Household Preparedness for Tornado Hazards: The 2011 Disaster in DeKalb County, Alabama

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ABSTRACT

This paper contributes to existing knowledge on factors that influence adoption of hazards adjustments for tornadoes. The Protective Action Decision Model provides the theoretical basis for the study, which was conducted after the 2011 disaster in DeKalb County, Alabama. Most of the 124 survey participants had received public safety information on how to prepare for a tornado, understood the definition of a tornado warning, had participated in a tornado drill, and had a plan for seeking shelter. Few owned a NOAA weather radio or had a tornado-resistant shelter on the premises. Demographic analysis found that older residents (60+ yr) and households without children were significantly less likely to have participated in a tornado drill, lower income residents were significantly less likely to have a tornado-resistant shelter on the premises or a plan for seeking shelter, and mobile home residents were significantly less likely to have a plan for seeking shelter. Locus of control and past experience were not significantly associated with adoption of hazards adjustments, but suspected reasons for these results are discussed. Many plans that involved evacuating to another location included excessively long travel distances, and several mobile home residents planned to seek shelter inside their residence. Failure to adopt effective preparedness actions in each of these areas could serve as a situational impediment to making an appropriate protective action decision when a tornado threatens the household. The results identify aspects of household preparedness where there is opportunity for improvement, which would reduce vulnerability and enhance community resilience.

1. Introduction

The vulnerability and resilience of communities are of great interest in contemporary hazards research, with the meaning and scope of these terms receiving much attention (Cutter 1996; Cutter et al. 2008; Adger 2000; Klein et al. 2003; Manyena 2006). In general, vulnerability is the characteristics of a community that increase its potential for harm and resilience is the ability of a community to respond, recover, and adapt for future threats. When evaluating the vulnerability of a community to the threat of a tornado, household preparedness is an important issue because lead time for responding to warnings is extremely limited (Simmons and Sutter 2008; Brotzge and Erickson 2009; Hoekstra et al. 2011). Documenting strengths and weaknesses in household preparedness would help a community decide where to devote resources that would reduce vulnerability and enhance resilience.

Household preparedness for a tornado includes actions such as purchasing a National Oceanic and Atmospheric Administration (NOAA) weather radio for receiving

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warnings and developing a plan for where to seek shelter. These types of risk-reducing actions are also known as hazards adjustments (Burton et al. 1978). In addition to conducting an inventory of hazard adjustments when assessing vulnerability, it is also important to understand what factors motivate people to adopt these adjustments. Mileti and Sorenson (1987) identified four steps in the process of adopting precautions against natural hazards: 1) assess the probability of a hazard event; 2) review the behaviors (i.e., options) available to mitigate risk; 3) evaluate the impacts of these behaviors in terms of their risk abatement potential and consequences for other aspects of life; and 4) decide which option, if any, to adopt. Many factors have been found to have a positive influence on adoption of hazard adjustments, with some of the more prominent factors being perception of the risk, perception of the hazard adjustment options, past experience, and demographic characteristics (Mileti and Sorenson 1987; Lindell and Perry 2000; Tierney et al. 2001; see also Lindell and Whitney 2000; Lindell and Hwang 2008; Lindell and Perry 2012).

Risk perception generally encompasses people's perceptions of the probability and consequences of a hazard, which includes expectations of personal impacts such as death, injury, and property damage (Lindell and Whitney 2000). A person's perception of the risk would appear to be the best indicator of their level of preparedness. However, adoption of hazard adjustments has been found to be more closely associated with perceived characteristics of the hazard adjustments (e.g., effectiveness of the adjustment, cost, skill and knowledge requirements, effort, and time commitment) than with perceived characteristics of the hazard itself (Lindell and Perry 1992; see also Lindell and Whitney 2000).

Some characteristics of the hazard adjustment have been identified as characteristics of the person (Lindell and Whitney 2000). This issue was addressed in person-relative-to-event (PrE) theory by Mulilis and Duval (1995) and Duval and Mulilis (1999). The PrE theory is a model of coping that suggests that preparedness is a function of a person's perception of their personal resources relative to the hazard threat, with personal resources including self-efficacy (e.g., personal assessment of their knowledge, skills, financial resources) and response efficacy (assessment of the effectiveness of preparedness actions). Mulilis and Duval (1995) found that preparedness for earthquakes was associated with assessment of personal resources, but only when a high sense of personal responsibility (as opposed to perceiving preparedness as government's responsibility) was present. When sense of personal responsibility was low, level of assessment of personal resources had no influence on preparedness. The utility of the PrE model in explaining household preparedness was later extended to tornado hazards with similar findings (Mulilis and Duval 1997; Mulilis et al. 2000, 2001, 2003).

A concept related to PrE theory is locus of control (LOC), which refers to generalized beliefs about the causes of people's outcomes in life (Tobin and Montz 1997; Spittal et al. 2008). People who believe that such outcomes are dependent on their own effort or intelligence are described as having an internal LOC while those who believe outcomes are mostly dependent on external and environmental circumstances, including fate, are described as having an external LOC (Spittal et al. 2002). Sims and Bauman (1972) found that people with an internal LOC were better prepared for a tornado. However, their conclusions about regional differences in LOC, with people from the southern United States having a more fatalistic outlook on life than people from the northern United States, were challenged in subsequent studies (Biddle 1994; Cohen and Nisbett 1998).

It should be noted at this point that studies on earthquake hazards have determined that, in addition to insurance, there are two types of household preparedness: mitigation (actions that provide protection at impact) and survival (actions that enhance survival after impact such as food and water) (Lindell and Perry 2000; Spittal et al. 2008). Furthermore, Spittal et al. (2008) found that adoption of these two types were associated with different perceptual factors, with LOC predicting mitigation actions but not survival and with risk precaution (i.e., risk avoidance) predicting survival actions but not mitigation. This distinction is important because preparedness studies often use multi-item indexes that include both survival and mitigation (see Lindell and Perry 2000; Mulilis et al. 1990; Mulilis and Duval 1995, 1997). Mitigation actions are clearly the more important of the two types of household preparedness for tornado hazards; therefore, Spittal et al.'s (2008) findings suggest that studies focusing on mitigation actions should consider LOC.

Past experience with a hazard is generally associated with higher levels of preparedness because it enhances awareness of the consequences of disasters (Tierney et al. 2001). For earthquake hazards, enhanced preparedness has been linked to number of past events (Russell et al. 1995), amount of damages (Jackson 1981), and intensity of experience (Dooley et al. 1992). People with past experience have also been found to be more likely to develop a plan for responding to the disaster (Lindell and Perry 1992; Tierney et al. 2001). Although little research exists on past experience with tornado hazards, Blanchard-Boehm and Cook (2004) found that it was associated with enhanced preparedness.

Demographic characteristics such as gender, age, education, income, marital status, and children in the household

are commonly included in studies of household preparedness and vulnerability (Morrow 1999; Lindell and Perry 2000; Tierney et al. 2001; Cutter et al. 2003; Phillips and Morrow 2007). This topic has received considerable attention in earthquake studies (Lindell and Perry 2000). For example, Dooley et al. (1992) found that marital status, children in the household, and age were associated with enhanced earthquake preparedness. Relatively little information, however, is available on demographics and tornado preparedness (Lindell et al. 2012). One demographic factor that has received considerable attention is mobile homes (Golden and Adams 2000). Ashley (2007) determined that mobile homes were a major factor in the high tornado-related fatality rate in the southern United States, and Schmidlin et al. (2009) and Chaney and Weaver (2010) found that mobile home residents were inadequately prepared for a tornado.

A more recent approach to integrating the many factors that contribute to household preparedness is the Protective Action Decision Model (PADM) by Lindell and Perry (1992, 2000, 2012). Although initially developed to understand how people respond to evacuation warnings, they suggest it could also be used for long-term hazard adjustment. Lindell and Perry (2012) describe the process as beginning with the flow of information from various sources (e.g., environmental cues, social information) to the person at risk, which initiate a series of predecision processes (e.g., reception, attention, comprehension, interpretation) that elicit core perceptions of the threat, alternative protective actions (i.e., hazard adjustment options), and relevant stakeholders (e.g., personal versus government responsibility in preparedness). These core perceptions are noted to form the basis for protective action decision making: the outcome of which combines with situational facilitators and impediments to produce the behavioral response (e.g., information search, protective response, or emotion focused coping).

In relating PADM to household preparedness for a tornado hazard, a household's awareness of the hazard, as well as its core perceptions of the risk, adjustment options, and stakeholders, could be influenced by information received from friends, family, neighbors, and government agencies. Furthermore, a household's core perceptions could also be influenced by factors such as past experience, demographic characteristics, and perception of control. Finally, a household's decision to adopt adjustments would serve as situational facilitators in reducing risk of death or injury while its failure to adopt would serve as situational impediments.

This paper reports the findings of a study on factors associated with household adoption of hazard adjustments for a tornado. The first objective was to conduct an inventory of household preparedness. The second objective was to examine three hypotheses about factors associated with household preparedness: 1) demographic characteristics are significantly associated with adoption of hazard adjustments; 2) locus of control perception is significantly associated with adoption of hazard adjustments; and 3) past experience with a tornado is significantly associated with adoption of hazard adjustments. The third objective was to examine the details of household plans for seeking shelter when a tornado threatened the home. The findings of this study also contribute to developing a baseline for understanding the state of household preparedness within a community, to understanding potential movements of people when a tornado warning is issued, and to identifying potential weaknesses in plans for seeking shelter. The study was conducted in DeKalb County, Alabama, following the multistate tornado disaster of April 2011. Official records indicate DeKalb County suffered 23 direct deaths (NCDC 2011, 2012), which was among the highest fatality counts in Alabama.

2. Household preparedness for tornado hazards

There are two basic types of household preparedness as discussed in the previous section: mitigation (protection at impact) and survival (health and safety supplies after impact) (Lindell and Perry 2000; Spittal et al. 2008). For tornado hazards, mitigation actions are clearly the more important of the two types. Existing data on mitigation actions for tornadoes are typically derived from field studies, which mostly focus on how people respond to warnings. A review of the literature by Lindell et al. (2012) highlights many warning communication issues (e.g., warning channels/sources, warning channel preferences, and warning message characteristics) that are relevant to the opening stage of the PADM process and also provide insight into how information flows to a household that could influence its decisions about adopting long-term hazard adjustments. Another review of the literature that focused on mitigation actions was published recently in this journal (Chaney and Weaver 2010). The findings of that review indicate that household preparedness actions investigated in post-disaster field studies typically include 1) knowledge about tornado hazards and safety; 2) channels or devices used to receive warnings and warning broadcasts (e.g., TV, radio, Internet, telephone/mobile phone); 3) access to safe shelter; and 4) planning for where to seek shelter.

Previous studies have found that most people understand the definition of a tornado warning (Balluz et al. 2000; Chaney and Weaver 2010), but little is known about the extent of public safety knowledge on tornadoes and participation in tornado drills. Eidson et al.

(1990) found that more informed people were more likely to have participated in a tornado drill, and Liu et al. (1996) found that failing to understand a tornado warning was linked with failing to seek shelter.

Television is typically the most common source for receiving warnings (Balluz et al. 2000; Brown et al. 2002; Hammer and Schmidlin 2002; Schmidlin et al. 2009), but TV broadcasts of warnings are unavailable when electric power is disrupted by storm activity (Chaney and Weaver 2010). The most reliable source is a NOAA weather radio (battery operated); however, their usage (typically 10% or less) is not widespread (Balluz et al. 2000; Brown et al. 2002; Hammer and Schmidlin 2002; Comstock and Mallonee 2005; Chaney and Weaver 2010). Schmidlin et al. (2009) found no relationship between having a weather radio and shelter seeking. Nevertheless, the reliability of these devices suggests that they should still be considered an essential item. Furthermore, newer versions of these devices are designed with a critical safety feature in their capability to automatically deliver tornado warnings, as opposed to other communication channels that require individuals to purposefully seek out risk information. This safety feature is especially important when considering that nocturnal tornadoes accounted for 39% of tornado fatalities and 42% of killer tornadoes from 1950 to 2005 (Ashley et al. 2008).

Access to safe shelter includes public shelters and sturdy houses, preferably ones with a tornado-resistant shelter on the premises such as a basement, an underground storm shelter, or a safe room. Studies have shown that tornado warnings are 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). Furthermore, recent studies suggest that few residences (25% or less) include a tornado-resistant shelter on the premises (Balluz et al. 2000; Brown et al. 2002; Chaney and Weaver 2010). Sturdy housing includes permanent homes (i.e., brick and wood-frame houses), which provide greater protection than mobile homes. For example, the average annual fatality rate in mobile homes was found to be approximately 20 times higher than in permanent homes by Brooks and Doswell (2002). Furthermore, National Weather Service tornado safety publications urge mobile home residents to go to the nearest sturdy building or storm shelter (NOAA 2009). This point reinforces the importance of access to shelter and planning.

Planning includes developing a plan for seeking shelter upon receiving a tornado warning and practicing the plan in a tornado drill. These factors have been shown to have a positive influence on shelter-seeking behavior (Balluz et al. 2000; Chaney and Weaver 2010). People who do not live in a sturdy house (e.g., mobile home residents) or do not have a tornado-resistant shelter on the premises should investigate local public shelter options or at least investigate nearby sturdy houses or buildings where one could go for shelter. Unfortunately, some people are unaware of nearby shelter options or do not take advantage of them. Schmidlin et al. (2009) found that many mobile home residents had not investigated nearby potential shelter sites, and many of them 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. Not surprisingly, knowledge of shelter location was found to be a positive indicator of shelter-seeking behavior.

3. The 27 April 2011 tornado disaster in DeKalb County, Alabama

The tornado outbreak of 27–28 April 2011 produced 175 tornadoes during a single convective day, which begins and ends at 1200 UTC (0700 CDT) and is currently ranked as the largest outbreak in U.S. history (Storm Prediction Center 2012a). This event was responsible for 317 direct deaths in five states: Alabama (235), Mississippi (31), Tennessee (32), Georgia (15), and Virginia (4) (Storm Prediction Center 2012b). On 27 April, an enhanced Fujita (EF) scale EF-5-rated tornado hit DeKalb County, Alabama, which is located in the northeastern corner of the state. The county is mostly rural with a total population of 71 109 (U.S. Census Bureau 2012). The tornado touched down near Lakeview, Alabama, at 1719 CST and lifted off the ground just past the state line near Rising Fawn, Georgia, at 1756 CST. The pathlength was 54.17 km (33.66 miles) and the path width was 1.21 km (1320 yards) (NCDC 2011, 2012; National Weather Service, Huntsville 2012). The path ran along State Highway 75 and affected many communities in the county including Fyffe, Rainsville, Sylvania, and Cartersville.

4. Postdisaster survey methods and analysis

A postdisaster survey was conducted in DeKalb County on 6–11 May 2011. The primary site for conducting the survey was a community center building (Tom Bevill Enrichment Center) in the city of Rainsville, which the Federal Emergency Management Agency (FEMA) had selected for establishing a disaster aid center. Rainsville provided a good central location relative to the tornado damage path, and it was the most heavily damaged community in the county. The city of Rainsville is located near the center of the county and has a total population of 4948 (U.S. Census Bureau 2012). The FEMA personnel at the disaster center granted permission to survey individuals on the site and were most helpful in various other ways.

The community center had a large covered area at the main entrance that provided a good location for surveying local residents after they completed their enquiries about disaster aid. When a local resident exited the building, a member of the survey team (primary author and two coauthors) would inform the person of the purpose of the survey and then ask if they were willing to participate. The survey form consisted of structured (multiple choice) questions on preparedness, response to warning, past experience, LOC perception, and demographics. Each individual survey lasted approximately 10 min. Although the intent was to survey every potential participant observed at the disaster center, several people declined to participate because of tornado-related fatalities/injuries in the family, some were not approached because they were visibly distressed, some declined because they were in a hurry to attend to other business, and some exited too quickly to be asked to participate. A total of 109 local residents were surveyed at the FEMA disaster center and an additional 15 local residents were surveyed in the field while inspecting the damage along the storm track. Therefore, the total number of survey respondents included 124 local residents who were present during the tornado.

The following household preparedness actions were included in the survey: 1) having previously received some type of public safety information on tornado safety; 2) understanding the definition of a tornado warning; 3) having participated in a tornado drill; 4) owning a NOAA weather radio; 5) having a tornado-resistant shelter on the premises, and 6) having a plan for seeking shelter. Having received information was measured as 1 = no, 2 = yes, and 3 = don't know. Respondents were given multiple options to choose from in the question about understanding the definition of a tornado warning, with the responses coded as 1 = correct, 2 = incorrect, and 3 = don't know. Tornado drill and NOAA weather radio were measured as 0 = no and 1 = yes. Having a tornado-resistant shelter on the premises was measured as 1 = no, 2 = basement, 3 = underground storm shelter, and 4 = safe room. Plan for seeking shelter was measured as 0 = no and 1 = yes. Specific wording of the survey questions and the responses are presented in Table 1.

The following demographic variables were included in the survey: gender, age, race, marital status, children in the household, house type, education, and average annual household income. Gender was measured as 1 = male and 2 = female. Age was measured as 1 = 20–39 yr, 2 = 40–59 yr, and 3 = 60 yr and above. Race was measured as 1 = white and 0 = nonwhite. Marital status was measured as 1 = married and 0 = not married. Children in household was measured as 1 = yes and 0 = no. House type was measured as 1 = permanent home, 2 = mobile home, and 3 = apartment/other. Education was measured as 1 = less than high school graduate/GED and 2 = high school graduate or greater. Income was measured as 1 = less than $40,000 and 2 = $40,000 and above. A demographic profile of the survey respondents is provided in Table 2.

TABLE 1. Preparedness profile of the survey respondents (n = 124).

Survey questions and responses	%
Have you ever received any public safety information on how to prepare for a tornado?	
No	18
Yes	81
Don't know	1
What does a tornado warning mean?	
Correct response	72
Incorrect response	24
Don't know	4
Have you ever participated in a tornado drill?	
No	43
Yes	57
Do you own a NOAA weather radio?	
No	67
Yes	33
Do you have a basement, underground storm shelter, or safe room at your house?	
No	85
Basement	8
Underground storm shelter	5
Safe room	2
Do you have a plan for seeking shelter when a tornado threatens your house?	
No	26
Yes	74

In designing a locus of control question, there was concern that even people with a strong internal locus of control might perceive that no amount of effort on their part would protect them against an EF-5-rated tornado. Therefore, an attempt was made to construct the question in a way that would avoid this conflict. The question was presented in a 5-point, Likert-scale format where survey participants were asked if they agreed or disagreed with the following statement: "Except in extreme circumstances, my safety is under my control when a tornado threatens." Responses were measured as 1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, and 5 = strongly agree. Finally, past experience with a tornado was measured as 0 = no and 1 = yes.

Chi-square tests were used to evaluate associations between demographic characteristics (except race) and household preparedness actions (i.e., hazards adjustments). Logistic regression was used to assess the impact of demographic variables on having a plan for seeking shelter, which was viewed as the most critical component of household preparedness. The dependent variable of

TABLE 2. Demographic profile of the survey respondents ($n = 124$) and the total population of DeKalb County, Alabama (71 109), based on the 2010 census.

Demographics	Respondents (%)	DeKalb County (%)
Gender		
Male	48	49
Female	52	51
Age		
20–39 yr	23	35[a]
40–59 yr	44	37
60 yr and above	33	28
Race		
White	90	84
Nonwhite	10	16
Marital status		
Married	61	77
Not married	39	23
Children in household[b]		
No	63	69
Yes	37	31
House type		
Permanent home[c]	66	69[d]
Mobile home	32	24
Apartment/other	2	7
Education		
Less than high school graduate/GED	22	32
High school or greater	78	68
Annual household income[e]		
Less than $40,000	60	50
$40,000 and above	40	50

[a] Percentages based on population aged 20 yr and above for comparison.
[b] Children legally defined as 18 yr and below in Alabama.
[c] Traditional brick and wood-frame houses.
[d] Single unit, detached housing.
[e] 24 survey participants selected ''no response.''

interest is the indicator for whether the respondent has a plan for seeking shelter (coded as 1 = yes and 0 = no). Given the enhanced vulnerability of mobile home residents discussed earlier, the primary independent variable consists of whether the respondent's house type was a mobile home (coded as 1 = yes and 0 = no). Control variables included in the model were gender, age, marital status, children in household, education, and income. Chi-square tests were also used to evaluate the association between LOC and household preparedness actions and the association between past experience and household preparedness actions.

The investigation of the details of the plans for seeking shelter when a tornado threatened the home focused on three points: 1) whether the household members planned to shelter at home or evacuate to another location; 2) specifically where they planned to seek shelter (e.g., inside the house, basement, or underground shelter); and 3) for the households that planned to evacuate, the travel distance to the location where they intended to seek shelter.

5. Household preparedness inventory

Most survey participants indicated that they had previously received some type of public safety information on how to prepare for a tornado, were able to identify the correct definition of a tornado warning, had participated in a tornado drill, and had a plan for seeking shelter when a tornado threatens their home (Table 1). Note that the participants were asked to select the correct definition of a tornado warning from a list of options, rather than simply state whether they knew the definition. However, only one-third of the participants owned a NOAA weather radio, and very few had some type of tornado-resistant shelter on the premises (i.e., basement, underground storm shelter, or safe room). These results are consistent with previous studies that found a majority of people understand the definition of a tornado warning (Balluz et al. 2000; Chaney and Weaver 2010), but few own a NOAA weather radio (Balluz et al. 2000; Brown et al. 2002; Hammer and Schmidlin 2002; Comstock and Malonee 2005) or have some type of tornado-resistant shelter on the premises (Balluz et al. 2000; Brown et al. 2002).

A summary count of preparedness characteristics per person showed 0 traits for 1 respondent, 1 trait for 7 respondents, 2 traits for 19 respondents, 3 traits for 25 respondents, 4 traits for 32 respondents, 5 traits for 14 respondents, and all 6 traits for only 2 respondents. While this summary count provides some insight into household preparedness in the community, future studies should investigate developing a system for assigning weights to each action (most critical to least critical) to provide a more complex evaluation.

The results for DeKalb County differ slightly from the findings of a recent study in Macon County, Tennessee (Chaney and Weaver 2010). It would be of great interest to know if the variations were significant. However, the wording of survey questions used in each study was slightly different, so any conclusions drawn from statistical analysis of these data would be open to question. Future studies should investigate developing a standardized set of survey questions for making a consistent measure of household preparedness that would indicate the strengths and weaknesses of a community relative to others.

6. Demographic factors

The chi-square test results indicated that several demographic factors (age, children in household, house type, and income) were significantly associated with

TABLE 3. Household preparedness and demographics (see Table 1 for preparedness questions).

	Public safety information (%)	Tornado warning (%)	Drill (%)	Radio (%)	Shelter (%)	Plan (%)
Gender						
Male	87	72	52	37	15	73
Female	75	72	63	30	16	75
Age						
20–39 yr	64	64	64	27	7	71
40–59 yr	85	78	71	38	16	80
60 yr and above	85	68	34*	34	20	68
Marital status						
Married	83	74	59	38	16	79
Not married	77	69	54	25	15	67
Children in household						
No	83	73	50**	32	18	74
Yes	76	70	70	35	11	74
House type						
Permanent home	82	71	56	33	20	85
Mobile home	80	74	64	36	8	51*
Education						
Less than high school	78	81	48	26	7	63
High school or greater	81	69	60	35	18	77
Annual household income						
Less than $40,000	78	67	55	28	10**	63***
$40,000 and above	88	78	68	38	25	90

* $p < 0.001$.
** $p < 0.05$.
*** $p < 0.01$.

adoption of household preparedness actions (Table 3). More specifically, survey participants aged 60 and above were significantly less likely to have participated in a tornado drill than those aged 20–39 and 40–59 ($p < 0.001$). Possible explanations for this pattern include younger age groups being exposed to more tornado drills at school or work or members of the older age group having fewer opportunities to participate or having forgotten about participating in a drill years earlier. Little information is available about participation in tornado drills; however, as noted earlier, being more informed about tornado hazards has been linked with participation in a tornado drill (Eidson et al. 1990). Given that the tornado-related fatality rate among people aged 60 yr and above was significantly higher than all other age groups during the period 1985–2000 (Ashley 2007), any precaution that might reduce this pattern is worthy of further investigation.

Households without children were significantly less likely to have participated in a tornado drill than those with children ($p < 0.05$). Given that there was no difference between households with children and without children in having a plan for seeking shelter, this pattern suggests households with children took the precaution to practice the plan. Previous studies have found that households with children were better prepared than those without children (Turner et al. 1986; Edwards 1993; Dooley et al. 1992). A possible explanation for this contrast can be found in earthquakes studies where concern and responsibility for others (e.g., children, family members) was associated with enhanced preparedness, whereas people without those concerns or responsibilities were less inclined to take precautions (Dooley et al. 1992; Russell et al. 1995; McIvor and Paton 2007; Becker et al. 2012). Greater concern or responsibility for others was also thought to be associated with stronger community ties or bonds, which leads to interactions with others that heighten awareness about the risk and preparedness options (see Turner et al. 1986; Becker et al. 2012). An additional factor to consider is that many of the households without children might belong to the older age group (60 yr and above) while the households with children most likely belong to the younger age groups, as discussed above.

Households with an average annual income of less than $40,000 were significantly less likely to have some type of tornado-resistant shelter (i.e., basement, underground storm shelter, or safe room) on the premises than those with an income of $40,000 or higher ($p < 0.05$). Furthermore, households with an average annual income of less than $40,000 were significantly less likely to have a plan for seeking shelter than those with an

TABLE 4. Household preparedness and locus of control as determined by following question: ''Except in extreme circumstances, my safety is under my control when a tornado threatens?'' Responses: strongly disagree ($n = 8$), disagree ($n = 20$), neither agree/disagree ($n = 15$), agree ($n = 48$), and strongly agree ($n = 33$).

	Public safety information (%)	Tornado warning (%)	Drill (%)	Radio (%)	Shelter (%)	Plan (%)
Strongly disagree	63	75	63	0	0	88
Disagree	90	80	50	30	10	65
Neither agree/disagree	80	53	53	47	27	87
Agree	81	71	56	27	21	73
Strongly agree	79	76	64	39	9	73

income of $40,000 or higher ($p < 0.01$). Clearly those with a higher income are more likely to be able to afford a house with a basement or to pay for the installation of an underground shelter or safe room. Although it costs nothing to develop a plan for seeking shelter, income might still play a role in that people who live in a house without a shelter on the premises might be less aware of the need to develop a plan. Another factor to consider is that many of the people in the lower income category might also have a lower level of education and thus might be less aware of the need to develop a plan for seeking shelter. Higher levels of income and education have long been associated with enhanced preparedness (e.g., Turner et al. 1986; Edwards 1993; Russell et al. 1995).

Mobile home residents were significantly less likely to have a plan for seeking shelter than permanent home residents ($p < 0.001$). This pattern has been documented previously (Chaney and Weaver 2010). A possible explanation is that mobile home residents are perceived to have a lower education and income than permanent home residents. However, the popularity of mobile homes among the retirement community complicates the issue. More specifically, many retirees with higher levels of education and income simply choose to live in a mobile home for the amenities offered by some mobile home parks or for reasons of convenience such as the opportunity to downsize to a smaller, less expensive dwelling that will allow more time and income for leisure activities (Hart et al. 2002). Morrow (1999) noted that demographic categories were not mutually exclusive and that combinations of factors complicated the matter. Another possible explanation for this pattern is that many mobile home residents rent rather than own their place of residence. Homeownership (and length of residence) has been found to be associated with enhanced preparedness and is thought to enhance community bonds (Russell et al. 1995; Tierney et al. 2001; Spittal et al. 2008). The authors intend to investigate these issues for mobile home residents in a future manuscript.

Logistic regression results (not shown) reveal that living in a mobile home was the only variable significantly related (negatively) to having a plan for seeking shelter when a tornado threatened the home ($\alpha < 0.001$). This finding provides additional support for the perception that mobile home residents are highly vulnerable to tornado hazards, and failure to develop a plan may be a contributing factor in their high tornado-related fatality rate (Brooks and Doswell 2002; Ashley 2007).

7. Locus of control

A majority of the survey respondents appeared to have an internal LOC based on their responses to the survey question: strongly disagree (6%), disagree (16%), neither agree nor disagree (12%), agree (39%), and strongly agree (27%). The chi-square analysis results indicated that LOC was not significantly associated with adoption of household preparedness actions. More specifically, survey respondents with an external LOC were not significantly less prepared than those with an internal LOC (Table 4). However, the difference in NOAA weather radio ownership between those who strongly disagreed (0%) and those who strongly agreed (39%) was noteworthy. This contrast suggests that people with a strong external LOC are much less likely to have a NOAA radio than those with a strong internal LOC. Future studies should investigate this pattern more extensively.

It is likely that the interpretation of the survey participants as having an internal or external LOC based on their response to a single question was overly simplistic. Future studies should consider using a more comprehensive evaluation of LOC such as the internal control index (Duttweiler 1984) or the spheres of control index (Spittal et al. 2002). For instance, many survey participants struggled with their choice of how to respond to the question as they openly commented on what they thought might be the role of God and religion in protecting a person from a tornado, with the final decision going one way (agree/strongly agree) for some and the opposite (disagree/strongly disagree) for others.

8. Past experience

Out of the 124 survey participants, 69 (56%) had experience with being in a tornado prior to the 27 April 2011 disaster. The chi-square analysis results indicated

TABLE 5. Household preparedness for those with past experience ($n = 69$) and no past experience ($n = 55$).

	Public safety information (%)	Tornado warning (%)	Drill (%)	Radio (%)	Shelter (%)	Plan (%)
No past experience	74	69	54	24	13	76
Past experience	86	74	60	40	17	73

that past experience was not significantly associated with adoption of household preparedness actions (Table 5). However, it should be noted that all past experiences were considered equal in this analysis. Although past experience is generally associated with enhanced preparedness, this topic is more complex than it may appear. For example, Dow and Cutter (2000) found that longer-term coastal residents were more likely to seek shelter at home during a hurricane instead of evacuate to safer ground as one might expect.

Personal experiences vary based on factors such as intensity of the tornado, proximity to the tornado's path, number of tornadoes experienced, and time elapsed since the last tornado. Normalization bias (Mileti and O'Brien 1992) may occur when people who experience little or no loss perceive that future disasters will produce similar results. Conversely, people who have experienced loss may develop a sense of learned helplessness where they perceive that it is useless to take precautions against future disasters (Tierney et al. 2001). Another point to consider is the influence of optimistic bias, where people believe that their risk of personal harm is less than others (Weinstein 1980; Helweg-Larsen 1999; Spittal et al. 2005), thus making them less likely to adopt hazards adjustments. Past experience has been found to reduce optimistic bias (Helweg-Larsen 1999), but it is possible that optimistic bias returned in many of those survey respondents with past experience. Burger and Palmer (1992) found that optimistic bias returned within months after experiencing an earthquake; however, Helweg-Larsen (1999) challenged this conclusion based on methodological issues. Future studies should consider conducting an extensive evaluation of the characteristics of the past experience (e.g., intensity, proximity, losses, number of experiences, and time elapsed) and consider investigating various perceptual factors (e.g., normalization bias, perception of adjustment options) that might influence adoption of household preparedness actions.

It is also interesting to note that those with past experience were more likely to have previously received public safety information on how to prepare for a tornado (86% versus 74%) and to own a NOAA weather radio (40% versus 24%). This pattern suggests that the past experience influenced these people in some way that enhanced their awareness and interest in receiving tornado safety information. Hazards managers should consider taking advantage of the opportunity to initiate education programs while awareness is elevated following a tornado disaster. These programs should encourage community-wide support and participation. Turner et al. (1986) and Becker et al. (2012) found that community bonds, such as participating in community organizations, were associated with enhanced preparedness for earthquakes. People with greater community involvement are thought to have greater access to hazard awareness education programs (Lindell and Perry 1992). Furthermore, hazards managers should incorporate activities that will enhance the potential for greater preparedness such as providing free or discounted NOAA weather radios and providing information on how to apply for financial aid for installing an underground shelter.

9. Plans for seeking shelter

As noted earlier, 74% of the survey respondents had a plan for seeking shelter when a tornado threatened their house (Table 1). The majority of those plans involved seeking shelter at the person's place of residence (67 of 92, or 73%; Table 6), while the remainder involved evacuating to some other location (25 of 92, or 27%). For those who planned to seek shelter at home, 75% planned to stay in a room inside the residence while 25% planned to stay in the more tornado-resistant environment of

TABLE 6. Places where survey respondents intend to seek shelter for those who plan to stay at their place of residence ($n = 67$) or evacuate to some other location ($n = 25$) and for both groups combined ($n = 92$).

	Shelter at home (%)	Evacuate (%)	Combined (%)
Inside permanent home	64	24	53
Inside mobile home	9	0	7
Inside apartment	2	0	1
Basement	13	20	15
Underground shelter	9	16	11
Safe room	3	0	2
Public place	0	12	3
Public shelter	0	24	7
Other	0	4	1
Total	100	100	100

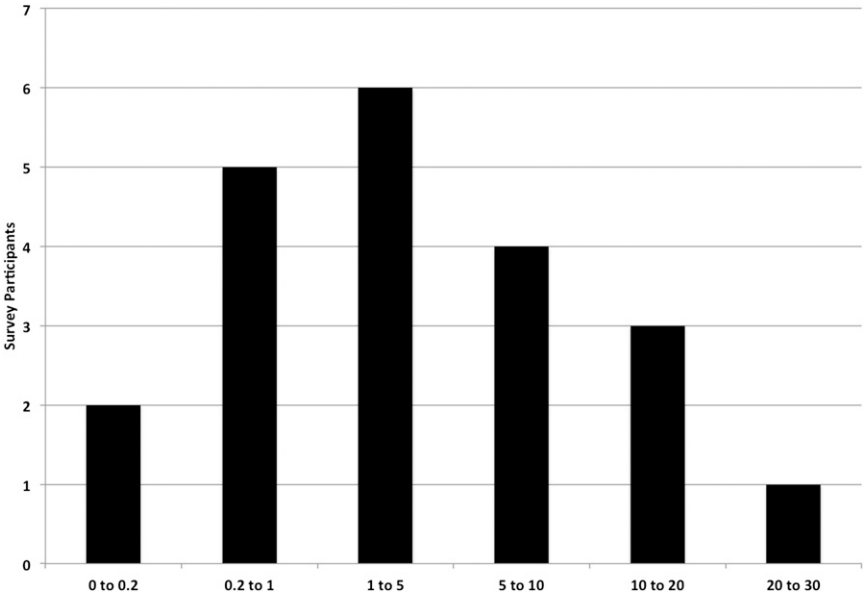

FIG. 1. Distances (km) survey participants plan to travel when evacuating from their place of residence to seek shelter at a safer location.

a basement, underground shelter, or safe room. For those who planned to go to some other location, 24% planned to stay in a room inside someone else's house; 36% planned to stay in a basement, underground shelter, or safe room at someone else's residence; 24% planned to go to a public shelter; and 16% planned to go to a public place (e.g., grocery store, shopping mall) or their workplace. When all plans are combined, the results indicate that 61% planned to stay in a room inside a residence; 28% planned to stay in the more tornado-resistant environment of a basement, underground shelter, or safe room; 7% planned to go to a public shelter; and 4% planned to go a public place or their workplace. The distances to these other locations ranged from 6 m to 25.75 km (16 miles), with a mean distance of 5.6 km (3.5 miles; Fig. 1).

Most of these plans appear acceptable in the sense that they should reduce risk of harm during a tornado; however, it would be desirable to find that a higher percentage of these plans involved staying in the more tornado-resistant environment of a basement, underground storm shelter, or safe room. The obvious exceptions are the plans that involve seeking shelter at home when the residence is a mobile home. Also, some of the distances that people plan to travel appear excessive given the additional time required to complete the plan. Schmidlin et al. (2009) found that mobile home residents would choose to drive when the distance was over 200 m, which suggests that 90% (19 of 21) of these plans will involve traveling in an automobile to the evacuation site (Fig. 1). Unfortunately, the survey did not include follow-up questions on why the respondents chose the places where they plan to seek shelter. Clearly future research should investigate why some mobile home residents plan to seek shelter inside the mobile home and why some people plan to evacuate to shelter locations that are relatively long distances from their place of residence.

Developing an effective plan is important, but the plan is of little value if it is not implemented. The survey participants who planned to seek shelter at their home were more successful at following their plan than those who planned to evacuate to some other location (81% versus 68%; Table 7). When all plans are combined, the success rate was 77% with the most common reasons for

TABLE 7. Success rate in following the plan for those who intended to shelter at their place of residence ($n = 67$) or evacuate to some other location ($n = 25$) and for both groups combined ($n = 92$).

	Shelter at home (%)	Evacuate (%)	Combined (%)
Yes (followed plan)	81	68	77
No, reacted without thinking about plan	0	0	0
No, did not have time	2	16	5
No, not at home	9	8	9
No, other*	9	8	9
Total	100	100	100

* Did not receive warning ($n = 5$) or did not think tornado would hit nearby ($n = 1$).

failure being that the person was not at home when the tornado hit or did not receive the warning. However, the most common reason given by the survey participants who planned to evacuate to another location was that they did not have enough time. Two of those participants had less than 15-min lead time, which might not have been adequate time, but the other two had more than 15-min lead time. One possible explanation for these four failures is the long distances to the places where they intended to go for shelter, which ranged from 5.6 to 16 km (3.5–10 miles). Clearly an excessive travel distance would limit the effectiveness of what might otherwise appear to be an acceptable plan to reduce risk.

10. Summary

The objectives of this study were to conduct an inventory of household preparedness, investigate three factors (demographics, locus of control, and past experience) known to influence adoption of household preparedness actions, and investigate the details of plans for seeking shelter. The Protective Action Decision Model provided the theoretical foundation for this investigation.

Few survey respondents owned a NOAA weather radio for receiving tornado warnings or had a tornado-resistant shelter (i.e., basement, underground storm shelter, or safe room) on the premises. These shortcomings are not unique to the study site, but it is uncertain how common these problems are across the region. This lack of knowledge helps define the need to establish a baseline for understanding the state of household preparedness in a community relative to others, which should be based on a standardized set of survey questions.

Demographic factors (age, children in the household, house type, and income) were found to have a significant influence on adoption of hazards adjustments. More specifically, older residents (60 yr and above) and households without children were significantly less likely to have participated in a tornado drill, lower income residents were significantly less likely to have a tornado-resistant shelter on the premises or a plan for seeking shelter, and mobile home residents were significantly less likely to have a plan for seeking shelter. Future studies should evaluate opportunities for people to participate in tornado drills, participation rates, and associations between drills and other aspects of tornado safety. Furthermore, future studies need to investigate the reasons for the lack of plans among lower income groups and mobile home residents.

Locus of control was not found to be significantly associated with adoption of hazards adjustments in this study; however, it is suspected that the use of a single question to differentiate between internal and external LOC was overly simplistic. Nevertheless, the difference in NOAA weather radio ownership between those who had extreme opposite responses to the survey question suggests that people with a strong external LOC are much less likely to have a NOAA radio than those with a strong internal LOC. Future studies should use a more complex measure of LOC such as the Internal Control Index (Duttweiler 1984) or the Spheres of Control Index (Spittal et al. 2002).

Past experience was not found to be significantly associated with adoption of hazards adjustments in this study. However, this result was based on a single question rather than a more extensive evaluation of the details of that experience (e.g., intensity, proximity, damage, time elapsed). The survey results suggest that past experience enhanced interest in tornado safety information. Given that a majority of the survey participants had past experience with a tornado, this pattern bodes well for the community's potential to learn from the recent disaster. As noted earlier, hazards managers should take advantage of such opportunities to initiate education programs immediately after a disaster while awareness is high. These programs should seek community-wide support and participation because people with stronger community bonds have been found to be better prepared than others. Furthermore, these programs should incorporate activities such as providing free or discounted NOAA weather radios that will increase the potential to enhance preparedness.

A majority of the survey participants had a plan for seeking shelter, which is a positive finding because it is one of the most critical aspects of preparedness. However, it is important to evaluate those plans to better understand exactly where the members of the community intend to seek shelter. For example, the community needs to know whether it provides adequate capacity in public shelters to meet the demand. In this case, unfortunately, one survey participant stated that the family drove to a local shelter but was forced to return home because it was overcrowded. It is also important to determine whether the plans actually reduce risk of personal injury. The survey found that most plans appeared to reduce risk, with the obvious exception being mobile home residents who planned to seek shelter inside the mobile home. Given that tornado-related fatalities in mobile homes are exceptionally high, these plans are unacceptable. Another problem is the excessively long distances some people would have to travel to reach their planned destination when they evacuate, which likely contributed to several people failing to execute their plan during the recent disaster. Future studies need to investigate these plans more extensively and address

critical issues such as the logic or reasoning behind choosing a particular location to seek shelter, especially for mobile home residents, and the barriers that prevent executing the plan.

In keeping with the Protective Action Decision Model, this study investigated the potential influence of three factors on adoption of hazards adjustments. Demographic characteristics were the only factor found to be significantly associated with adoption of hazards adjustments, which included low participation in tornado drills, limited access to shelter, and lack of plans for seeking shelter. Closer scrutiny found that a particular demographic group (mobile home residents) was also prone to developing plans that were ineffective. Failure to adopt household preparedness actions in each of these areas could serve as a situational impediment to making the appropriate protective action decision when a tornado threatens the household. Lindell and Perry (2012) urged further research on the association between demographics and other critical factors that influence adoption of hazards adjustments. In addition to the other factors included in this study (i.e., LOC and past experience), perception of the hazard adjustment options warrants attention in future studies.

Public policy efforts could be made to address the shortcomings in household preparedness identified in this study. Educational programs could be designed to help people develop plans for seeking shelter, and these programs should emphasize conducting tornado drills to practice the plans. Financial support programs could be designed to help people purchase NOAA weather radios and install tornado-resistant shelters. Communities also need to evaluate their public shelter capacity. Furthermore, these programs should target specific demographic groups where shortcomings in preparedness are evident. Cutter et al. (2008) observed that postdisaster reviews often produce ''lessons learned'' reports that make recommendations for future events, which may or may not be implemented; therefore, these ''lessons learned are merely lessons identified.'' The challenge at this point is taking these lessons identified and turning them into lessons learned.

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