

The Vulnerability of Mobile Home Residents in Tornado Disasters: The 2008 Super Tuesday Tornado in Macon County, Tennessee

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ABSTRACT

Mobile home residents are known to be highly vulnerable to tornadoes and account for a considerable portion of tornado-related fatalities. The problem is partially related to the limited protection provided by the structure; however, shortcomings in preparedness and response to warnings may also play a role. This study investigated mobile home resident preparedness and responses to warnings for identifying areas where they might be more vulnerable than permanent home residents (brick and wood-frame houses). The study site was Macon County, Tennessee, which reported the highest number of fatalities during the 2008 Super Tuesday tornado outbreak. A post-disaster survey was conducted within days of the disaster, and the study group included 127 local residents: 35% mobile home (MH) residents, 61% permanent home (PH) residents, and 4% other. An unconditional exact test was used to test for statistical significance (0.05 level) because the sample was nonrandom. The MH residents were less prepared than the PH residents in all six categories evaluated. The difference was significant in having participated in a tornado drill, having a tornado-resistant shelter on the premises, and having an emergency response plan for seeking shelter. The MH residents were also less likely to follow the plan, and the difference was significant. Furthermore, the MH residents were much less likely to take shelter in a safe location. Preparedness factors that promoted higher evacuation rates among MH residents included having participated in a tornado drill, understanding the definition of a tornado warning, and having a plan for seeking shelter.

1. Introduction

Mobile home residents have been recognized as being highly vulnerable to hazards both for socioeconomic reasons and because of the limited protection provided by their housing structure (White and Haas 1975; Morrow 1999; Cutter et al. 2000; Fothergill and Peek 2004; Phillips and Morrow 2007; Kusenbach et al. 2010). Their vulnerability to tornadoes (Simmons and Sutter 2007; Schmidlin et al. 2009) and hurricanes (Morrow 1999; Montz and Tobin 2003; Lindell et al. 2005; Chakraborty et al. 2005; Kusenbach et al. 2010) has received considerable attention in recent years. For example, Golden and Adams (2000) advocated expanding tornado research beyond

detection and prediction to warning communication and behavioral response to further reduce tornado-related injuries and fatalities, which they noted were especially high among mobile home residents.

Preparedness and response among mobile home residents might be influenced by socioeconomic factors (e.g., low income or education) in ways that enhance their vulnerability to tornadoes, which might translate to them being less likely to receive the tornado warning, less likely to understand the warning, or less likely to know how to respond to the warning than their neighbors who live in traditional brick or wood-frame houses. To identify areas where mobile home residents might be more vulnerable, this study compares mobile home resident preparedness for a tornado hazard and response to warning with permanent home (i.e., brick or wood frame) resident preparedness and response. The study site for this research is Macon County, Tennessee, which reported the highest number of tornado-related fatalities (13) during the 2008

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Super Tuesday tornado outbreak (NWS 2008, 2009). Seven of these fatalities (54%) occurred in mobile homes (NWS 2009). This paper presents the findings of a post-disaster questionnaire survey that was conducted in the area within days of the event.

2. Tornado-related fatalities and mobile homes

Mobile homes have been widely recognized as a contributing factor in U.S. tornado fatalities. Brooks and Doswell (2002) found that the average annual death rate in mobile homes (1.23 per million over 1975–2000) was approximately 20 times higher than in permanent homes (0.06 per million over 1985–2000). Ashley (2007) discovered that mobile homes (44%) were the most common location for tornado fatalities from 1985 to 2005, followed by permanent homes (25.3%) and vehicles (9.9%). This disparity is more striking when considering that mobile homes accounted for a mere 5%–8% of U.S. housing units during this period (i.e., 5.3% in 1980, 7.2% in 1990, and 7.6% in 2000; U.S. Census Bureau 1994, 2003) while permanent homes accounted for most of the remaining 92%–95% of housing units (boats, recreational vehicles, and vans accounted for 0.2% in 2000; U.S. Census Bureau 2003).

Nocturnal tornadoes are especially dangerous (Simmons and Sutter 2005) because visibility is limited and the probability of people not being awake to receive warnings is increased (Paul et al. 2003; Ashley et al. 2008). From 1950 to 2005, 27.3% of tornadoes occurred at night in the United States, and they accounted for 39.3% of tornado fatalities and 42.1% of killer tornado events (Ashley et al. 2008). Ashley et al. (2008) also found that, from 1985 to 2007, nocturnal tornadoes were responsible for 60.8% of mobile home fatalities in the United States.

Although most tornadoes in the United States occur in the Great Plains region, most tornado fatalities occur in the southeast (Ashley 2007). The high frequency of mobile homes in the southeast was thought to play a critical role in this unique pattern. For example, Ashley (2007) noted that mobile homes make up a greater percentage of housing stock in the southeast (20% and above in many counties) than in any other region east of the Continental Divide and, from 1985 to 2005, 52% of tornado fatalities within the region comprising Arkansas, Alabama, Georgia, Mississippi, and Tennessee occurred in mobile homes.

3. Tornado preparedness for mobile home residents

Improvements in building design and construction techniques since the U.S. Department of Housing and Urban Development established regulations in 1976 have

helped to reduce tornado-related fatalities in mobile homes (Hart et al. 2002; Simmons and Sutter 2008a). Nevertheless, the National Weather Service (NWS) still considers them unsafe during a tornado and advises mobile home residents to go to the nearest sturdy building or storm shelter (NOAA 2009). Therefore, tornado preparedness is especially important for mobile home residents.

One of the first steps in preparing for a tornado should be to obtain some type of information or training on tornado hazards. This training might include participating in a tornado drill or learning the definition of a tornado warning, which has been shown to reduce risk in previous studies. For example, Eidson et al. (1990) found that the age group that was best informed on how to respond to a tornado warning also had the largest percentage of members who had previously participated in a tornado drill. Liu et al. (1996) found that people who did not understand the definition of a tornado warning were less likely to seek shelter. Fortunately, the definition of a tornado warning appears to be relatively common knowledge, as Balluz et al. (2000) found that 96% of local residents in Saline and Clark Counties in Arkansas understood the term. Capability to receive warnings is another important aspect of preparedness. Emergency weather radios are specifically designed to receive tornado warnings; however, their low usage is well documented (Balluz et al. 2000; Brown et al. 2002; Hammer and Schmidlin 2002; Comstock and Mallonee 2005). Given that previous research found no relationship between weather radio ownership and shelter seeking (Schmidlin et al. 2009), this pattern might not be considered a critical breakdown in preparedness. Nevertheless, emergency weather radios are a reliable source of warning communication and should still be considered an important element of preparedness.

Tornado warnings are also less effective if access to shelter is limited (Liu et al. 1996; Balluz et al. 2000; Hammer and Schmidlin 2002; Comstock and Mallonee 2005; Schmidlin et al. 2009). Therefore, mobile home residents should consider constructing a tornado-resistant shelter (e.g., basement, underground shelter, or safe room) on the premises. The number of mobile homes that have a tornado-resistant shelter on the premises is unknown, but data from previous studies suggest that it is rather low. Although Balluz et al. (2000) did not distinguish between house types, they found that only 12% of homes had a basement in their study area in Arkansas. Brown et al. (2002) found similar results (14%) in Oklahoma City. Interestingly, Brown et al. (2002) noted that most of the survey participants (79%) would support a law for underground shelters in mobile home parks, and Simmons and Sutter (2007) found that it was economically feasible

for mobile home park operators in Oklahoma to provide shelters. Schmidlin et al. (2001) found that approximately 33% of mobile home parks in the United States provided a tornado shelter for the residents but noted many of these facilities were above-ground rooms with windows designed for uses other than as a tornado shelter. Most recently, Schmidlin et al. (2009) found that 21% of mobile home residents at study sites in Georgia, Mississippi, Illinois, and Oklahoma had access to a basement or underground shelter, but only 2% had a shelter on the property.

Mobile home residents should also consider developing an evacuation plan for seeking shelter at a safer location such as a neighbor's house or basement. Having a plan of action has been shown to be a positive indicator of shelter-seeking behavior (Balluz et al. 2000). However, Schmidlin et al. (2009) found that many mobile home residents had not investigated potential shelter sites near their home, which suggests that they either did not have a plan for seeking shelter or the plan was poorly prepared. Many of the mobile home residents indicated that they would not seek shelter in a nearby basement, underground shelter, frame house, or sturdy building mostly because they did not know the owners. Furthermore, a majority of the mobile home residents did not seek shelter after receiving the warning. Not surprisingly, Schmidlin et al. (2009) also found that factors such as knowledge of shelter location and perception of danger were positive indicators of shelter-seeking behavior.

4. Super Tuesday tornado disaster at Macon County, Tennessee

Macon County, located approximately 50 miles northeast of Nashville, is a rural area with a total population of approximately 21 838 (U.S. Census Bureau 2009). The largest city in the county is Lafayette, with a total population of approximately 4426. A recent estimate of housing characteristics in Tennessee indicated that Macon County was slightly below the state average for single-unit, detached houses (65.4% versus 68.6%) but substantially above the state average for mobile homes (26.5% versus 10.4%) (U.S. Census Bureau 2010). The county was well below the state average in per capita income (\$16, 796 versus \$24, 094).

On 5–6 February 2008, a weather system passing over the mid-South and Tennessee Valley regions of the United States produced 87 tornadoes across nine states (NWS 2009). This event is known as the Super Tuesday tornado outbreak, in reference to the Presidential primary elections held at the time. Fifty-seven tornado-related fatalities were reported after the event: Alabama (5), Arkansas (14), Kentucky (7), and Tennessee (31). Thirty-six of these

fatalities (63%) occurred in mobile homes. Note that these states ranked between 7 and 14 in the United States in percent of mobile homes: Alabama (14.7%), Arkansas (12.7%), Kentucky (12.2%), and Tennessee (10.2%).

The National Weather Service Forecast Office at Nashville identified 13 tornadoes in its region during the Super Tuesday tornado outbreak (NWS 2008, 2009) and issued 26 tornado warnings from 1930 Central Standard Time (CST) 5 February 2009 to 0159 CST 6 February 2009 (J. Orchanian, NWS Nashville, 2008, personal communication). Macon County was issued a tornado watch at 2020 CST, followed by a tornado warning at 2206 CST. The tornado that hit Macon County was later determined to be an EF3 on the enhanced Fujita scale. The tornado path across Macon County was estimated to be 19.3 miles long and 880 yards wide (NCDC 2008). Most of the 13 fatalities reported in Macon County occurred in the northern outskirts of the city of Lafayette (NCDC 2008; NWS 2009). There were no mobile home parks in the disaster zone.

Prior to entering Macon County, the tornado moved northeastward across Trousdale County where it destroyed a component of the local electric grid (Columbia Gulf Transmission Company pumping station near Hartsville), which cut off electric power in the area (Ellefson 2008; NCDC 2008). Many of the local residents were relying on local TV stations for storm reports, so the loss of electric power disrupted a primary source of information at a critical time. Macon County did not have an outdoor warning siren system, so that method of warning dissemination was not an option. Most of the local residents interviewed for this study indicated that they were aware of the tornado warnings for the area; however, some said they did not receive the warning for Macon County, which was issued at the same time as the warning for Trousdale County (2206 CST). Several people stated that they were aware of the warnings because they received the warning issued earlier for Sumner County at 2140 CST, which is adjacent to Macon County's western boundary.

5. Post-disaster survey methods and analysis

A post-disaster survey was conducted in the city of Lafayette, Tennessee, on 9–15 February 2008. The survey form consisted of approximately 30 structured (multiple-choice) questions on preparedness, awareness, response to warnings, and demographics (see Table 1 for a list of key questions). The interview process consisted of informing the survey participant of the purpose of the study and then sitting/standing with them while filling out the survey form. Each interview lasted approximately 5–10 min, and all

TABLE 1. Selected survey questions on preparedness, awareness, and response to tornado warnings.

Preparedness
1) Have you ever received any information or training on how to prepare for, or respond to, a tornado?
2) Have you ever participated in a tornado drill?
3) Which one of the following options describes the meaning of a tornado warning?
4) Do you own an Emergency Weather Radio?
5) What type of tornado-proof shelter do you have at your home?
6) Do you have an emergency response plan for seeking shelter from a tornado at your home?
Awareness of, and response to, tornado warning
7) Were you aware that the National Weather Service had issued a tornado warning for the area?
8) How did you become aware of the tornado warning (select all that apply)?
9) How much personal danger did you think you were in when you became aware of the tornado warning?
10) How did you respond to the tornado warning (select all that apply)?
11) Where did you go for shelter?
12) How long was it between when you received the tornado warning and when the tornado hit?
13) Did you follow the emergency response plan for seeking shelter at your home?

interviews were conducted in person by the primary author of this paper. Interviews were initially conducted in the field early in the week, but a snow storm hit the area, forcing a change in strategy. The Red Cross had set up a temporary aid station at a rented building by that time, so interviews were conducted at that facility during the remainder of the week. The facility was set up with an area for tornado victims to sit while waiting for assistance from the Red Cross staff, so tornado victims were approached in the waiting area and asked to participate in the survey. It should be noted that the Red Cross staff agreed to allow the interviews to be conducted in their waiting area. Although the intent was to interview every available tornado victim observed at the Red Cross station, five people declined to participate because of tornado-related fatalities/injuries in the family and several others were not approached about participating because they were visibly distressed. Fortunately, the Red Cross volunteer staff included mental health professionals to assist these people.

The total study group consisted of 127 local residents who were present during the tornado. Fifteen of those people were interviewed in the field, and the remaining 112 people were interviewed at the Red Cross station. Seventy-eight (61%) of the survey participants lived in a site-built permanent home (i.e., traditional brick or wood frame), 44 (35%) lived in a mobile home, and 5

TABLE 2. Demographic and housing characteristics of Macon County (total estimated population 21 838) and the 127 survey participants (Source: U.S. Census Bureau 2010).

	Macon County %	Survey participants % (n)
Female	50.2	48 (61)
White	97.8	98 (125)
Age 18 to 64	63.0	72 (92) ^a
High school graduate, equivalent, and higher	71.7	72 (91)
Single unit, detached houses	65.4	61 (78) ^b
Mobile homes	26.5	35 (44) ^c

^a Age 19–59.

^b Participants living in a brick or wood-frame house.

^c Participants living in a mobile home.

(4%) lived in an apartment or nontraditional home. A comparison of demographic and housing characteristics of Macon County residents and the survey participants is provided in Table 2.

Stage 1 of the analysis investigated preparedness characteristics. All survey participants were included in this stage ($n = 127$), with the primary focus on mobile home (MH) residents ($n = 44$) and permanent home (PH) residents ($n = 78$). Stage 2 investigated awareness of, and responses to, the tornado warning. This analysis was limited to survey participants who were at home during the tornado and were aware of the warning ($n = 115$), with the primary focus on MH ($n = 39$) and PH ($n = 71$) residents. An unconditional exact test (Berger 1996; applet available online at <http://www.stat.ncsu.edu/exact/>) was used in stages 1 and 2 because the sample was non-random. In stage 1, the test was used to determine whether differences in MH and PH resident responses to survey questions 1–6 (Table 1) were statistically significant. In stage 2, the test was used to evaluate responses to questions 7–10 and 13. Stage 3 investigated the shelter-seeking actions of MH residents who were at home and aware of the warning ($n = 39$), with a focus on evacuation rates. Significance testing was not conducted in stage 3 because the number of cases available for analysis was considered too small to produce meaningful results beyond basic percentages. Note that the responses for some survey questions (e.g., 5 and 9) were grouped together to simplify the analysis.

6. Preparedness for a tornado threat

A majority of MH residents were able to identify the definition of a tornado warning (80%; Table 3). However, only 50% indicated that they had previously

TABLE 3. Preparedness characteristics of mobile home (MH) residents ($n = 44$), permanent home (PH) residents ($n = 78$), and all survey participants ($n = 127$). Table values indicate percent and frequency of positive responses to survey questions 1–6 in Table 1.

Preparedness characteristics	MH % (n)	PH % (n)	All % (n)
Previous info/training	50 (22)	60 (47)	57 (72)
Tornado drill	45 (20)*	64 (50)	58 (74)
Tornado warning definition	80 (35)	90 (70)	87 (110)
Emergency weather radio	18 (8)	26 (20)	23 (29)
Tornado-resistant shelter	7 (3)*	32 (25)	24 (30)
Emergency response plan	39 (17)*	73 (57)	60 (76)

* Difference between MH and PH residents was found to be significant (0.05 level).

received some type of information or training on how to prepare for, or respond to, a tornado, and even less had participated in a tornado drill (45%), owned an emergency weather radio (18%), had a tornado-resistant shelter on the premises (7%), or had an emergency response plan for seeking shelter (39%). In contrast, most PH residents had previously received some type of information or training on how to prepare for, or respond to, a tornado (60%), had participated in a tornado drill (64%), were able to identify the definition of a tornado warning (90%), and had an emergency response plan for seeking shelter (73%). However, few owned an emergency weather radio (26%) or had a tornado-resistant shelter on the premises (32%).

These results indicate that MH residents were less prepared for a tornado than the PH residents in each category (Table 3). Furthermore, the difference between MH and PH residents was found to be statistically significant in three of the six categories: 1) having participated in a tornado drill, 2) having a tornado-resistant shelter on the premises, and 3) having an emergency response plan for seeking shelter. These three issues are of even greater concern when considering previous findings on tornado drills (Eidson et al. 1990), access to shelter (Liu et al. 1996; Balluz et al. 2000; Hammer and Schmidlin 2002; Comstock and Mallonee 2005; Schmidlin et al. 2009), and having a plan for seeking shelter (Balluz et al. 2000). Although the difference between MH and PH residents who were able to identify the definition of a tornado warning was minor, this issue is more serious when considering Liu et al.'s (1996) research that found that people who did not understand the definition of a tornado warning were less likely to seek shelter. Given these results, it is not surprising to discover that the majority of MH residents (61%) possessed two or less of the six preparedness traits evaluated in this study while the majority of PH residents had four or more (52%; Table 4).

TABLE 4. Distribution of mobile home (MH) residents ($n = 44$) and permanent home (PH) residents ($n = 78$) by frequency of preparedness characteristics (see Table 3 for list).

Frequency of preparedness characteristics per person	MH % (n)	PH % (n)
0	7 (3)	0 (0)
1	18 (8)	8 (6)
2	36 (16)	15 (12)
3	16 (7)	24 (19)
4	16 (7)	33 (26)
5	5 (2)	15 (12)
6	2 (1)	4 (3)

There are several additional points of interest about the study group as a whole that should be noted. The high percentage of all the survey participants that were able to identify the definition of a tornado warning was comparable with previous research by Balluz et al. (2000). The low usage of emergency weather radios for receiving tornado warnings was consistent with other studies (Balluz et al. 2000; Brown et al. 2002; Hammer and Schmidlin 2002; Comstock and Mallonee 2005). Furthermore, several people commented that they did not know where their weather radio was at the time (e.g., "I think the last place I saw it was in the camper . . ."). The low percentage of homes with a tornado-resistant shelter on the premises (24%) is unfortunate; however, this value is still higher than results found in Arkansas (12%) by Balluz et al. (2000) and in Oklahoma City (14%) by Brown et al. (2002). The most common type of tornado-resistant shelter people had at their home was a basement (21%), followed by underground storm shelter (2%) and interior safe room (1%). The most common source of information or training on tornado preparedness was public announcements on TV or radio (24%), followed by work (18%) and school (17%). The most common places for participating in a tornado drill were school (37%) and work (28%).

7. Awareness of, and response to, tornado warnings

Ninety-one percent of the 127 survey participants indicated that they were at home and aware of the warning when the tornado hit the area. This group included 89% (39 of 44) of the MH residents and 91% (71 of 78) of the PH residents. The analysis in this section is limited to these members of the study group. Awareness and response was similar in most areas for the MH and PH residents. The most common sources of information for receiving the warning were local TV stations and family/friends (Table 5). Multiple sources were listed by 38% of MH residents and 44% of PH residents. A slight majority

TABLE 5. Most common sources of tornado warning, and perception of danger upon receiving the warning, for mobile home (MH) residents ($n = 39$), permanent home (PH) residents ($n = 71$), and all survey participants ($n = 115$). Analysis restricted to survey participants who were at home and aware of the warning. Question wording listed in Table 1 (questions 8 and 9).

	MH % (n)	PH % (n)	All % (n)
Sources of tornado warning			
Local TV	77 (30)	89 (63)	85 (98)
Family or friends	44 (17)	38 (27)	41 (47)
Weather radio	3 (1)	10 (7)	8 (9)
Perceived personal danger			
Yes	51 (20)	58 (41)	56 (64)

of both MH and PH residents perceived that they were in personal danger when they received the warning (Table 5). The difference between MH and PH residents who were aware of the warning and the difference between MH and PH residents who perceived that they were in personal danger when they received the warning were not found to be statistically significant (0.05 level). Furthermore, the differences between MH and PH residents who received the warning from local TV stations and from family/friends were not significant (0.05 level).

The most common responses to the warning were to seek shelter and look outside (Table 6), and multiple responses (e.g., look outside and seek shelter) were listed by 59% of MH residents and 64% of PH residents. The difference in the rate at which MH and PH residents sought shelter was not significant (0.05 level). The most common places for seeking shelter were inside the house such as bathroom, closet, or hallway. The majority of both MH and PH residents received the warning 15 min or less before the tornado hit (Table 7), and most of these MH and PH residents were at a location that experienced some damage (85% versus 86%).

Although there was essentially no difference in the rate at which MH and PH residents sought shelter, there was an important difference in where they sought shelter from a safety (i.e., risk reduction) standpoint (Table 6). Seeking shelter inside the house was a safe option for PH residents, but seeking shelter inside the house was clearly not a safe option for MH residents. Since the MH and PH residents included in this analysis were at home at the time, “did not seek shelter” was a safe option for PH residents and an unsafe option for MH residents. Safe options for MH residents included evacuating to someone else’s house, basement, public shelter/local business, and vehicle. Note that the option “someone else’s house” was defined as meaning a traditional brick or wood-frame house, and not a mobile home, while conducting interviews with all survey participants. Furthermore, no

TABLE 6. Most common responses to tornado warning and shelter options for mobile home (MH) residents ($n = 39$), permanent home (PH) residents ($n = 71$), and all survey participants ($n = 115$). Analysis restricted to survey participants who were at home and aware of warning. Question wording listed in Table 1 (questions 10 and 11).

	MH % (n)	PH % (n)	All % (n)
Response actions			
Look outside	51 (20)	48 (34)	50 (57)
Call someone	18 (7)	18 (13)	18 (21)
Seek more information	13 (5)	18 (13)	17 (20)
Seek shelter	87 (34)	96 (68)	91 (105)
Shelter options			
Inside house	41 (16)	56 (40)	51 (59)
Basement	5 (2)	31 (22)	21 (24)
Someone else’s house	36 (14)	9 (6)	17 (20)
Public shelter/local business	8 (3)	1 (1)	3 (4)
Vehicle	3 (1)	0 (0)	1 (1)
Did not seek shelter	8 (3)	3 (2)	6 (7)

survey participant indicated that they took shelter at someone else’s mobile home. We also considered getting in a vehicle to drive to safety a safer choice than staying in the mobile home based on discussions of vehicle occupant risk in Hammer and Schmidlin (2002, p. 578) and Schmidlin et al. (2009, p. 199). Therefore, we determined that 49% of MH residents took shelter inside the house while 51% evacuated to a safer location. These results indicate that a mere 51% of MH residents took shelter in a safe location, as opposed to 100% for PH residents. Note that the shelter-seeking rate of MH residents who were aware of the warning was much higher in this study than the 31% observed by Schmidlin et al. (2009), but of those that actively sought shelter, the percentage that chose locations that did not reduce their risk of harm (16 of 36) was similar (44% and 33%, respectively).

As noted earlier, the PH residents were more likely to have a plan for seeking shelter than the MH residents (Table 3). We found that for the MH and PH residents who were at home and aware of the warning, 76% of

TABLE 7. Warning lead times reported by mobile home (MH) residents ($n = 39$), permanent home (PH) residents ($n = 71$), and all survey participants ($n = 115$). Analysis restricted to survey participants who were at home and aware of the warning. Question wording listed in Table 1 (12).

Warning lead time	MH % (n)	PH % (n)	All % (n)
0–5 min	36 (14)	30 (21)	30 (35)
5–15 min	33 (13)	38 (27)	36 (41)
15–30 min	15 (6)	27 (19)	23 (27)
Over 30 min	10 (4)	6 (4)	9 (10)
Not known	5 (2)	0 (0)	2 (2)

TABLE 8. Shelter options of mobile home residents based on preparedness characteristics and following the emergency response plan. Analysis restricted to the 39 MH residents who were at home and aware of the warning. Question wording listed in Table 1 (questions 1–3, 6, 11, and 13).

	Inside mobile home % (<i>n</i>)	Evacuate % (<i>n</i>)	Did not seek shelter % (<i>n</i>)
Previous info/training?			
Yes (<i>n</i> = 22)	45 (10)	50 (11)	5 (1)
No (<i>n</i> = 17)	35 (6)	53 (9)	12 (2)
Tornado drill?			
Yes (<i>n</i> = 19)	37 (7)	63 (12)	0 (0)
No (<i>n</i> = 20)	45 (9)	40 (8)	15 (3)
Tornado warning definition?			
Yes (<i>n</i> = 31)	42 (13)	55 (17)	3 (1)
No (<i>n</i> = 8)	38 (3)	38 (3)	25 (2)
Emergency response plan?			
Yes (<i>n</i> = 17)	29 (5)	59 (10)	12 (2)
No (<i>n</i> = 22)	50 (11)	45 (10)	5 (1)
Followed ER plan?			
Yes (<i>n</i> = 13)	23 (3)	77 (10)	0 (0)
No (<i>n</i> = 4)	50 (2)	0 (0)	50 (2)

MH residents with a plan followed the plan; whereas, 94% of PH residents with a plan followed the plan, and this difference was found to be significant (0.05 level). Furthermore, the finding that there was little difference between MH and PH residents in perception of danger upon receiving the warning is problematic, especially when considering Schmidlin et al.'s (2009) research showing that perception of danger is a positive indicator of shelter-seeking behavior.

There are several additional points of interest that should be noted. Most MH and PH residents were aware of the tornado warnings despite the disruption in warning communication. The high reliance on TV and minimal usage of weather radio as a source of warning was consistent with previous findings (Balluz et al. 2000; Brown et al. 2002; Hammer and Schmidlin 2002; Comstock and Mallonee 2005; Schmidlin et al. 2009). Informal means of warning communication via family and friends have also been identified as an important source in previous studies (Sorenson 2000; Hammer and Schmidlin 2002). The multiple sources of warnings identified by the MH and PH residents, combined with the range of activities that they undertook after receiving the warnings (e.g., look outside, call someone, seek more information, and seek shelter) were characteristic of warning response models that describe how people evaluate a warning and consider their options for how to respond (Lindell and Perry 1992; Milette and Sorenson 1990; Sorenson 2000). The survey participants were not asked to identify the order in which these activities took place, so it is possible that some sought shelter before looking outside or calling someone. However, survey participants typically stated in the interview that they looked outside and/or called someone before they sought shelter.

8. Mobile home resident evacuation factors

The analysis in this section is limited to MH residents who were both at home and aware of the warning when the tornado hit. Previous information or training evidently had little influence on the rate at which MH residents sought shelter or, more importantly, on the rate at which they evacuated to a safer location (50% versus 53%; Table 8). These results suggest that information and training programs are not meeting their potential among MH residents. Balluz et al.'s (2000) finding that many people did not correctly use information provided on TV is an example of the barriers to successful mitigation in this area. The MH residents who had participated in a tornado drill sought shelter at a higher rate than those who had not; furthermore, their evacuation rate was substantially higher (63% versus 40%). These results suggest that tornado drills promote shelter-seeking behavior among MH residents that is more likely to reduce risk. The MH residents who understood the definition of a tornado warning sought shelter at a higher rate than those who did not, and they evacuated to a safer location at a higher rate (55% versus 38%). In addition to supporting Liu et al.'s (1996) findings on seeking shelter, these results suggest that this knowledge contributes to more effective shelter-seeking behavior among MH residents.

Although MH residents with a plan for seeking shelter actually sought shelter at a slightly lower rate than those without a plan (88% versus 95%; Table 8), those with a plan evacuated to a safer location at a higher rate (59% versus 45%). The evacuation rate for those who followed the plan was 77% whereas the evacuation rate for those who did not follow the plan was 0%. If the MH

TABLE 9. Shelter options of mobile home residents based on perception of danger and warning lead time. Analysis restricted to the 39 MH residents who were at home and aware of the warning. Question wording listed in Table 1 (questions 9, 11, and 12).

	Inside mobile home % (<i>n</i>)	Evacuate % (<i>n</i>)	Did not seek shelter % (<i>n</i>)
Perceived danger?			
Yes (<i>n</i> = 20)	35 (7)	60 (12)	5 (1)
No (<i>n</i> = 19)	47 (9)	42 (8)	11 (2)
Warning lead time			
0–5 min. (<i>n</i> = 14)	50 (7)	43 (6)	7 (1)
5–15 min. (<i>n</i> = 13)	38 (5)	54 (7)	8 (1)
15–30 min. (<i>n</i> = 6)	33 (2)	67 (4)	0 (0)
Over 30 min. (<i>n</i> = 4)	25 (1)	75 (3)	0 (0)
Don't know (<i>n</i> = 2)	50 (1)	0 (0)	50 (1)

residents who did not follow the plan intended to stay inside the mobile home, then only 58% (10 of 17) of the plans reduced risk by evacuating to a safer location. If they intended to evacuate to a safer location, however, then 82% of the plans reduced risk. These results appear to provide only minimal support for Balluz et al.'s (2000) finding that having a plan of action has a positive relationship with responding to warnings. However, the MH residents with a plan evacuated at a higher rate, which suggests that having a plan for seeking shelter reduces risk among MH residents. This pattern also indicates that it is important to have an effective evacuation plan (as opposed to seeking shelter somewhere inside the mobile home) and that the plan be implemented correctly. These results, along with Schmidlin et al.'s (2009) finding on poor planning efforts among MH residents, indicate that this is an aspect of preparedness where there is potential to reduce risk among MH residents through educational programs.

Ninety-five percent of the MH residents who perceived personal danger upon receiving the warning sought shelter (Table 9), which appears to support Schmidlin et al.'s (2009) finding that perception of danger is a positive indicator of shelter-seeking behavior. However, 89% of the MH residents who did not believe they were in danger when they received the warning also sought shelter. More importantly, those who believed they were in danger evacuated to a safer location at a much higher rate (60% versus 42%). In this case, perception of danger led to more effective shelter-seeking behavior.

The percent of MH residents who evacuated to a safer location increased as warning lead time increased (Table 9). This finding appears to conflict with previous research that found the effectiveness of warnings with respect to reducing fatalities declines after 15 min (Simmons and Sutter 2008b). The data indicate that 26% of these

MH residents had 15 min or more warning time, and that this group had an evacuation rate of 70%. Note that some inaccuracy of time estimates reported by the survey participants is to be expected. Furthermore, the questionnaire survey did not address the issue of whether or not the survey participants were aware of how much warning lead time they had before the tornado hit. Although the statistical significance of this relationship was not tested because of the low number of observations, this pattern provides support for National Weather Service efforts to increase warning lead time and should be investigated further.

9. Summary and conclusions

The purpose of this study was to identify aspects of tornado preparedness and response to warnings where MH residents might be more vulnerable than PH residents. The results clearly indicate that the MH residents were less prepared for a tornado than the PH residents, but there was little difference between them in terms of being aware of the tornado warning, sources for receiving the warning, perception of danger upon receiving the warning, and the rate at which they sought shelter. There was, however, a distinct difference in where they sought shelter from a risk-reduction perspective. Many MH residents sought shelter inside the mobile home, rather than evacuate, which resulted in MH residents being much less likely to seek shelter in a safe location (51% versus 100%).

The MH residents were less prepared for a tornado than the PH residents in all six categories evaluated in this study, and the difference was statistically significant (0.05 level) in three categories: 1) having participated in a tornado drill, 2) having a tornado-resistant shelter on the premises, and 3) having an emergency response plan for seeking shelter. Furthermore, the MH residents were less likely to follow the plan than the PH residents, and the difference was significant (0.05 level).

Three preparedness factors were associated with higher evacuation rates among MH residents: 1) having participated in a tornado drill, 2) understanding the definition of a tornado warning, and 3) having an emergency response plan for seeking shelter. We also found that perception of danger and longer warning lead times increased evacuation rates among MH residents. The statistical significance of the influence of these factors on evacuation rates was not tested because of the low number of mobile home residents included in this study. Nevertheless, the patterns were evident and should be investigated in future research.

The need for public health education programs designed to help people develop an emergency response plan for

seeking shelter from a tornado has been discussed in previous studies (Lillibridge 1997; Balluz et al. 2000; Brown et al. 2002). The differences between MH and PH residents identified in this study support these efforts, especially efforts that promote more effective shelter-seeking behavior. For example, more appropriate planning might help to reduce responses like the one documented in this study where three mobile home residents indicated that they followed their plan for seeking shelter, but they still sought shelter inside the mobile home (Table 8). It is not clear that they understood that this was an inappropriate response. The implication of our finding that there was essentially no difference between MH and PH residents in perception of danger is another point of concern that should be addressed in these programs.

For future research, we recommend additional studies on differences between mobile home and permanent residents to further document issues addressed in this study. Furthermore, we recommend additional studies focusing specifically on mobile home resident access to shelter (on premises and at nearby locations), response plans for seeking shelter in locations that reduce risk, and preparedness or other factors that promote evacuation so that these issues can be addressed in educational or public policy programs.

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