations, and proximity to interstate transportation routes. Three counties contained historic river towns with seasonal tourism and preservation interests. All counties had at least one facility where large groups of people were confined in nursing homes, hospitals, county jails, or state prisons. Several communities had experienced extreme weather conditions in the past 10 years, which likely influenced EMP's interpretation and response to the interview questions.

Demographics

Government forecasters are the primary source for the creation and dissemination of weather warnings; secondary disseminators convey warning information to others, while emergency managers develop response plans for their communities. However, individuals determine the response that will actually be taken. In severe weather situations, secondary disseminators are the first link in the information chain between weather forecasters and the general public. If a secondary disseminator does not perceive that a threat exists, it is possible that individuals further down the chain will not comprehend the danger, either.

Secondary disseminators can be members of law enforcement, dispatchers for first response crews, members of the emergency management community, or members of the broadcast media. Secondary disseminators serve in positions of trust; by distributing emergency information to others, they assume the role of local experts for emergency communication

messaging. This study was narrowed to focus on perceptions held by a subset of secondary disseminators identified as EMP.

Table 1

Emergency Management Personnel Participant Demographics

	Position	Experience	Requirements	Gender
EMP 1	EM	8.5	Certifications	M
EMP 2	Telecommunication	16	Certifications	M
EMP 3	Telecommunication	27	OJT & in-service	F
EMP 4	EM	25	Certifications	M
EMP 5	EM intern	17	Certifications	M
EMP 6	Telecommunication	28	Certifications	F
EMP 7	Law/EM assistant	29.5	Certifications	M
EMP 8	EM	20	OJT & in-service	F
EMP 9	Telecommunication	5	OJT	F
EMP 10	EM assistant	15	Military & OJT	M
EMP 11	EM	7	Certifications	F
EMP 12	EM assistant	4.5	OJT & in-service	M
EMP 13	Telecommunication	6	OJT & in-service	F
EMP 14	EM	8	Certifications/OJT	M
EMP 15	EM	15	Certifications	M
EMP 16	EM deputy	15+	Law enforce/OJT	M
EMP 17	Telecommunication	6	OJT & in-service	F
EMP 18	EM	13.5	Certifications/OJT	M
EMP 19	EM	18	Certifications	M
EMP 20	Telecommunication	8	OJT & Certs	M

Note. Table 1 depicts the demographic breakdown of emergency management personnel by their position of responsibility, years of experience, training required for position, and gender.

Job requirements for EMP differ from state to state and by the position held. Some states require specialized coursework and certifications; in others, previous experience or on-the-job training is sufficient. Annual refresher training is necessary for most positions. Previous experience of participants including: job position, gender and training (see Table 1) were assumed to influence EMP responses to interview questions.

Data Collection

The primary data collection stage was bypassed by focusing on open-access, non-proprietary data from NOAA. By conducting secondary analysis of previous storm assessments and surveys, the time and expense of data collection and additional field studies were reduced. Meanwhile, the reuse of existing data supported an underlying function of knowledge management. Authenticity and reliability of data were relatively easy to document, since VTEC warnings are archived according to NOAA protocols. Assessing data completeness was a challenge. It was unknown whether data such as storm surveys or disaster assessments were biased by selective survival or selective deposits of information in the written record. This possibility may need to be examined through future research.

Contact information for emergency managers was available in phone books and on public access web pages. Initially, seven emergency managers were invited to participate in the study. Similar invitations were sent to seven individuals who worked at United States government scientific agencies, to ask whether they would be members of a control group. In both groups, the invitation doubled as a consent form. All of the scientists consented within 24 hours. No one in the emergency manager study group responded. Seven days later invitation/consent forms were sent to a different group of emergency managers and one week later invitation/consent forms were sent to a third group of seven emergency managers. When no responses were forthcoming I contacted a retired emergency manager to ask what he believed was the reason that no one in the three groups of emergency managers had responded to the request. He suggested four possible reasons: (a) the invitations may have been sent to SPAM folders, (b) emergency managers might be focused on high priority activities like end of year reports and

budget proposals, (c) the invitation might not be engaging, (d) the invitation may have been overlooked or set aside to be read at a later time. Based upon this information, invitation/consent forms were sent to another group of five emergency managers in Illinois and the original invitation was sent again to the first group of seven emergency managers. Five emergency managers responded to this final invitation within 24 hours, a sixth emergency manager responded within one week, and four others replied after the data collection interview process started. Many participants were shift workers, so individual appointment times were set for the convenience of the participants. These difficulties caused the data collection period to be several weeks longer than originally planned.

Prior to an interview, each emergency manager was asked if he or she knew of dispatchers or emergency management support staff who might be willing to participate in the study. Emergency managers shared a copy of the informed consent document that described the basic purpose of the research, role of the researcher, and informed consent process with potential volunteers. Individuals who were interested contacted the researcher, who thereby augmented the sample of participants with law enforcement dispatcher/telecommunicators and emergency management support staff. The combined group of EMP included eight emergency managers, seven telecommunicators, and five support staff.

Travel and ancillary costs associated with interviewing were reduced by scheduling and conducting several interviews on the same day. Neutral public locations, within the primary counties of emergency manager participants, were selected for interview sites; every emergency manager and snowball sampling volunteer had a separate interview time and participated in a single interview. Public library study rooms were frequently chosen as interview locations,

because the rooms were removed from a workplace setting, were easily accessible to participants, and provided a quiet setting for tape recording interviews. Alternative locations included conference rooms at courthouses, civic centers, and county planning offices. In rural communities, these types of rooms are available to clubs and community groups for a variety of meetings and activities. Although interview locations were convenient logistically, in two instances recordings obtained in conference room settings had background noise interference. A similar interview scheduling process was used for control group interviews.

Prior to scheduling interviews, I used a random number generator and a three-step process to select specific VTEC-encoded warnings and statements used in the study. Coding in VTEC messages allows all weather and water warnings from the United States and its territories to be archived and retrieved. In Step 1, I determined the year from which the warnings would be selected. To reduce variation, the selection was narrowed to VTEC warnings from 39 weather forecast offices in the Central United States where weather patterns were climatologically consistent. Storms in tropical surroundings and mountainous areas were not considered, to ensure the type of weather warning provided to study participants was consistent with the type of warning that study participants routinely disseminated. Three warnings were randomly selected from the hundreds of severe thunderstorm, flood, and tornado warnings issued by the 39 weather offices. By chance, these were all tornado warnings. After retrieving VTEC warnings, I collected supplemental information associated with each warning and placed these documents into the warning folder. Supplemental information included follow-up statements to warnings, a map depicting the warned area, and a list of storm reports associated with each storm.

During the interviews, EMP participants were provided with an information sheet (Appendix B) and copies of three tornado warnings. EMP participants took between 2-5 minutes to read and evaluate the preselected tornado warnings. In real-time severe weather situations, the time for reading, understanding and disseminating a warning is about 30–90 seconds. Folders of additional documents associated with the warnings were readily available to the interviewees. Participants were then asked a series of questions about the warning and their perceptions of risk and response. Numbers and aliases were assigned to interviews to mask each participant's identity and protect their privacy (Bernard, 2013; Tracy, 2013).

The choice to interview rather than survey was based upon Bernard's (2013) assertion that interviews provide an opportunity for natural interactions between the researcher and interviewee. By asking pre-approved, standardized questions during interviews I was able to discern the level of familiarity participants had with severe weather and maintain consistency from interview to interview. Each interview was audio recorded and then transcribed with voice recognition software. I evaluated transcriptions for consistency to determine individual perceptions, identify linkages between interviews, and crystallize core assumptions. I also studied the responses to ascertain whether participants identified warning threats and whether responses revealed perceptions of risk, susceptibility, and efficacy.

Data Analysis

NVivo 11 computer program was used to help in the management and analysis of data. Qualitative data were conveniently stored and retrieved from document NVivo 11 files; search features of the program were used to locate words, passages, or themes associated with a data code; and comparison of data from multiple sources or among code labels was possible.

Unfortunately, my lack of experience with this program created some difficulties when it came to data organization and deep analysis.

The interviews of 20 EMP and of a control group of scientists were imported into the program and a word frequency query was run to discover the 100 most common words in the interviews with emergency managers, communicators, scientists, and law enforcement participants. The initial word cloud view was interesting, but not useful for evaluating response trends, because interview questions were included in this view. Since interview participants were asked the same questions during interviews the questions themselves may have had greater weight than responses in the word cloud. Once the interview questions were removed it became easier to identify common words.

I searched for patterns and trends in coded responses to interview questions first by focusing on interview questions and their alignment to the three research questions. Emerging trends included the relational aspect of weather and job function. An individual's primary responsibilities appeared to provide a framework for how words were interpreted. Communicators associated warning criteria of wind speed and hail size with the term severe, while emergency managers equated the term severe with damage response criteria such as injuries, or downed trees and power lines. An unexpected difference between the responses of the control group and responses of EMP was the frequency with which EMP mentioned floods, flash flooding, and heavy rain as severe. No one in the control group, which included a hydrologist, identified the aspect of water associated with a storm when they considered the word severe. The frequency of words was evident in other ways. Some words were mentioned only once; for example, a dispatcher's reference to page-outs and an emergency manager's use

of the term “take action,” but these too seemed related to job function since dispatchers’ alert first responders to hazardous events and emergency mangers develop response plans that specify protective actions.

Interview Questions 1 through 3 assessed an individual’s experience with severe weather as a basis for perception while questions 4 through 8 were designed to explore warning comprehension and perception of risk. It was assumed that, by the nature of their work, EMP would be able to perceive risk and severity. Previous weather experience influenced perception. The seriousness of a threat was perceived by all. Responses to determine vulnerability and protective actions were similar, but not consistent. Those individuals who had personally experienced a severe weather episode of any type had more examples of vulnerability than those with fewer storm experiences. The seriousness of the threat was linked to trust, but with variation. In some situations, it was trust in the source and, in others, trust in the information provided. Storms with a history of damage or confirmed spotter reports were taken more seriously than warnings for tornadic storms with radar indicated rotation.

Interview Questions 4 and 7 examined the perceptions of susceptibility and severity by asking whether a protective action was warranted. All participants recognized the seriousness of the threat based upon information in the warning and the fact that a warning had been issued. They identified locations or individuals who could be affected by the threat and all participants noted that some type of protective response might be needed. Specific words in the warnings alerted study participants to take action, and keywords helped participants to determine the next steps they would pursue in their work environments. These actions frequently included the activation of sirens or alerting spotters.

Interview Questions 5, 6, and 8 were developed to examine the preconceptions that form a basis for perception of response. Overall, the participants recognized the responses that should be taken, but they expressed less faith that others would take these actions. It was important to determine whether the source of a warning influenced a participant's response. Questions 9 and10 examined trust in the information source. The source of a warning or report appeared important to EMP. The NWS was regarded highly for the ability to detect a threat and disseminate a warning, but the specific information in each of the warnings caused concerns for EMPs as they questioned the accuracy of threat information, duration time for the warning, and location. Responses also indicated that information sources and reports that were mentioned within a warning mattered. Overall, confirmed warnings were better than unconfirmed warnings, but there were hierarchal levels to trust. Reports from trained spotters had more credence than media reports or reports from the general public.

Interview Questions 11a, 11b, and 14 were designed to examine perceived vulnerability. A perception of vulnerability is identified as a contributor to an effective response. All participants detected vulnerable locations and populations, but EMPs had considerable concern about response effectiveness. These concerns were mainly directed toward public responsiveness to warnings in general and questions as to whether members of the public would or could take effective actions to protect themselves. The potential effectiveness of a response was examined with questions 11c and 11d. Participants recognized that a warning that triggered a sheltering action would be effective response. They also recognized that some individuals might not be able to take the appropriate actions because they might not receive the warning, might need to depend on others to protect them, or might not have a suitable location for sheltering.

Interview Questions 15 and 16 considered the quality and sufficiency of warning information. Interview participants reviewed tornado warnings that had been issued by three different forecast offices. These warnings conformed to standardized templates developed by the NWS to speed the warning issuance and reduce variation in formats and messaging. Interview participants deemed all warnings as credible, but inconsistencies among the messages caused EMPs to be less satisfied with information quality or sufficiency of information.

Participants' voiced concerns about warnings that contained little information about a storms movement, too much information about safety measures, and warning information that did not consider their dissemination needs for identifying locations in the path of the storm. In large warnings that included many counties, it was difficult to find specific counties quickly and this could delay siren activations. Warnings with too little information left questions and concerns about the basis of the warning (i.e. what had previously occurred with this storm and where was it headed?). Warnings that included reports of damage, the speed of movement, a warning path, and the timing of storm arrival for points along the path ranked higher than warnings lacking this information. EMP asserted that sufficient information helped them to be more effective in alerting spotters to dangers at their spotting locations and be more specific in alerting communities in the path of the storm.

Evidence of Trustworthiness

Credibility

To maintain credibility, avoid conflicts of interest, and ensure that only non-proprietary data were evaluated during interviews I retrieved warnings, storm surveys, and disaster assessments from public access portions of Government-owned websites. In the study, the

credibility of VTEC-encoded warnings for severe weather were evaluated to gauge whether words or cues in these products had the ability to convey information, inspire a protective response, or alter the perception of risk. In previous studies, perceived severity, perceived susceptibility, and efficacy were necessary elements for perceiving risk and choosing a response (Hochbaum, 1958; Witte, 1992). Understanding the seriousness of a threat matched perceived severity; belief about the chances of experiencing the threat represented perceived susceptibility; belief that a response prevents or mitigates a threat corresponded to response-efficacy; and an individual's belief that they could take protective action was associated with self-efficacy (Severtson, 2013; Witte, 1992).

A quasi-comparative correlational study was used to evaluate the credibility of weather warnings, advisories, and statements by considering the risk an individual perceives from reading a VTEC-encoded warning. I looked for relationships among various perspectives held by dispatchers and emergency managers. The variables included work setting, age, gender, and experience.

Transferability

EMP are a first link in the warning chain. They receive warning information in a standardized format, and then share this information with others. EMP become communication experts due to the nature of their work with emergency communication protocols and are assumed to have greater familiarity with severe weather warnings and emergency response than the general public, although they are not scientists. By measuring the communication experts perceptions of risk toward weather warnings I attempted to capture and codify the tacit knowledge of these individuals, and make this knowledge explicit. This was done through the

transcription of interviews into documents that can be analyzed and reused. A preliminary goal was to identify areas within a warning where scientific information was not adequately conveyed to nonscientists. Information discovered through the open interview process may eventually lead to the development of a closed question instrument to be used in future research

Dependability

The study was developed to maintain a consistent strategy throughout the interview process. I used a list of pre-prepared questions at each interview and questions were asked in the same order each time. Interview locations were selected to provide less distraction and a measure of privacy to interview participants. Each interview was unique, because participant responses were based on a person's previous experience and training. However, I was able to ascertain similarities in responses by interviewing several members of each work group. An example of job-related differences were telecommunicator responses that reflected a need to get the warning message out so people could take shelter, while emergency manager responses reflected a need position themselves to render aid.

Confirmability

I used NVivo 11 for the management and analysis of data. Knowledge assets, such as the transcribed interviews from this study, have value to an organization when they can be reused. Confirmability of the study exists when knowledge objects created by this study can be found, modified, or reused for other research. Confirmability becomes a measure of corroboration after the study when the researcher examines data gathering procedures and contradictions in data to make judgments about bias or distortion (Trochim & Donnelly, 2007).

Study Results

I developed the study to comprehend how the wording of a severe weather warning affected EMP's perceptions of risk response. The study group was comprised of emergency managers from eight counties in the Midwestern United States, emergency management support staff, and telecommunicators for these locations. These individuals serve as a first link in the information chain between a forecaster issuing a severe weather warning to the general public for whom the warning is intended. I assumed that EMPs would be familiar with warnings of all kinds and experts in crisis communication messaging and response due to the nature of their jobs.

Interviews were conducted with EPM participants to establish a baseline that did not previously exist. In the interviews, participants were provided with tornado warnings from NWS offices in North Dakota, Wisconsin, and Missouri. These warnings had been randomly selected from VTEC-encoded warnings issued by 39 forecast offices in the central United States. Participants were asked a standard set of questions concerning the warnings. Each interview was recorded; the responses were transcribed, and then imported into NVivo for data analysis. The study addressed three research questions.

- RQ_1. How does a VTEC-encoded warning affect EMP's perception of risk toward a severe weather threat?
- RQ_2. How does information in a VTEC-encoded warning affect EMP's perception of an effective response?
- RQ_3. How does a VTEC-encoded warning affect EMP's perception of efficacy?

In numerous studies of human behavior, perceived severity is linked to understanding the seriousness of a threat; perceived susceptibility is associated with an individual's belief that there is a chance that he or she will experience the threat; response-efficacy is related to belief that a response will prevent or mitigate a threat; and self-efficacy is tied to the belief that an individual has the ability to take protective action (Severtson, 2013; Witte, 1992). This study was designed to uncover perceptions of risk and response. In the study, EMP received three tornado warnings for storms that occurred in 2013 and 2014. They then were asked a series of questions about the warnings and their personal experience with severe weather. These questions can be found in Appendix C. Interviews were chosen because they offered greater flexibility than questionnaires in regards to types of questions asked and the format used.

All EMP interviewees were told in advance that the study concerned storm warnings and that the warnings had not been used in the counties in which they were located. Participants were reminded that they could withdraw from the study for any reason and that there were no incentives for participation. All participants were required to sign an informed consent document prior to the interview. Interviews were audio recorded and aliases were assigned to mask the identity of participants. An aggregate of responses provides a composite picture of the study.

With RQ1, I was investigating the perception of EMP toward the wording in severe weather warnings. Words used by a weather forecaster have specific meanings, but for other individuals or groups the meaning may be different. Interview questions 1–3 were developed to examine each participant's level of experience with severe weather warnings as experience provides a foundation for perception. Interview questions 4–8 were designed to address warning comprehension and perception of risk by considering the seriousness of the threat, taking into

account the timing of the occurrence, identifying who could be vulnerable, and judging the type of protective actions that are needed.

For RQ 2, I was interested in learning how information in a VTEC-encoded warning affected EMP's perception of an effective response to the threat. Interview questions 4 and 7 were developed to examine perceptions of susceptibility and severity. Questions 5, 6, and 8 were designed to examine preconceptions that underpin a chosen response. Interview questions 9 and 10 were developed to examine trust in the information source**.** Question 11a, 11b, and 14 were asked to explore perceived vulnerability, since this affects any response decision that is made. Interview questions 11c and 11d were designed to examine the potential effectiveness of a response, and questions 15 and 16 were developed to comprehend the quality and sufficiency of information

In RQ3, I investigated the perception of efficacy that EMP have toward the wording used in severe weather warnings. The interview questions that addressed this aspect were questions 2 and 3, which explore the basis for making a decision. Interview question 3, questions 11a through 11e and question 12 are associated with response efficacy: EMPs considered the types of responses appropriate for the situation and the response that they believed the public would choose. Interview questions 2 and 13 were used to examine self-efficacy, which reflects participant perceptions of personal responsiveness to a warning and whether their perceived responses change when threats are different.

Mosby (2012) defined perception as a conscious recognition and interpretation of stimuli that help one to understand, learn, know, or be motivated. Findings from previous research state that risk communication requires trust. The most effective warnings address the public's need for

knowledge (Lachlan & Spence, 2014), and when the level of risk is uncertain, information from a credible source helps improve trust (Bonkiewicz & Ruback, 2012; Gray et al., 2012; Sutherland, 2012). Trust that others will provide protection can affect an individual's perception of probability and severity of a threat, as well as his or her risk judgment, personal control, and susceptibility to harm (Kahlor et al., 2003; Scolobig, De Marchi, & Borga, 2012).

Data analysis of participant responses revealed evidence of trust, but there were two components to this trust: trust in the source and trust in the information. Examples of these aspects are found in the following comments. When asked about confidence with information in the warning, most respondents viewed the warning source favorably.

> REL: I'd be pretty confident in it. Um, it's coming from the National Weather Service—they have trained weather spotters telling them about a confirmed tornado that they see. They are telling you which way it is going, the towns that it's gonna be in. Um, I would feel, I'd feel confident with that information.

> SSH: They're coming from the National Weather Service, they indicate radar, they indicate spotter activity. I've been doing this for over 20 years and just know.

> CBR: My overall level of confidence is, well they are seeing it on radar and a spotter is actually seeing it. So if, if you get a spotter confirmation and those two it's usually pretty accurate. . . . Does it mean it will make it here? Maybe not; by the time it gets here it could change direction, intensity, so I'm pretty confident with it.

> GHA: Actually really high, especially when you start talking about a weather spotter confirming it. You know—radar indicated, we have that confidence, but it's not as much as if we can see it our self and confirm it. Um, we definitely trust the experience and knowledge of the meteorologists at the Weather Service Office. If they say it's radar indicated, there's something there if we can see it or not. The one that's rain wrapped, that's really concerning too, but very high confidence.

Trust in message information was variable. Comments that addressed message content were contained in responses in several question categories for all three research questions. Some examples are comments made by emergency management coordinators and support staff.

CHA: This one out of North Dakota—the thing I found interesting on the precautions and preparedness, it doesn't tell you what to do. It just tells you to call your nearest law enforcement agency.

SCI: But for some reason that third one really just didn't, I don't know I guess it's the way it's presented. It just didn't come across as being severe as the first.

CHA: I guess in a roundabout way it's dumbing down the warnings. Make it more people friendly.

RWU: For me, for me I would get more out of, out of the actual damage reports, what's happened on the onset of the storm instead of what to do. We should know that stuff already.

BBR: Maybe a little more specific area, isolating it to what areas are affected much more.

A lack of trust in the crisis message communicated, or toward the source of the message, can cause people to seek additional information before taking action (Love, Mackert, & Silk, 2013). Research in a variety of disciplines suggests that insufficient or conflicting information, fear, lack of trust in the information source, information that is overly technical, economic circumstances, and perception of risk can interfere with the response action an individual will consider (Collins, 2012; Stein et al., 2011). Experience and its influence on response are difficult to define and measure (Bourque et al., 2012) and affective judgments that are determined by a person's mood can be misleading. According to Jenkins (2006), keeping people safe is not sufficient— people must also feel safe.

People perceive risk differently and these perceptions can affect trust and the decisions that are made (Slovic, 1987). The concept of risk can be quantifiable and predictable, but the qualitative aspects of risk perception apply to the relationships that underlie the behaviors, actions, and decisions associated with risk. Sources of information must be trustworthy, credible, honest and consistent. During warning situations it is important for risk messaging to be

authoritative, clear and accurate because language that describes risk reveals and shapes the assumptions of those responding to a threat (Habermas, 1998; McLuckie, 1974).

Perception of risk encompasses an individual's recognition that a threat exists, the understanding that the individual is susceptible to the threat, and the individual's sense of efficacy in choosing a response. Risk perception can be influenced by past experience, age, gender, and culture. However, perception of risk most frequently refers to the judgment an individual will use to assess the severity of a direct or indirect threat and the probability that it will occur (Keller et al., 2012; Wachinger et al., 2013). People rely on personal knowledge and experience when interpreting their individual levels of safety (Bourque et al., 2012; Lazo et al., 2009; Zhang et al., 2013).

The concern of classical risk communication literature has been to build trust and convey the message that those in authority have the technology and expertise to resolve an issue (Handmer & James, 2007). When experts judge risk, their responses correlate to probabilities based upon statistical data and estimates of casualties; meanwhile, a lay person's judgment of risk is related to possibilities such as hazard characteristics and catastrophic potential (Fleischhauer et al., 2012; Jenkin, 2006). For this study, I assumed that EMP responses concerning perceived risk and effective response would be similar to the responses of control group members. The assumption was based upon the training and levels of experience EMPs acquire through their jobs. This assumption appeared to be correct except in one area. Several EMPs included water-related risks of flooding, flash flooding, and heavy rain in their responses related to the type of weather they would expect with the warnings. No one in the control group,

including the hydrologist, associated water risks with tornado warnings. The aspect of water and tornados may need to be examined in greater depth in future research.

Previous research has indicated that a person's feelings about a risk influence the choice of action that they will take to respond to the threat. If feelings about an action are favorable the risk is perceived as low and the benefit high (Slovic & Peters, 2006). A frightening experience may carry a disproportionate amount of weight, while a previous experience in which the threat was minimal may diminish an individual's perception of risk (Hartley & Phelps, 2012). Analysis of risk focuses narrowly on the probability that an event will occur and the magnitude of the consequences (Fleischhauer et al., 2012).

Response decisions are shaped by an individual's analysis of risk. Decisions are usually made during periods of uncertainty when the full extent of the threat may be unknown. The specific goodness or badness of a decision is experienced as a feeling state, or affect, that helps guide a judgment (Slovic & Peters, 2006). The psychological, social, and cultural processes that shape human perception toward risk depend on the individual involved and the level of satisfaction that individual has with the information provided (Elstad et al., 2012). Big gaps between a person's knowledge about a risk and the amount of information they consider sufficient can impact evacuation behaviors and decisions (Lazo et al., 2009; Morrow, 2009; Zhang et al., 2013); and, because decision-making about anything is complex, the differences in the perception of risk often lead to disagreements between technical experts and the general public (Slovic, 1987).

There were significant differences between what an EMP perceived as an effective response and what actions they perceived individuals receiving warning information would take.

In many instances EMPs blamed social media for contributing to a lack of response. Examples of these comments are listed below.

> LBR: We saw the rise of the chasers that coincided perfectly with *Twister*. In 1975, I mean 1995, it did, it truly did. It let people think, "Wow I can do that" you know? And after that, it became a whole different game. People that are out to experience the storm but not necessarily to give a warning to anybody else. And I think that, to me, that is the biggest threat— that people see it and they believe that they can live through it, too. And, um, it doesn't always work that way.

> SSI: From the public's perspective now, with all the cell phone cameras and videos and stuff, they want to get on the Weather Channel, they want to be on the news, so they will run outside and endanger themselves just so they can have a video that they can put on, you know that can get seen, just so they get their 15 minutes of fame.

Lack of response was also associated with a perceived lack of trust in warning information. Reasons for these beliefs were related to a cry-wolf syndrome, "It can't happen to me," and "nothing happened last time." An individual's perception of risk, whether it is perceived to be unlikely or real, shapes an individual's response to severe weather events (Stein et al., 2011).

Summary

Argyris and Schön (1974) asserted that scholars in a single profession may fail to grasp the complexity and interconnectedness of a problem by relying upon perspectives that support their own limited views. In this study I used an expanded perspective into storm investigation by incorporating human behavior theories and communication models not traditionally associated with severe weather analysis.

Findings from health behavioral studies suggested that perceived severity, perceived susceptibility, and perceptions of efficacy are necessary elements for perceiving risk and choosing a response (Hochbaum, 1958; Witte, 1992), while crisis communication literature

indicated that effective warnings require detection of the threat, communication, and response (McLuckie, 1974; Fritz & Williams, 1957; Morrow, 2009). Although crisis communication literature was widely cited within the weather enterprise, no studies were found to verify previous research; current research that applied findings from health behavioral models and risk perception studies were not tested in regards to weather or environmental hazards. Studies often identified risk perception as an area for future research, but follow-up studies did not address this topic (Sheppard, Janoske, & Liu, 2012). This study was proposed to fill these gaps in examining the detection of a threat, the perception of risk, communication, and response by exploring the perceptions of risk and response that EMP associate with severe weather warnings.

In the study, EMP were provided with three warnings for tornados that occurred in the central United States in 2013 and 2014. The warnings were randomly selected from VTEC-encoded severe weather warnings issued by National Weather Service forecast offices in North Dakota, Wisconsin, and Missouri. After reading the warnings, EMP were asked a series of questions regarding their personal and job-related experience with severe weather, their understanding of weather threat, their ability to comprehend information in the warning, their ability to determine an effective response, and the likelihood that they would take the actions they proposed. The individual interviews were audio recorded and transcribed with voice recognition software; the responses were analyzed with NVivo to uncover trends and patterns in the data.

Although many unanswered questions remain regarding warnings and human response, I was able to establish a baseline for future research into severe weather warnings by capturing the perceptions of risk and response held by EMP who convey warning information to others.

Chapter 5 contains a summary of research that describes the problem and purpose for the study, the implications of the findings, the conclusions, and suggestions for future research.

Chapter 5: Discussion, Conclusions, and Recommendations

The purpose of this qualitative exploratory study was to investigate the perceptions of risk and response that communication experts discerned in severe weather warnings. Severe weather has caused billions of dollars of damages and claimed hundreds of lives in the past decade. There have been unified efforts to assess storms effects, modernize warning technology, and improve communication and disaster preparedness planning efforts, but even with advance notice many people do not heed the warnings (NOAA, 2011b; NOAA, 2011c; NOAA, 2013a; NOAA, 2014). The problem was that it was not known how people perceive severe weather risks or perceive which responses will be effective.

A lack of response to warnings is not a new problem. Fritz & Williams (1957) and McLuckie (1974) addressed it, but social scientists assert that more must be done to ensure warnings by scientists are understood by the people for whom they are intended (Demuth et al., 2007; Fischhoff, Brewer, & Downs, 2011). The topic of risk is addressed in the fields of terrorism, law enforcement, finance, and medical practice (Ansari, 2012; Bonkiewicz & Ruback, 2012; Sadiq & Graham, 2014). Studies have examined human understanding and response to natural hazards and flooding (Buchecker et al., 2013; Uhlemann, Thieken & Merz, 2013), but across the sciences, research on risk is fragmentary, with different scientific disciplines applying various paradigms, hypotheses, and terms to explain cultural attitudes and perspectives toward risk (Brady, 2012; Elstad et al., 2012; Morrow, 2009).

This research was developed to explore the breach between warning and response. It was unknown whether severe weather warnings and statements provided sufficient information for

message recipients to perceive severity of a weather risk and make informed decisions about a viable response. Studies in public health, fire, and earthquake response indicate that focusing on a risk is one of the least effective means for changing behavior (Prati et al., 2013), and that, to create lasting change, the information process must possess some mechanism for researchers to engage the public, understand how the hazard is appraised, and identify different characteristics of risk perception (Cummings, Berube, & Lavelle, 2013). This study was developed to understand how a select group of individuals (EMP) perceive severe weather risk and an effective response to weather warnings.

EMP are the first link in the warning dissemination chain between a warning forecaster and the general public. Narrowing the scope to investigate this link provided an opportunity to examine how nonscientists interpret the information in weather warnings and learn how people in a particular setting come to understand, account for, take action, and manage severe weather situations. The results and findings from this study are discussed and interpreted in Chapter 5. This chapter also includes study limitations, opportunities for future research, and implications of the study.

Interpretation of Findings

Perception of risk is defined by how an individual processes information and responds to the threat (Slovic, 1987). Individuals and groups may perceive risk differently since past experience, age, gender, or culture can influence perception. This perception gap is one reason that real world problems can be difficult to research (Kanno, Furuta & Chou, 2012). In peer reviewed literature, perception of risk is identified with an individual's need to seek additional information (Demuth et al., 2007; Mileti & Sorenson, 1990; Quoetone et al., 2001), with warning

siren effectiveness (Plotnick, Hiltz, & Burns, 2012), and with health behavioral models and communication studies (Witte, 1992). Yet many of the studies are outdated. Findings from natural disaster research indicates that not enough is known about public perception of vulnerability, public willingness to evacuate, what makes hazard information believable, or whether government or media advisories are a significant source of information (Bourque et al., 2012).

Social scientists are interested in learning how humans respond to natural disaster (Convello, von Winterfeld, & Slovic, 1986; Feldman & Ingram, 2009; Kuligowski, 2013), but according to Morrow (2009), but most social science research is fragmentary and only available within a respective discipline. Seminal studies in risk perception and risk communication (Chaiken & Maheswaran, 1994; Griffin, Dunwoody, & Neuwirth, 1999; Sandman, 1987; Slovic, 1987; Slovic & Peters, 2006; Tiedens & Linton, 2001) provide a foundation for natural disaster studies. However, studies that examine human vulnerabilities and natural disaster are often opportunistic with most research conducted after an event has occurred (Argyris & Schön, 1974).

Research is not usually conducted during emergency situations, because crisis situations are normally times of response, not research (Wild, 2004). Real time problems are also difficult to research rigorously, because diagnostic techniques may be unavailable (Argyris & Schön, 1974). In the field of operational meteorology case studies, storm surveys and disaster assessments are the predominate methods of research. These types of studies provide considerable information for understanding the atmospheric processes associated with a severe weather event, but they are less relevant to quantitative or qualitative studies of human response and perception of risk. Outside the field of meteorology, researchers have examined the

perception of risk and response to hurricanes (Eisenman et al., 2007), in flood risk communication (Faulkner et al., 2007; Knocke & Kolivras, 2007; Morrow, 2009), and water inundation (Fischer et al., 1995).

Post storm investigations, that focus on timely and accurate warnings, the structural integrity of sheltering options, and forecasters' expertise in using technology to detect threats and disseminate warnings, can help forecasters and state and local agencies prepare for future disasters (Blair & Leighton, 2014; Drabek & Evans, 2007). But when responders and emergency planners do not understand how individuals comprehend warnings or perceive risk, communities may remain vulnerable when inappropriate actions are taken (Kanno, Furuta, & Chou, 2012; Morrow, 2009). This study, concerning risk perception and severe weather warnings, provides an opportunity to understand how words in a weather warning contribute to individuals' perceptions of risk, susceptibility and response.

Scholarly research documenting the perceptions of risk and response are common for environmental hazards such as flood risk (Buchecker et al., 2013; Scolobig, De Marchi, & Borga, 2012), but qualitative research to understand perceptions toward warnings for severe weather had not been conducted prior to this study (NOAA, 2016). The findings from my study add to the knowledge base and establish a baseline for future research.

Research Question 1

In this study I wanted to determine how EMP perceived the risk conveyed by tornado warnings to confirm previous research findings that stated a warning must be credible to be believed (Griffin et al., 1999), and that the content of the warning must contain sufficient information to convey the seriousness of the threat (Witte, 1992). These studies were based upon

health behavioral models and, although they are frequently cited in crisis communication studies, it was unclear whether these findings applied to severe weather situations.

The words used by a weather forecaster have specific meanings, but other individuals or groups may understand the word differently. Study participants were asked about their levels of experience with severe weather warnings to determine whether they perceived the same dangers as did a forecaster, and to evaluate whether the prior experience of the respondent and the context of the situation altered the perceived meaning of a message (Mehrabian, 1966; Mehrabian & Reed, 1968; Mehrabian & Wiener, 1967). The job experience levels of study participants ranged from 8 weeks to nearly 40 years. Each individual was familiar with severe weather and the dangers associated with thunderstorms, tornados, flooding, and winter weather. Individuals who had personal experience with disaster situations were more sensitive to potential hazards than those who had learned about disasters only though media broadcasts. An individual's sensitivity to potential hazards was also greater if a friend or family member had experienced a significant weather event.

Warning comprehension and perception of risk were assessed by providing EMP with randomly selected tornado warnings from the severe weather seasons in 2013 and 2014 and asking them questions about the seriousness of the threat, the timing of the occurrence, who could be vulnerable, and the type of protective actions needed. Overall, EMP were able to comprehend both the seriousness of the threat and the area of concern in warnings. Responses to determine vulnerability and protective actions were similar, but not consistent. Individuals who had personally experienced a severe weather episode of any type had more examples of vulnerability than did those with less experience. The seriousness of the threat was linked to

trust, but with variation. In some situations, it was trust in the source and, in others, trust in the information provided. Storms with a history of damage or confirmed spotter reports were taken more seriously than were storms with radar indicated rotation.

Research Question 2

For the second research question I was interested in learning how information in a warning affected EMP's perceptions of an effective response. Findings from other studies claimed that four elements of perception are needed for communicating risk and choosing a response: perceived severity, perceived susceptibility, perceived efficacy, and response efficacy (Witte, 1992), that there is a human tendency to gather additional information before taking action (Morrow, 2009; Griffin, Neuwirth, Dunwoody, & Giese, 2004), and that trust in the information source helps to bridge communication gaps (Bonkiewicz & Ruback, 2012; Gray et al., 2012; Love, Mackert, & Silk, 2013).

During the interviews EMP were asked questions to assess how information gleaned from the tornado warnings affected their perceptions of susceptibility and severity or their beliefs about protective actions. All participants recognized the seriousness of the threat based upon information in the warnings they were given. Some individuals considered the warning source as significant. For these individuals, the fact that a warning had been issued was sufficient for them to believe protective actions were warranted. Other individuals relied upon trigger words within the warning that alerted them to wind speeds, hail size, or reports of damage. Three individuals indicated they would like an image that showed the cities and towns within the warning, but this was in context to their duties to notify emergency response crews. From the words in the warning, all EMP identified locations or individuals who could potentially be affected by the

threat, and all participants believed that some type of protective response might be needed. Specific words in the warnings alerted study participants to take action, and keywords helped EMP to determine the next steps they would pursue in their work environments. These actions frequently included the activation of sirens or alerting first responders to a storm's location and direction of movement.

Human response to warnings has been associated with the phenomenon of risk information sufficiency (Mileti & Sorenson, 1990; Shepard, Janoske, & Liu, 2012). Information sufficiency contains two variables: knowledge about risk and the level of understanding needed for one to make a confident decision (Kahlor et al., 2003). There were significant differences between what EMP perceived as an effective response and what they perceived would be the actual response by individuals receiving warning information. Most respondents believed that seeking shelter was the best response for people who were vulnerable to the threat. When sheltering options were limited, such as in the case where a tornado warning encompassed a portion of an interstate highway system, there was disagreement on what was considered a safe location. Although EMP agreed that a response was needed, many also believed that a response would not be taken by the general public.

Scholars have indicated that perception of risk, whether it is perceived to be unlikely or perceived to be real, shapes an individual's response to severe weather events, and that a lack of response may be due to perceived lack of trust in warning information (Stein et al., 2011). EMP perceived that a lack of response by the public was related to a cry wolf syndrome if warnings were issued too frequently, due to the perception of inaccuracy in warnings since damage did not occur on a specific street at a specific time, and due to media over-kill with continuous coverage

of storms overriding normal programing. Several respondents referenced feelings of invincibility as a contributing factor, stating that family and friends had commented “it won’t happen to me”, or “nothing happened last time warnings were issued.” Most EMP and members of the control group blamed social media, broadcast media, and weather related adventure movies as contributing to the public’s diminished lack of response to storm warnings. Some respondents stated that people were curious and wanted to see it for themselves, and that it was becoming common for the general public to head outside to capture photos of an approaching storm instead of seeking shelter.

Research Question 3

In the third research question I investigated EMP’s perception of efficacy. Response efficacy and self-efficacy are linked to knowledge about a risk and the needed level of understanding for one to make a confident decision (Kahlor et al., 2003). The concern of classical risk communication literature has been to build trust and convey an authoritative message about the risk (Handmer & James, 2007). Other literature has indicated that aspects of the risk message can alter an individual’s judgment and trust (Kuligowski, 2013; Morrow, 2009). People who define the situation optimistically may believe nothing will happen or that they have more time in which to act (Kuligowski, 2013; Morrow, 2009). Conversely, confidence in warning accuracy can drop when forecast lead time is too long (Lazo, Morss, & Demuth, 2009), and human responsiveness may change when new or conflicting threat information is presented (Morss et al., 2008).

EMP were asked evaluate the tornado warnings and consider whether protective actions were needed, the possibility that these actions could be taken, the likelihood that they would take

protective action, and whether their perceived response would change when characteristics of the threat were changed. All respondents indicated that the warnings were credible and, that they believed a response was needed. But their perceptions of what these actions should be varied considerably. Most EMP had little faith that the public would respond appropriately. These beliefs were based on the number of 911 callers who ask why the sirens are going off during a warning, the number of complaints they received on their web pages or by phone if severe weather did not personally affect the caller, and the amount of storm photos being posted on social media. When asked about their own responses to a tornado warning EMP's perceptions were noticeably different depending on whether the individual was at work or at home. High priority was given to work related responsibilities over seeking shelter, but even these responsibilities varied according to work group. Response actions noted by dispatchers concerned their abilities to provide updated information to spotters and first responders, while the actions noted by emergency management coordinators reflected a need for positioning themselves or their teams for disaster recovery activities.

Prior to a disaster, people may believe they know what their response will be, but during crisis situations, their chosen response may be quite different (NOAA, 2014). This assertion did not appear to correspond to the responsive actions of EMP, because these individuals were accustomed to responding during crisis situations and the nature of their work caused them to have a high regard for the safety of others. Most EMP believed they were generally safe at work due to post 911 building modifications that incorporated reinforced walls, few windows, or the relocation of emergency command centers into interior parts of the buildings. Two emergency management coordinators had unwritten policies that allowed members of their support staff to

bring their families to work during extreme weather conditions. Two other emergency management coordinators indicated that their families understood that they might not be home for several days if a weather disaster occurred in their county or in an adjoining county. Three emergency management support staff indicated that, during an event where they believed they were in the path of a tornado, they had sheltered in a more protected location than the command center. Two had moved to underground rooms and the other individual moved into an interior room.

According to scholarly literature, human response to warnings is associated with knowledge of risk and sufficient information to make a confident decision (Kahlor et al., 2003; Mileti & Sorenson, 1990; Shepard, Janoske, & Liu, 2012). Due to the nature of their work, EMP may have a better understanding of risk and crisis communication than the general public. Most of the respondents had personally experienced severe weather, or they were aware of the consequences of catastrophic weather events. Five individuals had family members whose homes had been damaged by storms, and three emergency managers described their experiences in assisting a community devastated by an EF5 tornado. Overall, EMP's perception of response changed when the threat changed. One individual stated that he used to be young and invincible, but with the wisdom of age he'd come to realize that he couldn't help others if he did not take care of himself first. Many emergency management coordinators indicated that they would not seek shelter for a tornado warning. Three reasons were given for this response: the coordinators were trying to get into position to provide resources to a devastated community, they knew where the safe spots were for tornado spotting, and they used radar apps on their cell phones to monitor to discern where the storm was located. Responses were different for severe

thunderstorm warnings that indicated the storm was producing 70 mph wind. In this instance, most emergency management coordinators were willing to seek shelter, or at least position their vehicle to face into the wind. The sheltering response was based on the widespread damage they expected from a storm of that magnitude and personal experience from previous storms. Several individuals said that they would check the radar first to see where the storm was located and what way it was moving. Most dispatchers indicated that, if they were home, they would either head to the office to "help-out" or plan to take cover. The altruistic response of returning to work when they were off duty was most often related to a personal experience of being the only person on duty and knowing that the "phones would be crazy."

Limitations of the Study

Limitations to this study, as described in Chapter 1, included trustworthiness, credibility, dependability, transferability, and confirmability. Weather is an uncontrollable process and uncontrollability creates challenges for researchers. I was interested in finding out why people do not respond to severe weather warnings, but needed to use a proxy method since research into the perception of risk conveyed by a weather warning was not likely to occur in real time. As noted by Argyris and Schön (1974) and Wild (2004), conducting research during a crisis situation is difficult and diagnostic techniques may be unavailable. To overcome the real time limitation, I relied upon historic data relevant to storms during the 2013–2014 severe weather seasons and narrowed the study to evaluate VTEC-encoded tornado warnings to determine whether words or cues in these products had the ability to convey information, inspire a protective response, alter the perception of risk, or some combination of these.

VTEC warnings are created with software and standardized templates designed to reduce variation in warning messaging. They were chosen because they are archived and retrievable. Audio products that play on NOAA weather radio were eliminated because they are perishable and drop out of a broadcast cycle when the warning expires, or is replaced by a follow-up statement or warning. Media broadcasts were not evaluated because of inconsistent messaging due to multiple broadcast markets across a geographic area and the priorities that station managers allocate to storm coverage. Outdoor warning systems and sirens were considered unsuitable because they do not provide information about the particular threat, there is no consistency in activation requirements, and sirens may fail to work if a community experiences a power failure.

A second limitation was to narrow the scope and find a stakeholder group that could evaluate the weather warnings and share comments about the risks they perceived from the warning message. Findings from storm assessments conducted after deadly storms indicated research into risk perception was needed, but no qualitative studies that investigated this phenomena were found. In order to establish a benchmark for future research, I decided to document the perceptions of risk and response of individuals in the dissemination chain between a weather forecaster and the general public. The general public was excluded, because information the public receives may be filtered by the information provider. It is common for the public to receive warnings and statements in a variety of formats (e.g. radio, television, the internet, graphical display, telephone alerting protocols, etc.); also, some members of the public may not have the ability to comprehend text warnings due to language barriers, vision impairment, or physical, emotional, or educational difficulties.

Emergency management coordinators, law enforcement dispatchers, and media broadcasters were considered because they serve as a first link in the warning dissemination chain. These individuals receive warning information in a standardized format, and then interpret and share the information with others. I eliminated broadcasters because a broadcaster's perception of risk may be influenced by station policies that determine how severe weather warnings will be broadcast and the level of attention that station managers are prepared to dedicate to live coverage. I classified the remaining members of the stakeholder group as EMP. EMP become communication experts due to the nature of their work with emergency communication protocols. These stakeholders were assumed to have greater familiarity with severe weather warnings and emergency response than the general public, but were not scientists. By measuring the perception of risk that these communication experts had toward VTEC-encoded warnings, I attempted to capture and codify tacit knowledge held within the individual, and transform it into explicit knowledge to be used by others.

A perceived limitation to the study may be the small sample and narrowed scope. This has implications on whether it is possible to generalize findings to other settings. However, because a qualitative study into the perception of risk had not been previously attempted, this study establishes a baseline for future research. Open ended interview questions were developed with the assistance of an expert panel, and researcher bias and selective memory was reduced by recording and transcribing all interviews. This study focused on the perception of risk in a specific population chosen for the study. Obtaining the perceptions of individuals farther away from the warning source would have caused the study to shift from the actual warning to information interpreted and conveyed by a secondary dissemination source.

Recommendations

In order to improve knowledge and understanding about risk perception and the perception of an effective response to severe weather warnings, similar research should be conducted with EMP in other geographic locations, with other types of weather phenomena for which warnings are issued, and within other stakeholder groups like broadcast meteorologists, FEMA coordinators at state or federal levels, or with school, hospital, or nursing home administrators who are responsible for the safety and protection of a confined population. Findings from other groups and locations may confirm or contradict the perspectives of the small group of EMP in the central United States, while findings from studies that explore other weather threats may identify patterns of response not observed in this study.

Data for this study were collected via individual interviews with EMP. Repeating the interviews with the same individuals would provide a longitudinal perspective and allow responses to be compared over time. The responses may show how perceptions can be influenced or altered by an individual's personal experience. Repeating the interviews with the same individuals and evaluating a different type of weather phenomena may show how risk perceptions are shaped or modified by perceived threats.

In the study I assumed that responses of EMP perceptions of risk and response would be similar to the responses of control group members. This assumption was based upon the training and levels of experience that EMP acquire through their jobs. The assumption appeared to be correct except in one area. Several emergency management participants mentioned water-related risks of flooding, flash flooding, and heavy rain in their responses related to the type of weather they would expect with the warning. No one in the control group, including the hydrologist,

associated water risks with tornado warnings. This outlier may need to be examined in greater depth in future research.

This study revealed that EMP perceived the threat and perceived that a response was needed, but had little faith in the general public to take appropriate actions to protect themselves. Based upon these assumptions, opportunities for future research could include the role of curiosity in responsiveness, the impact of social media in perception of risk, the proximity to a threat and perception of risk, the impact of damage reports on perception of risk and response, and the perception of risk toward secondary threats during severe weather warnings.

Assessing data completeness created a challenge because it was unknown whether data, such as storm surveys or disaster assessments, were biased by selective survival or selective deposits of information in the written record, or whether findings from these assessments provided a comprehensive picture of the weather event. Although data completeness was beyond the scope of my study, this aspect may need to be examined through future research

This qualitative study was developed to understand how EMP perceived risk and their perception of response from the words used in a tornado warning. Open-ended questions used in each interview allowed participants to explain their thoughts and concerns; the responses provided me with a wealth of information for this study and future research. Information discovered through the open interview process was used to establish a benchmark that did not previously exist. Additional research should be conducted to determine whether the findings from this study are repeatable at other points along the warning dissemination chain. Questions about validity may exist due to the small sample size, and this has implications on whether it is possible to generalize the findings to other settings.

Implications

This study evaluated EMP's perceptions of risk and response toward information in a severe weather warning. The definition of risk is generally misunderstood. Risk is an intangible concept of probability and effect that is interpreted differently by individuals in different situations (Marynissen & Ladkin, 2012). This level of complexity makes it difficult to adequately warn large populations that cannot directly perceive the danger of disaster (Fritz & Williams, 1957). Understanding how severe weather risk is perceived and using this information to improve the warning process has potential for positive social change.

Humans can become insensitive to numerical risk strategies that focus on hazard potential. Quantitative assessments linked to these types of risk may fail to trigger emotions or feelings needed for a response (Marynissen & Ladkin, 2012), and various cognitive biases can cause people to endorse whatever position reinforces their connection to others (Kahan, Jenkins-Smith & Braman, 2011). People are generally more willing to believe information from people they know and trust, and they are more willing to follow instructions when the basis for the message makes sense (Mileti & Sorenson, 1990; Kuligowski, 2013; Wachinger et al., 2013). Trust in the source of information is crucial during urgent moments, because it affects the perception of risk, and governs the behaviors one will take to respond to a crisis (Khan, 2012; Morrow, 2009; Wild, 2004). Friends and family are generally considered trustworthy, while government agencies and media have diminished credibility (West & Orr, 2007). Unfortunately, most research on trust has been conducted in samples, not emergency situations (Wild, 2004).

Many organizations and individuals provide weather information, but Public Laws 100-695 and 102-567, designate the NWS as the sole provider of severe weather warnings.

Technologies have been developed to detect severe weather, to standardize warnings and statements, and to increase forecaster skill, yet even with advance notice, many people do not heed severe weather warnings (NOAA, 2011b; NOAA, 2011c; NOAA, 2013a), and there is a growing trend for people to respond inappropriately in disaster situations (NOAA, 2014; Paul & Stimers, 2012).

While this explicit knowledge has been documented for generations (Fritz & Williams, 1957; McLuckie, 1974), tacit knowledge of why people fail to heed warnings has not. Tacit knowledge is hard to formalize, difficult to communicate, and challenging to capture (Polanyi, 1966). The warning process has been studied and improved, but social scientists assert that more must be done to make certain that information conveyed by scientists is understood by the people for whom the warning is intended (Demuth et al., 2007; Fischhoff, Brewer, & Downs, 2011). The problem is that it is not known how people who receive severe weather warnings perceive risk or the efficacy of response.

Findings from a 2013 tornado event in central Oklahoma indicated that, even with timely warnings, thousands of people jammed the highways trying to escape the storm (NOAA, 2014). It was estimated that the death toll could have been as high as 1000 had the two-mile wide tornado not lifted before it reached these traffic clogged highways (NOAA, 2016). Storm assessments following storms that produced significant damage or loss of life have documented how some humans have chosen to behave (NOAA, 2013a; 2014), but studies pertaining to how humans perceive and respond to weather related threats are difficult to find. Conversely, research into human responsiveness towards threat or risk is abundant in crisis communication literature,

with many studies in topics related to healthcare, law enforcement, terrorism, and finance (Ansari, 2012; Bonkiewicz & Ruback, 2012; Elstad et al., 2012; Sadiq & Graham, 2014).

Mead (1934) and Parsons (1997) have asserted that any action taken by a human is the result of a behavioral or decision-making process. This implies that basic human response to a threat or risk can be applied to individuals facing weather-related threats. However, across the sciences research on risk and response is fragmentary, with different scientific disciplines applying various paradigms, hypotheses, and terms to explain cultural attitudes, and perspectives toward risk (Brady, 2012; Elstad et al., 2012; Morrow, 2009).

Morrow (2009), Schumacher et al. (2010), and Stein et al. (2011) have claimed that that there is little documentation concerning how people experiencing a weather crisis are sensitized to respond to future warnings, how they perceive risk before or after a storm, the levels of trust that must be present for a warning to be believed, or the amount of risk one must sense before a behavioral change is made. Real-time events can be difficult to research rigorously, because diagnostic techniques may be unavailable (Argyris & Schön, 1974). For this reason, research in natural disaster tends to be opportunistic, with most research conducted after an event has occurred.

In storm related literature, theories rooted in health belief models (HBM) have been cited as applicable to human responsiveness to warnings, but an exhaustive search of the literature found no evidence that these theories had actually been tested in natural disasters, during severe weather episodes, or in severe weather research after weather catastrophes. Components of the HBM have been applied to a variety of health-related behaviors, from screening for disease, to immunizations, chronic illness, and health maintenance activities (Updefraff et al., 2015).

However, HBM has limitations. It does not take into account the personal attitudes and beliefs of the individuals facing the threat nor does it consider, the environmental or economic factors that may prohibit the recommended actions; furthermore, HBM assumes that all individuals have equal access to information and decision-making cues.

Social psychology theories, such as the theory of planned behavior (TPB) which focuses on behavioral intent (Ajzen, 1991), the social cognitive theory (SCT), which considers how past experiences shape a person's behavior (Bandura, 1986), and the heuristic-systematic model of information processing (HSM), which attempts to explain how people receive and process persuasive messages (Chaiken & Maheswaran, 1994), are cited in crisis communication literature and in studies of risk judgement and information sufficiency (Sheppard, Janoske, & Liu, 2012; Trumbo, 1999). However, little is known about the impact of warning information after a warning is issued, or how the public interprets, filters, shares, or perceives the message (Schumacher et al, 2010). Ultimately, there is no one-size-fits-all method for communicating risk (NOAA, 2016).

The purpose of my study was to investigate how wording used in severe weather warnings affected individuals' risk perception and to validate whether these documents contained sufficient information for decision-makers. By investigating perception of risk and response at the first link in the warning dissemination chain between a weather forecaster and the general public I established a baseline for future research. Interest in warning response is not new. The topic of perception has been identified as an area for future research in crisis communication publications for over 50 years (Sheppard, Janoske, & Liu, 2012). Yet, follow-up

studies have not addressed how individuals interpret threat and determine a response to severe weather warnings.

According to Bostrom (2014), social trust in risk communication and governance has declined and that new perspectives and strategies are needed to achieve social change. My research builds upon risk communication research done in other fields of study (Elstad et al., 2012; Sheeran, Harris, & Epton, 2014; Zhang et al., 2013). In the study I evaluated characteristics in warning text that could be associated with perceived severity, susceptibility and response efficacy, as well as to discern whether severe weather warnings created from standardized warning templates contain sufficient information for decision-making.

The belief that humans have a need to confirm a health threat (Griffin et al., 1999) is frequently discussed in crisis communication literature (Sutherland, 2012). Although the research has been widely cited within the weather enterprise in regard to natural disasters like flooding and hurricanes (Eisenman et al., 2007; Morrow, 2009; Wild, 2004), no studies were found to indicate that this assertion was evaluated in a severe weather context. It was unknown whether people used a confirmation process to assess the validity of severe weather warnings; whether there was a need to confirm threat if a warning was provided by a trusted source, or how the confirmation process was affected by different types of warnings.

The interconnections in relationships are such that a change in one area can result in an unexpected change elsewhere. According to chaos theory (Lorenz, 1963), a perfect weather forecast is not possible. Yet people are expected to respond appropriately when warning information is provided. In situations where actions are required, individuals resort to internalized knowledge (Argyris & Schön, 1974) and it is not known how people internalize

knowledge of weather threats into actionable behaviors. Lessons from systems theory state that informational deficiencies may not be due to a lack of information, but from an "overabundance of irrelevant information" (Ackoff, 1967, p. B-147). Research was needed to determine what aspects of weather warning information were relevant to human perception.

My challenge was to find a proxy group that could provide subjective insight into the problem. Members of the proxy group needed to possess knowledge of weather threats, warning protocols, and response behaviors, but did not need to comprehend the atmospheric processes that made a warning necessary. It can be "difficult to trace a path from knowledge to action" (Davenport & Prusak, 2000, p. 6). While explicit knowledge can be expressed in formal language that can be packaged, stored in documents, or encoded, tacit knowledge is held within an individual. Tacit knowledge is generally transmitted through face-to-face communication, by watching, or through learning-by-helping interactions. In the practice of knowledge management nothing is totally new. Much of what has previously been learned, including information emanating from other groups, may be useful (Senge, 2006), and when insight is applied, new knowledge can be created or developed (Koenig, 2012).

Social Change Impact

Prior to my research, numerous researchers had scrutinized the quantitative aspects of human responsiveness to severe weather and environmental risk, yet findings indicated that the underlying factors that caused an individual to respond to a weather warning needed to be explored (NOAA, 2016). Researchers in Europe investigated communication and perception of risk in regard to flood response (Fleischhauer et al., 2012; Uhlemann, Thieken, & Merz, 2013), but findings from flood research do not apply to severe weather communication due to different

time scales for response, the actions required to prepare for flooding, greater frequency of reoccurrence, and the underlying purpose of the research to improve communication about flood mitigation efforts.

Previous social science research has been cited in studies concerning severe weather; however, no studies were found that tested these findings in severe weather situations. Lack of research was likely due to the complexities involved in developing diagnostic techniques and conducting research during crisis situations. According to knowledge management practitioners, nothing is entirely new (Koenig, 2012) and using what is known to create new knowledge can have a positive impact on an individual or group.

Knowledge resides within people. When one wants to learn, it is good to talk with an expert. In my study, the experts were secondary disseminators of severe weather warnings. These individuals were members of law enforcement, county or city dispatchers, and emergency managers who routinely distribute emergency information to others; they serve in positions of trust and are considered local experts for emergency communication messaging. I was able to test previous theories and discover how nonscientists who are the first link in the information chain between a weather forecaster and the general public assessed the seriousness of a weather threat and determined an effective response by exploring the perceptions of risk that storm warnings conveyed to the local experts.

The discovery of communication methods that effectively convey risk and improve responsiveness to warnings has the potential to save lives. My study was developed to establish a baseline for future research. Implications for positive social change from this research include knowledge that can be reused by meteorologists, emergency managers, broadcasters, educators,

and researchers seeking ways to improve severe weather forecasts, warnings, and public response. The long term impact of positive social change could mean that fewer injuries and deaths will be attributed to severe weather.

Conclusions

The problem addressed in this study was a lack of scholarly research to understand human perception of risk and response to severe weather warnings. Perception of risk applies to relationships that underlie personal behaviors, actions, and decisions associated with risk. Past experience, age, gender, or culture can influence how risk is perceived. Individuals and groups often perceive risk differently, and this perception gap is one reason real world problems can become difficult to research (Kanno, Furuta, & Chou, 2012). Prior to this study it was not known how people who receive severe weather warnings perceived risk or the efficacy of a response.

Results from the study determined that perception of risk and perception of response are relational. EMP considered the NWS as a trusted source for accurate warning information about a threat, but they were less confident that a threat would actually occur at a given location at a specific time. In most instances, EMP indicated that “close” was good enough when it came believing the warning. However, an exact measure of close could not be established. Close could mean in the next block or storms occurring in a nearby county.

Perception of risk was greater when a weather warning included reports of previous damage or ground truth information from a trusted source, like a trained spotter. Ground truth reports from public sources or the media were perceived by EMP as accurate, but less trusted. EMP indicated that warnings containing both ground truth and radar indication of rotation were most trusted, but some preferred one type of confirmation over the other. Tech savvy individuals

perceived more risk when a tornado was radar indicated, while individuals who valued relationships perceived greater risk when ground truth information came from a person they knew.

EMP understood the uncontrollable nature of weather and recognized that a warning did not guarantee that damage would occur. However, most EMP perceived that the public would not respond appropriately to a warning. This perception was based upon personal experiences during and after severe weather warnings and EMP's perception that the public wanted pin-point accuracy from warnings.

In the study, EMP perceived the severity of a tornado warning, they identified susceptible locations and individuals, they perceived that a response was needed, and they perceived that they would take action to respond to the warning. Seriousness of the threat was linked to trust, but with variation. In some situations, it was trust in the source and, in others, trust in the information provided. Storms with a history of damage or confirmed spotter reports were taken more seriously than storms with radar indicated rotation alone.

Response was relational and the actions taken by EMP appeared to be job specific. Telecommunicator and dispatcher perceptions of response focused on the protection of others who needed information to stay safe. Emergency management coordinator perceptions of response were focused on identifying threatened locations and getting into position to render aid and mitigate damage. Perceptions of self-efficacy were also relational. EMP recognized a need to protect themselves from an immediate threat, but their responses were many times altruistic and involved providing assistance to a coworker or neighboring community.

Although study findings indicate that perception of risk and response were evident in a small group of individuals in the central United States, these results, particularly the altruistic motives and behaviors centered around the welfare of others, may be an artifact of the cultural influence of Midwestern hospitality. Perceptions of risk and response appeared to depend upon relationships: relationship of trust in the source of the message, relationship of job responsibly, relationship to knowledge of risk based upon personal experience, and relationship to the type of threat that was perceived.

This study successfully applied risk communication research from other fields of study to determine whether severe weather warnings that use standardized warning templates contain sufficient information for decision-making. The study also revealed that information in severe weather warnings affect EMP's perceptions of severity, susceptibility, and response, but not always in the way that the warning forecaster intends. Although more research is needed before warnings can be improved, this study establishes a baseline for that research. Positive social change will be achieved when people understand severe weather warnings, they take appropriate action to respond to the threat, and lives are saved.

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Appendix A: Definition of Terms

Call-to-Action: the portion of a warning statement that describes protective actions

CERT: community emergency response team

CD: civil defense

Derecho: widespread, long-lived windstorm associated with a band of rapidly moving thunderstorms. The wind damage swath can extend more than 240 miles with wind gusts of at least 58 mph, or greater, along most of its length.

EM: emergency manager

EMA: emergency management agency

EMP: emergency management personnel (i.e. dispatchers and emergency managers)

EPA: Environmental Protection Agency

EPPM: extended parallel processing model

ESDA: Emergency Service and Disaster Association

FEMA: Federal Emergency Management Agency

Hurricane: type of severe tropical storm that forms in the southern Atlantic Ocean, Caribbean Sea, Gulf of Mexico, or eastern Pacific Ocean

IBW: impact based warning

IPEM: Illinois Professional Emergency Manager

NAWAS: National Warning Activation System

NCDC: National Climatic Data Center

NOAA: National Oceanic and Atmospheric Administration

NWR: NOAA All Hazards Radio

NWS: National Weather Service

Perceived severity: beliefs about the significance or magnitude of a threat

Perceived susceptibility: perception of the risk, or perception of vulnerability to the risk

Response-efficacy: belief that a recommended response deters or alleviates a threat

RISP: risk information seeking and processing model

Self-efficacy: an individual's belief in his or her ability to succeed in a particular situation

SOO: science and operations officer

SPC: Storm Prediction Center

SPS: special weather statement

SVR: severe thunderstorm warning

SVS: severe weather statement

Thunderstorm: a storm with thunder, lightning, heavy rain, and sometimes hail

TOR: tornado warning

Tornado: A violently rotating column of air with a circulation that is reaching the ground. Can include wind speed of up to 300 miles per hour; damage can be greater than one mile wide and 50 miles long.

VTEC: valid time event code

WarnGen: graphical interface text creator used for warnings and statements

Warning: An alert for conditions that pose a threat to life or property. A warning is issued when a hazardous weather or hydrologic event is occurring, is imminent, or has a very high probability of occurring.

Watch: An alert term used to identify situations and locations where the risk of a hazardous weather or hydrologic event is significant, but its occurrence, location, timing or some combination of these is still uncertain. A watch is intended to provide enough lead time so those who need to set their plans in motion can do so.

WCM: warning coordination meteorologist

Weather enterprise: public private partnerships of government, media, academia, and emergency management groups whose professional duties focus on aspects of weather

WFO: weather forecast office

Appendix B Study Information Sheet

The Perception of Weather Risk and Response

I am asking you to participate in a research study to examine how weather warnings are interpreted by emergency management personnel. I am particularly interested in learning how information contained in a severe weather warning is understood by people who are not scientists.

I will be conducting interviews with emergency managers, county or city dispatchers, and members of law enforcement who receive warning information from government agencies and who then relay this information to others. These groups of people interest me because they are frequently the first link in the warning dissemination chain from a weather forecaster to the general public.

My goal is to understand a severe weather warning from your point of view. During the interview I want to know what you know and the way in which you know it. I want to understand your perception of a warning and your perception of a response to a warning. I want to feel things as you feel them and explain things as you explain them.

Should you have questions, you may speak to me at 563-324-6329 or email me at teresa.simmons@waldenu.edu For questions about the rights of research subjects, call Walden University's office for the protection of research subjects at 612-312-1210

Appendix C Interview Questions

Weather comprehension:

1. When I use the term severe, what type of weather do you think of? Why that type of weather?
2. What is your experience with severe weather?
3. How does your job-related experience relate to your personal understanding of weather?

Warning comprehension: (interviewees' will refer to an actual warning for Q4-12)

4. Are there conditions in this message which cause you concern? If so what are these concerns?
5. What effects would you expect from this type of storm?
6. How do you determine seriousness of this weather-related threat?
7. Who, or what location, is most affected by the threat? Is anyone else affected?
8. What effects will the threat pose? What can be done to minimize vulnerability?

Efficacy:

9. What is your level of confidence with information in this warning? Why?
10. What would increase your confidence?
11. Help me understand your perspective of public response to a warning such as this:
    a. What should a person do to reduce vulnerability?
    b. What other actions could be taken to limit exposure or consequences from the threat?
    c. How easy would it be to take these actions? Why?
    d. What could prevent a person from taking protective action?
    e. What would cause a person to decide anything is more valuable than their life?
12. What are the reasons you hear for a warning not being heeded?
13. In general, tell me how responsive you are to taking shelter from:
    a. a thunderstorm with 70 mph wind? Why?
    b. a tornado? Why?

About this warning:

14. Assuming this warning is 100% accurate what 'worst-case' planning is needed?
15. What do you not see that you would like to see?
16. What is missing that would make it better?