THE CURRENT STATUS OF LIGHTNING SAFETY KNOWLEDGE AND THE
EFFECTS OF LIGHTNING EDUCATION MODES ON COLLEGE STUDENTS

A thesis submitted
to Kent State University in partial
fulfillment of the requirements for the
degree of Master of Arts

by
Melissa Catherine Koeka Phillips

August, 2011

Thesis written by

Melissa Catherine Koeka Phillips

B.S., University of Oklahoma, 2008

M.A., Kent State University, 2011

Approved by

_____, Advisor
Thomas Schmidlin, Ph.D.

_____, Chair, Department of Geography
Mandy Munro-Stasiuk, Ph.D.

_____, Associate Dean for Graduate Affairs,
John R.D. Stalvey, Ph.D. College of Arts and Sciences

TABLE OF CONTENTS

LIST OF FIGURES	v
LIST OF TABLES	vi
ACKNOWLEDGEMENTS	viii
CHAPTER 1 – INTRODUCTION	1
CHAPTER 2 – LITERATURE REVIEW	4
Natural Hazards	4
Lightning as a Natural Hazard	5
Types of Lightning Strikes	12
Effects of Lightning on the Human Body	13
Natural Hazard Education	16
Education Modes	18
Lightning Education	21
CHAPTER 3 – METHODOLOGY	23
Overview	23
Study Areas	25
Demographic of Participants	26
Consent	26
Data Collection	27
Sample	28

Scale	29
Data Entry	29
Data Exclusion	31
Data Application	32
Data Analysis	34
CHAPTER 4 – ANALYSIS & RESULTS	36
Sample Demographics	36
Analysis & Results	41
CHAPTER 5 – DISCUSSION	67
Discussion	67
Recommendations	72
CHAPTER 6 – CONCLUSION	74
Limitations	74
Conclusion	76
REFERENCES	80
APPENDICES	85
A – Pre-mode & Post-mode Survey	85
B – Consent Form	90
C – Permission to Use NWS Materials	92

LIST OF FIGURES

Figure 1	A 5-Year Flash Density Map of Lightning Activity in the United States from 1996 - 2000	6
Figure 2	Number of Lightning Fatalities per State 2000 – 2009	7
Figure 3	Number of Lightning Fatalities per State Weighted by Population 2000 - 2009	7
Figure 4	Summary of Study Process	24
Figure 5	Responses for Minutes to Wait After Hearing Thunder Before Resuming Outdoor Activities	45
Figure 6	Responses for Number of Miles Ahead of a Storm Lightning Can Strike the Ground	46

LIST OF TABLES

Table 1	Number & Percentages of Lightning Deaths: 1995 – 2009	11
Table 2	Course Participation by Type of Course and University	29
Table 3	Omitted Survey Responses	30
Table 4	Accepted Correct Responses for List Two Signs of Lightning Danger	33
Table 5	Vulnerability Using Knowledge and Risk Levels	35
Table 6	Pre-Mode Demographic Summary	37
Table 7	Pre-Mode Distribution by All Home States	38
Table 8	Post-Mode Demographic Summary	39
Table 9	Post-Mode Distribution by Education Mode	40
Table 10	Post-Mode Distribution by Gender and Education Mode	40
Table 11	Overall Lightning Safety Knowledge	42
Table 12	Percent of Correct Responses & P-Values by State	48
Table 13	Percent Received of Lightning Safety Programs by Study Area & P-Values	51
Table 14	Pre-Mode vs. Control Group Percent of Correct Responses & P-Values	54
Table 15	Pre-Mode vs. Post-Mode Percent of Correct Responses & P-Values	56
Table 16	Pre-Mode Sample vs. Brochure Post-Mode Sample & P-Values	59
Table 17	Pre-Mode Sample vs. Video Post-Mode Sample & P-Values	60
Table 18	Pre-Mode Sample vs. Brochure & Video Post-Mode Sample & P-Values	61

Table 19	Female Pre-Mode/Post-Mode Percent of Correct Responses & P-Values	63
Table 20	Male Pre-Mode/Post-Mode Percent of Correct Responses & P-Values	64
Table 21	Gender Knowledge Rate Analysis Using Only Significant Variables	66

ACKNOWLEDGEMENTS

Many individuals have influenced and aided me throughout this thesis process. First, I would like to thank my advisor, Dr. Thomas Schmidlin. I can still remember the day I walked into your office with a list of ideas for this project, not knowing where to begin. Your ability to guide me in the right direction as well as read too many pages in a matter of hours undoubtedly sped up this process. You have influenced and taught me more about research and my career than any other professor. I look very forward and am excited to continue learning from you throughout my Ph.D.

I would also like to thank my additional two committee members, Dr. Rebecca Parylak and Dr. Scott Sheridan. Dr. Parylak, your suggestions throughout this process have taught me the difference between good writing and writing well. Thank you for being my sounding board throughout this past year! Dr. Sheridan, thank you for always being available. I cannot count how many times I wandered through your open door when I am sure you were busy, yet you always had a moment to talk and answer my questions.

Thirdly, I would like to thank the Department of Geography at Kent State University for all their support and believing in me. I especially would like to acknowledge Mary Lou Church (Poster Printing Queen), for always having a smile and an answer. To all the graduate students, especially Derrin Smith, Christina Longo, and John Barr, thank you for your companionship throughout this process, especially the

comedic relief. All of you somehow managed to make whatever frustration I had hilarious.

A special thank you to all of my survey administrators, Dr. Kevin Archer (USF), Dr. Timothy Vowles (UNC), Joni Palmer (CU), Dr. Scott Sheridan (KSU), Dr. Rebecca Parylak (KSU), Dr. David Kaplan (KSU), and Jeremy Spencer (KSU), without you this thesis would not have been possible. I would like to thank the National Weather Service for providing the safety education materials.

To Dr. Susan Postawko, Dr. Scott Greene, Dr. Kevin Kloesel, and Dr. Darren Purcell, thank you for always pushing me throughout my undergraduate career and sparking my interest in natural hazards and education.

To my parents, Gary and Mary Koeka, thank you for everything! You both taught me the importance of family, going after your dreams, never giving up, and taking pride in your work. So much of what I am today is from my upbringing. You have sacrificed so much for my brothers and I to be where we wanted to be in life. I am truly grateful you are my parents and I got to be your daughter.

Thank you to my brothers Gregory Koeka (Hooey) and Douglas Koeka (Shnuey), for never treating me like I couldn't do something because I was a girl. When you played tackle football, I played tackle football. I will always treasure your friendships growing up and all the memories we made together.

To my friends, especially Sarah Cricks, Ashley Snyderburn, Lauren Bodenhamer, Katherine Hawley, and Becky Marr, thank you for being there for me and supporting me

even though we are miles apart. The amount of mischief we created together made lasting memories, many of which I will never speak of and take to my grave.

Finally, a thank you more significant than words can convey, I would like to thank my husband, Matthew James Phillips. Love, your name belongs on here just as much as mine. Your encouragement and support pushed me to do what you knew I could do, even when I didn't. You're My Inspiration. The day I met you, I won the lottery. No matter where we live, what we have, or the road we'll travel, I'm happy because I am with you. I love you. Today, tomorrow, until the end of time, I could not imagine you being Anything But Mine.

CHAPTER 1

Introduction

Every year citizens of the United States are struck and injured or killed by lightning. These deaths and injuries are senseless given that lightning danger is understood and mitigation strategies are well known in the research community. Therefore, a lack of communication between research and citizens may exist for deaths and injuries to occur. It is also possible that mitigation strategies are being communicated and citizens are not heeding warning signs or taking precautions.

Lightning research has taken on many forms since lightning has been understood. Published guidelines and safety recommendations can be found since 1900 when it was suggested that individuals on horseback dismount during a storm and clotheslines be moved further from the dwelling to avoid injury (Henry, 1900). Safety recommendations and guidelines are more advanced today along with several other types of lightning research. These types of research include: an effort to make uniform the reporting of lightning mortality, effects on humans once struck, as well as safety recommendations and updates to previous guidelines (Ashley and Gilson, 2009; Cooray et al., 2007; Holle et al., 2005; Zimmermann et al., 2002; Holle et al., 1999). What is lacking in these studies is education. Lightning education, the status of education, mitigation strategies, and modes for best education practices have not been widely studied with regard to lightning. Thus, the goal of this research is to determine a current status of lightning

safety knowledge, explore the relationship between variable risk and lightning safety education programs, evaluate vulnerability in areas of variable risk, determine the best mode for educating students on lightning safety, and compare gender differences in learning about lightning safety. This research will answer several questions:

- 1) Can the current status of lightning safety knowledge be established for college students in the areas of study?
- 2) Are particular areas of lightning safety misunderstood more than others?
- 3) Do past death rates affect lightning safety knowledge for each area of study?
- 4) Can current levels of risk and lightning safety responses determine vulnerabilities for each area of study?
- 5) Is relative risk related to the existence of K – 12 lightning education programs in each area of study?
- 6) Is relative risk related to the existence of non-school lightning education programs in each area of study?
- 7) Does the mode of education affect the efficacy of lightning safety knowledge?
- 8) Does gender affect lightning safety knowledge prior to the exposure of education modes?
- 9) Does gender affect lightning safety knowledge after exposure to education modes?

Three modes of education regarding lightning safety were selected from the National Weather Service (NWS): brochure, video, and brochure and video. The study areas chosen for this research include Florida, Colorado, and Ohio, with universities

selected as the survey distribution location. Undergraduate geography students were given an initial survey, exposed to an education mode, and given a post survey. The initial survey as well as a comparison between the initial and post surveys will determine responses to the study questions.

CHAPTER 2

Literature Review

Natural Hazards

A natural hazard can be defined as a natural process which can threaten life or property (Hyndman and Hyndman, 2009). A hazard can be viewed as:

$$\text{Hazard} = f(\text{risk} \times \text{exposure} \times \text{vulnerability} \times \text{response})$$

Risk is the probability that an event will occur. Exposure defines the populations who reside in the risk area. Vulnerability is the potential for loss. Response refers to mitigation measures occurring either before or after an event, if a plan is in place (Tobin and Montz, 1997).

A term closely related to natural hazard is disaster which means “when an event causes significant damage to life or property” (Hyndman and Hyndman, 2009: 3). A disaster has different components which comprise its definition. One of these prevalent terms is mitigation, which can be defined as “measures to reduce risk and the impact of an event,” (Bird and Dominey-Howes, 2008: 104). Perceived risk encompasses the idea that people in certain societies who are exposed to hazards think they understand the amount of risk involved, but usually their perception of this risk is altered from the actual reality of that risk. Finally, risk communication clarifies and replaces the misperception with correct information. “Risk communication is undertaken to persuade people,

formally or informally, to adopt self-protective behaviors and practices,” (Bird and Dominey-Howes, 2008: 102).

Lightning as a Natural Hazard

Lightning can be defined as “a strong separation of charge that builds up between the top and bottom of cumulonimbus clouds,” (Hyndman and Hyndman, 2009: 432). Air is a poor conductor of electricity; however the resistance in the air is often overtaken by the attraction of charges resulting in lightning (Hyndman and Hyndman, 2009).

Lightning is arguably the most dangerous natural hazard due to its unpredictability and frequency of strikes (Holle et al., 1999; Lengyel et al., 2005). The National Lightning Detection Network (NLDN) recorded an average of 25,000,000 cloud-to-ground flashes per year in the United States (Zimmermann et al., 2002).

In the United States, there are more deaths due to lightning than any other natural disaster, except floods (Lopez et al., 1993; Curran et al., 1997; Holle et al., 1999; Cooray et al., 2007). With underreporting taken into account, lightning kills on average 100 people per year and injures more than 500 in the United States with an overwhelming majority being male (Curran et al., 2000; Duclos and Sanderson, 1990; Holle et al., 1999; Holle et al., 2005; Fieux et al., 2005). Annual mortality rates from lightning decreased from six per one million people to 0.6 per one million people between 1890 and 1990 (Holle et al., 2005; Lopez and Holle, 1998). However, the decrease in mortality rate “...occurred throughout the 20th century in the U.S., and closely follows the decrease in

percentage of the population living in rural areas” (Holle and Lopez, 2003: 1). Over the past century, the shift in population can be seen again in the locations of fatalities. In 1899, 563 people were killed by lightning and 820 injured. It was noted that majority of the women killed were removing clothes from clotheslines during a storm or were in close proximity to a clothes wire during a storm (Henry, 1900). In the past, individuals died mostly while farming or gardening, whereas in present time, numbers of lightning related fatalities increased while individuals partook in recreational activities (Holle et al., 2005).

The United States has spatially variable risk. Risk can be defined as the probability that an event will occur (Tobin and Montz, 1997). Areas of risk can be determined from flash density (Figure 1) (National Weather Service, 2010e), lightning deaths by state (Figure 2), and lightning deaths by state weighted by population (Figure 3) (National Weather Service, 2010d).

Figure 1 – A Five-Year Flash Density Map of Lightning Activity in the United States from 1996 - 2000

Figure 2 – Number of Lightning Fatalities per State 2000 - 2009

Figure 3 – Number of Lightning Fatalities per State Weighted by Population 2000 - 2009

The flash density map reflects the number of flashes per square kilometer per year (km^2/yr) or the likelihood of lightning strikes occurring in an area. This map represents the risk across the United States. The final two maps are deaths and deaths weighted by population, which should reflect risk per state. Three states with different risks are discussed below to compare and contrast the threat of lightning to citizens throughout the United States in areas of variable risk.

Figure 1 illustrates that risk in Florida is the greatest in the country with an average of eight to 16 flashes per km^2/yr from 1996 to 2000 (National Weather Service, 2010e). This risk is reflected in lightning deaths for the state. Florida experienced 70 deaths, ranking it first in the country from 2000 to 2009 (Figure 2) (National Weather Service, 2010d). When weighting the deaths by population, Florida still ranks in the top ten nationally (Figure 3) (National Weather Service, 2010d). In the past, Florida has had the same statistics. From 1959 to 1994, Florida was ranked first in the country for lightning deaths, and when weighted by population, this 1959 – 1994 time period placed Florida fourth in the nation (Curran et al., 1997). In particular, Tampa, Melbourne, and Miami have the highest rates of injuries and deaths by lightning strikes from 1998 to 2003 (Fieux et al., 2005). Regarding high risk, mortality, and mortality rate nationally, Florida students have the highest risk for loss of life from lightning strikes. In addition to high risk, the death rate in Florida may also be due to poor choices in personal lightning safety by Florida citizens which affects Florida's vulnerability. Florida may have a higher vulnerability due to recreational activities, such as boating on open waters, which

can expose a greater number of residents and tourists to lightning danger, who may not be properly educated on lightning safety.

Figure 1 illustrates that risk in Ohio to be fairly moderate. This state averages two to four flashes per km²/yr from 1996 to 2000 (National Weather Service, 2010e).

Therefore, Ohio is ranked 19th in the country regarding cloud-to-ground flash densities. Ohio's risk is reflected in lightning deaths for the state. Between 2000 and 2009, Ohio had 13 deaths, ranking it eighth in the country (Figure 2) (National Weather Service, 2010d). Given its large population, Ohio has a much lower ranking in death rates when compared to Florida (Figure 3) (National Weather Service, 2010d). In the past, Ohio experienced the same statistics. From 1959 to 1994, Ohio was ranked eighth for lightning deaths, and when weighted by population, this 1959 – 1994 time period placed Ohio in the 80th percentile in the nation (Curran et al., 1997). Regarding moderate risk, mortality, and mortality rate nationally, Ohio students have a moderate risk for loss of life from lightning strikes. This may be reflected as a moderate vulnerability when including lightning safety knowledge and mitigation efforts.

Figure 1 illustrates that risk in Colorado varies across the state. The western mountainous area of the state has a very low to low risk with an average of 0.25 to two flashes per km²/yr from 1996 to 2000. The eastern flat area of the state has a moderate to high risk with an average of two to eight flashes per km²/yr from 1996 to 2000 (National Weather Service, 2010e). This ranks the state 31st in the country for cloud-to-ground flash densities. However, the risk is not reflected in lightning deaths for this state. From 2000 to 2009, Colorado had 27 deaths, ranking it second in the country, tying Colorado

with Texas (Figure 2) (National Weather Service, 2010d). When weighting the deaths by population, Colorado still ranks in the top ten nationally (Figure 3) (National Weather Service, 2010d). In the past, Colorado has had somewhat different statistics. From 1959 to 1994, Colorado was ranked 11th in the country for lightning deaths, and when weighted by population, this 1959 – 1994 time period placed Colorado sixth in the nation (Curran et al., 1997). Colorado's death rates are higher than expected. This may be due in part to the moderate to high risk area being centered within an area of increased population. However, the high rate of mortality could also be due to a high rate of vulnerability. Colorado's outdoor recreation includes activities above tree-line which exposes residents and tourists to increased lightning danger. These dangers may or may not affect the vulnerability in Colorado. If citizens are knowledgeable about lightning safety, these characteristics may have little impact.

For a state to have a high rate of vulnerability, its citizens may not have the proper safety knowledge, mitigation strategies, and they may place themselves in dangerous situations. Typically, this occurs during recreation. The cause for significantly higher death rates in Florida and Colorado may be attributable to recreation. From 1959 – 1994, 50.9% of lightning deaths in the Southern Rocky Mountain States, including Colorado, were during recreation. Other significant activities resulting in lightning fatalities are taking shelter under a tree (13.4%), outdoor work or farming (2.1%), and use of a telephone (1.5%). Approximately 31.7% of lightning deaths were not reported or unknown in activity (Curran et al., 1997). In the Midwest, including Ohio, the most common activity associated with lightning fatalities was recreation at 40.7%, which is

substantially lower than the Southern Rockies. Other areas of activity resulting in death are taking shelter under a tree (14.8%), outdoor work or farming (2.6%), and use of a telephone (2.7%). Approximately 38.6% of lightning deaths were not reported or unknown in activity. In the Southeast, including Florida, the largest activity causing death was recreation at 50%, which is the same rate as the Southern Rockies. Other significant activities resulting in lightning deaths are taking shelter under a tree (13.6%), outdoor work or farming (2.7%), and use of a telephone (2.5%). Approximately 39.2% of lightning deaths were not reported or unknown in activity (Curran et al., 1997).

In more recent years, the dominant location and activity during a strike which caused death remains recreation (Table 1) (National Climatic Data Center, 2010).

Table 1: Number & Percentages of Lightning Deaths: 1995 - 2009

Type	CO	CO %	FL	FL %	OH	OH %
Under a Tree	8	19	8	7.1	2	7.1
Work/Farming	7	16.7	21	18.6	6	21.4
Telephone	0	0	0	0	0	0
Recreation	23	54.8	53	46.9	12	42.9
Unknown	4	9.5	31	27.4	8	28.6
Total	42	23	113	62.1	28	15.4

Curran et al. (1997) focused on casualties and regions while the data in Table 1 focuses on the three specific states and deaths only from 1995 – 2009. In all states, a majority of deaths occur during recreation (Table 1). When adjusted to remove unknown activities from the data, the percentage of deaths during recreation are similar, 61% in Colorado,

65% in Florida, and 60% in Ohio. This finding does not support the theory that increased recreation, especially recreation above tree-line may be the reason for such high death rates in an area of moderate risk. Colorado has a high rate of deaths occurring under trees when compared to Florida and Ohio. This may also occur during recreation or outdoor activities, which could affect the high death rate for Colorado. Working and farming remains a source of activity while being struck by lightning (National Climatic Data Center, 2010).

Types of Lightning Strikes

An integral part of formulating and dispensing mitigation strategies for lightning safety is understanding the ways in which the human body can be struck. There are six ways the human body can be struck by lightning: direct strike, side flash, touch voltage, step voltage, subsequent stroke, and connecting leaders. A direct strike occurs when lightning directly strikes and discharges on the human body. A side flash occurs when a current creates a channel through an object to the ground as well as to another object. The current will then attempt grounding through both objects. If a human is standing within range, they may become the additional object. This accounts for at least 50% of all lightning injuries that occur outdoors (Cooray et al., 2007).

Touch voltage strikes occur when a human is holding an object that is struck. The current will flow through the object, to the human, and ground through the human. A step voltage strike occurs after a lightning strike when the current has already been

grounded. The current will continue to flow outward, and if a human is standing within this radius, they will experience the current flow up one leg and down the other, causing minimal injuries. Subsequent stroke strikes are direct strikes which follow a step voltage strike, or being struck twice in two different ways. The final way to be struck by lightning is through a connecting leader strike. When a lightning strike occurs, it begins with a step leader from the cloud and is met by a connecting leader from the ground. If a human is in the path of that connecting leader, they will be struck and most likely struck again by the return stroke. The return stroke occurs once both step leader and connecting leader meet, resulting in a flash. Both return stroke and connecting leader can cause injury or death (Cooray et al., 2007).

Effects of Lightning on the Human Body

When lightning current and the human body come in contact with one another, an electric current will begin by flowing through the body. "...a very small fraction of the current may generally flow through the body and the rest will flow over the surface of the body," (Cooray et al., 2007: 387). It will continue to do so until there is too much resistance in the body. At this point, the path of least resistance will exist as a channel over the skin to the ground. Therefore, injuries occurring from strikes are both internal and external (Cooray et al., 2007).

The leading cause of death in a lightning strike is cardiopulmonary arrest (Cooray et al., 2007; Zimmermann et al., 2002). This can occur in two forms: asystole or

ventricular fibrillation. Asystole is a lack of heart beat or activity and ventricular fibrillation is an uncontrolled rhythm. It is possible to recover from cardiopulmonary arrest with cardiopulmonary resuscitation (CPR). Even with the option of CPR, the mortality rate of a lightning strike remains at 20% (Cooray et al., 2007).

In addition to cardiopulmonary arrest, respiratory functions of the body can be disrupted during a lightning strike. A strike that forces current flow along the lines of communication between the respiratory centers in the brain inhibits their ability to control the rate, rhythm, and depth of respiration which can cause respiratory arrest. In some cases, during cardiopulmonary arrest, the heart can recover to a normal beat however; respiratory arrest without recuperation will cause a second cardiopulmonary arrest, resulting in mortality (Cooray et al., 2007).

Lightning strikes can also cause injuries to the eye due to the current from the strike and intense radiation. The most common injury is cataracts, which cloud the lens of the eye. In addition, lightning can cause blurred or distorted vision, blind spots, and retinal detachment. Retinal detachment is the shifting or pulling of the retina from its position. Finally, change in vision or complete loss of vision is probable (Cooray et al., 2007).

Another injury associated with lightning is ear damage, which is frequently seen among survivors. The cause of ear damage is the extreme change in pressure surrounding a lightning strike. When a return stroke occurs, the air surrounding that stroke expands rapidly due to the increase in temperature. This pressure causes a sound impulse equivalent to 200 decibels (dB). The pain threshold for the human ear is 120dB.

A lightning strike survivor has a 20% to 50% chance of experiencing a cochlear membrane rupture. This membrane contains thousands of hair cells and nerve endings which transmit sound to the brain. As a result, a human will experience partial hearing loss, ringing of the ear, or complete hearing loss (Cooray et al., 2007).

Neurological injuries from lightning strikes occur in 70% of survivors. These include hemorrhages, swelling of tissue, epilepsy, tremors, paralysis, unconsciousness, paraplegia from a damaged spinal cord, impaired language, and the inability to read or write. These conditions are permanent and irreversible in most cases. Finally, lightning victims usually experience weakness, numbness, and/or tingling sensations which can last from weeks to years (Cooray et al., 2007). The contact of lightning with skin is expected to cause lacerations or burns which vary in location and severity depending upon the strike. Some survivors will experience a permanent red-brown skin discoloration (Cooray et al., 2007).

Lightning victims can also experience blunt trauma depending upon the strike. It is not uncommon for lightning to displace a human by blunt force causing broken bones or head trauma. In addition, the implosion of nearby objects, such as tree trunks, can cause severe lacerations, broken bones, and/or head trauma (Cooray et al., 2007). Finally, lightning survivors come away with a variety of psychological disorders, such as fear of thunderstorms, anxiety, depression, irregular sleep, panic attacks, memory loss, learning disabilities, constipation, gastric dilation, and post-traumatic stress disorder (Cooray et al., 2007).

The types of injuries associated with lightning strikes are clearly life altering and in some cases life threatening. A human who comes in contact with lightning or is near lightning will experience some sort of trauma. Therefore, it is imperative that knowledge regarding lightning safety be understood and widely distributed. It is also necessary for individuals to take action to mitigate their risk and alter their vulnerability.

Natural Hazard Education

Natural hazard education has progressed over the recent decade. Particular to hazards, the focus has remained not only on general education, but also on what kind of education promotes various types of mitigation and awareness. Education in hazards has been identified as not only one of the most important parts of strategic planning, but also as the first step to informing the public (Dengler, 2005). A study of the United States west coast tsunami risk area found that education is the primary tool in reducing risk and increasing awareness (Dengler, 2005). This knowledge is applicable to other forms of hazards, especially earthquakes, where education is viewed as the most important mitigation tool (Shaw et al., 2004; Shiwaku et al., 2007). Finally, not only has education been proven as a tool for increased awareness and mitigation, but it can be influential in increasing a public's trust of a community's ability to properly understand their risk and plan competently (Bird and Dominey-Howes, 2008).

Education has been proven to yield a more informed public, however there is a debate surrounding who and where to educate. This debate involves research findings

surrounding hazard mitigation actions and adults. Adults have been shown to have incorrect risk perception, lack of awareness, and lack of education, which negatively affects preparedness and readiness (Ronan and Johnston, 2001). It is important to note that adults may pass this misinformation onto their children. The most obvious answer is to educate adults which would assist in both issues. However, it has been noted that education measures for hazards may reduce perceived risk and individual preparation because it unintentionally transfers responsibility from self to government entities (Paton, 2003). It is a safe assumption that this unintentional transfer occurs with adults and not children, given most children have a limited view and understanding of government. Therefore, the most logical approach is to educate children.

Educating children instead of adults is an emerging subject in natural hazard research. Originally, it was expected that experience with a natural hazard would provide a greater impact on knowledge and awareness in children than education. However, this theory has been questioned with research suggesting that the most effective way of increasing awareness in children is through education and the most effective location for educating children is the classroom (Bird and Dominey-Howes, 2008; Johnston et al., 2005; Ronan and Johnston, 2001; Ronan et al., 2009; Shaw et al., 2004; Shiwaku et al., 2007; Soffer et al., 2010). Natural hazard education programs increase schoolchildren's awareness, education, proper risk perception, and at-home mitigation actions (Ronan and Johnston, 2001). Educating children in the classroom supports the transfer of that information into their homes. It also supports hazard mitigation practice discussions in

the home, which increases preparedness, readiness, and causes realistic risk perceptions (Bird and Dominey-Howes, 2008; Johnston et al., 2005; Ronan et al., 2009).

The final debate surrounding education is who should be involved in children education practices. Research has shown that promoting action in students is primarily influenced by community activities and its relationship in daily life (Shiwaku et al., 2007). While the community involvement and relationship is influential, the most significant element is family (Shaw et al., 2004). Despite this disagreement or lack of evidence, it is clear that self-education, which is the initiative to learn and take measures independently, is most effective in proper perception, awareness, and overall mitigation actions (Shaw et al., 2004; Shiwaku et al., 2007). It is apparent that educating children in school about natural hazards is most effective and should include the community and their families while promoting self-education.

Education Modes

The best practices for whom and where to educate has been established, but this research is limiting because it omits discussion of methods in conveying the material. Regarding ways to educate, multiple modes have been identified such as lecture, project papers, maps, simulations, discussions, field work, field trips, memorial events, television, radio, brochures, video, posters, and internet (Bird and Dominey-Howes, 2008; Dengler, 2005; Shiwaku et al., 2007). Recently, internet-based education has grown in popularity and greatly aids in increasing student education experiences when

accompanied by posters, teacher guides, quizzes, photos, and video (Dunbar, 2007).

While it is important to note the accessibility of all these modes, not every mode may be as effective as others.

Research surrounding education modes in natural hazards is minimal. Yet this type of research is prevalent in the medical community given their increased exposure to disaster events and requirements for contingency plans. Research has shown that a visual demonstration, such as a video, along with reading a disaster plan is more effective than only reading a disaster plan (Bartley et al., 2007). This is attributed to a video's ability to promote individual thought which supports discussion (Bartley et al., 2007). This type of research was conducted on adults with specific backgrounds and typically only included a drill method, which is not always applicable for lightning and will not be used in this study.

A more pertinent area of research in the school environment is earthquake education. Even though few studies exist on earthquake hazard education, it provides insight and understanding on the most effective method in natural hazard education. In one particular study, a group of students read a manual with earthquake information while another group watched a video. The content of these two forms of education varied slightly. Those who watched the video had less awareness than those who read the manual. This was attributed to the mode of education and not the content (Shiwaku and Shaw, 2008). The results showed that reading was the more effective method in conveying earthquake safety information. These findings contrast with those found in the previously discussed medical study and shows the difference between educating adults

and educating children. Shiwaku and Shaw (2008) tested modes of education regarding natural disasters, but the students involved had experienced this disaster previous to the study and it is not apparent if a survey was distributed prior to their educational modes. It is possible the students who learned more from reading the manual already had that knowledge.

A similar study surrounding earthquake education modes was conducted with students. This study used three groups of fifth and sixth grade students and exposed them to a drill, a lecture, or a combination of both (Soffer et al., 2010). The results showed that students who had multiple modes of education, drill and lecture, achieved more knowledge of earthquake education than students only exposed to one mode (Soffer et al., 2010). This study focused on drills and lectures, but these are not relevant in all forms of disaster education. In addition, the knowledge gained from these education modes is retained. One study found that this retention lasts up to a year, while another suggests re-educating once every three years (Schütz and Wiedemann, 2000; Soffer et al., 2010).

Another area of natural hazards that lacks hazard education research is floods. Recent research on flood fatalities in Australia calls for more research on hazard education modes. FitzGerald et al. (2010: 185) states that, "...further research should identify the evidence behind intervention programmes so as to inform cost-benefit analysis of intervention strategies." Soffer et al. corroborates this statement, "no studies were found that evaluated the effectiveness of different education interventions on knowledge acquisition, awareness of preventative measures, or protective behavior,"

(Soffer et al., 2010: 206). Although research has been conducted on general natural hazard education and on some specific forms such as earthquakes, more research is needed to result in a general consensus. In addition, most natural hazard education research is not applicable to lightning. Lightning affects objects and humans differently than other hazards regarding geography. Lightning is an individual hazard, occurring at a point while earthquake, tsunami, and tornado hazards affect communities. This difference causes a discrepancy when applying previous research to lightning.

Lightning Education

Lightning education is an area of natural hazards research which has been greatly neglected. While research surrounding mortality databases, effects on the human body, and safety recommendations is present, nothing exists applying these findings to citizens in at-risk communities. This type of research has been suggested on several occasions. Some researchers advise that lightning education needs to focus upon recreation and not agriculture, given the shift in mortality patterns (Holle et al., 2005). Others suggest that lightning is a personal responsibility for those outdoors, because outdoor workers are not protected by lightning guidelines from the Occupational Safety and Health Administration (OSHA) (Adekoya and Nolte, 2005).

Lightning is a risk and some people do not take precautions to mitigate that risk. Previous research states that 42% of deaths from lightning are caused by a lack in lightning safety knowledge (Lengyel et al., 2005). This research suggests that people

take risks about lightning danger because lightning is viewed as an uncommon threat and rarely causes damage or casualties. Warnings from the NWS include lightning but do not specify lightning; therefore people do not recognize it as a threat (Ashley and Gilson, 2009). According to Ashley and Gilson (2009), people will always take risks and lightning casualties will occur, but may increase if education efforts do not take place. It is the purpose of this study to begin those education efforts by first evaluating current lightning safety knowledge, testing modes of education to determine which may be the most effective in relaying lightning safety knowledge, and gauging vulnerability for populations with different levels of lightning risk.

CHAPTER 3

Methodology

Overview

This study involved distributing a survey, exposing participants to an education mode, and re-administering the same survey to measure lightning safety knowledge learned. Participants first received the initial survey or pre-mode survey. Two weeks later, participants were exposed to an education mode regarding lightning safety. Finally, after an additional two weeks, participants received the final survey or post-mode survey. This interval was chosen to allow participants to return to normal practices and focus on other information, letting any safety information gained be considered part of a normal thought process.

The education modes used in this study were one of three forms: brochure format, video format, or both brochure and video formats. All education modes were obtained from the NWS for distribution with the purpose of education. A statement from the NWS with permission to use such materials can be found in Appendix C. The brochure can be found on the NWS website (National Weather Service, 2010c). The two videos chosen, both were shown to all participants in a video group or video and brochure group can be found on the NWS website (National Weather Service, 2010a; National Weather Service, 2010b). A portion of the participants did not receive an education

mode and represent the control group in this study. These modes were chosen based upon available modes of education (i.e. lecture, brochure, video, field trips, etc.) and previous studies using one, two, and a combination of modes (Bird and Dominey-Howes, 2008; Dengler, 2005; Shiwaku et al., 2007, Soffer et al., 2010). A summary of this study process can be found in Figure 4.

Figure 4 - Summary of Study Process

The questions in the surveys collected information regarding demographics and proper lightning safety knowledge. The questions directed toward lightning safety knowledge were based on lightning safety recommendations in two previous studies as well as the information covered in the education mode materials (Holle et al., 1999; Zimmermann et al., 2002). To avoid order and question wording issues, a test survey was distributed before the pre-mode survey took place. This survey was distributed to at least 20 participants, therefore meeting the qualifications for a test survey to be relevant (Bird and Dominey-Howes, 2008).

Study Areas

The study areas were chosen to represent geographic regions of high or moderate risk as well as areas of variable risk. Risk data along with past death rates supported the selection of Florida, Ohio, and Colorado as the three study areas. The state universities with geography programs selected for survey distribution included the University of South Florida in Tampa, Kent State University in Kent, University of Colorado at Boulder in Boulder, and Northern Colorado University in Greeley. The test survey was distributed at Kent State University in Kent during a physical geography class in the summer of 2010.

Demographics of Participants

Participants in this study were college students who were taking an introductory geography course. College students were selected because they guarantee that time was spent in high school and elementary school where lightning safety education programs may have occurred. Introductory geography courses were selected because it reduces bias in using a similar sample from each area. The majority of students in these classes were freshmen who recently completed high school. This approach was used due to an increased likelihood that a memory of a lightning safety education program during youth education would be present.

Several studies have discussed the benefits of educating younger children about natural hazards (Bird and Dominey-Howes, 2008; Johnston et al., 2005; Ronan and Johnston, 2001; Ronan et al., 2009; Shaw et al., 2004; Shiwaku et al., 2007; Soffer et al., 2010). College students who are of 18 years of age and older were chosen instead of children to remove the need for guardian consent forms. Several additional steps would be necessary to perform this study if participants were children. Due to a common lack of returned consent forms and likely increase in time, college students were chosen.

Consent

To allow for fair disclosure of the survey process as well as inform participants of their right to participate, not participate, and possible risks and benefits, a consent form was read by survey administrators prior to the distribution of the first survey. This

consent form was also offered to the participants for further review. The consent form can be found in Appendix B.

Data Collection

The data was collected from two surveys. Both surveys consisted of basic demographic questions, multiple choice questions regarding lightning safety, and a few open-ended lightning safety questions. Both pre-mode and post-mode surveys can be found in Appendix A. The variables included:

- University where the survey took place
- Whether the survey took place in a physical geography course
- Gender of participant
- Age of participant
- College level of participant (freshmen, sophomore, etc.)
- City and state where participant lived a majority of their life
- Where participant may have received lightning safety information in the past
- Three yes/no questions regarding lightning occurrence
- Identifying activities safe to participate in when lightning is present
- Identifying appropriate locations to seek shelter when lightning is present
- Administering CPR to a lightning victim
- Lightning deaths in the United States versus other natural hazards
- Two signs of lightning danger

- How many individuals in the United States are killed annually by lightning
- How many minutes before resuming outdoor activities when lightning has occurred
- How many miles ahead of a thunderstorm lightning can strike the ground

The post-mode survey had two additional questions to determine whether or not the participant was present for the first survey and education mode. The additional two variables were:

- Present for first survey
- Type of education mode

Sample

Table 2 summarizes the sample for this study which included a total of 12 geography courses from four different universities.

Table 2: Course Participation by Type of Course and University

School	Physical Geography	Introduction to Geography	World Geography	Human Geography	Geography of US & Canada
Kent State University	2	1	1	0	1
University of South Florida	1	0	1	1	0
University of Northern Colorado	0	0	3	0	0
University of Colorado	0	0	0	1	0

Scale

The scale for this research was at the state level. This scale was chosen because the data collection dictates that participants be represented by their university, however it is also necessary to this research that the location of the students previous schooling be known. Therefore, the survey requested a location that each participant recognized as a place where they spent a majority of their life, or what was termed home state. This home state variable allowed participant responses to be associated with the study areas at the state level.

Data Entry

All returned surveys were entered into a Microsoft Excel spreadsheet. The data was then converted into a SPSS spreadsheet for further analysis. If a participant skipped

a question or left it blank, the response was entered as “not available”. If a participant marked a question with “do not know”, “don’t know”, “?”, or “DK”, the response was entered as “do not know”.

All surveys eligible for analysis were entered. Surveys which were deemed ineligible were omitted. Surveys were omitted for several reasons (Table 3).

Table 3: Omitted Survey Responses

Cause for Removal	Number Removed
Did Not Adhere to Survey Protocol	42
Under the Age of 18	26
Did Not Specify City & State	14
Included Name	5
Did Not Specify Gender	1
Did Not Take the 1 st Survey & Did Experience a Mode	91
Total Surveys Removed	179

Participants who did not adhere to survey protocol would include individuals who did not take the survey seriously or who neglected to complete the back of the survey. Not specifying the city and state where they lived a majority of their life or their gender would eliminate that participant from analysis proceedings. Individuals who included their name were omitted because that violates the anonymity promised in the consent form. Finally, if an individual did not take the first survey and experienced a mode, their second survey response would not be eligible for use to measure knowledge gained from a mode.

There were a total of thirty-one individuals who did not receive a survey, did not receive a mode, and took the second survey. The data was entered initially in this form. It was decided that these participants, since they were not in a physical geography course, could be classified as individuals who were taking the survey for the first time. The data for these thirty-seven individuals was adjusted to reflect that decision.

There were a total of six individuals who did not receive the first survey, did not receive a mode of education, took the second survey, and were in a physical geography class. These individuals were removed from the sample because their presence in a physical geography class could create a bias in their second survey response different from those who were not in a physical geography.

Data Exclusion

Several questions and answer options were removed from the study following data collection for either lack of clarity or environmental restrictions. The first eliminated option pertains to the fourth question on the pre-mode survey regarding lightning safety which was *which of the following activities are safe to do when lightning is present*. Nine responses were supplied to the participant however; the last possible response *get the mail* was not analyzed because the safety of retrieving mail depends upon where the mail delivery box was located.

The second eliminated option pertains to the fifth question on the survey regarding lightning safety which was *where is it safe to take shelter from lightning*.

Seven responses were supplied to the participant however; the third possible response *baseball dugout* was not analyzed because seeking shelter in a baseball dugout is only appropriate if the structure has electrical wiring.

The third elimination from the analysis was the seventh question on the survey regarding lightning safety which was *lightning kills more people in the United States than which natural hazard*. Four responses were given, tornadoes, hurricanes, high winds, or all of these. The association commonly made between hurricanes and flooding could cause a bias in the answers throughout the sample. Flooding causes the most deaths in the United States per year causing the question to be irrelevant to the study.

Two additional questions were eliminated in the post-mode samples because they were not discussed in all three education modes. The first and third questions on the survey regarding lightning safety, *do all thunderstorms produce lightning* and *can lightning strike the same place twice*, were not discussed and therefore were not analyzed.

Data Application

The analysis concerning pre-mode lightning knowledge included the entire pre-mode sample. Vulnerabilities for each of the three test states used only the sample of students who identified their home state as that state. For example, to test vulnerability in Florida, students who recognized the state of Florida as their home state were included. Gender analysis for the pre-mode sample included the entire pre-mode sample.

The analysis concerning post-mode lightning safety knowledge focused on education modes and gender. The analysis regarding the best mode of education when instructing lightning safety information included the entire post-mode sample. The answers chosen by students prior to education modes were compared with answers chosen by students after an education mode. As a hypothesis, the student sample as a whole should become more knowledgeable about lightning safety following the education mode regardless of previous knowledge or the number of students who did not participate in the second survey. The control group who did not receive a mode tested this hypothesis. Gender analysis for the post-mode sample included the entire post-mode sample.

Four questions on the survey require an open-ended answer and those answers were coded as correct or incorrect. The question *list two signs of lightning danger* had several accepted correct responses which can be found in Table 4.

Table 4: Accepted Correct Responses for List Two Signs of Lightning Danger

Accepted Responses	Examples of Response
Lightning	Hearing Lightning, Seeing Lightning
Thunder	Hearing Thunder, Loud Thunder
Rain	Heavy Rain, Rain Storm
Clouds	Cloud the Sky
Ominous Sky	Dark Clouds, Bad Clouds, Storm Clouds
Atmospheric Change	Temperature Rise, High Winds, High Humidity
Warning	Storm Warning, Lightning Warning

The responses for *list two signs of lightning danger* were separated when analyzing responses because the rate of correct responses for the first listed sign versus the second listed sign may be different. The question *on average, how many people are killed by lightning in the United States every year* had an accepted correct response range of 55 – 75 people. The question *to avoid being struck, how many minutes should you wait after the last sound of thunder to resume outdoor activities* had an accepted correct response of 30 minutes. Finally, the question *how many miles ahead of a thunderstorm can lightning strike the ground* had an accepted correct response of 10 miles. While lightning can strike the ground up to 10 miles ahead of a storm, the question was directed toward the maximum number of miles or how far ahead of a storm an individual can be in danger. Therefore, the selected correct response is 10 miles.

Data Analysis

To answer some of the study questions, it was necessary to perform a chi-square test for significance. When a chi-square test for significance was performed, all responses designated as “do not know” or “not available” were changed to incorrect. If the result of the chi-square test had cells with an expected value of less than five, that number of cells was reported. Significance at $p < 0.10$ level was noted with bold type. Significance at $p < 0.05$ level was noted with bold type and underlined.

Disaster vulnerability has not been defined within the limits of risk and knowledge previous to this study. This study attempts to define vulnerability in this

manner. In order to define vulnerability, knowledge must be assigned a scale. This study considered correct response percentages of 75% or greater as high knowledge, correct response percentages of 50% - 74% as moderate knowledge, and correct response percentages less than 50% as low knowledge. This scale was used considering that if less than one in two people know proper lightning safety knowledge, minimal knowledge is available or shared. If one in two people know proper lightning safety knowledge, knowledge is likely to be available and shared. Finally, if three of four people know proper lightning safety, knowledge is very likely to be available and shared. It is important to note that this scale does not reflect acceptable or unacceptable knowledge. It is merely a simplistic measure of the responses to make them applicable in determining vulnerability by a matrix.

In order to define vulnerability, a scale must be assigned to vulnerability using knowledge and risk. This scale is summarized in Table 5.

Table 5: Vulnerability Using Knowledge and Risk Levels

Level of Knowledge	Level of Risk		
	Low Risk	Moderate Risk	High Risk
Low Knowledge	Moderate Vulnerability	High Vulnerability	Very High Vulnerability
Moderate Knowledge	Low Vulnerability	Moderate Vulnerability	High Vulnerability
High Knowledge	Very Low Vulnerability	Low Vulnerability	Moderate Vulnerability

CHAPTER 4

Analysis & Results

The total sample included 1,512 participants with 878 participants in the pre-mode sample and 634 participants in the post-mode sample.

Sample Demographics

The analysis and results for this study primarily compared two samples, one sample from the pre-mode survey and one sample from the post-mode survey. Therefore, all demographics were analyzed in two samples, pre-mode and post-mode.

Pre-Mode Demographics

A summary of the pre-mode demographics by each participating university can be found in Table 6.

Table 6: Pre-Mode Demographic Summary

University	Gender		Age				Total
	Female	Male	18	19	20	21+	
University of South Florida	60%	40%	44%	21%	14%	21%	114
Kent State University	47%	53%	26%	28%	19%	27%	247
University of Colorado	44%	56%	34%	27%	18%	21%	379
University of Northern Colorado	63%	37%	55%	22%	10%	13%	138
Total	438	440	320	227	147	184	878

The pre-mode demographics showed that overall pre-mode gender was 49.8% female and 50.1% male. The majority of students were 18 years of age followed by 19 years of age. This was the targeted age group.

The distribution of the pre-mode student sample by home state can be found in Table 7.

Table 7: Pre-Mode Distribution by All Home States

State	Students	State	Students	State	Students
Alabama	1	Louisiana	0	Ohio	212
Alaska	3	Maine	5	Oklahoma	0
Arizona	2	Maryland	18	Oregon	3
Arkansas	0	Massachusetts	11	Pennsylvania	28
California	75	Michigan	8	Rhode Island	2
Colorado	221	Minnesota	4	South Carolina	1
Connecticut	12	Mississippi	0	South Dakota	0
Delaware	0	Missouri	5	Tennessee	2
Florida	102	Montana	0	Texas	11
Georgia	5	Nebraska	0	Utah	1
Hawaii	6	Nevada	3	Vermont	5
Idaho	3	New Hampshire	3	Virginia	6
Illinois	25	New Jersey	21	Washington	7
Indiana	2	New Mexico	3	West Virginia	2
Iowa	3	New York	18	Wisconsin	4
Kansas	1	North Carolina	3	Wyoming	0
Kentucky	1	North Dakota	0	Other	30

All but 10 states within the United States were recognized as a home state in this pre-mode sample. Participants who spent a majority of their life outside the United States were assigned a home state of “Other”. The distribution of home states shows that 212 students identified Ohio as their home state, 221 identified Colorado as their home state, and 102 identified Florida as their home state. These participants were included in the analysis based on home state.

Post-Mode Demographics

A summary of the post-mode demographics by each participating university can be found in Table 8.

Table 8: Post-Mode Demographic Summary

University	Gender		Age				Total
	Female	Male	18	19	20	21+	
University of South Florida	54%	46%	38%	23%	16%	23%	74
Kent State University	51%	49%	29%	26%	21%	24%	156
University of Colorado	43%	57%	34%	26%	21%	19%	302
University of Northern Colorado	65%	35%	54%	23%	14%	9%	102
Total	314	320	232	158	120	124	634

The post-mode demographics showed that overall post-mode gender was 49.5% female and 50.5% male. The majority of students were 18 years of age followed by 19 years of age. This was the targeted age group.

The distribution of the post-mode student sample by mode including the control group can be found in Table 9.

Table 9: Post-Mode Distribution by Education Mode

University	Control	Brochure	Video	Brochure & Video	Total
University of South Florida	4%	24%	54%	18%	74
Kent State University	11%	35%	26%	28%	156
University of Colorado	27%	20%	27%	26%	302
University of Northern Colorado	10%	35%	28%	27%	102
Total	111	169	192	162	634

The post-mode distribution by education mode showed that 17.5% of participants were in the control group, 26.7% received the brochure mode, 30.3% received the video mode, and 25.6% received the brochure and video mode. This distribution was acceptable for performing education mode analysis.

The distribution of the post-mode student sample by gender and education mode, excluding the control group, can be found in Table 10.

Table 10: Post-Mode Distribution by Gender and Education Mode

Gender	Brochure	Video	Brochure & Video
Female	53%	52%	48%
Male	47%	48%	52%
Total	169	192	162

The post-mode distribution by gender showed that each education mode was near a 50/50 ratio of gender, similar to the gender distribution of the entire sample. This distribution was acceptable for performing pre-mode and post-mode gender analysis.

Analysis & Results

Lightning Safety Knowledge

All pre-mode survey responses regarding lightning safety knowledge, questions six through sixteen, were reviewed for percent of correct responses. The overall performance of the pre-mode sample was used to answer the following study questions.

- 1) Can current status of lightning safety knowledge be established for college students in the area of study?
- 2) Are particular areas of lightning safety misunderstood more than others?

A summary of pre-mode responses by percent of correct responses can be found in Table

11. Correct answers to questions six through eleven are noted so in teal.

Table 11: Overall Lightning Safety Knowledge

Pre-Mode Survey Question	Yes	No	Do Not Know	N/A
All Thunderstorms Produce Lightning	42%	57%	< 1%	< 1%
Hearing Thunder Means Being in Danger of Being Struck by Lightning	52	48	0	< 1
Can Lightning Strike the Same Place Twice	75	25	< 1	0
Safe to Use a Corded Telephone When Lightning is Present	21	79	0	0
Safe to Use a Cellular Phone When Lightning is Present	45	55	0	0
Safe to Use a Cordless Telephone When Lightning is Present	48	53	0	0
Safe to Shower When Lightning is Present	23	77	0	0
Safe to Take a Bath When Lightning is Present	21	79	0	0
Safe to Boat When Lightning is Present	2	98	0	0
Safe to Fish When Lightning is Present	1	99	0	0
Safe to Drive When Lightning is Present	58	42	0	0
Safe to Seek Shelter in a Car	63	37	0	0
Safe to Seek Shelter Under a Tree	4	96	0	0
Safe to Seek Shelter in a Picnic Shelter	28	72	0	0
Safe to Seek Shelter on a Deck	4	96	0	0
Safe to Seek Shelter on a Porch	11	89	0	0
Safe to Seek Shelter in a House	89	11	0	0
Safe to Seek Shelter by Laying Down in an Open Field	24	76	0	0
Safe to Administer CPR to Lightning Victim if Lightning Danger is No Longer Present	68	31	< 1	1
Open-Ended Survey Question	Correct	Incorrect	Do Not Know	N/A
Two Signs of Lightning Danger: First Response	75%	10%	3%	12%
Two Signs of Lightning Danger: Second Response	60	16	4	20
Number of People Killed by Lightning in the United States per Year	3	76	14	7
Minutes to Wait After the Last Sound of Thunder to Resume Outdoor Activities	36	55	4	5
Number of Miles Ahead of a Thunderstorm Lightning Can Strike the Ground	17	67	9	7

A current status of lightning safety knowledge was determined for college students with the data collected which discussed various facts regarding lightning safety, activities safe to partake in when lightning is present, safe shelters, and signs of lightning danger. These variables described the importance of knowledge for lightning safety. Using the level of knowledge scale, twelve of the twenty-four variables resulted in high knowledge. Six variables resulted in moderate knowledge and six variables resulted in low knowledge. While having a high rate of knowledge in the sample was positive, 50% of the twenty-four variables had moderate or low knowledge, which could be considered inadequate. The overall average percent of correct response rate for the entire sample was 66%, which means the sample had moderate knowledge.

There are several areas of lightning safety which were misunderstood. These will be reviewed in two sections; those results where responses were given and open-ended responses. General knowledge regarding lightning was misunderstood. Nearly half of responses were wrong for questions six and seven; *all thunderstorms produce lightning* and *hearing thunder means being in danger of being struck by lightning*. Some shelters and activities which are safe to seek or partake in were misunderstood. Using a cellular phone and using a cordless phone had correct response rates of less than 50%. These activities are safe to partake in and while the sample did not know the correct response, the responses showed more caution. While both of these variables showed more caution, it would be ideal for more participants to know that using a cordless or cellular phone when lightning is present is safe, because it allows individuals the possibility to call for help when lightning is present.

Areas of lightning safety knowledge which were misunderstood regarding open-ended responses were *number of people killed per year*, *minutes to wait after thunder to resume outdoor activities*, and *number of miles lightning can strike ahead of a storm*.

The number of people killed per year was drastically misunderstood with a 3% correct response rate. The incorrect responses showed no pattern related to the correct answer of 55 – 75 people. Clearly, the participants were not aware of how many people are killed per year by lightning in the United States and the incorrect responses did not show systematic values above or below the correct value.

The question regarding *minutes to wait after thunder to resume outdoor activities* had a low correct response rate of 36%. The responses can be found in Figure 5.

Correct Response: 30 Minutes

Figure 5 - Responses for Minutes to Wait After Hearing Thunder Before Resuming Outdoor Activities

The responses showed that there was an overall underestimation of minutes to wait before resuming outdoor activities when lightning is present. The correct response for this question was 30 minutes. A majority of participants answered with a lower number than 30 minutes meaning that they consider the danger to lessen more quickly and are likely putting themselves in danger by being outdoors too soon following the presence of lightning.

Finally, the question regarding *number of miles lightning can strike ahead of a storm* had a very low correct response rate of 17%. The responses can be found in Figure 6.

Figure 6 – Responses for Number of Miles Ahead of a Storm Lightning Can Strike the Ground

The responses showed that there was an overall underestimation of *number of miles lightning can strike ahead of a storm*. The correct response was 10 miles. A majority of

participants answered with a lower number than 10 minutes, meaning that they consider the danger before a storm to be less, when actually they are already in danger.

Lightning Safety Knowledge by Study Area

All pre-mode survey responses regarding lightning safety knowledge by study area were reviewed for percent of correct responses. This included questions six through sixteen and only participants who identified Florida, Ohio, or Colorado as their home state. The overall performance of the pre-mode sample by study area as well as p-values were used to determine the following study questions.

- 3) Do past death rates affect lightning safety knowledge for each area of study?
- 4) Can current levels of risk and lightning safety responses determine vulnerabilities for each area of study?

A summary of the study areas' pre-mode responses by percent of correct responses as well as significance can be found in Table 12. The p-value was a test of the assumption of no difference among the three states.

Table 12: Percent of Correct Responses & P-Values by State

Pre-Mode Survey Question	CO	FL	OH	Count < 5	P-value (df = 2)
All Thunderstorms Produce Lightning	40%	46%	39%	No	.472
Hearing Thunder Means Being in Danger of Being Struck by Lightning	53	70	46	No	.001
Lightning Cannot Strike the Same Place Twice	77	77	76	No	.991
Unsafe to Use a Corded Telephone When Lightning is Present	83	81	76	No	.233
Safe to Use a Cellular Phone When Lightning is Present	43	47	45	No	.771
Safe to Use a Cordless Telephone When Lightning is Present	47	51	45	No	.590
Unsafe to Shower When Lightning is Present	75	85	85	No	.016
Unsafe to Take a Bath When Lightning is Present	78	86	86	No	.069
Unsafe to Boat When Lightning is Present	99	97	98	Yes (3)	.598
Unsafe to Fish When Lightning is Present	99	99	99	Yes (3)	.581
Safe to Drive When Lightning is Present	65	46	58	No	.007
Safe to Seek Shelter in a Car	67	61	60	No	.230
Unsafe to Seek Shelter Under a Tree	97	97	97	Yes (1)	.978
Unsafe to Seek Shelter in a Picnic Shelter	74	79	64	No	.009
Unsafe to Seek Shelter on a Deck	96	100	94	Yes (1)	.042
Unsafe to Seek Shelter on a Porch	91	92	83	No	.020
Safe to Seek Shelter in a House	89	88	93	No	.332
Unsafe to Seek Shelter by Laying Down in an Open Field	70	82	80	No	.018
Safe to Administer CPR to Lightning Victim if Lightning Danger is No Longer Present	71	64	67	No	.368
Two Signs of Lightning Danger: First Response	76	79	74	No	.582
Two Signs of Lightning Danger: Second Response	62	71	61	No	.226
Number of People Killed by Lightning in the United States per Year	3	2	4	Yes (1)	.692
Minutes to Wait After the Last Sound of Thunder to Resume Outdoor Activities	32	35	41	No	.154
Number of Miles Ahead of a Thunderstorm Lightning Can Strike the Ground	20	11	21	No	.074

When analyzing past death rates and lightning safety knowledge, the level of knowledge may reflect past death rates in two ways. First, high death rates may cause a high level of knowledge due to increased education. Second, high death rates may cause low levels of knowledge due to lack of education. The first option would yield higher correct responses in Florida, then Colorado, and finally Ohio. The second option would yield higher correct responses in Ohio, then Colorado, and finally Florida.

Six variables when comparing the home states of Florida, Colorado, and Ohio had p -values < 0.05 and expected counts greater than five. These variables were associated with pre-mode questions *hearing thunder means being in danger of being struck by lightning, showering is not safe when lightning is present, driving is safe when lightning is present, taking shelter in a picnic shelter is not safe when lightning is present, and laying down in an open field is not safe when lightning is present*. These guidelines and variables were used for the following study question.

If responses about lightning safety correlate with past death rates for the three study areas, results which were deemed significant should follow the guidelines previously mentioned. Only three of the six variables deemed significant followed a guideline. All three of these variables supported the first guideline where high death rates cause high knowledge. Florida had the highest rate of knowledge, followed by Colorado, and then Ohio for *hearing thunder means being in danger of being struck by lightning, taking shelter in a picnic shelter is not safe, and taking shelter on a porch is not safe*. The other variables did not support the two guidelines and a connection was not

conclusive, therefore, past death rates do not affect lightning safety knowledge in these three areas of study.

Current levels of risk and lightning safety responses determined vulnerabilities for each area of study using risk and current lightning safety education levels. No relationship between the three study areas was shown in the previous analysis.

Therefore, to gauge vulnerabilities for each study area, all variables were included. The overall average percent of correct responses for each study area was used to determine the level of knowledge for that home state. When including all variables, Florida, Colorado, and Ohio had an overall average percent of correct response rates of 69%, 67%, and 66% respectively, indicating no overall difference in knowledge, therefore all three states were assigned a moderate level of knowledge. When coupled with risk and using the knowledge versus risk vulnerability assignments previously discussed, Florida could be assigned a high vulnerability and Ohio a moderate vulnerability. Colorado could be assigned a low to moderate vulnerability because they have a low to moderate risk however, majority of the population in the state of Colorado resides in a moderate risk area; therefore, Colorado should be assigned a moderate vulnerability.

Lightning Safety Education Programs by Study Area

All pre-mode survey responses regarding existence of lightning safety programs were reviewed by percent of responses as well as a test for differences among states. A p-value test was used to determine if there was a difference between the states in the

presence of lightning safety education programs. This included question five and only participants who identified Florida, Ohio, or Colorado as their home state. The overall responses of existing lightning safety programs by home state as well as significance were used to determine the following study questions.

- 5) Is relative risk related to the existence of K - 12 lightning education programs in each area of study?
- 6) Is relative risk related to the existence of non-school lightning education programs in each area of study?

A summary of pre-mode responses by percent can be found in Table 13.

Table 13: Percent Received of Lightning Safety Programs by Study Area & P-Values

Source of Lightning Safety Information	CO	FL	OH	Expected Count < 5	P-value (df = 2)
School	65%	67%	67%	No	.878
Community Activity	5	9	5	No	.345
YMCA	2	4	< 1	Yes (3)	.091
Girl Scouts/Boy Scouts	15	12	11	No	.346
Church Group	1	4	< 1	Yes (3)	.060
Radio	19	14	26	No	.026
Television	45	53	51	No	.260
Internet	18	33	25	No	.010
Never Received	20	17	16	No	.469

When analyzing risk and sources of education, the level of risk should dictate the rate of sources for lightning safety. The greater the risk, the more sources of lightning safety should be present. Florida should have the highest rate of knowledge received, followed

by Ohio, and Colorado. These guidelines were used to answer the following two study questions.

If relative risk was related to the existence of K – 12 lightning education programs, the results for school as a source of lightning safety information would be significant and follow the rate of knowledge received guidelines. The results for school as a source were not significant with a p-value of 0.878. Therefore, relative risk was not related to the existence of K – 12 lightning education programs in these three areas of study.

If relative risk was related to the existence of non-school lightning education programs, the results for non-school sources of lightning safety information would be significant and follow the rate of knowledge received guidelines. Two variables, radio and internet, were deemed significant with expected counts greater than five allowing these results to be admissible. Receiving lightning safety information via radio was most frequent in Ohio (26%), followed by Colorado (19%), then Florida (14%). Receiving lightning safety information via internet was most frequent in Florida (33%), followed by Ohio (25%), then Colorado (18%). Neither of these source results displayed the required order for rate of received as stated by the guidelines. Therefore, relative risk was not related to the existence of non-school lightning education programs in these three areas of study.

Lightning Safety Education Modes

To ensure the quality of the post-mode data, all responses from the pre-mode survey and the control group of the post-mode survey were compared to determine whether or not the entire sample was influenced throughout the study to increase their lightning safety knowledge. The p-values of the pre-mode sample versus the control group of the post-mode sample were used to determine if a variable could or could not be used in the remaining analysis of post-mode results. The p-value test was a test of no difference between the pre-mode and the post-mode control group samples. A summary of the pre-mode and post-mode control group responses by percent of correct response as well as significance can be found in Table 14.

Table 14: Pre-Mode vs. Control Group Percent of Correct Responses & P-Values

Survey Question	Pre-Mode	Control Group	Expected Count < 5	P-value (df = 1)
Hearing Thunder Means Being in Danger of Being Struck by Lightning	51%	58%	No	.220
Unsafe to Use a Corded Telephone When Lightning is Present	79	73	No	.169
Safe to Use a Cellular Phone When Lightning is Present	45	54	No	.061
Safe to Use a Cordless Telephone When Lightning is Present	47	53	No	.261
Unsafe to Shower When Lightning is Present	77	74	No	.464
Unsafe to Take a Bath When Lightning is Present	79	77	No	.662
Unsafe to Boat When Lightning is Present	98	100	Yes (1)	.100
Unsafe to Fish When Lightning is Present	99	97	Yes (1)	.223
Safe to Drive When Lightning is Present	58	59	No	.943
Safe to Seek Shelter in a Car	63	61	No	.671
Unsafe to Seek Shelter Under a Tree	96	94	Yes (1)	.253
Unsafe to Seek Shelter in a Picnic Shelter	72	62	No	.024
Unsafe to Seek Shelter on a Deck	96	95	Yes (1)	.604
Unsafe to Seek Shelter on a Porch	89	85	No	.198
Safe to Seek Shelter in a House	89	86	No	.487
Unsafe to Seek Shelter by Laying Down in an Open Field	76	84	No	.066
Safe to Administer CPR to Lightning Victim if Lightning Danger is No Longer Present	68	76	No	.104
Two Signs of Lightning Danger: First Response	75	80	No	.256
Two Signs of Lightning Danger: Second Response	60	69	No	.070
Number of People Killed by Lightning in the United States per Year	3	3	Yes (1)	.829
Minutes to Wait After the Last Sound of Thunder to Resume Outdoor Activities	36	37	No	.882
Number of Miles Ahead of a Thunderstorm Lightning Can Strike the Ground	17	13	No	.279

In order for a variable to be removed from all post-mode analysis, it must have a p-value < 0.10 , expected count greater than five, and an increase in percent of correct responses. Therefore, the following variables were not included in any post-mode analysis, *safe to use a cellular phone when lightning is present*, *unsafe to seek shelter by laying down in an open field*, and *two signs of lightning danger second response*. It is likely that the removal of these variables was due to the smaller sample size of the control group and not due to gaining lightning safety knowledge outside of the administered education modes. However, to maintain the integrity of this study, they were removed.

All responses from the pre-mode survey and post-mode survey were compared to determine whether or not the education modes had an effect on the overall lightning safety knowledge. The overall performance of the pre-mode sample versus the post-mode sample as well as a test of p-values were used to determine if further analysis was possible regarding individual modes of education. The p-value test was a test of no difference between the pre-mode and post-mode samples. The control group was not included in this test for significance. A summary of the pre-mode and post-mode responses by percent of correct response as well as significance can be found in Table 15.

Table 15: Pre-Mode vs. Post-Mode Percent of Correct Responses & P-Values

Survey Question	Pre-Mode	Post-Mode	Expected Count < 5	P-value (df = 1)
Hearing Thunder Means Being in Danger of Being Struck by Lightning	51%	84%	No	<u>< .001</u>
Unsafe to Use a Corded Telephone When Lightning is Present	79	88	No	<u>< .001</u>
Safe to Use a Cordless Telephone When Lightning is Present	47	48	No	.750
Unsafe to Shower When Lightning is Present	77	89	No	<u>< .001</u>
Unsafe to Take a Bath When Lightning is Present	79	90	No	<u>< .001</u>
Unsafe to Boat When Lightning is Present	98	99	No	.101
Unsafe to Fish When Lightning is Present	99	99	No	.613
Safe to Drive When Lightning is Present	58	55	No	.252
Safe to Seek Shelter in a Car	63	67	No	.151
Unsafe to Seek Shelter Under a Tree	96	97	No	.370
Unsafe to Seek Shelter in a Picnic Shelter	72	73	No	.747
Unsafe to Seek Shelter on a Deck	96	97	No	.166
Unsafe to Seek Shelter on a Porch	89	91	No	.196
Safe to Seek Shelter in a House	89	89	No	.743
Safe to Administer CPR to Lightning Victim if Lightning Danger is No Longer Present	68	73	No	.061
Two Signs of Lightning Danger: First Response	75	88	No	<u>< .001</u>
Number of People Killed by Lightning in the United States per Year	3	19	No	<u>< .001</u>
Minutes to Wait After the Last Sound of Thunder to Resume Outdoor Activities	36	49	No	<u>< .001</u>
Number of Miles Ahead of a Thunderstorm Lightning Can Strike the Ground	17	29	No	<u>< .001</u>

Eleven variables did not result in a statistically significant p-value of < 0.05 . Of those eleven, six began with high knowledge and therefore, had minimal opportunity for improvement. The remaining five variables without significance were all previously considered as the most misunderstood components of lightning safety knowledge except for *unsafe to seek shelter in a picnic shelter*.

All variables with a p-value < 0.05 showed an increase in percent of correct responses. The minimum increase was 9% and maximum increase was 33%. The overall average percent of correct responses for significant values in the pre-mode sample was 52%. The overall average percent of correct responses for significant values in the post-mode sample was 67%. Clearly, this increase was due to participant exposure to the education modes. Therefore, analysis of each education mode, brochure, video, brochure and video, was allowed to determine the best mode of education for lightning safety. Only variables which were deemed significant in this comparison were included in the education mode comparison.

All pre-mode survey responses and post-mode survey responses with significant increases were reviewed by education mode for percent of correct responses. This included questions *hearing thunder means being in danger of being struck by lightning*, *unsafe to use a corded telephone when lightning is present*, *unsafe to shower when lightning is present*, *unsafe to take a bath when lightning is present*, *two signs of lightning danger first response*, *number of people killed by lightning in the United States per year*, *minutes to wait after the last sound of thunder to resume outdoor activities*, and

number of miles ahead of a thunderstorm lightning can strike the ground. This included all participants in the pre-mode sample and only participants in the post-mode sample who were exposed to the particular education mode being analyzed. The overall performance of the pre-mode sample versus each education mode sample as well as p-values was used to determine the following study question.

7) Does the mode of education affect the efficacy of lightning safety knowledge? A summary of the pre-mode responses and post-mode responses by education mode as well as significance can be found in Table 16, Table 17, and Table 18. The p-value was a test of the assumption of no difference among the pre-mode sample and each education mode samples.

Table 16: Pre-Mode Sample vs. Brochure Post-Mode Sample & P-Values

Survey Question	Pre-Mode	Brochure	Expected Count < 5	P-value (df = 1)
Hearing Thunder Means Being in Danger of Being Struck by Lightning	51%	78%	No	<u>< .001</u>
Unsafe to Use a Corded Telephone When Lightning is Present	79	85	No	.054
Unsafe to Shower When Lightning is Present	77	88	No	<u>.002</u>
Unsafe to Take a Bath When Lightning is Present	79	89	No	<u>.002</u>
Two Signs of Lightning Danger: First Response	75	87	No	<u>.001</u>
Number of People Killed by Lightning in the United States per Year	3	9	No	<u>< .001</u>
Minutes to Wait After the Last Sound of Thunder to Resume Outdoor Activities	36	43	No	.116
Number of Miles Ahead of a Thunderstorm Lightning Can Strike the Ground	17	20	No	.271

Table 17: Pre-Mode Sample vs. Video Post-Mode Sample & P-Values

Survey Question	Pre-Mode	Video	Expected Count < 5	P-value (df = 1)
Hearing Thunder Means Being in Danger of Being Struck by Lightning	51%	85%	No	<u>< .001</u>
Unsafe to Use a Corded Telephone When Lightning is Present	79	89	No	<u>.001</u>
Unsafe to Shower When Lightning is Present	77	91	No	<u>< .001</u>
Unsafe to Take a Bath When Lightning is Present	79	91	No	<u>< .001</u>
Two Signs of Lightning Danger: First Response	75	88	No	<u>< .001</u>
Number of People Killed by Lightning in the United States per Year	3	21	No	<u>< .001</u>
Minutes to Wait After the Last Sound of Thunder to Resume Outdoor Activities	36	53	No	<u>< .001</u>
Number of Miles Ahead of a Thunderstorm Lightning Can Strike the Ground	17	32	No	<u>< .001</u>

Table 18: Pre-Mode Sample vs. Brochure & Video Post-Mode Sample & P-Values

Survey Question	Pre-Mode	Brochure & Video	Expected Count < 5	P-value (df = 1)
Hearing Thunder Means Being in Danger of Being Struck by Lightning	51%	90%	No	<u>< .001</u>
Unsafe to Use a Corded Telephone When Lightning is Present	79	88	No	<u>.005</u>
Unsafe to Shower When Lightning is Present	77	87	No	<u>.004</u>
Unsafe to Take a Bath When Lightning is Present	79	88	No	<u>.008</u>
Two Signs of Lightning Danger: First Response	75	88	No	<u>< .001</u>
Number of People Killed by Lightning in the United States per Year	3	25	No	<u>< .001</u>
Minutes to Wait After the Last Sound of Thunder to Resume Outdoor Activities	36	51	No	<u>< .001</u>
Number of Miles Ahead of a Thunderstorm Lightning Can Strike the Ground	17	33	No	<u>< .001</u>

To determine the best education mode, all results were reviewed for significance. These significant values determined the overall average percent of correct responses. The brochure group showed significant increase in knowledge for five of the eight variables. Both the video and brochure and video group showed significant increase in knowledge for all eight variables. If just reviewing the p-values, the video group would be the most effective education mode but this does not account for a greater change in percent of correct responses. Therefore, the overall performance of correct responses for these post-mode groups was reviewed. The average percent of correct responses for all eight variables in the brochure group was 52.13%. The average percent of correct

responses for all eight variables in the video group was 68.75%. The average percent of correct responses for all eight variables in the brochure and video group was 68.75%.

Both the video education mode and the brochure and video education mode were equally effective and better than brochure alone.

Gender and Lightning Safety Knowledge

All responses from the pre-mode survey and post-mode survey which were not removed by the control test were compared to determine whether or not gender had an effect on overall lightning safety knowledge and knowledge learned following the education modes. The overall performance of the pre-mode sample versus the post-mode sample for both genders as well as a test for significance was used to determine the following two study questions.

- 8) Does gender affect lightning safety knowledge prior to the exposure of education modes?
- 9) Does gender affect lightning safety knowledge after exposure to education modes?

A summary of the pre-mode and post-mode responses for each gender by percent of correct responses as well as significance can be found in Table 19 and Table 20.

Significant variables used for analysis are noted so in teal.

Table 19: Female Pre-Mode/Post-Mode Percent of Correct Responses & P-Values

Survey Question	Pre-Mode	Post-Mode	Expected Count < 5	P-value (df = 1)
Hearing Thunder Means Being in Danger of Being Struck by Lightning	54%	84%	No	<u>< .001</u>
Unsafe to Use a Corded Telephone When Lightning is Present	81	88	No	<u>.016</u>
Safe to Use a Cordless Telephone When Lightning is Present	44	48	No	.244
Unsafe to Shower When Lightning is Present	81	89	No	<u>.005</u>
Unsafe to Take a Bath When Lightning is Present	84	90	No	<u>.020</u>
Unsafe to Boat When Lightning is Present	99	99	Yes (2)	.597
Unsafe to Fish When Lightning is Present	99	99	Yes (2)	.597
Safe to Drive When Lightning is Present	54	52	No	.565
Safe to Seek Shelter in a Car	61	63	No	.673
Unsafe to Seek Shelter Under a Tree	96	97	No	.452
Unsafe to Seek Shelter in a Picnic Shelter	74	76	No	.560
Unsafe to Seek Shelter on a Deck	97	98	No	.127
Unsafe to Seek Shelter on a Porch	89	91	No	.466
Safe to Seek Shelter in a House	87	88	No	.597
Safe to Administer CPR to Lightning Victim if Lightning Danger is No Longer Present	63	71	No	<u>.026</u>
Two Signs of Lightning Danger: First Response	73	85	No	<u>< .001</u>
Number of People Killed by Lightning in the United States per Year	2	15	No	<u>< .001</u>
Minutes to Wait After the Last Sound of Thunder to Resume Outdoor Activities	37	52	No	<u>< .001</u>
Number of Miles Ahead of a Thunderstorm Lightning Can Strike the Ground	17	26	No	<u>.004</u>

Table 20: Male Pre-Mode/Post-Mode Percent of Correct Responses & P-Values

Survey Question	Pre-Mode	Post-Mode	Expected Count < 5	P-value (df = 1)
Hearing Thunder Means Being in Danger of Being Struck by Lightning	49%	84%	No	<u>< .001</u>
Unsafe to Use a Corded Telephone When Lightning is Present	77	88	No	<u>.001</u>
Safe to Use a Cordless Telephone When Lightning is Present	51	49	No	.487
Unsafe to Shower When Lightning is Present	73	88	No	<u>< .001</u>
Unsafe to Take a Bath When Lightning is Present	75	89	No	<u>< .001</u>
Unsafe to Boat When Lightning is Present	96	98	No	.126
Unsafe to Fish When Lightning is Present	98	98	Yes (1)	.798
Safe to Drive When Lightning is Present	62	58	No	.308
Safe to Seek Shelter in a Car	66	72	No	.094
Unsafe to Seek Shelter Under a Tree	96	97	No	.607
Unsafe to Seek Shelter in a Picnic Shelter	71	70	No	.893
Unsafe to Seek Shelter on a Deck	95	96	No	.575
Unsafe to Seek Shelter on a Porch	88	91	No	.275
Safe to Seek Shelter in a House	90	90	No	.937
Safe to Administer CPR to Lightning Victim if Lightning Danger is No Longer Present	73	74	No	.694
Two Signs of Lightning Danger: First Response	78	90	No	<u>< .001</u>
Number of People Killed by Lightning in the United States per Year	4	23	No	<u>< .001</u>
Minutes to Wait After the Last Sound of Thunder to Resume Outdoor Activities	35	46	No	.003
Number of Miles Ahead of a Thunderstorm Lightning Can Strike the Ground	16	31	No	<u>< .001</u>

The average percent of correct responses for all variables were used to compare knowledge levels for gender before the education modes. Females and males had a pre-mode average percent of correct responses of 68%. Therefore, gender did not affect the knowledge rate of the sample prior to the education modes.

To determine if gender affects the rate of learning following the education modes, only variables which were deemed significant with a p-value < 0.05 , expected counts greater than five, and were considered significant in both genders' pre-mode vs. post-mode comparisons were used. These variables included *hearing thunder means being in danger of being struck by lightning*, *unsafe to use a corded telephone when lightning is present*, *unsafe to shower when lightning is present*, *unsafe to take a bath when lightning is present*, *two signs of lightning danger first response*, *number of people killed by lightning in the United States per year*, *minutes to wait after the last sound of thunder to resume outdoor activities*, and *number of miles ahead of a thunderstorm lightning can strike the ground*. These variables are noted in teal in Tables 19 and 20.

The knowledge rate for females prior to education modes using only significant variables was 54%. The knowledge rate for males prior to education modes using only significant variables was 51%. These rates were expected to be lower than the overall average because some variables included in the overall average had higher knowledge allowing for less improvement by the education modes. The knowledge rate for females after exposure to the education modes using only significant variables was 66%. The knowledge rate for males after exposure to the education modes using only significant variables was 67%. The rate of knowledge increase for females was 12%. The rate of

knowledge increase for males was 16%. A summary of these results can be found in Table 21.

Table 21: Gender Knowledge Rate Analysis Using Only Significant Variables

Gender	Pre-Mode	Post-Mode	Difference
Female	54%	66%	+ 12%
Male	51	67	+ 16

Both genders had the same initial rate of knowledge prior to the education modes however; males gained more knowledge following the education modes than females when using variables of significance. The demographic gender distribution between the education modes, previously found in Table 10, showed minimal differences among genders so this increase from pre-mode to post-mode is accurate. The increase in knowledge from pre-mode to post-mode was greater in males by 4%.

CHAPTER 5

Discussion

Discussion

The overall percent of correct responses for the sample resulted in twelve of twenty-four variables with rates greater than 75%. Six variables had rates between 50% and 75%. Finally, six variables had rates below 50%. With half of the variables tested resulting in high knowledge, the sample did have significant knowledge regarding lightning safety. Two of the six variables with correct response rates between 50% and 75% were marked incorrect because participants did not think taking shelter in a car or driving were safe activities when lightning is present but they are safe, showing more caution from the sample. Therefore, only four of the six variables between 50% and 75% showed less than desirable knowledge that could result in lack of safety.

Of the variables with rates below 50%, which are unacceptable, two involved safe activities, two involved lightning safety before and after lightning is present, one was general knowledge about lightning, and one was a statistic on lightning deaths. All of these variables were areas of lightning safety which were the most misunderstood along with the variable *hearing thunder means being in danger of being struck*. The two safe activity variables actually showed participants being more cautious about using a cellular phone and cordless phone when lightning is present. The two lightning safety before and

after lightning is present and one general knowledge about lightning variables were more pertinent to understanding what is lacking in lightning safety education.

The variables *all thunderstorms produce lightning*, *hearing thunder means being in danger of being struck by lightning*, *minutes to wait after the last sound of thunder to resume outdoor activities*, and *number of miles ahead of a thunderstorm lightning can strike the ground* are the most pertinent and misunderstood areas of lightning safety in this study. *All thunderstorms produce lightning* is a variable focused on general lightning knowledge. A lack of knowledge in this area showed that participants do not understand the relationship between lightning and thunder. Not understanding this relationship could cause a person to underestimate their level of danger.

The remaining three pertinent and misunderstood variables of this study all involved safety before and after lightning is present. The variables *hearing thunder means being in danger of being struck by lightning*, *minutes to wait after a storm to resume outdoor activity*, and *number of miles lightning can strike ahead of a storm* need the greatest increase in education. *Hearing thunder means being in danger of being struck* is a rule an individual can use to prevent themselves from being in danger. Approximately 52% of the sample correctly identified this rule leaving 48% of the sample in need of education. This variable is a concern because part of past lightning safety education programs have involved when thunder roars, go indoors. Since half of the sample was not aware of this rule, it is possible that either education programs are lacking or the rule is not effective.

Minutes to wait after lightning to resume outdoor activities had a similar issue as the previous variable. However, this variable had a much lower rate of correct responses at 36%. What was more concerning than the low correct response rate was that most of the sample underestimated the time needed to wait before returning outdoors. The 30-30 rule which incorporates this variable has been used in past lightning safety education programs. Again, the very poor knowledge on this topic could mean either education programs are lacking or the rule is not effective. This needs to be rectified because individuals who are unaware of the 30-30 rule are likely putting themselves in danger when thinking it is perfectly safe.

The final most pertinent and misunderstood area of lightning safety was *number of miles ahead of a storm lightning can strike*. This variable had the lowest correct response rate of the misunderstood variables at only 17%. As with the previous variable, minutes to wait, participants underestimated the radius that lightning can strike ahead of a storm. While this information is not commonly communicated in lightning safety education programs, it may be beneficial to couple this rule of 10 miles with hearing thunder means being in danger. If both rules are taught in conjunction, it may cause individuals to better understand the range of danger related to the location of a storm. Without the 10 mile rule, individuals may think that a storm is too far to affect them. While a person cannot measure the distance they are from a storm, knowing that a 10 mile range exists may cause them to be more inclined to seek shelter when hearing thunder. As with the previous variable, those unaware of the ten mile radius may be more likely to put themselves in danger while thinking they are perfectly safe.

It was clear that past death rates did not affect responses about lightning safety in this study. Only three of the six variables deemed significant supported one of two hypotheses. While past death rates may have some input in how much knowledge is taught to individuals regarding lightning safety, the minimal number of deaths per population in the United States could overshadow risk and this theory. Therefore, more research is needed to reach a conclusion on this matter.

Even though past death rates did not have an effect on lightning safety knowledge in the three study areas, it was still possible to assign vulnerabilities to each state. The way in which vulnerabilities were assigned in this study is greatly simplified, but does begin the necessary work to assign vulnerabilities. Individuals may understand that they have a level of risk living within a state, but further relating this risk to citizens may help in getting residents to better understand their danger. Vulnerabilities may be able to aid in this form of awareness. Vulnerability was calculated using only risk and the level of knowledge seen during analysis, although other variables reaching beyond this study's limitations could aid in providing more accurate vulnerability assignments. With the data available, all three study areas had similar knowledge levels, 69%, 67%, and 66%, and were assigned a moderate level of knowledge. Coupled with their risk, Florida was assigned a high vulnerability, Colorado moderate vulnerability, and Ohio a moderate vulnerability. These assignments do reflect the level of risk more than the level of knowledge determined during this study. Further research is needed to specify more accurate vulnerability assignments; however the assignments made are a start in attempting to make the danger of lightning more relatable to citizens.

It was clear that current levels of risk in Florida, Colorado, and Ohio do not affect the presence of K – 12 lightning education programs or the presence of non-school lightning safety education programs. Only two of the nine variables were deemed significant and only one of these significant variables reflected the individual level of risk from each state. The presence of lightning safety education programs should be reflected in a state's level of risk. Florida should have higher presence of programs in schools and outside of schools than a state with lesser risk like Ohio. All three study areas have insufficient programs outside of schools. A rise in non-school programs needs to occur in all areas of study, especially Florida. Florida also needs to increase their rate of school programs. All of these increases in programs should occur at the state level, perhaps by creating a schedule where five minute videos are shown once a month pertaining to hazard safety, each month focusing on a different hazard. To be the most effective, this needs to occur yearly in grades K – 12.

The most effective education modes for lightning safety were the video and the brochure and video. Both of these modes had the same rate of knowledge for the admissible eight variables. The brochure alone was the least effective method. Since the rate of knowledge increase was the same for the video and the brochure and video modes, it may be possible to achieve the same result with just a video. Further research is needed regarding brochure education modes to determine if they are effective. If not, brochures may no longer be applicable in lightning safety education and possibly all natural hazard education. Currently, this method is used by several government institutes, the NWS, and many private industries. The printing and distributing of these materials may no

longer be needed, which could allow for funds to be used in other areas of natural hazard education. This analysis also calls for more education mode research in all areas of natural hazard education. This study included only three types of education modes. There are many more possible ways to educate. Therefore, more research is needed in the area of natural hazard education modes to determine which are the most effective.

Gender did not affect the initial rate of lightning safety knowledge prior to the education modes. Both males and females started the study with an overall correct response rate of 68%. It is possible that gender did affect lightning safety knowledge following exposure to education modes because males finished the study with a higher rate of knowledge than females when viewing only the significant variables. However, the difference between males and females was only 4%. This difference was minimal and does not constitute a conclusion that males learn at a greater rate than females. This research does begin to explore the role of gender and its possible effect in natural hazard education but the results are not conclusive and calls for further research in this area in the future.

Recommendations

- Increase in lightning safety education especially safety information prior to and following the presence of lightning
- Increase in presence of non-school lightning safety programs in all study areas

- Increase in presence of school lightning safety programs in all study areas especially Florida
- State governments need to require effective natural hazard education in K – 12 schools by scheduling short videos to be shown each month pertaining to a different natural hazard
- Further research the efficacy of all natural hazard education modes
- Further research the efficacy of brochures and pamphlets in lightning safety education
- Further research the role of gender following lightning safety education
- Further research the role of gender in natural hazard safety education

CHAPTER 6

Conclusion

Limitations

This study has five limitations. The introduction of the study given to the participants was done so by survey administrators. It is possible that this introduction varied from one sample to another. In order for this to have an effect on the outcome of this research, participants needed to be notified that there was an initial survey, education mode, and a post-mode survey. This may have caused participants to research lightning safety on their own time. It is unlikely that this took place because administrators were given scripts to read. Even if it did occur, the effect on the outcome would be minimal because the questions were designed specifically to test only the material covered in the education modes.

The second limitation was the quality of the video involved in the video education mode and the brochure and video education mode. The video used from the NWS was a slide presentation video with a voiceover. In today's technology standards, the resolution and format of the video was sub-standard. It is possible that the lack of quality in the video affected the rate of learning involving these two modes; however it is believed that these two modes, video and brochure and video, would remain as the most effective compared to the brochure education mode. However, if another video was used and this

study was replicated, there may be a different outcome between the video mode and the brochure and video mode. It is believed that with a higher standard of video, the video education mode would be the most effective. Further research is needed to corroborate this statement.

This study only tested three modes of education, brochure, video and brochure, and video. There are many other forms of educating about lightning safety including poster, lecture, simulation, memorial event, etc. Other education modes may be more effective than those tested however, the three modes chosen were with the intention that they would be the three most effective. Limiting the number of education modes, limits the application of these findings regarding best mode to educate regarding lightning safety. It is believed that if all possible modes were tested, including a higher standard of video, the video mode would be the most effective. Further research is needed to corroborate this statement.

This study only tested three modes of education regarding lightning safety. Natural hazards come in many forms including earthquake, tsunami, tornado, avalanche, etc. Lightning safety was chosen because no research has occurred in this field regarding education. Not testing the modes with other natural hazard safety information limits the application of these findings in general natural hazard safety education.

The final limitation was regarding the demographic chosen for this study. Majority of the participants were 18 and 19 years of age. This selection was made so participants would remember and experience any lightning safety program they may have received in a K – 12 school and to eliminate the need for parental consent. Testing young

adults and not school children limits the applications of these findings in all classrooms. It is possible that when testing school children, a different mode of education would be the most effective. However, it is believed that if school children were tested using these three modes, including a higher standard of video, the video education mode would remain the most effective. Further research is needed to corroborate this statement.

Conclusion

This research begins to evaluate an area of lightning safety and lightning safety education which has been neglected in past studies. The principal investigation surrounds current lightning safety knowledge in three areas with variable risk. This investigation includes misunderstood areas of lightning safety, presence of lightning safety programs, effect of different education modes, and the role of gender. The focus of this study was on college students in Florida, Colorado, and Ohio. Using comparative analysis including chi-square statistical testing, the samples from each area were analyzed for differences in general knowledge and lightning safety programs. Each pre-mode sample was then compared with the post-mode sample to investigate differences regarding education mode and gender.

Research regarding ways to educate involving natural hazards has seen minimal activity in the past. Education regarding lightning safety has been completely overlooked by the research community. This study is important because it begins to shed light on ways to educate about natural hazards, particularly lightning safety. Lightning is an

individual hazard in the sense that mitigation efforts require self-awareness of risk. Other forms of natural hazards tend to affect communities and not just individuals, placing some of the mitigation effort responsibilities at the hands of community leaders. If the best way to educate individuals about lightning safety is better understood or determined, that determination may be applicable at the community level as well as in overall natural hazard education.

The results of this thesis show that the level of lightning safety knowledge for college students in Florida, Colorado, and Ohio is not ideal nor does it represent the scientific community's understanding of lightning and the resources available to convey this information. There are several areas of lightning safety which are misunderstood and primarily involve the time before and after lightning is present. This is the information that needs to be included in lightning safety education programs or receive more emphasis in the future. The rate of past deaths and current levels of risk do not affect the rate of presence for lightning safety programs in schools and outside of schools in the study areas. Areas with higher levels of risk, such as Florida, should have a higher rate of lightning safety programs since the population in this region are at a greater risk. More programs need to be instituted in Florida to compensate for that high level of risk. When educating college students about lightning safety, it was found that a video method and a combination of video and brochure method were the most effective. Due to the use of a video with poor quality, it is expected that a video meeting today's technology standards would be more effective than the combination of brochure and video. Finally, gender did

not affect the initial rate of knowledge about lightning safety and minimally affected the rate of knowledge following the distribution of education modes.

Future research in this area needs to occur to better understand the relationship between natural hazards, natural hazard education, and citizens. Lightning safety is a small portion of the various kinds of natural hazards that effect citizens. While much of the information gained in this research may be transferable to other areas of natural hazard education, it is possible that each hazard has its own unique recipe for effective education methods. Further research is needed in the natural hazard community regarding the prevalence of natural hazard education programs, best modes for education, and the role of gender in obtaining and retaining safety information. More specifically, lightning safety requires further research to determine if video is the best method of education and if gender plays a more significant role in obtaining and retaining lightning safety information.

The scientific community as well as local government, state government, and non-government organizations have succeeded in instructing citizens on safe practices during thunderstorms. This is evident by the reduction in fatalities and injuries caused by lightning over the past century; however, there is still work to be done. Areas of lightning safety are misunderstood by citizens and need further emphasis. While education programs are in place, they are not enough. More programs need to be instituted but before that can occur, scientists and community leaders must be informed of the best method to educate. Not understanding the most effective mode of educating will waste time and resources for communities. Finally, if gender plays a larger role than

seen in this study, it may be necessary to direct those education programs towards a particular gender, based on their ability to receive and retain safety information. All of these steps are imperative to further increase citizen awareness of lightning risks, advance the availability of tools for safe and educated decision-making, and increase citizen awareness of the need for individual responsibility in mitigating lightning danger.

REFERENCES

- Adekoya, N., and K. B. Nolte, 2005: Struck-by-lightning Deaths in the United States. *Journal of Environmental Health*, 67: 45 – 50.
- Ashley, W. S., and C. W. Gilson, 2009: A Reassessment of U.S. Lightning Mortality. *Bulletin of the American Meteorological Society*, 90 (10): 1501 – 1518.
- Bartley, B., J. Fisher, and J. Stella, 2007: Video of a Disaster Drill is Effective n Educating Registrars on the Hospital Disaster Plan. *Emergency Medicine Australasia*, 19: 39 – 44.
- Bird, D., and D. Dominey-Howes, 2008: Testing the Use of a ‘Questionnaire Survey Instrument’ to Investigate Public Perceptions of Tsunami Hazard and Risk in Sydney, Australia. *Natural Hazards*, 45: 99 – 122.
- Cooray, V., C. Cooray, and C.J. Andrews, 2007: Lightning Caused Injuries in Humans. *Journal of Electrostatics*, 65: 386 – 394.
- Curran, E. B., R. L. Holle, and R. E. Lopez, 1997: Lightning Fatalities, Injuries, and Damage Reports in the United States from 1959 – 1994. NOAA Technical Memorandum NWS SR-193, 64pp. NOAA Scientific Services Division, Fort Worth, Texas.
- Curran, E. B., R. L. Holle, and R. E. Lopez, 2000: Lightning Casualties and Damages in the United States from 1959 to 1994. *Journal of Climate*, 13: 3448 – 3464.

- Dengler, L., 2005: The Role of Education in the National Tsunami Hazard Mitigation Program. *Natural Hazards*, 35: 141 – 153.
- Duclos, P.J., and L.M. Sanderson, 1990: An Epidemiological Description of Lightning-Related Deaths in the United States. *International Journal of Epidemiology*, 19: 673 – 679.
- Dunbar, P. K., 2007: Increasing Public Awareness of Natural Hazards via the Internet. *Natural Hazards*, 42: 529 – 536.
- Fieux, J. L., R. J. Sharp, C. H. Paxton, and J. A. States, 2005: Florida Lightning Deaths and Injuries 1998 – 2003 and Mitigation Strategies Using Lightning Data. Preprints, *Conference on Meteorological Applications of Lightning Data*, San Diego, CA, American Meteorological Society: 4.6.
- FitzGerald, G., W. Du, A. Jamal, M. Clark, and X. Hou, 2010: Flood Fatalities in Contemporary Australia (1997 – 2008). *Emergency Medicine Australasia*, 22: 180 – 186.
- Henry, A. J., 1900: Loss of Life in 1899 by Lightning. *Monthly Weather Review*, 28(3): 100.
- Holle, R. L., and R. E. Lopez, 2003: A Comparison of Current Lightning Death Rates in the U.S. with Other Locations and Times. Preprints, *International Conference on Lightning and Static Electricity*, September 16 – 18, Blackpool, England, Royal Aeronautical Society, paper 103-34 KMS, 7pp.

- Holle, R. L., R. E. Lopez, and B. C. Navarro, 2005: Deaths, Injuries, and Damages from Lightning in the United States in the 1890s in Comparison with the 1990s. *Journal of Applied Meteorology*, 44: 1563 – 1573.
- Holle, R. L., R. E. Lopez, and C. Zimmermann, 1999: Updated Recommendations for Lightning Safety – 1998. *Bulletin of American Meteorological Society*, 80: 2035 – 2041.
- Hyndman, D. and D. Hyndman, 2009: “Thunderstorms and Tornadoes,” in *Natural Hazards and Disasters*, ed. Boggs, M. and R. Heider. 2ed. Belmont, CA: Brooks/Cole.
- Johnston, D., D. Paton, G. L. Crawford, K. Ronan, B. Houghton, and P. Bürgelt, 2005: Measuring Tsunami Preparedness in Coastal Washington, United States. *Natural Hazards*, 35: 173 – 184.
- Lengyel, M. M., H. E. Brooks, R. L. Holle, and M. A. Cooper, 2005: Lightning Casualties and their Proximity to Surrounding Cloud-to-Ground Lightning. Preprints, 85th *American Meteorological Society Annual Meeting*. San Diego, CA, American Meteorological Society: P1.35.
- Lopez, R. E., and R. L. Holle, 1998: Changes in the Number of Lightning Deaths in the United States During the Twentieth Century. *Journal of Climate*, 11: 2070 – 2077.
- Lopez, R. E., R. L. Holle, T. A. Heitkamp, M. Boyson, M. Cherington, and K. Langford, 1993: The Underreporting of Lightning Injuries and Deaths in Colorado. *Bulletin of the American Meteorological Society*, 74: 2171 – 2178.

National Climatic Data Center, 2010: Storm Events. *Storm Data*. Accessed: July 10, 2010. Available:

<http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms>.

National Weather Service, 2010a: An Overview of Lightning and Lightning Safety. *Lightning Safety*. Accessed: August 10, 2010. Available:

<http://www.lightningsafety.noaa.gov/teachers.htm>.

National Weather Service, 2010b: Lightning Safety and Outdoor Activities. *Lightning Safety*. Accessed: August 10, 2010. Available:

<http://www.lightningsafety.noaa.gov/teachers.htm>

National Weather Service, 2010c: Lightning Safety for You and Your Family. *Lightning Safety*. Accessed: August 10, 2010. Available:

<http://www.lightningsafety.noaa.gov/more.htm>.

National Weather Service, 2010d: Lightning Statistics. *Lightning Safety*. Accessed: July 9, 2010. Available: <http://www.weather.gov/os/lightning/more.htm>

National Weather Service, 2010e: U.S. Lightning Map. *Lightning Safety*. Accessed: July 9, 2010. Available:

http://www.weather.gov/os/lightning/lightning_map.htm

Paton, D., 2003: Disaster Preparedness: A Social-Cognitive Perspective. *Disaster Prevention and Management*, 12 (3): 210 – 216.

Ronan, K. R., and D. M. Johnston, 2001: Correlates of Hazards Education Programs for Youths. *Risk Analysis*, 21: 1055 – 1063.

- Ronan, K. R., K. Crellin, and D. M. Johnston, 2009: Correlates of Hazards Education Programs for Youth: A Replication Study. *Natural Hazards*. Published online September 29, 2009. Available: <http://www.springerlink.com/content/v8v11524003720q7/>.
- Schütz, H., and P. M. Wiedemann, 2000: Hazardous Incident Information for the Public: Is It Useful? *The Australasian Journal of Disaster and Trauma Studies*, 200-1, ISSN: 1174 – 4707.
- Shaw, R., K. Shiwaku, H. Kobayashi and M. Kobayashi, 2004: Linking Experience, Education, Perception and Earthquake Preparedness. *Disaster Prevention and Management*, 13(1): 39 – 49.
- Shiwaku, K., R. Shaw, R. C. Kandel, S. N. Shrestha, and A. M. Dixit, 2007: Future Perspective of School Disaster Education in Nepal. *Disaster Prevention and Management*, 16(4): 576 – 587.
- Shiwaku, K. and R. Shaw, 2008: Proactive Co-Learning: A New Paradigm in Disaster Education. *Disaster Prevention and Management*, 17(2): 183 – 198.
- Soffer, Y., A. Goldberg, G. Avisar-Shohat, R. Cohen, and Y. Bar-Dayana, 2010: The Effect of Different Educational Interventions on Schoolchildren's Knowledge of Earthquake Protective Behavior in Israel. *Disasters*, 34 (1): 205 – 213.
- Tobin, G. A. and B. E. Montz, 1997: "Risk Assessment", in *Natural Hazards: Explanation and Integration*. New York, The Guilford Press.
- Zimmermann C., M. A. Cooper, and R. L. Holle, 2002: Lightning Safety Guidelines. *Annals of Emergency Medicine*, 39 (6): 660 – 664.

APPENDIX A

Pre-Mode Survey

For questions 1 – 4, please circle **ONE** answer or fill in the blank.

1. Gender: Female Male
2. Age: _____
3. College Level: Freshman Sophomore Junior
Senior
4. **City** and **state** where you have lived a majority of your life:
(International students please write the country)

For question 5, please circle **ALL** that apply.

5. In the past, where have you received lightning safety information?
School Community Activity YMCA
Girl Scouts/Boy Scouts Church Group Radio
Television Internet Never Received

For questions 6 - 8, please circle **ONE** answer.

6. Do all thunderstorms produce lightning?
Yes No
7. If you hear thunder, are you in danger of being struck by lightning?
Yes No

8. Can lightning strike the same place twice?

Yes

No

For question 9 - 10, please circle **ALL** that apply.

9. Which of the following activities are safe to do when lightning is present?

Use a Corded Telephone

Use a Cellular Phone

Use a Cordless Telephone

Shower

Take a Bath

Boating

Fishing

Drive

Get the Mail

10. Where is it safe to take shelter from lightning?

Car

Under a Tree

Baseball Dugout

Picnic Shelter

Deck

Porch

House

Lay Down in an Open Field

For questions 11 - 12, please circle **ONE** answer

11. If a person is struck by lightning, is it safe to administer CPR or medical treatment if there is no longer a lightning risk?

Yes

No

12. Lightning kills more people in the United States than which natural hazard?

Tornadoes

Hurricanes

High Winds

All of These

For questions 13 – 16, please fill in the blank.

13. List 2 signs of lightning danger.

14. On average, how many people are killed by lightning in the United States every year?
- _____
15. To avoid being struck, how many **minutes** should you wait after the last sound of thunder to resume outdoor activities?
- _____
16. How many **miles** ahead of a thunderstorm can lightning strike the ground?
- _____

Post-Mode Survey

For questions 1 – 6, please circle **ONE** answer or fill in the blank.

1. Did you take the first survey administered in class? Yes No
2. Which mode of education did you receive about lightning safety during class?
Brochure	Videos	Brochure	None
Only	Only	& Videos	
3. Gender: Female Male
4. Age: _____
5. College Level: Freshman Sophomore Junior Senior

6. **City** and **state** where you have lived a majority of your life:

(International students please write the country)

For question 7, please circle **ALL** that apply.

7. In the past, where have you received lightning safety information?

School	Community Activity	YMCA
Girl Scouts/Boy Scouts	Church Group	Radio
Television	Internet	Never Received

For questions 8 - 10, please circle **ONE** answer.

8. Do all thunderstorms produce lightning?

Yes No

9. If you hear thunder, are you in danger of being struck by lightning?

Yes No

10. Can lightning strike the same place twice?

Yes No

For question 11 - 12, please circle **ALL** that apply.

11. Which of the following activities are safe to do when lightning is present?

Use a Corded Telephone	Use a Cellular Phone	Use a Cordless Telephone
Shower	Take a Bath	Boating
Fishing	Drive	Get the Mail

12. Where is it safe to take shelter from lightning?

Car	Under a Tree	Baseball Dugout
Picnic Shelter	Deck	Porch
House	Lay Down in an Open Field	

For questions 13 - 14, please circle **ONE** answer

13. If a person is struck by lightning, is it safe to administer CPR or medical treatment if there is no longer a lightning risk?

Yes

No

14. Lightning kills more people in the United States than which natural hazard?

Tornadoes

Hurricanes

High Winds

All of These

For questions 15 – 18, please fill in the blank.

15. List 2 signs of lightning danger.

16. On average, how many people are killed by lightning in the United States every year?

17. To avoid being struck, how many **minutes** should you wait after the last sound of thunder to resume outdoor activities?

18. How many **miles** ahead of a thunderstorm can lightning strike the ground?

APPENDIX B

Consent Form

You have been invited to participate in a research study. Your participation is voluntary. Please listen carefully as I read this form. It is important that you ask questions and fully understand the research. A copy of this form is available for you to take with you if you wish.

The title of this research is called “the current status of lightning safety knowledge and programs and the effects of lightning education modes in Florida, Ohio, and Colorado”. The principal investigator is Melissa Phillips. The purpose of this study is to obtain an understanding of student knowledge about lightning safety in Florida, Ohio, and Colorado. Also, this study hopes to determine the best mode to teach students about lightning safety. This research is being done because none of these elements have been tested before regarding lightning safety.

This research has no known risks or discomforts involved. Identifying information will not be asked or collected so your participation in this research is anonymous and cannot be linked to you in the future. Taking part in this research is entirely up to you. You may choose not to participate or may discontinue your participation at any time without penalty. Whether or not you participate will not affect your grade in this course.

If you have any questions or concerns about this research, you may contact Melissa Phillips at 440.334.3703 or Dr. Thomas Schmidlin at 330.672.3227. This project has been approved by the Kent State University Institutional Review Board. If you have any questions about your rights as a research participant or complaints about the research, you may call the IRB at 330.672.2704.

APPENDIX C

Permission to Use NWS Materials

Information on government servers are in the public domain, unless specifically annotated otherwise, and **may be used freely by the public**. Some NWS information changes rapidly in response to weather and climate events, so special attention should be given to the date and time of the data and products displayed.

In addition, NWS information may NOT be edited and then presented as official government material. NWS is providing this data “as is,” and the user assumes any risk related to using this data. NWS is not liable to you or anyone else due to your use of this data.

Finally, as required by 17 U.S.C. 403, if your page consists mostly of material appearing in NWS web pages, you must provide notice that it is NWS material incorporated and not subject to copyright protection.

NOAA, National Weather Service

Office of Climate, Water, and Weather Services

1325 East West Highway

Silver Spring, MD 20910

Last Updated: June 20, 2003

<http://www.weather.gov/om/reprint.shtml>