Tornado warning awareness, information needs and the barriers to protective action of individuals who are blind.

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Abstract

Individuals with disabilities are often vulnerable to the impacts of weather hazards, such as tornadoes. This is especially true in the Southeast where vulnerability to tornadoes is already heightened due to both physical and socioeconomic factors. To better understand and possibly reduce this vulnerability, we conducted interviews with 25 residents of Alabama, Louisiana, and Mississippi who are legally blind. The goal of the interviews was to understand how people who are blind receive and respond to tornado warnings. Participants were asked to discuss the sources they use for severe weather information, their likes and dislikes about the current warning system, warning elements that allow them to personalize the risk, and barriers in their ability to obtain warning information, assess risk, or respond to it. Results suggest that good verbal description or the lack of detailed verbal description were of the greatest importance in our participants' ability to effectively use warning information and act on it. This included audio for television warning crawls, and the level of description provided during severe weather coverage. Ample geographic description was important in their ability to personalize the threat. The greatest number of barriers were associated with the risk assessment phase; however, the single most common barrier mentioned by participants was that they would have no safe place to go during a tornado.

Keywords: communication, disability, severe weather, blindness, tornado warning

1. Introduction

Individuals with disabilities typically experience a heightened vulnerability to weather hazards. Despite the known vulnerabilities for people living with disabilities, research on how to provide assistance to people with disabilities or how to increase their self-efficacy during an emergency is lacking [1]. The need for research specifically focusing on severe weather emergencies was highlighted by Lindell and Brooks [2], who called for research that examines the sensory, cognitive and physical limitations that may inhibit an individual's ability to obtain, understand and respond to warnings. Similarly, Stough and Mayhorn, [3, p. 393] stated that communicating tornado alerts to individuals with disabilities is an area "of considerable concern."

The need for research on how members of vulnerable populations receive and respond to tornado warnings overlaps with the goals of the Verification of the Origins of Rotation in Tornadoes EXperiment-Southeast (VORTEX-SE) program, which seeks to understand "how people become aware of their threat and respond in ways that can protect their lives and property" [4]. The current study is part of a larger project that seeks to understand the current warning communication and response behaviors of people who are blind, who are culturally Deaf, hard of hearing, or experience deaf-blindness. This project, funded through VORTEX-SE, conducted research with these populations and tested methods to improve the warning process. Results discussed in this paper focus on people who are legally blind.

As noted by the proclamations of previous researchers, the need for additional research focused on understanding communication in the context of severe weather research is especially true for people who are blind. While some research exists on communication of emergency information to this population, very little specifically focuses on tornado warning information. In

the U.S., nearly 7.2 million people are blind or visually impaired [5], and a sizeable number of blind adults (35%) reside in the Southern states [6]. Mississippi, specifically, has the highest per capita prevalence of blindness among adults ages 40 and older (0.83%) and the third highest prevalence of visual impairment (2.35%) and these percentages are projected to increase substantially through 2050 [7].

Understanding how people who are legally blind receive and interpret tornado emergency communication is significant when combined with the heightened risk associated with tornadoes in the Southeast. While the frequency of tornadoes is higher in the Southern Plains, the frequency of fatal tornado events is greatest in the Mid-South, which includes portions of Alabama, Arkansas, Mississippi and Tennessee [8]. Alabama and Mississippi also experience the most active area for tornadoes with long pathlengths [9, 10]. Other factors combine with this to make tornadoes in the Southeast deadly. The area is more likely to have tornadoes that occur at night, in forested landscapes, and storms that occur outside the traditionally understood tornado season, as well as social factors such as a high percentage of mobile homes, elderly populations, and people living in poverty [8]. The rate of fatalities is higher among those living in a mobile home and for tornadoes occurring overnight or in the fall and winter months [11].

This research sought to increase our understanding of the warning information use and response of people who are blind, as well as to better understand how barriers associated with being blind contribute to tornado vulnerability in the Southeast. To that end, our research was conducted in Alabama and Mississippi. Specifically, we sought to answer the following research questions in this population.

Research Question 1: How do people who are blind currently obtain tornado warning

information?

Research Question 2: What are their preferences regarding current warning processes?

Research Question 3: How does warning information inform participants if they are at risk and need to take action?

Research Question 4: What barriers currently exist regarding tornado warning communication and response?

2. Literature

2.1 Enhanced Vulnerability

As mentioned in the introduction, individuals with disabilities typically are often vulnerable to experience harm or difficulties from hazards [12, 13]. Factors such as poverty, unemployment or patterns of exclusion or isolation frequently overlap with disability to contribute to enhanced social vulnerability [3, 13, 14]. Poverty itself also typically increases vulnerability through its influence on housing options [14]. Housing vulnerability and poverty are important contributing factors to risk in the Mid-South during severe weather and disasters[8].

Vulnerability can also be enhanced by barriers reproduced when social conventions treat impairments as anything other than a normal part of human diversity—a conception espoused by the social model of disability, which argued that people are "not disabled by [their] impairments but by the disabling barriers [they] face in society" [15, p.1024]. This can be manifested in lack of access to useful information, the potential for increased social isolation or barriers that inhibit protective action. Among adults who experience blindness or low vision, lack of access to visual information is a barrier that impacts overall independence [16]. The need to communicate

effectively with vulnerable populations is a major public health challenge [17]. A review of multiple hazards identified the lack of effective communication from authorities as an obstacle faced by individuals with disabilities [18]. People with disabilities experience challenges accessing and interacting with warnings, as well as difficulty responding to relevant warning information [3, 19]. People with physical disabilities have experienced trouble preparing for as well as responding to and recovering from disasters due to lack of transportation or concerns about the accessibility during the various stages [18].

2.2 Warning communication

Across many studies, research has demonstrated the importance of local television as a source for tornado warning information [e.g. 20, 21, 22, 23]. Television has also been the most used medium for emergencies for how people with disabilities (including blindness and deafness) receive and verify emergency information [19]. However, the format of television warning information can present problems and barriers for our study population. For example, the emergency crawl has been cited as a problem with warning communication for people who are blind or low vision. The blind may be able to hear the initial notification beep supplied to indicate a visual message or crawl is forthcoming, but the crawl information is not audible and weathercasters often refer to maps or other visual info without providing sufficient detail related to the information provided in the crawl text [24]. While television is still a primary source for severe weather warnings, smartphone use for this context has increased with studies showing use rates as high as 38% [21]. It is possible this rate is even higher now. A text message was the next most frequent way after television (27% vs. 49%) of receiving an emergency alert by respondents with a disability [19]. In the same study, smartphone apps were only mentioned by 9% of the people surveyed.

It is still unclear how the information communicated in severe weather broadcasts is processed by the sighted population, let alone people who are blind. For example, weathercasters may convey threats through facial expressions, which may possibly contribute to higher risk perceptions in their audience. However, research by Sherman-Morris and Lea [25] did not indicate a difference in risk perception related to whether a participant viewed a broadcast with the weathercaster onscreen or off. Research has found that visible hand gestures can both reinforce the message [26] as well as distract from it [27]. Research is mixed on whether verbal or visual messages lead to better recall of details; however, two studies focusing specifically on tornado warnings have shown a slight advantage to verbal information over visual components [25, 28]. Finally, individuals may not fully understand the imagery often used to support warning information such as radar visualization products [25, 29]. Studies such as these illustrate that there is much need to study the influence of hearing vs. seeing tornado warning information both for those who are limited to one of these sensory channels as well as for those with access to both.

2.3 Protective action responses

Lastly, it is important to understand how individuals generally respond to severe weather so that actions taken by participants in our study who are blind can be placed in context. Simply providing an easily understood message does not imply that individuals will receive it and act upon it in a way that makes them safer. Risk communication has long been characterized as a series of (not necessarily sequential) steps between the first cue of a threat to some response[30, 31] wherein an individual comes to some understanding of a warning message, seeks to confirm it and determines the personal relevance of the information before deciding on what action to take. How one acts upon a message can be influenced by information variables or social and

environmental cues as well as how much they attend to and comprehend a message [32]. An intended behavioral response is also influenced by perceptions of the threat as well as perceptions about the available protective actions [32, 33]. Situational factors can act as constraints or increase the likelihood of a response [32]. A meta-analysis of previous tornado studies indicated that a majority of individuals surveyed (~70%) did seek shelter in a tornado, but attempts to confirm the tornado threat were common, with 10-25% of people attempting to visually confirm the tornado before seeking shelter, which may increase the risk if a person must leave an interior location indoors to do so [20].

Having a physical disability can act as a constraint on taking protective action, but research is scarce on how much impact blindness has on protective action taking in tornadoes. Studies have found that other physical disabilities such as issues with mobility affected hurricane evacuation decisions in that households including a person with a disability were both less likely to evacuate in hurricanes and also likely to wait longer to make the evacuation decision [34]. However, physical and communicative disabilities were not significant factors in limiting protective action in the Tuscaloosa and Joplin tornadoes, possibly due to an increased ease of taking appropriate shelter during tornadoes as compared to hurricanes [35]. Other research stressed the importance of social support in enhancing the ability of individuals with disabilities to respond to hazardous events [18, 36].

3. Methods

To answer the research questions, 25 semi-structured interviews were conducted. The research was submitted to the university's Institutional review board and was granted an exemption determination. To recruit participants for the interviews, a message was first sent to

an email registry maintained by the National Research and Training Center on Blindness and Low Vision. Recruitment via the email list occurred during November and December, 2017 and generated 8 participants. A second wave of recruitment took place in mid-January 2018. The second wave included announcements on social media and led to 15 participants. The other two participants were referred by an individual contact of the research center and by one of the other participants. Participants responded by contacting the researchers by email or telephone and an interview time was arranged. All interviews were completed via telephone. Potential participants were screened for age, state of residence, type of residence (e.g. single-family home, apartment building, group facility, etc), whether they live alone or with others, and level of vision. Screening was performed in order to acquire a diverse sample of legally blind individuals, which would include individuals who are totally blind as well as those who have some usable vision, but meet the federal definition of legally blind which is based on a visual acuity of 20/200 or less or a visual field of 20 degrees or less. Participants were asked to describe their vision as being legally blind with no usable vision, legally blind with some usable vision, less severe vision loss, or no visual impairment. Only persons who described their vision as legally blind were interviewed. A goal was to obtain a sample that included individuals with no usable vision, as well as individuals that live alone (and preferably some for whom both characteristics applied). The combination of living alone and having no usable vision was expected to result in greater vulnerability and made responses from this group important. For their participation, participants were given a $25 gift card.

Twenty-five interviews were completed with an average length of 27 minutes. The majority of participants resided in Alabama (17), with 7 living in Mississippi and one in Louisiana. Slightly over half (14) reported being legally blind with some usable vision. Ten

reported having no usable vision, with an additional respondent whose level of vision was not recorded. Five participants lived alone, including three who had no usable vision. An additional participant with no usable vision reported being home alone often. The average age of participants was 50 with a range from 26 to 83. The gender of the participants was approximately even with 12 identifying as female and 13 identifying as male. The greatest number of participants were employed (14 including three who were self-employed.) Four participants were retired and seven were unemployed. Two participants identified as African American. The rest identified as White. Every level of education was represented, but the greatest number (13) had graduate degrees. Three participants each had high school education or less, an associate degree or post high school vocational training, some college, or a college degree. Eighteen of the participants reported using a walking cane to help with mobility. Three used a guide dog. Four used some other assistance and six people used no mobility device. Over half of the participants reported some other disability or health issue when asked. The most common were hearing loss (7) and diabetes (2), with four other disabilities mentioned once each.

A list of questions (Table 1) was prepared and followed to ensure completeness; however, participants were encouraged to elaborate or to talk other topics where relevant and applicable. Interviews were transcribed and entered into a spreadsheet. Initially, the first and second authors went through the interviews and made notes to assist with later coding of responses.

Table 1. Scripted questions for semi-structured interviews. Information in italics was provided for the interviewer.

I'd like you to think about how you find out that bad storms may happen. I'm talking about storms that might produce a tornado.

Q1. Can you tell me how you would know if you were at risk of getting hit by a tornado? *(Listen for warning information, social cues, and environmental cues. Ask participant to elaborate on any social or environmental cue they bring up. E.g. Can you tell me what you mean by…or what does that tell you?*)

Q2. What lets you know there is a real threat that you should pay attention to? Why is that? Is there anything you listen for or try to find out to let you know you should do something to make yourself safe from the storm? Can you tell me what you listen for? *(Suggestions to follow up on could include more details about what to do, more information about what is going on, more helpful in what actions to take*)

Q3. Let's talk some more about how you get that warning information. (*If they've already discussed this…check for missing information about the warning below and move on.)*

Q4. 4a. What is your preferred way of getting warning information? 4b.Why is that?
If they say their preferred way is their phone, follow up—do you have any kind of apps installed to give you warnings? What are they/how do they work?

If they say television/radio, follow up with what is the source of the information?

Q5. Are there other sources you use? What do you like or not like about these sources?

*If they don't mention it in any earlier questions…*Do you ever use the television for information about tornado warnings?
Q6. What do you like and dislike about television as a source of the warning?

Q7. Is there anything you would change about the way TV weathercasters communicate information about tornado warnings that would make it better for you?
(*unless already addressed*)

Q8. Does the weathercaster's description of what he sees on radar contribute to your understanding of whether you will be safe from a tornado or not? How so?

Q9. Are there any barriers for you in accessing information about tornado warnings?

Q10. Are there any ways that the warning process could be improved to better alert you?

If relevant/not covered earlier: Q11. Do you find the warning information pretty easy to understand or not? Are there things you wish made more sense or were clearer?

Q12. 12a. If you are at home and you receive a tornado warning, what do you usually do? How would you make yourself safe from the tornado? (*Probe for multiple steps*.)

If not already asked/mentioned: 12 b. Where would you go to feel safe from the tornado? (*Probe for details. E.g. Can you describe this place?)*

Q13. What about if you are in an unfamiliar environment?

Q14. Can you think of a recent time when you received a tornado warning? Would you describe your most recent experience? Is that experience pretty typical?

Q15. Do you think the county where you live is frequently threatened by tornadoes?

Q16. Has a tornado ever directly hit or come within 1 mile (*if asked: do not read…1.6 km*) of your residence, work, or car?

Q17. What is the highest level of education you have completed?

Q18. What is your current employment status?

Q19. How would you describe your race or ethnicity?

Q20. How would you describe your gender?

Q21. What is your zip code?

Q22. Do you use any type of mobility device? (What do you use?)

Q23. Do you have any additional disabilities/health conditions you haven't already mentioned? If yes, Could you please explain?

Transcripts were formatted to distinguish interviewer comments from those of the participant. The text of the interviews was organized by the interview question answered within the text. In some cases, a response to a particular question posed by the interviewer needed to be broken into separate chunks of text, referred to below as text segments, because more than one question was addressed in the response. Once this organizing of the transcripts was complete, we performed an analysis of the interviews based on a grounded theory approach. Open coding was utilized to "inductively build themes that represented participant experience without presuming knowledge" as in Good et al., [36 p. 428], who also interviewed participants who were blind. One reason for this approach was the lack of literature on tornado warnings and people who are blind. Line-by-line open coding was completed where an unrestricted descriptive phrase was

added to each text segment to summarize the response [37, 38]. In many cases, the response had to be summarized by more than one descriptive phrase. This open coding led to close to 200 coding categories for the open-ended portion of the interview (Q1-Q14).

After each interview was open-coded, the individual coding categories were extracted and examined for patterns and linkages. The initial descriptive codes were examined and integrated to identify the predominant themes from the interviews. The data were reviewed again as they related to these new categories [38]. Some questions produced very similar answers and common patterns emerged. For example, we sought to understand what participants liked and/or disliked about the sources they used as well as what they liked and/or disliked about television specifically.

The first step in the categorization process focused on responses associated with questions about warning information (Q3, Q4b, Q6, Q7, Q8, Q10 and Q11). The responses to these questions were first categorized as source characteristics and message characteristics. After the questions were categorized as message or source, the responses focusing on characteristics of the message and characteristics of the source were recoded with a shorter set of codes. A similar categorization and recoding was followed with other questions. How the information informs their decision making (Q 1b, 2 and 2b) was recoded and barriers (Q9) were analyzed further in terms of the phase of warning process at which the barrier was present. The results section provides examples of responses in each category as well as the frequencies of the refined codes used to categorize the responses.

4. Results

4.1 Research Question 1: Sources used

A variety of sources were used for warning information (Research Question 1). Television was mentioned by the greatest number of participants (21), but this number may have been biased slightly due to the interviewer asking participants specifically about television. This was necessary due to other study goals outside the scope of this paper. No other specific source was probed in the same way as television. Phone alerts were mentioned by 17 participants, followed by siren (15), radio (14) and other people (13). Other sources mentioned by fewer than five participants included NOAA weather radio, environmental cues, ham radio, the National Federation for the Blind (NFB) Newsline, social media, Fitbit, and fire truck siren (Table 2). Two people used smartphone apps that did not alert them. When asked which was their preferred source, phone alerts were mentioned the most (9), followed by television (6), radio (3), computer or phone apps (2), and other people (2).

Table 2 Sources used by participants. Choices were not provided, although participants were specifically asked whether they used television.

Sources	**Participants Using**	**Participant's Preferred Source**
Television	21	6
Phone alert	17	9
Siren	15	
Radio	14	3
Other people	13	2
Weather radio	4	
Environmental cues	4	
Ham radio	3	
Only phone apps	2	2
NFB Newsline	2	
Social media	2	
Fit bit	1	
Firetruck	1	

4.2 Research Question 2: Comments about warning sources and message information

Research Question 2 sought to determine what participants like and dislike about the

warning process. As described in the previous section, responses were first categorized as source characteristics and message characteristics. Out of 244 text segments examined, just over half (52%) included comments about the message, while 41% included comments about the source of the message. Only 7% were comments that could apply equally to source or message. These were included in the coding for both source and message since there was very little overlap between the categories.

There were nine codes assigned to the comments about the warning source (Table 3). With a small number of text segments classified by more than one code, 150 classifications were made. The greatest number of comments about the source were about its general aural quality (36/150). This included ideas such as wanting an app that speaks the warning, television not having any aural alerting feature, not being able to hear the siren, or a source being too visual (and thus inaccessible). Comments about the crawl or closed captioning accounted for 22/150 of the classifications. These included comments such as the crawl has poor contrast, the crawl could more accurately represent what the reporter/weathercaster is saying, or the crawl is inaccessible because it is not verbalized in any way.

Twenty-two comments were also classified as pertaining to convenience of the source. These comments were about how much effort the participant had to expend in receiving the warning. Sources that had to be monitored or actively sought out were sometimes mentioned as not being very convenient, while portability or no effort being required were key features in a source being coded as convenient. Portability is favored in the following comment, *"I just think that's the best communication is for me personally is my cell phone because I try to keep my cell phone, you know, it's just real portable so I can just keep it with me all the time."* (Subject 8) In some cases the convenience of a source was dependent on time of day. One participant (Subject

18) noted *"the APP is great for alerting me if I'm late, it's late at night, um, you know, I'm asleep or something like that. Um, whereas the TV is probably the better source if I'm awake and uh, you know, it's a normal hour of the day."*

Table 3. Codes used to classify responses associated with research questions 2-4

RQ 2 Preferences (likes and dislikes) regarding current warning processes (message or source)

Message codes (143 text segments, 55%)	Percentage (of 155 codes assigned)
Description	27.7
*Radar**	17.4
*Understandable**	16.8
Precision	10.3
No suggestions	7.1
Sensationalist/credible	5.8
Other message components	5.2
Safety information	3.9
Trajectory	3.2
Timeliness	2.6
Source codes (117 text segments, 45%)	Percentage (of 150 codes assigned)
General aural quality	24.0
Crawl/closed captioning	14.7
Convenience	14.7
Personalization	14.0
Reliability	8.7
Timeliness	8.7
Usefulness of audio	7.3
Accessibility of maps	4.7
Too fast	3.3

*Radar and Understandable were the result of a specific question about radar.

RQ 3 How do you know you are at risk and need to act? (How do you know it's a real threat/What do you listen for?)

Listen for/Real threat codes (128 text segments)	Percentage (of 174 codes assigned)
Alerting source	26.4
Message information	21.3
What about the message information? (37 text segments)	Percentage (of 56 codes assigned)
Geographic description	42.9
Trajectory	25.0
Other	16.1
Safety information	16.1
TV/TV Met	
Awareness	13.8
Other source they are monitoring	7.5
Personal contact	7.5
Environmental cues	7.5

RQ 4 What barriers currently exist?

Barriers codes (54 text segments)	Percentage (of 62 codes assigned)
No safe place	21.0
Cannot see (information)	17.7
Knowledge barriers	17.7
Nothing	12.9
Cannot get to shelter	11.3
Not aware	6.5
Cable/Satellite/Power	4.8

	Hearing	3.2
	No one to call/help	3.2
	No secondary TV channel	1.6

The level of (and usually the lack of) personalization provided by the source was also important accounting for 22 classifications. For example, sirens may sound when the warning is not located nearby, or television weathercasters may spend too much time talking about a tornado that is nowhere near the participant's location. While participants did not talk about these factors leading them to not act or identify them as false alarms, they did provide suggestions for how the sources could better serve them. Reliability and timeliness each accounted for 13 classifications. Reliability most often dealt with loss of power or the cable or satellite going out during severe weather. A few comments mentioned sources not alerting when the participant thought they should have. Timeliness focused on the time warning information was made available to the participant. These comments ranged from a source providing information a day ahead of time to comments about information being delayed on social media or television. The usefulness of the source's audio (11), accessibility of the information (7), and the source being too fast (5) were other codes classifying source comments. The crawl, weathercasters, NOAA weather radio and audio warnings on the phone were all criticized for being too fast.

There were 10 codes assigned to comments about the warning message. Participants were asked specifically about whether radar imagery was useful to them and whether warning information is understandable, so comments coded as focusing on these concepts accounted for

high numbers (27 and 26) of the 155 classifications made. Nearly all participants found warning information understandable. Only two participants qualified their responses, but no participant said information was not understandable. Many of the participants found radar imagery useful, including some with no usable vision. Participants mentioned some of the information radar provides, such as location of the tornado and its trajectory, even if they could not see it personally. For example, (Subject 11) explained, "weather radar tells you what's coming your way." Another participant described their perception of how the weathercaster used radar.

> *"I understand they're just reading street names off the, off the thing, but when they do read those street names, that's really very helpful because then you kind of have an idea because you sort of know the area that you live in and you know those streets. So you know whether or not you're in the problem spot."* (Subject 15)

Among the freely offered comments about warning messages, description classified the greatest number (43/155) of text segments. Most were in reference to warning messages on television, where the weathercaster typically provides warning information while talking about radar imagery. They could roughly be described as general comments such as weathercasters providing an overview of what they're seeing, what is going on, versus comments about description of geographic places. An example of a general text segment that was classified as a comment about the description of the message follows.

> *"I don't want to dis what's going on, but we do need to know exactly what's happening. Don't just tell me there's something in the bottom right hand of your screen if you'll*

look down there or do you see that pink shade over Vestavia up there--those pink dots moving. That's what you need to be looking at. Well, I can't do that. You need to tell me what that is, where it is, why it is, so a little bit more description." (Subject 11)

Participants provided both positive and negative comments about the description in a message. Participants' comments also indicated that some television weathercasters provided more geographic description than others. For example, one said the following.

"They talk about 'we're 10 minutes out for this town and five minutes out from this town,' you know, like they've lined it up and they tell you. And that gives you a really good sense that you're in the line of a storm or not." (Subject 14)

However, two other participants made negative comments.

"I dislike it when they put the radar up and they say, now, this is a debris ball and this over here. And they stop using actual locations and they start pointing at things on the map and, and they don't call out, you know, what areas they're actually talking about that. That makes it more complicated and I really don't like it when they do that." (Subject 15)

"They don't give a lot of verbal description. They're saying a lot of here and you know, if it's here headed, or it's right here and you can see it's moving this direction across here, see that, you know, the different colors and all that stuff and they don't

give necessarily a lot of description as to ok it's in Hoover heading towards Vestavia Hills you know along this corridor or something. They may talk in general terms, but sometimes they're not very specific. They're assuming that folks can see it." (Subject 24)

One participant also mentioned that NOAA weather radio usually provides more detail than their local television station.

4.3 Research Question 3: Awareness and personalization of the threat

Research Question 3 asked how warning information lets participants know if they are at risk and need to take protective action. There were 174 text segments analyzed for information regarding how participants know a threat is real and what they listen for. These text segments fell into seven codes. The code that represented the greatest number of the text segments (46) was alerting source, which indicated that they knew there was a threat because they had received a message by some alerting source. In fact, many of the responses could have equally answered the question 'how do you hear about a tornado warning?' Responses described the various sources from which they would typically receive a warning. An important distinction from sources of information, however, is that these responses are only those that actively alert the participant as opposed to sources they turn to once they know there is a warning.

Specific message information was described in 37 of the text segments. Of those that specifically commented on message information, 24 of the 37 referenced specific geographic information; 14 referenced trajectory information, 9 mentioned safety information and 9 described other message information (It was possible for a text segment to be coded in more than one category). Geographic information included specific information such as nearby roads, cities and county names, as well as general information such as whether the tornado is in "*your area*."

Trajectory information was similar but included information about movement such as "*which way the storm's headed*." Safety information typically included some direction to take shelter, as in when local television meteorologist "*James Spann says get in your safe spot*," or "*it's coming close to your area … you should take shelter*." Other responses included how severe the storm is, if there is a circulation, and other weather information.

Local television was mentioned in 28 of the 174 text segments. This primarily included statements about television being a main source of information. Awareness classified 24 of the text segments. This referred to comments where the participant mentioned knowing that a threat existed and know what weather was possible before the warning was issued. Five responses mentioned being aware of the tornado watch, and one participant mentioned a local station's "weather alert days." Personal contact, environmental cues and other sources the participant is monitoring classified the remaining text segments with 13 each. While not a dominant theme in the interviews overall, several of the participants mentioned listening for certain sounds that could alert them such as wind causing things to hit the window, the sound of a freight train, or changes in the rain. One participant also described watching the reaction of their service dog.

4.4 Research Question 4: Barriers to awareness, risk assessment and response

Lastly, Research Question 4 asked what barriers exist for people who are blind in receiving or acting upon a warning. There were ten codes that described responses regarding barriers that exist and a total of 62 text segments that were classified. The greatest number of text segments could be classified as having no safe place to go. This accounted for 13 of the text segments and 6 unique participants.[1] Two segments indicated no person available to help the

[1] In some cases, a participant may have mentioned the same topic multiple times throughout the interview. If a new topic emerged while they were responding to one question/topic and the participant returned to the previous topic we coded those responses as multiple occurrences.

participant. One respondent was living in temporary housing. Others cited the lack of any public shelters or basements in houses, or not being safe in their mobile homes. Similarly, not being able to get to a shelter was mentioned in seven text segments by four participants.

Not being able to see or not being able to hear classified 11 and 2 text segments respectively. Physical limitations were sometimes linked to a participant saying they may not be aware of the warning, which was mentioned four times. The most common issue not being able to see caused for the participants was the inability to examine the radar imagery for themselves. One participant expressed their frustration over this limitation.

> *"I know people that are sighted at work, they pull up the weather stuff and they can see the description of or they can see, you know, the color palettes and kind of interpret it themselves and I haven't found a way. I have to rely on the feedback that other folks are giving."* (Subject 24)

Other comments related to sight included not being able to see environmental cues, other visual information, the warning text, and the tornado itself.

Knowledge barriers accounted for 11 of the 62 text segments classified. This included five comments indicating the participant did not know where to get warning information. Other responses included two indicating a lack of knowledge about local geography, one response that the participant did not know what to listen for, and three that were classified as not knowing what to do. One of the participants who said they did not know what to do when they got

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Coming back to the same topic multiple times provided an indication that the topic was important to the participant in his or her formulation of the answer to the interviewer's question.

warning information was also someone who said they would not be able to get to a shelter.

Lastly, issues with television or other devices were mentioned in 4 responses. One participant stated that the lack of secondary audio channels for their local television station was a barrier. Three participants mentioned potential problems with their phones or satellite dish losing a signal, or power or cable going out. Eight comments indicated no barriers existed for them.

In order to place the barriers in the context of warning communication and response, the comments were also categorized as pertaining to awareness, risk assessment or response phase. These were screened so that a particular barrier did not get recorded more than one time per participant. A participant could, however, experience barriers in more than one phase. Most of the barriers were associated with the risk assessment phase (15/34). Barriers associated with vision were more of an issue at this phase than awareness or response, and most were associated with some action to confirm or personalize the warning. Not being able to see the radar to visually confirm the risk was one of the most prominent issues with risk assessment. Not knowing the local geography well enough to be able to personalize the risk was another barrier to the risk assessment phase. One participant with no usable vision described how they had ordered a braille map of Alabama to learn the nearby county names. Another participant echoed the added difficulty that a person who is legally blind might have in processing the geographic information; "*that's not something that you just automatically know, especially if you're not [from] the area and you've never seen a map before, you know, that makes it very difficult*."

Barriers with awareness (11) included issues like a poor phone or satellite dish signal preventing them from receiving a warning, not knowing where to get the warnings on their phone, or having trouble seeing or hearing the warning. Eight comments were associated with the response phase. All but one comment dealt with not having access to adequate shelter or not

knowing where a safe place would be. One participant also mentioned not knowing what to do if they were hit by a tornado. Their comment illustrates information that is seldom part of the warning message:

> *"If you do all their steps and you're sitting there in the midst of all and rubble and they don't tell you what to do, then how do you signal people, the first responders looking for you and then what do you do? How do you dig your way out of the rubble and how do you signal the people to say, Hey, I'm here in my bathtub and there's three piles of wood on top of me."* (Subject 20)

5. Discussion

Many of the results found through our interviews with our participants who are blind are similar to or would be expected to be similar to results among individuals with full use of sight. For example, many of our participants used television, even though it was not necessarily their preferred source. Television has historically been the primary source for tornado warning information [20] and remained an important source in surveys conducted as recently as 2016 [22, 23]. In a survey of over 3000 individuals living in the Southeastern U.S., traditional media was used by the greatest percentage of people, with local television specifically rated highest [22]. Radio and siren were used by a greater percentage of participants in our study, whereas social media was used by a lower percentage when compared to this study of the Southeastern U.S. [22]. Radio was also the most important source of earthquake information among people who are blind in another study, although participants noted the quality was poor [36]. Phone alerts were the preferred source by nine participants compared to six who preferred television. The use

of smartphones for receiving weather information has grown quickly in recent years [39]. The sending of warnings through the wireless emergency alert system has also helped increase the alerting function of the phone, and phones have been found to be especially important at night [23], which was supported by some of the comments in the current study. Participants also noted the convenience and portability of their phones, which unlike television allows individuals to have a customizable, accessible, information communication channel at their disposal in multiple parts of their home. In this way, mobile phones and devices can provide for a necessary access to information during the most extreme parts of a weather event, such as when people are asked to take shelter. Having a phone in the location of their safe place allows people up-to-date information that can help them in reducing uncertainty and to continue to take the most appropriate and safe actions (e.g., remaining in their safe place until the threat is gone).

There are often different ways to alert individuals who are blind or who are Deaf or hard of hearing in the event of an emergency. For example, weather radio can come with strobe lights to better alert people who are Deaf [40]. Malizia et al. [41] found that sound and touch can make emergency notifications accessible to the blind, but vibration technology can make this information accessible to people who are Deaf, blind or deaf-blind. In that vein, Gelmuda and Kos [42] proposed a wearable vibrating wristband for mobile safety for the blind. While not the same device as what Gelmuda and Kos [42] proposed, vibrating technology is now widely incorporated into smart watches. That source was used by one of our participants and can be fully integrated with wireless alert systems. The only source cited that was specifically for the blind was the NFB Newsline.

Comments from our interviews suggested that participants may prefer for common sources to be made accessible rather than use products designed specifically for people who are

blind. This view coincides with the spirit of the social model of disability, which holds that physically impaired people are disabled by being "unnecessarily isolated and excluded from full participation in society [43]." Speaking about television, one of the participants explained this feeling.

> *"I like the fact that that's mainstream, it's not like some random blindness product that you have to wonder, okay, is it really going to be around? I mean, it's not unusual for everybody to turn on the TV so you don't feel like you're sticking out like sore thumb because you're turning on the TV and that's accepted practice."* (Subject 15)

The desire to use the same products as everyone else was also reflected in a previous participant's comment that they would prefer to be able to assess their own risk via radar as their coworkers do.

Comments related to desire for warnings to provide details that can help an individual personalize the threat are also common among participants in this study as well as other studies not focusing on people who are blind. For example, a study also conducted in MS and AL found that participants were more able to understand and personalize the threat when their weathercaster was knowledgeable about local places and landmarks [44]. Likewise, our participants also highly valued the geographic description and rated some local weathercasters better at communicating this than others. What may be unique about the results from the participants who are blind is that they are not as able to follow weathercasters' discussion of radar imagery without being provided a high level of verbal description.

A need for geographic and other general description was the most frequently provided

comment about warning messages. One of the participants suggested deliverers of weather information needed to communicate like the game announcing of a radio sportscaster. The contrast of television with radio was made by blind participants in a previous study [45]. Providing adequate audio description has been described as "being to the blind what closed captioning is for the deaf" but adding verbal descriptions to predominantly visual channels is also useful for individuals with limited sight or simply those who cannot watch a screen such as drivers [45, p.75]. Participants found radar imagery useful because they realized its value in providing the location of a tornado, but negative comments indicated weathercasters did not always describe it with enough detail for participants to be able to personalize the threat. Participants also wanted the ability to examine the visual information for themselves. Methods to create accessible weather visualizations that rely on reading may not allow the user to explore the information according to their interests, an issue that was recognized in the development of a weather map for blind users [46]. Participants' frustrations with the lack of verbalization of the crawl is also a comment previously made in an earlier study [45].

Televised emergency information not part of a newscast (either regular or one that interrupts programming) is legally mandated and required to be accessible to individuals with disabilities [47]. To be accessible to people who are blind, emergency information must be provided at least twice aurally through a secondary audio stream [47]. Information that is considered critical includes "specific details regarding the areas that will be affected by the emergency, evacuation orders, detailed descriptions of areas to be evacuated, specific evacuation routes, approved shelters or the way to take shelter in one's home, instructions on how to secure personal property, road closures, and how to obtain relief assistance." [47, 47 CFR § 79.2(a)(2)] Among these critical details, the ones most applicable to tornado warnings are the areas to be

affected, the way to take shelter in one's home, and approved shelters if available.

Personal contact with others is a common step in the warning communication and response process. For example, individuals may verify a threat with others or take others' actions into account when deciding how to respond to a hazard event [20, 32]. Similarly, we found that personal contact was important for our participants with respect to awareness but also assistance with responding to the warning. Several participants reported receiving phone calls from family members or neighbors to make sure they knew about a threat. There were issues associated with the need to rely on others for this information, however. Because of tornados' short-fuse duration, as well as their frequency of occurrence at night, it could be more difficult for individuals to locate someone on short notice. Participants spoke about relying on neighbors when they are home from work, but not at night, or living with a spouse who travels often leaving them alone. Van Willingen et al. [34] found people with disabilities often did not have a backup person to count on for assistance in responding to hurricanes if their primary support person was not available. The participants in the current study echoed this finding in the context of tornado situations.

Other people may also be needed to aid some of our participants in responding to a tornado. Several participants reported having no safe place to go and no access to transportation if they needed it to get to someplace safe. Other studies have shown that lack of sufficient shelter from tornadoes is common in the southeast, especially for strong and violent tornadoes [48]. Many of the fatalities in the April 27th, 2011 outbreak occurred in permanent homes where residents followed the recommended advice to seek shelter in the lowest floor interior hallway, or bathroom suggesting that people may need to consider sheltering alternatives in advance of a high-risk outbreak. [48]. Residents of the region often use a "one size fits all" approach when

making tornado safety decisions, and the segment of the population who is blind may be the same; however, their vulnerability is even greater in the absence of detailed auditory description from TV weather forecasts. One participant also mentioned not wanting to contact neighbors overnight. Future research should examine whether individuals would be interested in leaving their home to go to a safer location if transportation was available. Unlike the decision to shelter in place, leaving for someplace safer would require making the decision well before the threat became imminent. The perceived lack of a safe shelter, and potential lack of transportation are also issues faced by mobile home residents [22] and this was true for several of our participants who lived in mobile homes and reported not having a safe place to shelter. Having no safe place to go was the most common barrier discussed by participants; however, barriers also existed at each phase of warning awareness, risk assessment and response.

6. Conclusion

This study examined the tornado warning process for people who are blind including participants' uses of and preferences for information as well as barriers experience to taking protective action. Apart from experiencing a greater need for the information to be accessible, participants used sources much like the sighted population. Barriers to responding such as the lack of a safe place to go in the event of a tornado are likely also to be shared by the population at large. Where blindness is accompanied by other factors that contribute to vulnerability such as poverty or social isolation, the lack of access to safe shelter may be even greater. Unfortunately, solutions to remove this barrier may be more difficult to implement than barriers to effective messaging.

A prominent thread across our interviews indicated that one of the most helpful ways the

media can assist people who are blind is by providing ample descriptive information when they are covering severe weather. This is especially true for geographic information, which individuals commonly used to determine if they were personally at risk. In reviewing the results of previous studies focusing on individuals with disabilities in disasters, Quail et al. [18] suggested that disaster professionals should be made aware of accessibility issues in responding to disasters. Similarly, Alexander [1] stressed the importance of alerting the media to their role in providing information to people with disabilities. Ideally, tornado warning information should be presented in a way that is accessible for all. To better serve people who are blind, the American Council of the Blind (https://www.acb.org/adp/guidelines.html) recommends that broadcasters should understand what someone with a visual disability needs to know and consider how many times the information will be said. When describing, they should avoid technical terms and avoid terms like 'we see.' Recommendations such as this can be implemented as soon as the next broadcast.

As is common with research that uses interviews to examine a topic in-depth, the sample size in this study was small therefore it is possible that the results may not be generalizable to the blind population at large. Regional influences also play a role in the study of emergency communication research as much of the information and behaviors are contextualized by the location and type of severe weather. Though the methods employed in this research allow us to adequately build inductive understanding in an understudied population and context, future research should aim to provide larger sampling methods such as surveys and research designs that might allow for the assessment of covariates and moderators relevant to emergency communication in communities with disabilities. This project allowed us to focus on a representative summary of the information needs and barriers of this population in a specific area

of the U.S. that is high risk for tornadoes.

Additionally, our interviews focused on those who often must depend on aural delivery of a warning message. As mentioned earlier, further research should also be conducted on the influence of hearing vs. seeing tornado warning information for those with full use of both senses as well as in situations where the context may limit use of both, such as while an individual is driving or using only a device or channel that restricts access to particular sensory channels before or during weather emergencies.

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