Studying Levels and Perceptions of Severe Weather Preparedness in University of Tennessee, Knoxville, Students

Anna E. Franklin[1]

Faculty Advisors: Drs. Matthew T. Kerr[2] and Kelsey N. Ellis[2]

[1]School of Communication Studies

[2]Department of Geography

University of Tennessee, Knoxville

Abstract

The University of Tennessee, Knoxville, faces several challenges when preparing for severe weather, including a high-risk location for straight-line winds, flooding, and tornadoes; a vulnerable population; and a lack of official preparedness education. Such a population of roughly 30,000 people concentrated in an area of only 910 acres increases the risk for a high-injury, high-casualty situation, should campus suffer a direct strike from a severe weather event. However, proper preparedness could lessen that risk. In most emergency situations, faculty and staff would be responsible for ensuring students' safety, but during vulnerable periods, such as between classes, students would need to rely on their own knowledge to respond to the event properly. Despite these vulnerabilities, few research studies have attempted to gauge preparedness levels in college students. Our study begins to fill that gap. We surveyed 62 University of Tennessee, Knoxville, students to investigate levels and perceptions of severe weather preparedness. Our data indicate that many students know basic concepts, but do not understand more nuanced actions, and thus engage in behaviors that could increase their risk of injury or death. However, some students do not know even basic concepts, such as 21% not knowing the difference between a severe weather watch and a warning. Our findings indicate that the University of Tennessee, Knoxville, should consider requiring official preparedness education that addresses these vulnerabilities. Future research should further define and address gaps in preparedness education to inform university preparedness efforts, and to provide students with the knowledge necessary to protect themselves and others in a severe weather emergency.

Keywords: college preparedness, crisis communication, severe weather preparedness, tornado, thunderstorm, emergency plan.

Studying Levels and Perceptions of Severe Weather Preparedness in UTK Students

Tornadoes kill more people in the southeastern United States annually than in "Tornado Alley," which is the colloquial name given to the tornado-prone region in the midwestern US (Gray & Miller, 2016). Several climatological and geographical factors contribute to higher fatality rates in the Southeast, including more nocturnal and cold-season tornadoes, mountainous terrain obstructing line of sight, and fewer residents having access to storm shelters or basements (Gray & Miller, 2016). Therefore, ideal preparedness efforts in these locations would be two-fold, accounting for both the phenomena itself and the unique location-related vulnerabilities that enhance the phenomena's impacts. College campuses, particularly those in the Southeast such as the University of Tennessee, Knoxville, comprise specialized populations with additional vulnerabilities. College campuses have small footprints, which minimizes the probability of a direct strike from severe weather, but if such a strike did occur, high population density would increase the risk of a serious, high-injury or high-casualty situation (Myer, James, & Moulton, 2011; Donner & Rodríguez, 2008). Therefore, to minimize the risk of disaster impacts on southeastern campuses, colleges must train students to respond properly to location-specific phenomena, such as tornadoes and severe thunderstorms, and equip students to protect themselves from additional geographic risk factors.

Climatological and Geographical Risk Factors

Colleges in the Southeast, like the University of Tennessee, Knoxville, must account for nocturnal tornadoes in their preparedness planning. Nocturnal tornadoes are over twice as deadly as daytime tornadoes and Tennessee has the highest nocturnal tornado rate in the nation, accounting for 46% of tornadoes in the state (Ashley, Krmenec, & Schwantes, 2008).

Additionally, from 2006–2016, Tennessee had 100 tornado fatalities, the highest 10-year tornado fatality rate in the US (National Weather Service, 2021), in no small part due to the prevalence of nighttime tornadoes. To account for the additional risk from nighttime tornadoes, students on southeastern campuses must be educated and well-equipped to receive and respond to nighttime warnings, and to use confirmation sources other than tornado sirens or waiting to see the tornado.

Given the risk of nocturnal tornadoes, southeastern colleges should provide reliable alert sources that will awaken students. Visually confirming approaching tornadoes at night is difficult, if not impossible, so students must understand that they cannot wait to seek shelter until they see a tornado. Additionally, research has indicated that nearly half of Tennessee residents may rely on tornado sirens as an alert source (Ellis et al., 2020), yet the City of Knoxville does not have a tornado siren system (WBIR, 2020). The University of Tennessee, Knoxville, must inform students that tornado sirens are not designed to be heard while indoors, much less asleep, and that a siren system does not exist in Knoxville, so that students are aware they cannot rely on sirens for sheltering decisions, particularly at night.

Even mobile alerts may not be a reliable method. If students sleep with their cellular phones silenced or with “do not disturb” mode enabled, they may not hear the alerts and be sleeping when a tornado strikes. Students housed in dormitories may have a better chance of being awakened, particularly if each hall has the capability to broadcast a campus alert system. Still, the alerting system might fail, which is a significant factor that makes colleges more vulnerable to disasters (Myers, James, & Moulton, 2011, Sheldon, 2018), as illustrated in March 2020 when an EF-3 tornado swept Nashville, TN, and hampered communications for hundreds of miles eastward (Ellis et al., 2020). The University of Tennessee’s “Blue Light” phones and the

"UT Alert" system both failed, which are essential means of communicating emergency information to students (University of Tennessee, Knoxville, 2021). The tornado that struck Nashville killed 24 people, ranking as one of the top 10 deadliest tornadoes in Tennessee history (National Weather Service Nashville, 2020). The same storm that impacted Nashville also swept through Knoxville. At 4:35 AM local time, radar-indicated rotation prompted a tornado warning for Knox County, but very few students were informed since the mobile UT alerts failed (WBIR; Iowa Environmental Mesonet, 2021). Fortunately, the storm did not produce a tornado in Knoxville, but the situation did illustrate vulnerabilities in the campus mobile alerting system and the need for a more reliable alerting method, such as a National Oceanic and Atmospheric Association (NOAA) weather radio (Center for Disease Control and Prevention; National Weather Service, 2021) If the storm had produced a tornado in Knoxville, thousands of students would have been asleep when it struck. To prevent a similar situation, campus preparedness planners should ensure that students have reliable alert sources that will awaken them.

Along with nocturnal tornadoes, southeastern colleges must also consider the increase of cold-season tornadoes in their preparedness efforts. Tornadoes are now occurring more often during autumn and winter seasons in the Southeast (Moore & DeBoer, 2019; Agee et al., 2016; Moore, 2018), when students are more likely to be on campus. Therefore, campuses in the Southeast region should ensure that students understand the tornado risk in both cold and hot seasons and maintain preparedness behaviors year-round so that they are not caught unprepared by a cold-season outbreak.

Finally, the most significant geographical factor that southeastern colleges must account for in preparedness efforts is an overall shift in tornado risk from Tornado Alley in the central

US to "Dixie Alley," a region in the Southeast that includes Alabama, Mississippi, Arkansas, and Tennessee (Coleman & Dixon, 2014). Tornadoes are trending significantly eastward over time. From 2000–2017, 45% of EF1+ tornadoes occurred in the Southeast, with only 20% occurring in the Great Plains (Moore & DeBoer, 2019), and Central Tennessee has seen the greatest increase in spring tornadoes (Agee et al. 2016). More tornadoes are occurring in regions that were once less threatened, yet preparedness levels may not have increased to meet those higher frequencies. Since a community's preparedness level tends to align with risk assessments of a hazard (Raphael, 1986), administrations and students that do not recognize the risk of tornadoes in the Southeast will likely have lower preparedness levels and be most vulnerable. Colleges must inform students of the risk in the Southeast so they can begin preparing before a tornado occurs. In an emergency, a few simple preparedness behaviors could mean the difference between life and death.

Factors that Enhance College Vulnerability to Disasters

Once colleges in the Southeast have accounted for an increased risk of severe weather, particularly cold-season and nocturnal tornadoes, they may begin refining their preparedness plans to compensate for institution-specific vulnerabilities. A high-quality plan will be well-designed and well-practiced, will account for possible failures in critical components, and will assess the impacts of a potential disaster on campus. Additionally, it will include education to help students understand the plan, so the moment an alert is issued, they will know the proper actions to take.

Only a high-quality preparedness plan can effectively protect students from severe weather on campus, yet the mere presence of a plan does not ensure that students will remain

safe (Robelen, 2007). A poorly-designed or unpracticed plan may collapse when an emergency reveals weak points (Myer, James, & Moulton, 2011). For colleges, institutional weaknesses include hampered authority structures, such as alert system failures or being unable to contact key personnel (Myer, James, & Moulton, 2011; Sheldon, 2018). Additionally, if a disaster were to occur during vulnerable periods, such as between classes, students would need to rely on their own knowledge to protect themselves and others. In the case of a tornado, students would have an average of only 7–15 minutes from the moment of receiving the alert until the tornado struck (Simmons & Sutter, 2008), which is very limited time to seek shelter if they do not know proper responses or the meaning of a tornado warning. The accumulation of rapid, well-informed decisions across a student population could mean the difference between minimal or substantial death tolls. Since the University of Tennessee, Knoxville, cannot plan for an emergency to happen only while students are under faculty and staff supervision, preparedness education should provide students with both the necessary knowledge and the opportunities to practice correct responses until the concepts are second nature so they can make proper decisions in a severe weather emergency.

As part of preparedness planning, Southeastern colleges must assess the possible impacts of a tornado on campus. While the probability of a devastating tornado striking a college town is low, the situation is not impossible. On April 27, 2011, a historic EF-4 tornado impacted Tuscaloosa, Alabama, including the outskirts of the University of Alabama. The tornado killed 65 people, including 6 University of Alabama students whose residences received heavy damage (Kellogg, 2011). Yet, if relatively weaker tornadoes (EF-1 and EF-2) strike a vulnerable community, the impacts may be as significant as those of a stronger storm (Stimers, 2012). College administrations should work to minimize the factors that make their campus more

vulnerable. For example, if a college determines that population size or density increases its risk, preparedness planners may consider emphasizing protocols for large group gatherings, such as sporting events, large classes, or student events on campus. If preparedness coordinators determine that certain buildings are poorly constructed and, therefore, are unsafe shelters, a plan may emphasize more ideal sheltering locations in stronger buildings on campus. By assessing campus-specific vulnerabilities, preparedness coordinators can provide customized information, increasing the likelihood that students will respond appropriately and lessen the risk to human life (Myer, James, & Moulton, 2011).

Experience has demonstrated the value of quality preparedness education as well as the consequences of poor education. In 2008, a tornado struck Union University in western Tennessee, but caused no fatalities. The university's focus on preparedness enabled students in the dorms to react properly and experts credited the rapid response with saving lives (Tornado rips through Tenn. campus, 2008). However, if students do not understand the plan, the confusion may cost lives. A tornado killed eight teenagers at a high school in Enterprise, Alabama, because the administration had never conducted a tornado drill. The school had created a preparedness plan but had never practiced it. In the confusion, students did not know how to react, and experts blamed the fatalities on poor preparedness education at the school (Robelen, 2007). Therefore, to minimize the risk of fatal tornado events, colleges in the Southeast should develop customized preparedness plans and test them regularly, to ensure students understand the plan and have practiced it thoroughly.

Study Rationale

Research has indicated that most students accurately understand the risk of weaker tornadoes for their area. However, students who reside in high-risk areas such as Tuscaloosa, Alabama, perceive their risk of strong tornadoes to be higher than actual rates, perhaps because of extensive television coverage of tornado events (Senkbeil et al., 2019). Since knowledge of risk boosts preparedness in a community (Raphael, 1986) and individual risk perception strongly correlates to preparedness levels (McNeill et al, 2018), students who accurately perceive their risk for severe weather are more likely to be adequately prepared. When studying actual levels of preparedness in southeastern colleges, research has shown that faculty and staff are generally more aware of severe weather threats than students, and both populations score relatively high for knowledge in basic preparedness terminology (Morris, 2009). In a study conducted at the University of Mississippi after a near-miss from a tornado, respondents indicated the least confusion about the term “shelter in place,” with the most confusion about the term “tornado watch” (Morris, 2009), indicating a need for education about alert terminology. Additionally, most faculty understand proper preparedness actions and generally rank higher than students in this knowledge (Morris, 2009). However, if a severe weather event occurred when minimal faculty or staff were present, such as during a class change, students would need to rely on their own preparedness knowledge to protect themselves and others.

Since college administrations are most prepared for disasters the campus has already experienced (Myer, James, & Moulton, 2011), coordinators may have difficulty assessing student preparedness for a disaster that has not yet occurred on campus. One indication of preparedness may be if students have accurately assessed the risk for their area (Senkbeil et al.,

2019). Since preparedness education increases preparedness in working adults (McNeill et al., 2018) and has saved lives in past tornado events (Tkachuck et al, 2018 & Tornado rips through Tenn. campus, 2008), another indication of preparedness levels may be the education that students have received from their college about proper responses to severe weather. More research is needed to understand how risk perception and education have influenced preparedness levels in college students.

The purpose of our study is to contribute to generalizable knowledge about severe weather planning by studying both perceived and actual levels of severe weather preparedness in students at the University of Tennessee, Knoxville, and to understand whether the University's current preparedness education is effective and sufficient. We also work to understand the most-needed aspects of preparedness education in college students, as well as attitudes toward, and perceptions of, severe weather preparedness. Our research questions include:

1. What are the current preparedness levels of University of Tennessee, Knoxville, students, based on knowledge and willingness to engage in proper preparedness actions?
2. How do perceptions of preparedness of University of Tennessee, Knoxville, students align with their actual levels of preparedness?
3. In what aspects are University of Tennessee, Knoxville, students least prepared for severe weather?
4. How has preparedness education from the University of Tennessee, Knoxville, affected students' actual and perceived preparedness levels?

Methods

Sample

Our study consisted of a convenience sample of 62 currently enrolled students ages 18+ at the University of Tennessee, Knoxville. We recruited participants from classes by email. To broaden our reach, we distributed our recruitment email to faculty and instructors, who then redistributed the email and survey link to their students. The email included a message introducing the study, explaining the purpose and objectives, and requesting participation by clicking on an included link (Appendix A). If a student chose to participate, they first read the study information page and an informed consent notice. Clicking to the next page indicated their assent that they were 18 years of age or older, a currently enrolled student at the University of Tennessee, Knoxville, and that they consented to participating in the study. The IRB approval number for this study is UTK IRB-20-05710-XM.

Instrument

We created a 17-item survey with perception-based, knowledge-based, and behavior-based questions, using the secure survey software QuestionPro (Appendix B). Eight questions were on a Likert-Type scale, with answers including “not confident,” “unsure,” “somewhat confident,” and “highly confident.” Five questions had yes/no answers. Two questions asked for respondents to check all applicable options. One question was knowledge-based. One question asked respondents to select the option that corresponds to their behavior. On all questions, options were included for “not sure” and “no answer” responses.

To protect respondent privacy, our survey was designed to be anonymous. Responses did not collect direct or indirect identifiers, such as names, demographics, class standing, or IP addresses. QuestionPro encrypted our data in transit, at rest, and in backups. Only the Co-PIs had access to the QuestionPro account for the survey and resulting data. Additionally, data and analysis files were stored on the Co-PIs' password-protected laptop computers and backup copies were stored in a Dropbox folder shared between the Co-PIs.

Analysis

Once we received 62 responses, we analyzed the data for trends by percentage of response for each option. Then, we drew conclusions based on perception-based and knowledge-based survey questions to determine how perceived levels of preparedness match actual levels of preparedness. Additionally, we analyzed the knowledge-based questions to determine which areas of preparedness education had the most common knowledge or behavior gaps. Lastly, we analyzed the perception-based questions to determine how students judge their abilities to protect themselves and others in different types of severe weather.

Limitations

Our small sample size may not represent the entire University of Tennessee, Knoxville, student population. Our data collection occurred at the beginning of the COVID-19 pandemic, which may have lowered the number of responses received. Future studies with larger sample sizes may be needed to confirm our results.

Additionally, the closed-response nature of our survey constrained participant choice to pre-determined options, which may have limited our knowledge of the nuances of real-world

preparedness levels. Future work should include qualitative methods, such as interviews and focus groups, or at the very least, open text boxes to allow students to elaborate on their chosen preparedness methods in their own words.

Further, student demographics, specifically related to field of study, may have skewed the results to show higher preparedness levels than a more diverse sample would have otherwise. We distributed the link to many students in Geography classes, which include coursework on basic preparedness concepts. Thus, preexisting knowledge, while possibly helpful for the argument that education boosts preparedness, may have skewed the baseline of what we considered average student preparedness levels. Future work should ensure responses from a more diverse sample.

Results

Perceptions

Our results indicate that students have more confidence in their ability to protect themselves in a severe thunderstorm (85% report highly or somewhat confident) than in a tornado (52% report highly or somewhat confident). For protecting themselves in a severe thunderstorm, 15% of respondents were unsure or not confident in their abilities, while 48% were uncertain or not confident in their abilities for protecting themselves in a tornado (Figs. 1 and 2). When asked to report current feelings of preparedness for severe weather, 20% felt highly prepared, 60% felt somewhat prepared, and 20% felt uncertain or poorly prepared. Only 23% felt more prepared because of training they received from the University, while the majority (65%) either did not feel more prepared or were uncertain (11%).

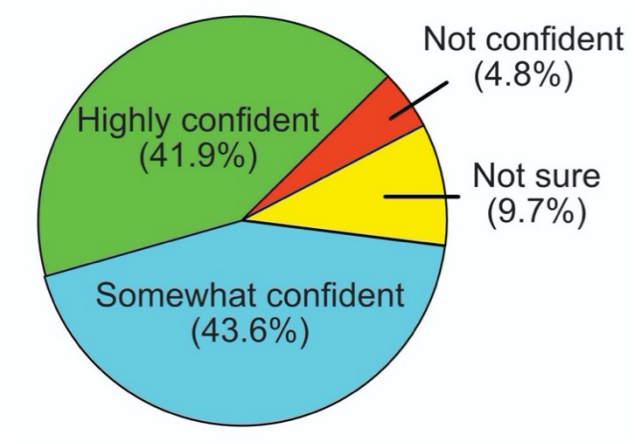

Figure 1. Student Confidence in Protecting Oneself in a Severe Thunderstorm.

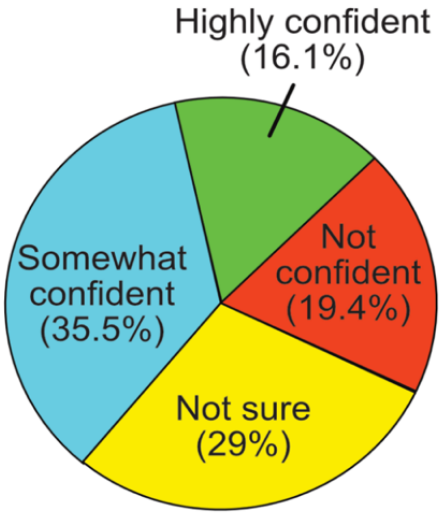

Figure 2. Student Confidence in Protecting Oneself in a Tornado.

When asked about confidence in knowing where to shelter in different locations, students reported less confidence in knowing where to shelter in their home/dorm (66% highly or somewhat confident) compared to in class (69% highly or somewhat confident) or outdoors on campus (68% highly or somewhat confident). When asked about confidence in knowing the difference between a severe weather watch and a warning, 63% were highly confident, 16% were somewhat confident, 11% were not sure, and 10% were not confident.

Knowledge

Most students know the difference between a watch and a warning, but 21% do not (Fig. 3). Interestingly, 79% of respondents were highly or somewhat confident they knew the difference and 79% chose the correct answer (Figs. 3 and 4). Since our data did not log individual responses, we were unable to determine if the same individuals who were confident in knowing the difference selected the correct answer.

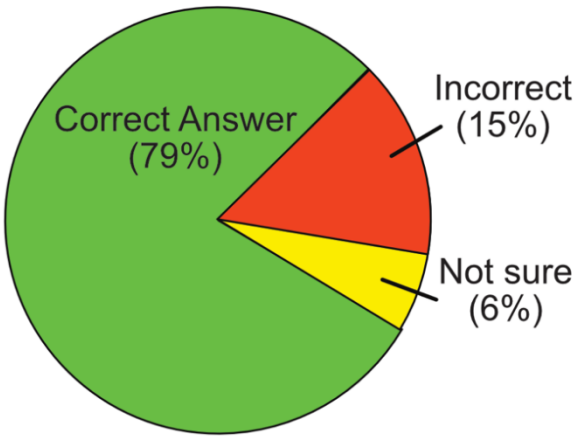

Figure 3. Student Answers on the Difference Between a Watch and Warning.

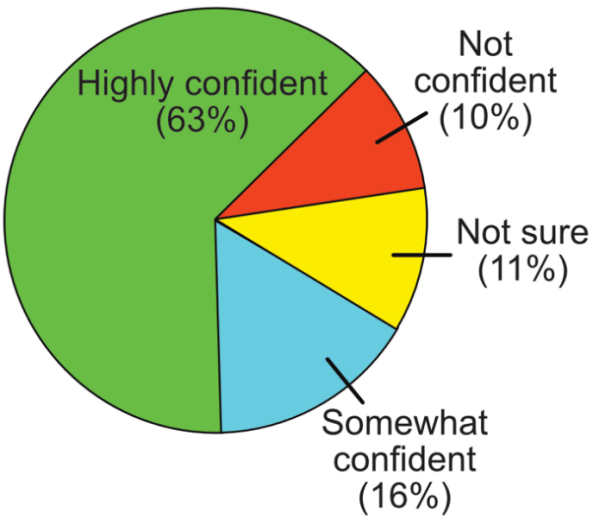

Figure 4. Student Confidence in Knowing the Difference Between a Watch and Warning.

When asked about frequency of checking weather forecasts, 60% of students reported checking forecasts daily, 31% reported checking several times a week, 5% reported checking once a week, and 5% reported checking even less often (several times or once a month). The top three sources of weather information for students were apps (28%), friends or family (16%), and television (15%). The next most frequent sources were government websites (11%), social media (10%), tornado sirens (8.6%), and radio (8.1%), with 2% using other sources, including looking outside, websites like weather.com, Amazon's Alexa, and weather radar. Additionally, 83% of respondents reported receiving no formal preparedness training from the University, but 63% of students had completed courses that included preparedness components.

Behavior

When asked about the number of sources they typically use to confirm the validity of a weather alert before sheltering, 8% of respondents reported using zero confirmation sources and

sheltering immediately, 52% reported using 1–2 sources, and 26% reported using 3–6 confirmation sources, while 15% reported typically not sheltering at all (Fig. 5).

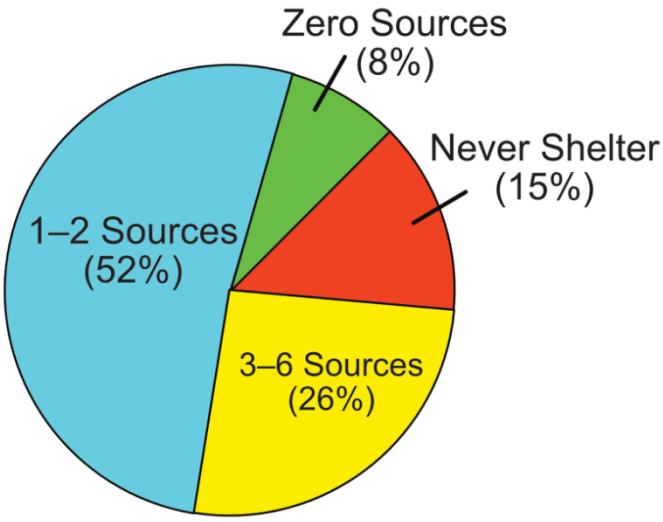

Figure 5. Number of Confirmation Sources Sought Before Sheltering.

The most frequent confirmation sources were looking outside (20%), apps (18%), and friends or family (17%). The next most frequent were television (14%), social media (12%), tornado sirens (11%), weather radios (4%), other (1%, including websites like weather.com, weather radar, other forecasts), and finally, none of the above (1%). Forty-three percent reported using dangerous or unreliable confirmation sources, such as tornado sirens (11%), looking outside (20%), and social media (12%).

Our results also indicate that more students have the UT alert system enabled on their mobile phones compared to federal mobile alerts (95% vs 77%). Interestingly, 16% were unsure if federal alerts were enabled on their phone.

Discussion

Our findings indicate that the University of Tennessee, Knoxville, should consider requiring formal severe weather preparedness training for students, covering both basic and more complex concepts. While students generally reported high levels of basic preparedness knowledge, such as the difference between a severe weather watch and a warning, they demonstrated lower preparedness in understanding proper behavior, such as delaying or avoiding the decision to shelter or using unreliable sources to obtain weather information. Preparedness training at the University of Tennessee, Knoxville, should, therefore, address these knowledge gaps to equip students to respond appropriately to severe weather events. While most students appear ready to handle content that focuses on recommended responses, the University cannot ignore the need for training in basic terminology, since some students did not understand the difference between a watch and a warning, which may increase the likelihood of responding incorrectly.

Most students (79%) understood the difference between a watch and a warning, which we used as a measure of basic preparedness levels, since the two alerts signify different situations and require proper responses. A weather watch means that the atmospheric conditions are favorable for severe weather, while a weather warning means that severe weather is imminent (NWS). A watch does not mandate immediate action, while a warning does. Students who understand the difference should have less confusion about proper preparedness actions. Also, if students receive a warning, they may be less likely to waste valuable time trying to determine the meaning. Similar to research conducted at the University of Mississippi (Morris, 2009), our sample scored relatively highly in basic preparedness terminology. Morris (2009) indicated that

faculty scored higher overall versus students in terminology knowledge and attributed student misunderstanding to ambiguous or confusing language, for example, the word “possible” in both a watch and a warning. Additionally, many students, faculty, and staff may learn about tornado warnings using personal communication (Morris, 2009), since face-to-face conversations and phone calls are generally perceived as trustworthy sources of information, although more people are now using digital resources (Robinson et al., 2019). Our findings indicate students use personal communication as the third most-frequent confirmation source. Therefore, students with basic preparedness knowledge may be more likely to communicate more accurate information about the alert, which would be valuable in helping other students to respond properly.

Preparedness education that teaches proper responses to impending severe weather will help prepare students for the complexity of an emergency. Generally, students were least confident in knowing where to shelter in their home or dorm, with 34% either uncertain or not confident. Given Tennessee’s risk of nocturnal tornadoes, knowing the shelter location in residences is perhaps one of the most important components of preparedness, so that students may move there quickly when awakened at night. Additionally, students will be more prepared if they can access safe, reliable sources to confirm a weather alert. Forty-three percent of participants reported using dangerous or unreliable confirmation sources, such as looking outside (20%), social media (12%), and tornado sirens (11%). Going outside to visually confirm the alert is one of the most dangerous responses to impending severe weather (Center for Disease Control and Prevention), especially considering mountainous terrain and the prevalence of nighttime tornadoes in Tennessee, both of which limit visibility of an approaching tornado until it is dangerously close. Yet, looking outside was listed as the most frequent confirmation source among students. Other studies with larger sample sizes and more diverse populations have also

indicated that looking outside is a common response to impending severe weather (Ellis et al., 2020; Morris, 2009). Therefore, this is one of the most-needed components of preparedness education on campus. The University must raise awareness of the danger of going outside to look for the tornado, since students will likely not see it and potentially endanger themselves by being in the path of flying debris instead of sheltering.

Other popular confirmation sources included tornado sirens and social media, which are both unreliable. Sirens are not designed to be heard while indoors, much less while asleep (Center for Disease Control and Prevention; Ellis et al., 2020). Additionally, the City of Knoxville does not have a tornado siren system (WBIR, 2020). Since some students may still wait to shelter until they hear sirens, they must be informed that such a system does not exist in this area. Research has indicated a shift from personal communication to digital resources in immediate response to a severe weather threat (Robinson et al., 2019), which our findings also indicate. For confirmation sources, nearly as many students listed using digital apps (17%) as personal communication (18%), with 12% using social media. However, with digital channels such as social media, students may have difficulty distinguishing inaccurate from accurate information, particularly during a severe weather event. Social media can be a reliable resource if used to watch live streams of news meteorologists, but students may also inadvertently receive or disseminate inaccurate information, potentially adding to confusion and misleading themselves or others. Therefore, students need to learn how to browse weather information on social media responsibly, so they can quickly locate the most reliable sources (Robinson et al., 2019). A final important note is that 26% of participants reported seeking at least 3–6 confirmation sources before sheltering. On average, only 7–15 minutes of lead time exist from the moment of receiving an alert until a tornado strikes (Simmons & Sutter, 2008), but if students are seeking

many confirmation sources, they may still be pursuing information when the tornado strikes. To address these vulnerabilities of using numerous, unreliable confirmation sources, the University of Tennessee, Knoxville, must inform students of the danger of looking outside, teach them how to browse weather information responsibly, and stress the importance of sheltering quickly.

While most students appear to have at least basic knowledge of weather alert terminology, our findings also indicate that some do not, and therefore need foundational education that addresses these definitions. Twenty-one percent of students did not know the difference between a severe weather watch and a warning, which would increase confusion regarding proper preparedness actions when they receive alerts. If our results accurately represent the University of Tennessee and generalize to the entire student population of about 30,000 (University of Tennessee, Knoxville, 2020), then approximately 6,300 students may not know the difference between a severe weather watch and a warning. In a best-case scenario, all less-prepared students would be surrounded by more prepared peers and be able to follow proper procedure based on social mirroring. However, with the high risk of nocturnal tornadoes in Tennessee, students may likely be asleep in their residences, instead of surrounded by peers. Combined with our finding that students are least confident in knowing where to shelter in their home or dorm (34% are unsure or not confident), and that 43% of students use unsafe or unreliable confirmation sources, a nighttime tornado warning could incite panic and confusion, causing these students to potentially endanger themselves with numerous, dangerous confirmation sources, and to waste valuable time determining where to shelter. Worse, some may ignore the warning altogether and avoid sheltering, as 15% of students reported typically not sheltering. Given that students may have only 7–15 minutes of lead time between receiving a warning and a tornado strike (Simmons & Sutter, 2008), less-prepared students will need to use

critical time to decide if, when, and where to seek shelter. First, they will need to distinguish the meaning of a tornado warning, and then verify the alert with as many as 3–6 confirmation sources, all of which could be potentially dangerous or unreliable. Second, once they understand the meaning of the warning and confirm it is true, they must identify the safest shelter, and then move to that shelter. Still, they may select a less-ideal shelter, such as a bathroom with a window or a closet with an exterior wall, putting them at greater risk of injury or death from flying debris. And third, in the worst-case scenario of an impending strong tornado (EF-3 to EF-5), which can have the longest lead times of 40+ minutes (Simmons & Sutter, 2008) students may not realize the importance of remaining sheltered until receiving an all-clear signal, thus exiting shelters too early and unknowingly placing themselves at risk of serious injury or death. To contrast, well-prepared students would ideally awaken to a warning, immediately know that severe weather is imminent, use one or two safe and trustworthy confirmation sources to verify it, and move quickly to their predetermined shelter. They would then remain in their shelter until receiving an all-clear signal. Fortunately, each of these components are trainable skills.

Conclusion

Our results show that most University of Tennessee, Knoxville, students have at least a basic level of preparedness in elementary concepts, such as knowing as the difference between a weather watch and a weather warning and could likely respond appropriately if a tornado warning were issued. Yet, our findings also indicate that students need customized information that focuses on campus-specific vulnerabilities to severe weather and proper responses that will minimize them. Preparedness education for the University of Tennessee, Knoxville, should therefore inform students of the need to use 1–2 reliable and safe confirmation sources, the

danger of looking outside, how to locate and disseminate accurate weather information, and the importance of sheltering quickly. Without addressing these vulnerabilities, students may panic, engage in dangerous behaviors, and spread misinformation if a tornado warning is issued, particularly at night. Fortunately, even less-prepared students may learn each of these skills.

Since real-world severe weather emergencies are inherently more complex than the scope of what this study could document, we hope that less-prepared students would be surrounded by others who could guide them to proper responses. Future work is needed to understand how student social and communication networks spread preparedness information immediately after receiving a tornado warning, and to better understand how communication affects student responses to an alert, particularly in less-prepared students.

Only one storm is needed to cause a massive loss of life and property. Considering the vulnerabilities our study has documented and their potential to substantially increase students' risk, we believe the University of Tennessee, Knoxville, should implement education measures to ensure that students are prepared to make rapid, well-informed decisions in a severe weather emergency to protect their lives and the lives of their fellow students.

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Appendix A – Recruitment Email

Dear Faculty Colleagues, Grad Teaching Associates and Assistants,

We are seeking student participants for our research study about severe weather preparedness in University of Tennessee-Knoxville students. If you wish to give your students the opportunity to participate in our study, please forward this email to them, and ensure that both the survey link and the researchers' statement below are attached. Your involvement is completely voluntary, and you may choose to not forward this email.

Instructors are significantly influential to students. If you choose to forward this email to your students, please refrain from including your own words about our study. Further, please refrain from offering incentives or pressure to participate in our study. Your students' participation is completely voluntary.

Students may take our online survey at the below link.

If you have any questions about our study, you may contact Anna Franklin at afrank25@vols.utk.edu or Dr. Matthew Kerr at mkerr6@utk.edu.

Thank you for your time.

Best,

Anna Franklin and Dr. Matthew Kerr

Hello,

We are seeking students to take our online survey about severe weather preparedness in UTK students. The survey has 17 questions and will take about 5-10 minutes to complete. Your participation is optional, and you can choose to not participate. Either way, your decision won't affect your grades, your relationship with your instructor, or your standing with the University of Tennessee.

You must be age 18 or older to participate in the study.

If you have any questions about our study, you may contact Anna Franklin at afrank25@vols.utk.edu or Dr. Matthew Kerr at mkerr6@vols.utk.edu.

If you would like to participate, please click the link below.

https://severeweatherutk.questionpro.com

Appendix B – Survey Questions

1. How confident are you that you could protect yourself during a severe thunderstorm?

2. How confident are you that you could protect yourself during a tornado?

3. Imagine that you are on campus, outdoors, and you must find shelter. How confident are you that you know where to take shelter?

4. Imagine that you are on campus, in class, and you must find shelter. How confident are you that you know where to take shelter?

5. Imagine you are in your home or dorm and you must find shelter. How confident are you that you know where to take shelter?

6. How often do you check weather reports or forecasts?

7. How confident are you that you know the difference between a weather watch and a weather warning?

8. What is the difference?

Options: A watch means severe weather is imminent, while a warning means it is possible; a warning means severe weather is imminent, while a watch means it is possible; I'm not sure.

9. Confirmation sources are ways that people check if a weather alert is accurate, such as watching the news, looking outside, or calling a friend. When you receive a weather alert, how many confirmation sources do you check before you take shelter?

Options: 0; 1-2; 3-6; 7-10; I don't typically take shelter.

10. Please select all the confirmation sources you typically use.

Options: app, social media, TV, radio, looking outside, calling a friend/family member, tornado siren, other (specify), none.

11. Do you have federal emergency alerts enabled on your phone?

12. Do you have UT Alert (the campus alert system) enabled on your phone?

13. Please select all the sources that you use for weather information.

Options: app, social media, TV, friends or family, government websites, radio, tornado sirens, other (specify), none.

14. Have you received any severe weather training from UT?

Options: Yes, as part of a first-year studies course; Yes, as part of a Canvas training course; Yes, as other (specify); No; I'm not sure.

15. Have you taken or are you now taking any classes at UT that include topics such as severe weather or weather preparedness, for example: GEOG 131 "Weather, Climate, and Climate Change" or GEOG 331 "Natural Hazards"?

16. How prepared do you now feel for severe weather?

17. Do you feel more prepared for severe weather because of any preparedness training you received from UT in any format?

Appendix C – Raw Data

Question 1: How confident are you that you could protect yourself during a severe thunderstorm?
Highly confident: (42%)
Somewhat confident: (43%)
Not sure: (10%)
Not confident: (5%)
Total: (100%)

Question 2: How confident are you that you could protect yourself during a tornado?
Highly confident: (16%)
Somewhat confident: (35%)
Not sure: (29%)
Not confident: (19%)
Total: (100%)

Question 3: Imagine that you are on campus, outdoors, and you must find shelter. How confident are you that you know where to take shelter?
Highly confident: (31%)
Somewhat confident: (37%)
Not sure: (13%)
Not confident: (19%)
Total: (100%)

Question 4: Imagine that you are on campus, in class, and you must find shelter. How confident are you that you know where to take shelter?
Highly confident: (29%)
Somewhat confident: (40%)
Not sure: (16%)
Not confident: (15%)
Total: (100%)

Question 5: Imagine you are in your home or dorm and you must find shelter. How confident are you that you know where to take shelter?
Highly confident: (47%)
Somewhat confident: (19%)
Not sure: (24%)
Not confident: (10%)
Total: (100%)

Question 6: How often do you check weather reports or forecasts?
Daily: (60%)
Several times/week: (31%)
Once a week: (5%)
Several times a month: (2%)
Once a month: (3%)

Never: 0
Prefer not to answer: 0
Total: (100%)

Question 7: How confident are you that you know the difference between a weather watch and a weather warning?
Highly confident: (63%)
Somewhat confident: (16%)
Not sure: (11%)
Not confident: (10%)
Total: (100%)

Question 8: What is the difference?
Correct answer (watch: possible; warning: imminent): (79%)
Incorrect answer (watch: imminent; warning: possible): (15%)
Not sure: (6%)
Total: (100%)

Question 9: Confirmation sources are ways that people check if a weather alert is accurate, such as watching the news, looking outside, or calling a friend. When you receive a weather alert, how many confirmation sources do you check before you take shelter?
0: (8%)
1-2: (52%)
3-6: (26%)
7-10: 0
I don't typically take shelter: (15%)
Total : (100%)

Question 10: Please check all the confirmation sources you typically use:
App: (18%)
Social Media: (12%)
TV: (14%)
Radio: (4%)
Looking outside: (20%)
Friends and/or family: (17%)
Tornado sirens: (11%)
Other: (weather.com, radar, other weather forecasts) (1%)
None of the above: (1%)
Total: (100%)

Question 11: Do you have federal emergency alerts enabled on your phone?
Yes: (77%)
No: (6%)
Not sure: (16%)
Total: (100%)

Question 12: Do you have UT Alert (the campus alert system) enabled on your phone?
Yes: (95%)
No: (2%)
Not sure: (3%)
Total: (100%)

Question 13: Please check the sources that you use for weather information:
App: (28%)
Social Media: (10%)
TV: (15%)
Friends and/or family: (16%)
Government websites: (11%)
Radio: (8%)
Tornado sirens: (9%)
Other: (2%) (going outside, weather.com, Alexa, radar)
Total: (100%)

Question 14: Have you received any severe weather training from UT?
Yes, as part of an FYS course: (3%)
Yes, as part of a Canvas training course: (2%)
Yes, as other: (5%) (GEOG 131, but not in FYS or any other format; Boy Scouts; work on campus – student union)
No: (83%)
I'm not sure: (6%)
Prefer not to answer (2%)
Total: (100%)

Question 15: Have you taken or are you now taking any classes at UT that include topics such as severe weather or weather preparedness, for example: GEOG 131 "Weather, Climate, and Climate Change" or GEOG 331 "Natural Hazards"?
Yes: (63%)
No: (37%)
Total: (100%)

Question 16: How prepared do you now feel for severe weather?
Highly prepared: (21%)
Somewhat prepared: (60%)
Poorly prepared: (10%)
Not prepared at all: (8%)
Not sure: (2%)
Total: (100%)

Question 17: Do you feel more prepared for severe weather because of any training you received from UT in any format?
Yes: (23%)
No: (65%)

Not sure: (11%)
Prefer not to answer: (2%)
Total: (100%)