Reducing Tornado Vulnerability in Residential Structures: Analysis of Survivor Stories from the Lee County, Alabama EF-4 Tornado

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ABSTRACT

On 03 March 2019 an EF4 tornado struck Lee County, Alabama killing 23 people. Shortly thereafter, a team of social scientists and engineers traveled to the damage path to pilot a protocol for an upcoming two-year study to combine interviews of direct survivors with the engineering assessment and larger wind context of residential structures. In the United States, 70% of all tornado fatalities occur in a residential structure. The Southeast United States sees a higher fatality rate than the national average due to known factors affecting vulnerability: a higher proportion of mobile and manufactured homes, growth in total housing units that are increasingly dispersed throughout rural areas, and lower or non-personalized perception of the risk of violent tornadoes. This paper focuses on survivors' knowledge and the communications they received prior to making sheltering decisions. On two trips, 38 participants were interviewed at 27 homesites. These interviews were transcribed and coded both inductively and deductively for communication modes. The coding was aimed at learning how survivors knew about the tornado before it struck, if they did. The resulting major communication mode codes were the chance of tornadoes, TV coverage, a friend or relative, phone alerts, outdoor warning device, and weather radio. Of these 27 homesites, it was found that people at 24 of them had more than one type of communication mode before they took action. In addition, 23 of the 27 homesites had a non-human source: the tornado itself. Participants at all but two homesites sheltered in place; those two did not seek shelter, unaware of the tornado.

1. INTRODUCTION

Beginning three days prior to 03 March 2019, the Storm Prediction Center began highlighting a risk for severe storms across Southern Alabama into Western Georgia. A deadly EF-4 tornado would strike Lee County, Alabama, before continuing into Georgia, destroying a total of 225 homes and severely damaging another 133 (NCEI, 2019). Despite the advanced notice, NCEI (2019) lists 90 injuries and 23 fatalities, with all but four fatalities occurring in a mobile or manufactured home. Examining fatal tornado statistics from the Storm Prediction Center (2020), the Lee County tornado was the nation's deadliest since Moore 2013.

As Ashley (2007) has shown, while the frequency of tornadoes, and specifically EF2+ tornadoes, peaks over the central plains, the highest frequency of killer tornado events has historically occurred in a region stretching from northeast Arkansas to northern Alabama. Ashley examined a number of potentially contributing factors to show causal links between the physical (general tornado frequency, high incidence of nocturnal tornadoes, and land cover) and social vulnerabilities (the density of mobile homes and dispersed population in general) present in the

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region. In the subsequent years, Ashley and Strader (2016) showed a recent, dramatic growth in total housing units that are increasingly dispersed throughout rural areas. States in the southeastern U.S. commonly experience tornadoes in the cool season, with estimates of between one third to one half of tornadoes occurring at night (Davies and Fischer 2009; Sherburn et al. 2016), when people are more likely at home (Simmons and Sutter 2005). The 03 March 2019 tornado occurred on a Sunday afternoon, another time during which many families are at home.

NOAA began a deliberate, concerted effort in 2016 to bring together meteorologists, researchers, and social scientists in a program called the Verification of the Origins of Rotation in Tornadoes EXperiment-Southeast, or VORTEX-SE. Many of the research projects supported through this program are interdisciplinary in nature, and cross a broad spectrum of meteorological, social, behavioral, economic, and engineering sciences (for example, see: https://www.nssl.noaa.gov/projects/vortexse/). In seeking to further promote exploration of how these disciplines might collaborate, a small quick-response pilot project was funded that enabled two social scientists to collaborate with two structural engineers to study the 3 March 2019 Lee County tornado. The team interviewed direct tornado survivors and conducted structural engineering assessments of the damage to their homes, with the aim of better understanding aspects of structural failure in order to ultimately increase survivability in tornadoes. The team is also interested in survivors' resilience and coping post-disaster.

This paper reports on our analysis of the factors leading to any sheltering actions that survivors took, and what the survivors saw, heard, or felt as the tornado approached.

2. BACKGROUND

Meteorologists and social scientists have studied some aspects of sheltering actions taken by survivors, early warning systems, and behavioral and other risk factors (for example, Morss et al. 2008; Kim and Choi 2017). Morss et al. (2008) specifically studied uncertainty in weather forecasts and how the general public interprets this information. They found that participants in their survey had their own personal perception of uncertainty and how that would affect their daily life. This becomes a challenge for weather forecasters when trying to communicate severe weather chances, specifically tornadoes. Hoekstra et al. (2011) found that the general public's perception of risk when it comes to weather disasters was fairly well understood and their favored tornado lead time was 34.3 minutes. Hoekstra et al. (2011) also explored how long their respondents deemed necessary for their sheltering decisions. The average number of minutes desired in order to just seek shelter was 10.2 minutes and the average number of minutes desired to take shelter and gather belongings was found to be 14.4 minutes. While the National Weather Service's Weather Forecast Offices are the ones who issue warnings, it is up to local emergency managers, television stations and members of the general public to seek out these warnings or have a method to receive these messages.

Survivors' recollections of their experiences immediately prior to and during a tornado are expected to be highly accurate up to several months post-disaster. Such memories are called *flashbulb memories*, which are formed after highly stressful or emotional events (Brown and Kulik 1977; Luminet and Curci 2018; Talarico and Rubin 2009). Such memories are not easily forgotten (Bernsten 2009), and longitudinal studies find high consistency in detail over time. Looking across several studies, Rice et al. (2018) found that the greatest percentage of inconsistencies found were 35%, with many studies showing lower percentages. Tyson et al. (2003; as reported in Rice et al. 2018) may have found one of the lowest, showing that over 700 people's memories of 9/11 on that day, 3 months, and 1 year post-event were extremely consistent; the authors saw only 7% inconsistencies, even when they classified forgotten details as an inconsistency. Thus it appears that survivors of a tornado are likely to remember much of what happened, and those recollections may be informative to understand optimal sheltering practices to increase survivability.

Few studies have linked survivor stories with engineering assessments. Engineers have historically worked alone, focusing on a structure's capacity to withstand winds by studying the structural response to wind loads (for example, FEMA 1999). More recently, the National Institutes of Standard and Technology (NIST) conducted a study in this cross-discipline space, publishing reports after the 2011 Joplin EF-5 (NIST 2014) and 2013 Moore EF-5 tornadoes (NIST 2013). These studies included interviewing people in the direct

path of the tornado using a semi-structured interview approach. Conducted in two phases, survivors were asked to share their experiences before, during, and after the tornado and then were asked specific questions about important, pre-established concepts such as actions taken, risk perception, and so on. The Joplin report included many stories from people who were in completely demolished structures and asked about the decisions they made when they knew the tornado was going to hit them. In structures where fatalities occurred, information about the structure of the building as well as the experiences of people who were in the structure were noted. Both reports cover various topics in terms of meteorology as well as engineering in the damage path.

The design of the current project was done in consultation with NIST researchers, who are still exploring the full potential of this interdisciplinary research area. This particular paper focuses on aspects of survivor's stories that relate to how they knew the tornado was approaching their location.

3. METHODS

Semi-structured interviews were conducted with direct tornado survivors of the 03 March 2019 Lee County, Alabama, tornado. Interviews followed Galea et al.'s (2007) interview structure used in a study of post-9/11 evacuees from the World Trade Center. Interviews began with a main prompt asking survivors to tell their story from when they first heard about the chance of a tornado to when the tornado struck their home. Follow-up prompts included asking when they first heard about the possibility of severe weather; how they knew the tornado was coming; what they did prior to or as the tornado struck; what they saw, heard, or felt; the pre-tornado conditions of the home; and questions to clarify the sequence of events they experienced.

Interviewees were asked permission to record their interview; handwritten notes were taken in one case when the interviewee did not consent to be recorded. In that case, notes were filled in a few hours later as the two researchers discussed the interview. Transcribed audio files were corrected by researchers, who applied Riessman's (1993) guidance on preparing transcriptions for narrative analysis. This included noting pauses, mood and emotion, voice inflections, emphases, and other notations that help a researcher analyze the interview holistically without the audio present. Transcriptions were then thematically coded for all modes of communication that interviewees experienced prior to the tornado. Things such as sheltering procedures, warning messages received, and words exchanged among each other were noted.

The first trip took place eight- and nine-days post-tornado; the second trip was just shy of three months afterward. During the first trip, many survivors were present, cleaning up or waiting on insurance adjusters or volunteer groups. At other sites no one was present and only an engineering assessment could be done; a few recruitment flyers were left on vacant, damaged homes but none yielded a response. The second trip coincided with an outreach event in Lee County, and targeted households for which an engineering assessment had already been completed. Table 1 summarizes the number of home sites visited and interviews conducted on each day of field work. No one declined to be interviewed and, in several cases, survivors helped researchers connect to family members who had also experienced the tornado. At the majority of home sites, one family member participated in the interview. At other sites, multiple family members participated. In total, interviews were conducted with 38 people at 27 homesites.

Date	# of Households Visited	# of Interview Locations
Tuesday, March 12	**22**	**9**
Wednesday, March 13	**19**	**8**
Friday, May 31	**9**	**3**
Saturday, June 1	**9**	**7**
Total	**59**	**27**

Table 1: Two separate trips were taken to Lee County, Alabama to interview tornado survivors. The first trip occurred eight- and nine-days post tornado. The goal of the second trip was to target households missed. In total, 59 households were visited where 27 interviews were conducted.

4. RESULTS

4.a. Estimates of lead time based on radar analysis

In order to understand the timeframe for the survivor's story relative to warnings issued for their area, radar-estimated tornado warning lead time was calculated using GR2Analyst Version 2 and archived radar data from NCEI. Interview locations were estimated using Google Maps and the limited road network included in the GR software. Radar reflectivity, velocity, and certain dual-polarimetric

products such as correlation coefficient were used to identify the tornado's location for each scan. Tornado warning issuance times were found by using archived NWSChat logs. There were four possible tornado warnings that the participants in this study, from between miles 5 and 17 of the track, may have received. These four possible received tornado warnings were just four of the six total warning updates from the National Weather Service. The first tornado warning issued was at 19:58 UTC, followed by a warning update to a particularly dangerous situation tornado warning at 20:07 UTC, an update to tornado emergency at 20:09 UTC, and an update reiterating the tornado emergency at 20:15 UTC.

Table 2 shows how interview locations were organized into four groups based upon radar calculated lead time for the tornado warning(s). The beginning section of the data, with nine homesites, may have had up to 8 minutes of lead time for the warning, depending on how quickly the warning was disseminated to them. The middle section of the data, with seven homesite interviews, had up to 12 minutes lead time for the first warning, and may have also received a tornado warning update noting that this was a Particularly Dangerous Situation (PDS). The last group, with nine homesite interviews, had up to 20 minutes lead time for the first warning, 11 minutes for the PDS tornado update, and 8 minutes for the tornado emergency. Two homesites were in the track of the second EF-2 tornado path that happened shortly after the EF-4.

Label	Warning Issued	Hit Home	Lead Time
B1	19:58	20:04	6 minutes
B2	19:58	20:04	6 minutes
B3	19:58	20:04	6 minutes
B4	19:58	20:04	6 minutes
B5	19:58	20:05	7 minutes
B6	19:58	20:06	8 minutes
B7	19:58	20:06	8 minutes
B8	19:58	20:06	8 minutes
B9	19:58	20:06	8 minutes
M1	19:58 20:07 PDS	20:08	10 minutes 1 minute
M2	19:58 20:07 PDS	20:08	10 minutes 1 minute
M3	19:58 20:07 PDS	20:08	10 minutes 1 minute
M4	19:58 20:07 PDS	20:08	10 minutes 1 minute
M5	19:58 20:07 PDS	20:09	11 minutes 2 minutes
M6	19:58 20:07 PDS 20:10 EM	20:10	12 minutes 3 minutes 0 minutes
M7	19:58 20:07 PDS 20:10 EM	20:10	12 minutes 3 minutes 0 minutes
End1	19:58 20:07 PDS 20:10 EM	20:11	13 minutes 4 minutes 1 minute
End2	19:58 20:07 PDS 20:10 EM	20:11	13 minutes 4 minutes 1 minute
End3	19:58 20:07 PDS 20:10 EM	20:11	13 minutes 4 minutes 1 minute
End4	19:58 20:07 PDS 20:10 EM	20:12	14 minutes 5 minutes 2 minutes
End5	19:58 20:07 PDS 20:10 EM	20:14	16 minutes 7 minutes 4 minutes
End6	19:58 20:07 PDS 20:10 EM 20:15 EM	20:17	19 minutes 10 minutes 7 minutes 2 minutes
End7	19:58 20:07 PDS 20:10 EM 20:15 EM	20:17	19 minutes 10 minutes 7 minutes 2 minutes
End8	19:58 20:07 PDS 20:10 EM 20:15 EM	20:18	20 minutes 11 minutes 8 minutes 3 minutes
End9	19:58 20:07 PDS 20:10 EM 20:15 EM	20:18	20 minutes 11 minutes 8 minutes 3 minutes

Table 2: The breakdown of survivor stories into four individual groups: beginning of the path, middle of the path, and the end of the path. Calculated tornado warning lead time as well as each individual warning each survivor could have received.

4.b. Communication modes

This paper focuses on how survivors knew the tornado was coming. Codes identified the following: knowing of the chance of tornadoes; knowing about the tornado itself via television, person, phone, siren or weather radio; and seeing, hearing, or feeling the tornado before taking shelter. The first few modes can be grouped as having originated from the weather enterprise. All codes were grouped as "communication," even if referring

		Messages from the Weather Enterprise					The Tornado Itself			
Group - Identifier	Knew About the Chance of Tornadoes	TV	Relayed Through Family or Friend	Phone Alert	Siren	WxRadio	Noise	Saw	Felt	Total
1-1		■	■	■			■			4
1-2	■		■	■			■	■		5
1-3	■						■	■		3
1-4				■			■			2
1-5				■			■	■		3
1-6				■			■	■		3
1-7		■		■				■		3
1-8				■			■	■		3
1-9		■	■				■			3
2-1			■				■		■	3
2-2	■			■				■		3
2-3	■	■	■				■		■	5
2-4			■	■	■		■			4
2-5			■	■			■	■		4
2-6							■	■		2
2-7				■				■		2
3-1		■		■			■	■		4
3-2	■	■						■		3
3-3		■								1
3-4							■			1
3-5	■	■	■	■						4
3-6				■		■	■			3
3-7	■	■	■	■		■				5
3-8	■	■	■	■	■					5
3-9	■	■					■			3
4-1			■				■			2
4-2			■					■		2
Total	9	11	12	16	2	2	18	13	2	
	33%	41%	44%	59%	7%	7%	67%	48%	7%	
		88% of survivors (all but 3) received a warning message from the weather enterprise					85% took their main (or last) sheltering action only after seeing or hearing the tornado			

Table 3: The breakdown of survivor stories into four individual groups: beginning of the path, middle of the path, end of the path, and the survivors who were in the path of the second tornado. Specific sub-codes (Chance of tornadoes, TV, Person, Phone, Siren, Weather Radio, Saw, Felt, Noise) are highlighted if the specific survivor mentioned receiving the communication mode before seeking shelter. Totals for the amount of sub-codes received per survivor as well as the total for each individual sub-code are shown.

to the tornado itself, which communicated its presence by sound (primarily), sight, or feeling. Everything described post-sheltering-decision was not analyzed for the purposes of this study.

Every homesite interviewed had at least one mode of knowing about the tornado, with only two people receiving only one mode. Table 3 shows the breakdown of each homesite with the various communication modes described in the interview highlighted. All but three survivors received a warning from the weather enterprise (88%), and 85% took their main (or last) sheltering action only after hearing (67%), seeing (48%), and/or feeling (7%) the tornado. When grouping the codes into alerts from the weather enterprise and seeing/hearing/feeling the tornado, survivors reported higher numbers of weather enterprise messages the further down the track they were (Fig. 2). Meanwhile, the number of interviewees who stated hearing, feeling, or seeing the tornado prior to sheltering decreased. Two homesites were not aware of the tornado, even after hearing a noise, and did not take any sheltering action.

Common stories were shared by survivors such as similar sounds, phone alerts, and a combination of both physical feelings and alerts. One survivor noted that "…if you hear something that's really loud, sounds like a freight train, get hidden." This noise was what prompted them to seek shelter, and was also noted by people at twelve other homesites. Noise was by far the most common signal that survivors had that the tornado was about to strike. The most common mode of communication from the weather enterprise that prompted survivors to seek shelter was a phone alert. While many survivors could not remember what app or alert specifically alerted them about the incoming tornado, 16 homesites described receiving a phone alert before seeking shelter. One survivor noted that "we got the alerts on our phone

and in no time it hit." Another survivor noted that the phrasing of the alert, combined with the noise they heard outside, helped them in their decision to shelter. They stated, "My phone says, take cover now. I mean, it was like, it was a serious message… Just as soon as it said that, I'm hearing it." This highlights the combination of messages from the weather enterprise and senses that in the end prompted a sheltering decision. In total, people at 23 of the 27 homesites stated that they saw, heard, or felt the tornado before seeking shelter.

Many people described hearing about the tornado from someone they knew before seeking shelter (12 of 27). This, in most cases, came from a phone call or a text. This mode was coded as "friends or family," and was separated from the "phone" sub code. A survivor recounted receiving phone calls from "everyone in Tuskegee" asking if they knew about the tornado. This code also covers someone in the household alerting about the incoming tornado, prompting shelter. One survivor noted that they would have been asleep if it wasn't for their nephew visiting them on the day of the tornado. The nephew helped this homesite avoid "getting trapped" by the tornado. Another survivor noted that the "tone of voice" of their nephew right before the tornado hit made them realize "something was wrong". Another survivor recalled having a missed call from a friend, and when he called back he saw a "dark cloud" coming towards him, and a few minutes later, the tornado hit. This personal connection to other people for many survivors was what helped them be aware of the incoming tornado.

Sometimes friends and family were aware of the tornado thanks to TV weather forecasts and during-event coverage. This tornado occurred on a Sunday afternoon, and some survivors had family over or had heard about the chance of tornadoes the night before or at church the morning of. One survivor recalled, "Me and my cousin over there Saturday evening, sat down in front of the T.V....and he said we'll get some bad weather tomorrow. I said yeah, I heard on the news, but I didn't know it was going to get this bad." Another survivor recalled that she knew about the chance of tornadoes from conversations at church that morning. The conversation was about how tornadoes are usually "pop-up, EF-1 or something like that," usually only damaging the roof.

These factors sometimes came together, when, for example, some relied on texts from relatives that were watching TV coverage and helped them understand the severity of the situation. One survivor stated, "because my daughter texted me and told me, she said, it's on fifty-one and be there by eight minutes," referring to the tornado being on a nearby road. This message was essential in the survivor understanding where the tornado was relative to their household.

People who were less connected locally relied mainly on TV coverage, such as the survivor who said, "we've only been here about three years… we don't know the names of a lot of the landmarks like the churches and that that they were referring to [...]." It took until there was a road name that his wife recognized that they realized they needed to shelter. Many others cited the impact of the television meteorologists on sheltering decisions with 11 homesites knowing the tornado was approaching due to having their TV on. The meteorologists on the television utilized landmarks and street names to warn viewers about the tornado. Using these landmarks, survivors were more likely to recognize areas near their residence and thus understand the severity of the situation. One survivor recalled hearing "38 and 39, get in your safe place NOW!" referring to the street names outside their residence. This statement was often the final piece of information a participant had prior to seeking shelter.

4.c. Example Timelines of Survivors' Experiences

From the individual survivor stories, timelines were created for each individual survivor story to display all the pieces of the story together and how they interplay. Figures 3, 4, and 5 each show an example timeline of the experiences of survivors. Each sub-code is shown in chronological order with a direct quote from the interviews with the survivor.

The timeline in Figure 1 is from the beginning of our dataset and is fairly representative for that group which had, at most, eight minutes lead time. This particular survivor thought that they essentially had no lead time, stating, "We got the alerts on our phones and in no time it hit." She looked outside, didn't like what she saw, and she and her son took shelter. Her husband paused by the door, then quickly joined them saying, "It's comin'! It's comin'!" All of the survivors from the beginning group described either seeing, hearing, or feeling the tornado before seeking shelter. They also described receiving some sort of message from the weather enterprise with 7 of 9 receiving a message via phone alert. In this example timeline,

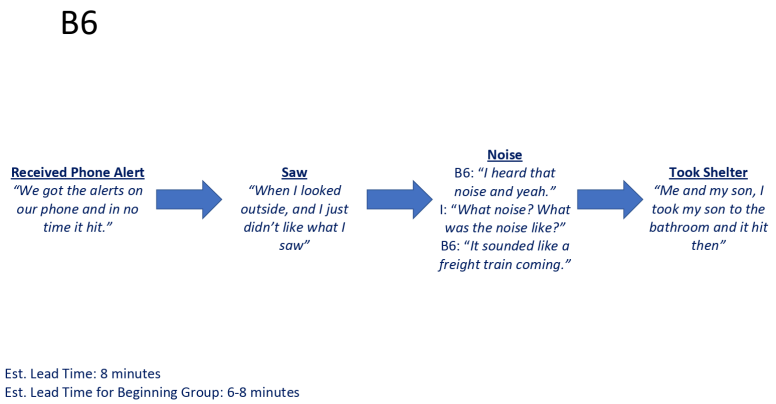

Figure 1: Timeline for specific survivor story in the beginning of the path of the tornado. Various communication modes are shown in chronological order beginning with the first message received via phone alert to the last indication they had that a tornado was coming towards them.

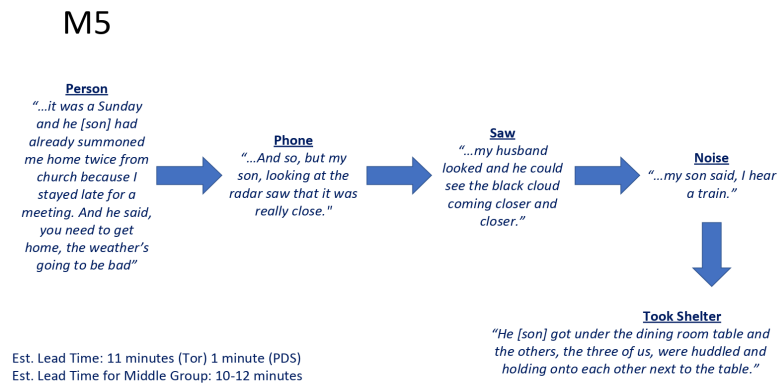

Figure 2: Timeline for specific survivor story in the middle of the path of the tornado. Various communication modes are shown in chronological order beginning with the first message received via a person to the last indication they had that a tornado was coming towards them.

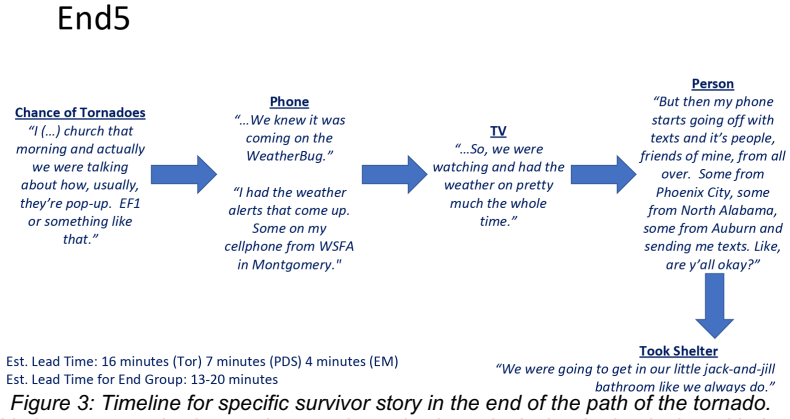

Figure 3: Timeline for specific survivor story in the end of the path of the tornado. Various communication modes are shown in chronological order beginning with the first message received via phone alert to the last indication they had that a tornado was coming towards them.

the survivor received a phone alert which coincided very closely to them hearing and seeing what they described as the tornado. The quote of “I looked outside and didn't like what I saw” is representative of many of the survivor’s stories with no one clearly describing a “tornado” or a “funnel.” This survivor also described the sound of the tornado as a freight train.

For the middle of our dataset, all but one survivor received messages from the weather enterprise and everyone either saw, heard, or felt the tornado before seeking shelter. In the specific case shown in Figure 2, the survivor relied heavily on another person giving her information about the tornado. First, she was summoned home from church, and from there, all the weather information that played into her sheltering decision came from her son. This homesite was classified as the middle of data with radar-estimated lead time of roughly 11 minutes. The other survivors in the middle of our dataset may have had as many as 10-12 minutes of lead time from the initial tornado warning and may have also received an updated PDS tornado warning. People at nearly every homesite in this group received several modes or instances of messaging from the weather enterprise as well as physical feelings in order to seek shelter.

In the last interviews in our dataset, all but one survivor received a message from the weather enterprise with 5 of these 9 survivors also seeing, hearing, or feeling the tornado before seeking shelter. The survivors in Figure 3 may have received three tornado warnings, including a tornado emergency, and had as much as 16 minutes of lead time from the first warning alert. They took their main sheltering action early, preparing their jack-and-jill bathroom and having the children shelter after they received messages from friends and family across the state. The husband sheltered with them after seeing what looked like paper flying in the air. All homesites in this group may have had anywhere between 13-20 minutes of lead time from the initial tornado warning, giving them the opportunity to receive more messages from the weather enterprise than those survivors in the beginning and middle of our dataset. This could be why fewer people saw, heard, or felt the tornado before taking any of their sheltering actions. Receiving multiple messages helped survivors realize the severity of the situation.

4.d Prior Experience

In the interviews, people at 14 of the 27 homesites provided information about previous tornado warnings that they had experienced prior to 03 March 2019. In these statements, storm trends and intensity were discussed. Many survivors understood tornadoes occurring in this part of Alabama as being primarily weak. One survivor clearly stated her belief that in this area of Lee County, only EF-1 tornadoes occur. The survivor’s impression of the storms was that they could expect at most “a little roof damage” or “roof shingles [could] come off.” When analyzing the climatology of Lee County, Alabama, Figure 4 shows tornadoes that have occurred between 2013 and 2018. These tornadoes would be in the recent memory of the tornado survivors and were discussed during interviews. Only one EF-3 tornado occurred in this time frame, but the path was southeast of the homesites visited. The other tornadoes were either EF-0 and EF-1 which matches with these survivors’ impressions of Lee County tornado climatology.

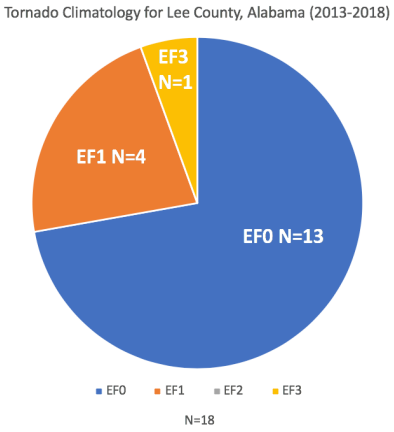

Figure 4 : Tornado climatology for Lee County, Alabama from 2013-2018. In total, 18 tornadoes have occurred with 1 EF-3, 4 EF-1, and 13 EF-0.

5. Discussion/Conclusions

Understanding how survivors received and processed cues before making sheltering decisions may help the weather enterprise strategize in how to more effectively prompt awareness, personalize threats, and prompt people to take sheltering actions for strong and violent tornadoes.

Although the actual warning that included Lee County did not technically have much lead time, other messages had gone out, including

warnings for locations upstream, and most people were aware of the threat prior to seeing, hearing, or feeling the actual tornado. It appears that the people living in the path of the Lee County, Alabama, tornado had more than one confirmation that a tornado was occurring before seeking shelter. Unfortunately, sheltering action was taken late or too late by many, when options were few. In most cases, seeing, hearing, or feeling the tornado prompted action by many survivors. For others it was the combination of physical feelings and messages from the weather enterprise. In total, all but four survivors made their sheltering decision from both physical feelings and messages.

In addition, friends and family alerting survivors about the incoming tornado was often shared as a reason for the survivors to seek shelter. Having connections to the local community and personal connections with other people was very useful for the survivors. Friends and relatives who were watching the television were able to report familiar road names and landmarks that the television meteorologists were calling out. The use of these landmarks and road names by the television meteorologists were extremely helpful in prompting action from the survivors that knew the area, and should be utilized in the future. Survivors who were new to the area did not realize their location relative to the threat until the tornado was getting close to them. Thus, when moving to a new area, it would be beneficial to get to know the roads and landmarks in the surrounding area. Further, when meteorologists create seasonal readiness severe weather educational campaigns they may wish to consider what directions tornadoes may most commonly come from and encourage people to become familiar with landmarks in those directions. In Lee County specifically, there are rural areas to the west and southwest, and if one had just moved to the area, one would probably be most familiar with roads and landmarks between them and the more densely populated areas to the north (Auburn and Opelika) and northeast (near Smiths Station) because of their employment, shopping activity, and restaurants. We suggest further work in this area regarding whether a lack of familiarity with areas from which strong to violent tornadoes are most likely to travel delays personalization of threat.

Finally, it may also be helpful to acknowledge and use what people have likely learned about what a tornado warning means for their area. This area of Lee County had not been hit by a strong tornado in recent memory. This created a sense of security with the survivors from this tornado due to the fact that they believed that the only tornadoes that hit this area were 'weak.' Many survivors were caught off guard by the intensity of this tornado, begging the question as to whether they would have acted differently if they had understood the likelihood of seeing a strong to violent tornado. It is not clear, but as the state of the science enables forecasters to anticipate such events it may be worth investigation as to whether messages that an impending natural disaster is stronger or more deadly than previously experienced prompts different types of actions than "normal" disaster messaging.

Additional analyses are occurring in parallel to this paper, including empirically identifying the best sheltering options in various home types. A full, two-year project was subsequently funded, into which this pilot data will be incorporated.

6. Acknowledgements

First and foremost, we are grateful to the survivors who willingly shared their stories with us. Our hearts go out to you and we wish you the best in your rebuilding and recovery. Thanks also to Dr. Erik Rasmussen for providing the opportunity for our team to pilot an idea to integrate survivor stories with forensic engineering analyses of homes affected by tornadoes. As this paper illustrates, there is much to be gained beyond integrating the survivor's recollections of the pre-tornado state of their home, how damage progressed during the tornado, and where things were immediately afterward that may have been moved during search and rescue and initial recovery operations.

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