MOBILE HOME RESIDENT PERSPECTIVES ON PREPAREDNESS, PROTECTIVE ACTION, AND EVACUATION FOR TORNADO HAZARDS

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DEDICATION

All my love and thanks to Cori, my parents Terry and Linda, my brother Darren, Ron and Carol Cooper, Lacy, Randy, Shelly and their respective families, and all the family and friends who have supported me over the years.
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ABSTRACT

More than 1,000 tornadoes strike the United States each year, and no population segment has been impacted to a greater degree than those who live in mobile homes. Despite being only about 7% of the total population, mobile home residents have comprised 40% to 50% of all tornado deaths over the past fifty years. Inhabitants of mobile homes must therefore act quickly to protect themselves when they are threatened by tornadoes. Warning messages instruct mobile home occupants to move to a sturdier building until the storm passes, but what are the residents’ perspectives on this recommended behavior? It is unknown whether mobile home residents plan ahead to protect themselves, how they develop these plans, where they plan to go, and what are some of the difficulties or obstacles that might discourage evacuation behavior.

This research provides new insights to better understand mobile home residents’ perspectives about tornado preparedness and protective actions, and reveals which factors are most influential in their evacuation planning and intentions. The study area is central South Carolina, where mobile homes are integral to the housing stock and casualties from tornadoes pose an appreciable risk. A wide range of data is utilized, from both qualitative interviews and mailed questionnaires, to develop a typology of tornado preparedness and response perspectives. Three types are identified: those who are relatively unconcerned about tornadoes, those who are concerned and informed about tornadoes, and those who anticipate warnings and take protective action. The three types are significantly associated with demographic and household variables such as gender,
race, the presence of children in the home, income, housing tenure, and home size and quality, as well as differing according to previous experience, places of residence, and urban/rural context.

Participants’ responses to several hypothetical evacuation scenarios are also presented and the most important factors for predicting tornado evacuation intentions of mobile home residents are identified. Respondents are more likely to evacuate if given fifteen minutes warning than if given five minutes warning, but are not more likely to evacuate if given forty-five minutes compared to the fifteen minute scenario. Evacuation intentions are significantly influenced by several factors, including the evacuation destination, travel time to the destination, previous evacuation experience, having an evacuation plan, race, gender, age, housing tenure, presence of children and pets in the home, expectation of harm, and the urban/rural context. The theoretical and practical implications of the research findings are discussed, along with the study limitations and potential directions for future research.
TABLE OF CONTENTS

Dedication ................................................................................................................................. iii
Acknowledgements .................................................................................................................... iv
Abstract ....................................................................................................................................... v
List of Tables .............................................................................................................................. x
List of Figures ............................................................................................................................ xiii
List of Abbreviations .................................................................................................................. xvi

Chapter 1: Introduction .............................................................................................................. 1
  1.1. Overview .......................................................................................................................... 1
  1.2. Research Objectives and Questions ............................................................................... 2
  1.3. Organization of the Document ....................................................................................... 4

Chapter 2: Relevant Literature .................................................................................................. 5
  2.1. Overview .......................................................................................................................... 5
  2.2. Tornado Casualties in the United States .......................................................................... 6
  2.3. Vulnerability, Resilience, and Mobile Home Tornado Casualties ...................................... 13
  2.4. Hazard Preparedness ....................................................................................................... 18
  2.5. Warning Messages and Protective Action ...................................................................... 29
  2.6. Evacuation Behavior ....................................................................................................... 39
  2.7. Chapter Summary .......................................................................................................... 42

Chapter 3: Research Setting ...................................................................................................... 44
  3.1. Overview .......................................................................................................................... 44
3.2. The Rise of Mobile Homes in the Southeastern United States ........................................ 46
3.3. Tornadoes, Tornado Hazards, and Warnings .............................................................. 54
3.4. Chapter Summary ........................................................................................................ 60

Chapter 4: Research Methodology ...................................................................................... 61
4.1. Overview ....................................................................................................................... 61
4.2. Qualitative Methodology ............................................................................................. 61
4.3. Quantitative Methodology .......................................................................................... 74
4.4. Chapter Summary ......................................................................................................... 95

Chapter 5: Qualitative Analysis and Results ...................................................................... 97
5.1. Overview ....................................................................................................................... 97
5.2. Perspectives on the Nature of Tornadoes .................................................................. 97
5.3. Perspectives on Tornado Warning Protective Actions .............................................. 100
5.4. Chapter Summary ....................................................................................................... 110

Chapter 6: A Typology of Perspectives on Tornado Preparedness and Protective Action .......... 112
6.1. Overview ..................................................................................................................... 112
6.2. Identification of Tornado Sheltering Perspective Typologies ..................................... 112
6.3. Three Perspectives and Individual, Household, and Geographic Attributes .............. 128
6.4. Combined Logistic Model to Predict Cluster Membership ........................................ 140
6.5. Chapter Summary ....................................................................................................... 143

Chapter 7: Quantitative Modeling of Intended Protective Actions ..................................... 148
7.1. Overview ..................................................................................................................... 148
7.2. Dependent and Independent Variables ........................................................................ 148
7.3. Logistic Models of Intention to Evacuate to a Sturdy Building .................................. 164
7.4. Chapter Summary ................................................................. 173

Chapter 8: Answering the Research Questions and Discussion of the Results .... 176
  8.1. Research Question #1 ...................................................... 176
  8.2. Research Questions #2 and #3 ...................................... 181
  8.3. Research Question #4 .................................................... 187

Chapter 9: Conclusions and Future Research .................................... 198
  9.1. Conclusions ................................................................. 198
  9.2. Practical Considerations ............................................... 199
  9.3. Limitations of the Research ......................................... 202
  9.4. Future Research Directions .......................................... 203
  9.5. Concluding Remarks .................................................. 205

References .................................................................................. 206

Appendix A – Interview Guide ...................................................... 227

Appendix B – Tornado Preparedness Questionnaire ......................... 230

Appendix C – Polychoric Correlation Matrix of Question #22 Items ........ 235

Appendix D – R Code for Model-Based Cluster Analysis .................... 237
LIST OF TABLES

Table 2.1. Fujita and Enhanced Fujita tornado damage rating scales used before and after 1 February 2007 respectively, adapted from Storm Prediction Center (2015a). ........................................ 10

Table 3.1. Descriptive mobile home and mobile home resident statistics for the combined study area and adjacent states. ........................................................................................................... 53

Table 3.2. Descriptive mobile home and mobile home resident statistics for the study area counties. .......................................................... 54

Table 3.3. Tornado fatalities and injuries, scaled by property damage over the period 1960-2013 for top 30 states in total damage, with ranks in parentheses; data obtained from HVRI (2015). ........................................................................................................ 58

Table 4.1. Key characteristics and perspectives sought for interviews on tornado preparedness and evacuation. .......................................................... 64

Table 4.2. Coding categories and sub-categories for analysis of interview transcriptions. .................................................................................. 72

Table 4.3. Raw and usable numbers of addresses obtained by county. .................. 78

Table 4.4. Number of mobile home addresses sampled by county. ...................... 81

Table 4.5. Numbers of undeliverable and completed questionnaires by county. .......... 88

Table 4.6. Demographic representativeness by sex, age, race/ethnicity, and education. . 93

Table 4.7. Demographic representativeness by income, vehicles, tenure, duration of residence, and household size. ............................................................. 95

Table 6.1. Questionnaire items used in cluster analysis. ........................................... 113

Table 6.2. Types of mixture models used in the mclust R package. ....................... 116

Table 6.3. Associations and statistical significance between questionnaire items and clusters, in descending order according to value of the uncertainty coefficient (U). ..... 121
Table 6.4. Associations and statistical significance between demographic questionnaire items and three preparedness and response clusters, in descending order according to value of the uncertainty coefficient (U) .......................................................... 130

Table 6.5. Associations and statistical significance between questionnaire items on communication, mobile home, and geographic attributes and three preparedness and response clusters, in descending order by the uncertainty coefficient (U) ......................... 133

Table 6.6. Variables used to predict preparedness and response cluster membership in logistic regression model, with statistical significance levels ........................................ 141

Table 6.7. Variables used to predict preparedness and response cluster membership in logistic regression model, broken down by models for clusters 1 versus 2, 1 versus 3, and clusters 2 versus 3, and with odds ratios and statistical significance levels .................. 142

Table 6.8. Three perspectives on tornado preparedness and response, with questionnaire items listed in order of importance for distinguishing the three clusters ...................... 144

Table 6.9. Three perspectives on tornado preparedness and response, with demographic, mobile home, geographic, and experiential attributes .......................................... 145

Table 7.1. Logistic regression results for five minute lead time during daylight scenario, with reference category provided in brackets for binary independent variables .......... 165

Table 7.2. Logistic regression results for fifteen minute lead time during daylight scenario, with reference category provided in brackets for binary independent variables ............................................................. 167

Table 7.3. Logistic regression results for forty-five minute lead time during daylight scenario, with reference category provided in brackets for binary independent variables ........................................................................ 169

Table 7.4. Logistic regression results for five minute lead time during nighttime scenario, with reference category provided in brackets for binary independent variables ........ 170

Table 7.5. Logistic regression results for fifteen minute lead time during nighttime scenario, with reference category provided in brackets for binary independent variables .................................................................... 171

Table 7.6. Logistic regression results for forty-five minute lead time during nighttime scenario, with reference category provided in brackets for binary independent variables ............................................................. 172

Table 8.1. Factors that are significant predictors of willingness to evacuate to a sturdy building during a tornado warning across six different scenarios ................................. 190
Table C.1. Polychoric correlations for question #22, items a through k. ....................... 235

Table C.2. Polychoric correlations for question #22, items l through v. ......................... 236
LIST OF FIGURES

Figure 2.1. Tornado deaths in the United States, 1916 to 1953, from Linehan (1957) page 46. ................................................................................................................................. 8

Figure 2.2. Pressure and Release Model of vulnerability, adapted from Wisner et al. (2004), page 51. ......................................................................................................................... 15

Figure 2.3. HUD wind zones for manufactured housing construction standards, image courtesy of the Manufactured Housing Institute (2015a). ................................................................. 27

Figure 2.4. Tornado warning process, from Brotzge and Donner (2013), page 1716. ..... 31

Figure 2.5. Example of an official tornado warning, retrieved from online archive hosted by the Iowa Environmental Mesonet (2015). ................................................................................. 33

Figure 2.6. Protective Action Decision Model, reproduced from Lindell and Perry (2012), page 617. ................................................................................................................................. 37

Figure 2.7. Conceptual context diagram for this research. ............................................. 43

Figure 3.1. Study area in central and northeastern South Carolina. ................................. 46

Figure 3.2. Annual shipments of manufactured homes in the United States, 1959 to 2013 (Manufactured Housing Institute 2015b). .................................................................................... 48

Figure 3.3. Areal density of occupied mobile homes, 1970 to 2010 (Minnesota Population Center 2014). ..................................................................................................................... 50

Figure 3.4. Mobile homes as percentage of all households, 1970 to 2010 (Minnesota Population Center 2014). ............................................................................................................... 50

Figure 3.5. Mobile home areal density (m$^2$) and percentage of all households for 2010, classified by quartiles. ................................................................................................................. 51

Figure 3.6. Mobile home areal density (m$^2$) and percentage of all households for 2010, classified by quartiles and with study area outlined in yellow. .................................................. 51

Figure 3.7. Tornado paths in the central and eastern United States (1950-2013), classified by Enhanced Fujita Scale ratings, with the study area outlined in yellow. ................................. 55
Figure 3.8. South Carolina tornadoes and tornado days by month, as percentages of the total tornado count and total number of tornado days. ......................................................... 57

Figure 3.9. National Weather Service forecast office areas of responsibility for Columbia, SC and adjacent offices, with the study area outlined in yellow. ........................................... 59

Figure 4.1. Numbers and locations of interview participants within South Carolina...... 67

Figure 4.2. Counties from which mobile home addresses were requested. ................. 77

Figure 4.3. Geocoded manufactured home addresses.................................................... 81

Figure 4.4. Number of mobile home addresses sampled within each census tract....... 82

Figure 4.5. Locations of questionnaires that were completed and returned. ............... 91

Figure 6.1. Scatterplot showing number of clusters on the x-axis and the Bayes Information Criterion on the y-axis for ten different mixture models. ...................... 118

Figure 6.2. Smoothed scatterplot demonstrating the location of the original clustering results relative to 999 simulations of the mclust algorithm using case-wise bootstrap resampling.............................................................. 119

Figure 6.3. Three clusters (blue, red, green dots) plotted by the three most distinguishing questionnaire items (22f, 22n, and 22s), with ellipsoids encompassing 25% of each cluster’s data points................................................................. 122

Figure 6.4. Mosaic plots with distributions of answers expressed as percentages within each of the three clusters for questionnaire items 22f, 22n, 22s, 22q, 22h, and 22p..... 124

Figure 6.5. Mosaic plots with distributions of answers expressed as percentages within each of the three clusters for questionnaire items 22m, 22i, 22k, 22g, 22o, and 22b.... 125

Figure 6.6. Mosaic plots with distributions of answers expressed as percentages within each of the three clusters for questionnaire items 22r, 22a, 22t, 22d......................... 126

Figure 6.7. Mosaic plots with distributions of answers expressed as percentages within each of the demographic segments (x-axis; 0=no and 1=yes) and by membership in three preparedness and response clusters (y-axis). ......................................................... 131

Figure 6.8. Mosaic plots with distributions of answers expressed as percentages within each of the communication, mobile home, and geographic segments (x-axis; 0=no and 1=yes) and by membership in three preparedness and response clusters (y-axis)........... 134

Figure 6.9. Map showing a) respondent locations by cluster membership, and b) mosaic plot demonstrating cluster membership (y-axis) percentages by county (x-axis). ......... 135
Figure 6.10. Dot density plots showing percentage of housing units in urban areas (a) and the log of the mobile home count within a 1 mile radius of each respondent’s location (b), both stratified by membership in three preparedness and response clusters. ................................ 137

Figure 6.11. Mosaic plots with distributions of answers expressed as percentages within each of the two experience segments (x-axis; 0=no and 1=yes) and by membership in three preparedness and response clusters (y-axis). ................................................................. 139

Figure 7.1. Percentages of respondents’ answers for five tornado warning behaviors across six lead time and daylight scenarios. ................................................................. 150

Figure 7.2. Percentages of respondents’ answers for the likelihood of receiving a warning via each of eight potential information channels. ................................................................. 153

Figure 7.3. Percentages of respondents’ answers for amount of trust for seven potential tornado warning information sources. ................................................................. 155

Figure 7.4. Percentages of respondents’ with and without access to a tornado shelter. .... 156

Figure 7.5. Percentages of respondents’ answers by evacuation destinations.............. 157

Figure 7.6. Directions of travel to shelter destinations by percentages of responses. .... 158

Figure 7.7. Respondent rankings of potential damage and injury outcomes for their mobile home (a and b), their first sheltering location (c and d), and second sheltering location (e and f). ................................................................. 160

Figure A.1. Page 1 of the interview guide. ................................................................. 228

Figure A.2. Page 2 of the interview guide. ................................................................. 229

Figure B.1. Page 1 of the 2014 Tornado Preparedness Survey. .............................. 231

Figure B.2. Page 2 of the 2014 Tornado Preparedness Survey. .............................. 232

Figure B.3. Page 3 of the 2014 Tornado Preparedness Survey. .............................. 233

Figure B.4. Page 4 of the 2014 Tornado Preparedness Survey. .............................. 234
### LIST OF ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>ACS</td>
<td>American Community Survey</td>
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<tr>
<td>BIC</td>
<td>Bayesian Information Criterion</td>
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<td>DHS</td>
<td>Department of Homeland Security</td>
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<td>EF</td>
<td>Enhanced Fujita</td>
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<td>F</td>
<td>Fujita</td>
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<td>FEMA</td>
<td>Federal Emergency Management Agency</td>
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<td>GA</td>
<td>Georgia</td>
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<td>GED</td>
<td>General Educational Development</td>
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<td>HUD</td>
<td>Housing and Urban Development</td>
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<tr>
<td>HVRI</td>
<td>Hazards &amp; Vulnerability Research Institute</td>
</tr>
<tr>
<td>IRB</td>
<td>Institutional Review Board</td>
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<tr>
<td>MH</td>
<td>Mobile Home or Manufactured Home</td>
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<tr>
<td>MPH</td>
<td>Miles per Hour</td>
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<td>NC</td>
<td>North Carolina</td>
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<tr>
<td>NHGIS</td>
<td>National Historical Geographic Information System</td>
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<td>NOAA</td>
<td>National Oceanic and Atmospheric Administration</td>
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<td>NRC</td>
<td>National Research Council</td>
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<td>NWS</td>
<td>National Weather Service</td>
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<td>PADM</td>
<td>Protective Action Decision Model</td>
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<td>SC</td>
<td>South Carolina</td>
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CHAPTER 1: INTRODUCTION

1.1. Overview

During April and May of 2011, a series of tornadoes devastated many
communities across the central and southeastern United States (US) causing over 500
fatalities. This was the first time since 1953 that more than 500 US citizens died as a
result of tornadoes (Simmons and Sutter 2012). These events served as yet another
recent reminder to social and physical scientists and emergency managers that even in
this age of burgeoning technology and communication infrastructures, societal
vulnerabilities continue to be exposed by extreme rapid-onset events such as tornadoes,
hurricanes, earthquakes, and tsunamis. Following these events, the National Weather
Service (NWS) and its parent institution the National Oceanic and Atmospheric
Administration (NOAA) pledged to continue fostering technological and scientific
improvements to monitor, analyze, and model extreme weather events (Lubchenco and
Hayes 2012). However, these improvements will be insufficient for coping with extreme
weather without equally vital contributions from social scientists to enhance knowledge
of how people understand and use information communicated by physical scientists
(Lubchenco and Karl 2012).

This need for social science research on how people plan for and react to extreme
weather events is not new; it has been recognized in the hazards/disasters academic
community for many years (Sorensen 2000; Gladwin et al. 2007; Phillips and Morrow
2007). Lindell and Brooks (2013) summarized key future research needs as discussed at
a 2012 workshop for Weather Ready Nation, and among those identified were better understandings of individual and/or household behavioral preparedness and response—especially for highly exposed or socially vulnerable populations—as well as extreme wind hazard mitigation strategies for mobile home communities. Simmons and Sutter (2011; 2012) stated that the foremost population of concern specifically for tornado hazards is mobile home residents. Mobile homes are easily damaged or destroyed when exposed to intense windstorms, including tornadoes. According to Simmons and Sutter’s (2011) analysis, about 45% of all tornado fatalities over the period 1985 to 2010 occurred in mobile homes.

Mobile homes are factory-built houses that are mounted on a chassis and then transported largely intact to the locations where owners wish to place them. Mobile homes are often referred to as manufactured homes since the industry overhauled its image in the 1970s and coined the latter term to avoid the connotation of mobile home predecessors which were more like recreational vehicles (Hart, Rhodes, and Morgan 2002). In this document, both terms are used interchangeably, though mobile home is used most often following the style of John Fraser Hart and coauthors (2002). The southeastern US is the most notorious region for tornado fatalities, with a high concentration of mobile homes and a higher frequency of nocturnal tornadoes interacting to enhance risk of damage and serious casualties (Ashley 2007; Simmons and Sutter 2012).

1.2. Research Objectives and Questions

Motivation to carry out this research stems from the fact that mobile home casualties from tornadoes are a long-standing problem in the US, and that mobile home
residents have not been widely engaged by the hazards and disasters research communities for the purpose of understanding their perspectives about planning and enacting a sheltering/evacuation strategy. There are four main research questions that drive the analysis:

1. What types of perspectives exist among mobile home residents about tornado preparedness and protective action responses?

2. Do different demographic segments of mobile home residents or those with prior tornado experiences tend to identify with certain types of perspectives about tornado preparedness and response?

3. Do mobile home residents living in different geographic contexts (e.g. urban/rural or mobile home park/single-site), or those living in larger mobile homes, identify with different types of perspectives about tornado preparedness and response?

4. Which factors are most important for explaining whether mobile home residents are willing to evacuate to a nearby sturdy building during a tornado warning?

This dissertation makes three contributions to social science research on hazards and disasters. First, whereas much previous work focused on threat or risk perception, far fewer studies gathered data on how a person’s perspective on hazard protection behaviors themselves can explain why some people plan and implement sheltering or evacuation strategies and others do not (Lindell and Perry 2012). This research gathers basic qualitative and quantitative data about mobile home residents’ perspectives on tornado preparedness and response, including the possibility of short-term evacuation and potential destinations. The second contribution is in the use of the qualitative and quantitative data to identify common perspectives on tornado preparedness and response expressed by mobile home residents within the study area in South Carolina. The third contribution of this research is in demonstrating which factors would be most likely to
encourage mobile home residents to evacuate (or discourage them from evacuating)
during a tornado warning using several hypothetical situations.

1.3. Organization of the Document

There are eight chapters in this document. Chapter 2 reviews past research to
establish how mobile homes came to be a focus of research on societal impacts of
tornadoes and then outlines relevant theoretical frameworks and empirical studies on
tornado preparedness and protective behaviors. Chapter 3 provides a short overview of
mobile homes and tornadoes in the study area, placing it in both national and regional
contexts. In Chapter 4, the qualitative and quantitative research methodologies employed
in this research are explained in detail. Chapter 5 presents several themes that emerged
from interviews with mobile home residents, while Chapter 6 addresses the first three
research questions by identifying perspectives on tornado preparedness and response and
then relating them to demographic, geographic, and experiential characteristics. Chapter
7 addresses the final research question with the results of regression models to predict the
intention to evacuate a mobile home for a sturdy building. The results are discussed in
the context of recent research on hazard preparedness and protective action in Chapter 8,
and a few suggestions for practical application are provided.
CHAPTER 2: RELEVANT LITERATURE

2.1. Overview

The research questions and subsequent data collection for this research were influenced by empirical research and conceptual frameworks primarily from the disciplines of geography, sociology, psychology, and meteorology, with additional influences from communication studies, public health, economics, engineering, and anthropology. However, this research is most deeply rooted in the hazards geography tradition that began with Gilbert White and his investigations of a range of alternatives for human adjustment and adaptation to flood hazards in the Mississippi River Valley (Wescoat 1992; Mitchell 2008).

Hazards geography has since evolved with a greater focus on social vulnerability and societal resilience (White, Kates, and Burton 2001), which is reflected in the concentration here on mobile home residents. The influences of disaster sociology and psychology, in particular the body of research on warning messages, preparedness, and response that began during the 1950s are also evident in this work (see Quarantelli 1988 for further context). In dealing with wind hazards such as tornadoes, there are several options for the national mobile home community and even individual households to lessen the possibility of damage and harm. This dissertation focuses on one option in particular—leaving a mobile home when thunderstorms approach in order to find safety in a sturdier building until the inclement weather passes. In reviewing the literature
relevant for this research, the author found that no single existing framework covered all of the necessary topics and therefore the purpose of the discussion that follows in this chapter is to set the context for the inductive design by covering a range of conceptual models and bodies of research.

2.2. Tornado Casualties in the United States

2.2.1. Secular Trend

The impacts of tornadoes in the US are dwindling over time as measured by the toll in human casualties. Tornado fatalities peaked in the 1920s and have steadily declined over time (Boruff et al. 2003; Ashley 2007; Simmons and Sutter 2012). Several factors have contributed to this decrease. Networks of volunteers were recruited and trained in many tornado prone areas to report dangerous weather to the National Weather Service and local emergency management (Doswell, Moller, and Brooks 1999; Bass et al. 2009; League et al. 2010). Technological advances in communications and in the monitoring and forecasting of severe thunderstorms have certainly aided in this endeavor as well (Brooks and Doswell 2002). Critical safety information is now widely disseminated via radio, television, and the internet (Smith 2010; Coleman et al. 2011).

The national implementation of the Doppler radar network in the 1990s has led to better remote sensing of tornadoes and therefore more timely, accurate, and effective warnings (Simmons and Sutter 2005; 2008a; 2009). Improvements in both housing and tornado shelter construction materials and practices further contribute to mitigation of casualties, especially with respect to weaker tornadoes (Prevatt et al. 2012).

Though the year 2011 was one of the most damaging and deadly on record for tornadoes in the US, it was an extreme outlier and does not necessarily represent a
reversal of the long-term net improvement in tornado safety (Simmons and Sutter 2012; Simmons, Sutter, and Pielke 2013). Nevertheless, the events of 2011 illustrated, unfortunately, what can happen when tornadoes strike more densely populated areas, as occurred in Joplin, Missouri, Tuscaloosa and Birmingham, Alabama, and the relatively densely populated rural portions of the Tennessee River valley of northern Alabama and eastern Tennessee. Despite the improvements noted in the previous paragraph, there remains the element of random chance that will be realized in some years wherein damaging tornadoes will happen to occur more in densely populated areas. There is also the fact that some cities in tornado prone regions of the central and eastern US continue to accrue greater numbers of people with expanding spatial urban and suburban footprints (Ashley et al. 2014; Short and Mussman 2014).

2.2.2. Differential Regional Impacts

Though tornado casualties have steadily decreased, several researchers noted over the past sixty years that tornado casualties have been concentrated in particular regions of the US. One of the earliest hazards dissertations written by a geographer (see Cross 1998), Urban Linehan at Clark University, was a key contribution on this topic. Linehan published this work in a report for the Department of Commerce and the Weather Bureau (1957). Using a variety of sources, he mapped tornado deaths in the US from 1916 to 1953 and identified the region most prone to deadly impacts (Figure 2.1), encompassing much of Oklahoma and northeastern Texas and stretching eastward across the lower Mississippi and Ohio River valleys, including most of the inland southern states and the southern Piedmont. Linehan outlined several features that defined this region: tornado frequency and intensity, population density (relative to the western US), poor home
construction, impoverished and crowded homes, and inadequate communication networks.

Figure 2.1. Tornado deaths in the United States, 1916 to 1953, from Linehan (1957) page 46.

Sims and Baumann (1972) built upon Linehan’s analysis with an updated version of the national tornado death map using their Tornado Death Index for the period 1953-1964. Their analysis also indicated the southern US to have a disproportionate number of tornado fatalities. They downplayed tornado frequency and intensity, time of day of tornado occurrence, population density, home construction quality, poverty, and warning communication as explanations for the higher death rate in the South, and focused instead on psychological dimensions as a primary cause. In a brief rejoinder to the Sims and Baumann article, Davies-Jones, Golden, and Schaefer (1973) argued that while psychological dimensions could be a contributing factor, the Sims and Baumann study
was errant in its dismissal of nocturnal tornadoes, poor housing construction, and tornado frequency as important contributors to the South’s tornado fatality problem.

Boruff and coauthors (2003) focused on the national pattern of tornado hazards—tornado events that impacted humans in some way—in the US over the period 1950 to 1999. They noted that the increased population density in the southeastern US that occurred during their study period was coincident with increased tornado hazards in that region. Ashley (2008) expanded temporally on previous research by analyzing tornado deaths using data from the period 1880-2005. His work demonstrated that killer tornado events continue to be concentrated in the southern US, and a subsequent study made a convincing empirical argument that nocturnal tornadoes indeed contribute to the regional fatality rate maximum in the South (Ashley, Krmenec, and Schwantes 2008). Both studies again raised the issues of housing construction quality, poverty, population density, warning systems, and psychology as the likely drivers of higher fatality rates, and additionally posited that lower visibility of tornadoes due to tree cover and precipitation-laden thunderstorms might also be contributing factors. Though all the reasons have still not been precisely diagnosed, there is little doubt that tornado fatalities in the US are of greatest interest in the South.

2.2.3. Tornado Casualty Epidemiology

While the geographic studies in the previous section were more interested in broad spatial and temporal patterns of tornado casualties, other researchers took an epidemiological approach. Almost two dozen case studies over the past fifty years—most of which were conducted by authors affiliated with the US Centers for Disease Control and Prevention—contributed to knowledge of who is most likely to be harmed by
tornadoes, where humans who are harmed by tornadoes are most likely to be located, and what kinds of bodily injuries most often lead to serious injury or death. Among the locations, dates, and damage ratings (Table 2.1) of the tornadoes under investigation in the earlier case studies were: 11 April 1965 F4 in Indiana (Mandelbaum, Nahrwold, and Boyer 1966); 10 April 1979 F4 in Texas (Glass et al. 1980); 29 May 1982 F4 in Illinois (Duclos and Ing 1989); several tornadoes on 28 March 1984, ranging from F1 to F4, in North Carolina and South Carolina (Eidson et al. 1990); several tornadoes on 31 May 1985, ranging from F0 to F5, in Pennsylvania and Ontario, Canada (Sellers et al. 1986; Carter, Millson, and Allen 1989); 28 August 1990 F5 in Illinois (Brenner and Noji 1995); and F3 and F4 tornadoes which struck Alabama and Georgia on 27 March 1994 (Schmidlin and King 1995). Notably, most of these case studies were rather high casualty events associated with large and intense tornadoes that produced severe to extreme levels of damage; these types of events make up only a small fraction of all tornadoes.

Table 2.1. Fujita and Enhanced Fujita tornado damage rating scales used before and after 1 February 2007 respectively, adapted from Storm Prediction Center (2015a).

<table>
<thead>
<tr>
<th>Fujita Scale (Used until 1 Feb 2007)</th>
<th>Operational EF Scale (Used after 1 Feb 2007)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F Number</td>
<td>3 Second Gust (mph)</td>
</tr>
<tr>
<td>0</td>
<td>45-78</td>
</tr>
<tr>
<td>1</td>
<td>79-117</td>
</tr>
<tr>
<td>2</td>
<td>118-161</td>
</tr>
<tr>
<td>3</td>
<td>162-209</td>
</tr>
<tr>
<td>4</td>
<td>210-261</td>
</tr>
<tr>
<td>5</td>
<td>262-317</td>
</tr>
</tbody>
</table>

Bohonos and Hogan (1999) summarized epidemiological research on tornado casualties, including several of the studies listed in the previous paragraph, and offered
several main findings and recommendations. Fatalities were most often associated with trauma to the head, neck, spine, or chest; the prominence of head injuries was enough to prompt the recommendation that persons in the potential path of a tornado should put on a helmet of some kind, if one is available. Bohonos and Hogan noted that elderly persons may be more likely to suffer harm during tornadoes, mostly due to reduced mobility, though they concluded that the empirical evidence was mixed. The stronger empirical evidence pertained to the location of persons harmed during tornadoes. The authors focused on persons in mobile homes, motor vehicles, and those caught outdoors as the groups with the highest relative risks from tornadoes. Common safety recommendations were to lie flat in a ditch or low area rather than be caught in the open, in an automobile, or in a mobile home.

After the Bohonos and Hogan (1999) summary, several additional case studies were published between 1997 and 2005. Some previous findings were further confirmed; persons in mobile homes were killed at a higher rate than those in more permanent structures in events in Arkansas (Schmidlin and King 1997), Florida (Schmidlin et al. 1998), and Oklahoma (Brown et al. 2002; Daley et al. 2005). Yet, two new findings emerged from these studies. Television was overwhelmingly the most used source of warnings and information, and persons receiving warnings from television were less likely to be injured or killed (Schmidlin and King 1997; Legates and Biddle 1999; Hammer and Schmidlin 2002). Also, motor vehicles were used more frequently as a means to escape the path of a tornado, despite official recommendations not to use a car to outrun a tornado (Schmidlin and King 1997; Hammer and Schmidlin 2002; Daley et al. 2005).
Recent work on the April 2011 tornado outbreak in Alabama suggested that older adults, females, and those in mobile homes were most susceptible to death and injury (Chiu et al. 2013; Niederkrotenthaler et al. 2013). Elderly residents also died at a high rate, unfortunately, in the May 2011 EF5 tornado in Joplin, Missouri (Paul and Stimers 2014). A number of these fatalities were at a nursing facility, and authors Paul and Stimers also noted an unusual number of casualties in commercial buildings.

Finally, two recent publications attempted to confirm relationships between several demographic, housing, and geographic variables and tornado casualties over a number of years. Donner (2007), using tornado casualty data from 1998-2000, confirmed a link between casualties and mobile homes, as well as population density. However, his model suggested only very weak evidence of a potential link between casualties and an index consisting of poverty, disability, and lower educational attainment. Simmons and Sutter (2011) analyzed an even longer time span of tornado casualty data, with regressions using both 1950-2007 and 1986-2007 data. Their work was the strongest statement thus far, and they did not find evidence in their analysis of strong relationships between poverty, age, or race/ethnicity and tornado casualties. Interestingly, their results did suggest that older homes are perhaps associated with reduced fatalities. Their greatest contributions were in their conclusions that mobile homes, timing of a tornado during the night or on a weekend, increased forest cover, and educational attainment are amongst the strongest predictors of tornado fatalities and injuries in the US. Specific to mobile home tornado fatalities, Simmons and Sutter (2011) suggest that they are especially likely to occur in nocturnal tornadoes and in tornadoes with damage ratings less than F3/EF3.
2.3. Vulnerability, Resilience, and Mobile Home Tornado Casualties

While this research does not focus directly on the concepts of vulnerability or resilience *per se*, it is certainly informed by and situated within these broader theoretical constructs. Furthermore, the discussion of vulnerability and resilience provides a segue into conceptual and empirical discussions of potential proactive behaviors to reduce likelihood of harm from tornadoes.

2.3.1. Vulnerability of Mobile Home Residents

If one suggests that mobile home residents are especially vulnerable to injury or death from tornadoes, what does that mean and what can be done about it? Defined most succinctly, vulnerability is the potential for harm (Cutter 1996; Adger 2006). This potential for adverse effects is often conceptualized as having at least two components. One aspect is exposure or risk; this is related to the spatial, temporal, and physical characteristics of the hazard agent such as the frequency of occurrence, magnitude, duration, areal extent, and so on (Emrich and Cutter 2011; Birkmann et al. 2013). Exposure is also a function of the spatial, temporal, and physical characteristics of the built environment (Morss et al. 2011).

Mobile home residents therefore experience different degrees of hazard exposure in at least two contexts: the geographic location of the home and the material quality of the actual structure. In a national geographic context, mobile homes tend to be located in warmer, more humid regions of the US because their designs are less suited to cold weather and snow. Compared to site-built homes, therefore, mobile homes are unevenly exposed to warm climate weather hazards such as tropical cyclones and tornadoes (Kusenbach, Simms, and Tobin 2010; Simmons and Sutter 2010). In local and regional
contexts, mobile home *parks* in particular may be disproportionately located in unsafe locations. Recent research provided an example of this in the context of floodplains in Vermont (Baker, Hamshaw, and Hamshaw 2014). Mobile homes are also unevenly exposed to extreme heat during the summer months, and if units are poorly constructed the costs of cooling the interior can be prohibitive (Harrison and Popke 2011; Wilson 2012). Likewise, newer mobile homes are built to better standards for withstanding high winds than older units, and some geographic regions enforce stricter construction codes (Simmons and Sutter 2008b).

The second component of vulnerability is sensitivity or susceptibility, the extent to which a person, group, system, or place is affected by a hazard agent (Turner et al. 2003; Morss et al. 2011; Birkmann et al. 2013). The causal structure of this sensitivity exists prior to onset of the hazard agent and is a complex interaction of social, cultural, political, economic, and psychological forces interacting in places as small as households and neighborhoods or as large as entire nation-states (Cutter 1996; Wisner et al. 2004; Birkmann et al. 2013). Wisner and colleagues’ (2004) Pressure and Release Model (Figure 2.2) is relevant for this study in conceptualizing the sensitivity of some mobile home residents to tornadoes. In the context of extreme wind hazards in the US, living in a mobile home can be an unsafe dwelling (exposure) in a locale with a lack of effective institutions to promote disaster preparedness and mitigation programs and lack of access to critical safety information. These conditions develop due to both personal lifestyle choices and larger macro-forces stemming from uneven access to power and resources.
It is instructive to think of sensitivity to hazards (or social vulnerability) as manifesting in everyday life (Wisner 1993; Eriksen and Gill 2010) for many mobile home residents, particularly those in parks or older units. For instance, they are often on a low income budget and have a high proportion of that income invested in rent and utilities; they have fewer resources to draw upon (MacTavish, Eley, and Salamon 2006). As noted before, residents often live in units with extreme energy inefficiencies and cannot pay their electricity bills during high usage periods (Harrison and Popke 2011; Wilson 2012). In some regions, residents are frequently of advanced age and limited mobility, reducing the ability to evacuate the mobile home for a safer location, if necessary (Ngo, 2001; Barusch, 2011). Higher rates of disability and alcohol and drug use also contribute to a higher death rate from residential mobile home fires (Runyan 1992; Hannon and Shai 2003; Mullins et al. 2009). Renters and residents who otherwise desire to move to a permanent home tend not to bond with other residents (MacTavish et
al. 2006), and those who do not live in mobile homes often view those who do quite unfavorably and attach stigma to those communities (Beamish et al. 2001; Kusenbach 2009). These factors can limit access to social networks and increase the susceptibility of residents to harm. One can see how the difficulties of day-to-day living can impair the ability or motivation to invest time and scarce resources in preparing for low probability environmental hazards such as tornadoes.

It is important to note at this point that the hazard sensitivity narratives outlined in the previous two paragraphs do not apply to all mobile home residents in South Carolina or the entire US. They are most applicable for those living in mobile home parks and for rental units; frequently, these conditions are met simultaneously and usually in closer proximity to urban centers, though mobile home parks and single-site units in rural areas can face serious economic, social, and health problems too (Aman and Yarnal 2010). Still, the stereotypical characterization of “trailer trash” living in squalor is not valid for unit owners who live on large lots of land in exurban and rural communities or for most retirement communities. Many of these units are newly built and consist of two units put together, so called double-section or double-wide mobile homes. Newer mobile homes offer the benefits of improved construction techniques and energy efficiency, and many are sited with real brick skirting around the lower portion of the home. These larger and improved units are indistinguishable in many respects from site-built homes (Beamish et al. 2001; Mimura et al. 2010).

Nationally, double-wide units were placed on lots at nearly the same rate as single-wide units from the late 1980s to the mid-1990s, and double-wide unit placements exceeded single-wide placements from the late 1990s until the mobile home market
began declining in about 2008 (Talbot 2012). Research on the vulnerability of mobile home residents to tornadoes—or other hazards—must recognize that those living in new and/or double-wide units will be perhaps less exposed to the hazard agent and potentially less sensitive in terms of economic resources. Other sensitivity factors, such as age, household size, disability, race or ethnicity, language barriers, and psychological aspects, among several additional factors, remain relevant (Cutter, Boruff, and Shirley 2003; Norris et al. 2008). Having summarized what it means to be vulnerable—exposed to tornadoes and susceptible to their physical effects—the following section conceptually addresses the issue of how to enhance mobile home residents’ likelihood of survival when tornadoes strike their communities.

2.3.2. Disaster Resilience and Mobile Home Residents

Recognizing the vulnerability of those living in mobile homes to wind hazards, some within the emergency management, public health, and weather forecasting professional communities are adamant to reduce the casualty rate of that particular segment of the population. There are many programs and mechanisms already in place: detection and warning systems, media partnerships for dissemination of safety and emergency information, mobile home construction standards, specially designated public shelters to accommodate dozens of people, specially built private shelters to accommodate one or two households, and more recently, evacuation. These efforts can be understood within the concept of resilience, which is used to theorize individual, group, and system dynamics, both human and non-human, vis-à-vis all manner of disturbances and hardships.
Disaster resilience, if adapted from a community-level context to a household context for the purpose of this study, can be characterized simply as the capacity of mobile home residents to anticipate, plan for, respond to, and survive tornado events while minimizing immediate and lasting effects and enhancing the ability to survive future tornado events (US NRC 2012). This research is most concerned with minimizing bodily injury and fatalities, and therefore the notions of different speeds or qualities of recovery of the built environment, while critical to disaster resilience theory in general (Cutter et al. 2008; Norris et al. 2008), are not the focus here.

One of the key components for addressing vulnerability and promoting resilience is adaptive capacity. While authors differ in their conceptualizations of the relationships between vulnerability, resilience, and adaptive capacity (see Cutter et al. 2008), the latter usually includes both shorter term coping responses and longer term adaptation practices (e.g. Cutter et al. 2008; Morss et al. 2011; Birkmann et al. 2013). Thus, the activities to reduce tornado casualties outlined in the first paragraph of this section are coping and/or adaptive responses intended to encourage resilience with respect to wind hazards in general and tornadoes in particular, within mobile home communities and the housing industry (Prior and Eriksen 2013). This provides the context for the subsequent literature discussions in this chapter on hazard preparedness, warning systems and warning response, and evacuation.

2.4. Hazard Preparedness

There are two general types of preparedness actions of interest in this study. The first type of preparedness is formulating a household plan of action for the possibility of a tornado threatening a person’s mobile home. This plan could entail any of several
actions, from shelter in-place plans to lying flat in a ditch or ravine to complete evacuation of the area under threat. The second type of preparedness action that warrants brief mention here is structural mitigation to harden mobile homes against extreme wind loads or to provide a building on the premises that can provide improved protection. While preparedness actions such as stocking non-perishable food and medical supplies or securing critical personal documents are commendable (Chaney et al. 2013), these are not the behaviors of interest in this study.

2.4.1. Relevant Concepts

Five recent studies in the hazards, risk, and disasters literature—by five different groups from a range of disciplinary backgrounds—proposed conceptual models that could be used in studies of hazard preparedness behavior. The studies were all conceived in different hazards contexts: earthquakes (Becker et al. 2012); multiple hazards (Keller et al. 2012; Wachinger et al. 2013); terrorism (Wood et al. 2012); and wildfires (Prior and Eriksen 2013). Five concepts can be found, often by different names, in most or all of the frameworks: preparedness information; coping strategies; risk perception; agency and self-efficacy; and outcome expectancy. The relationships between these concepts are also variable; there is not one clear structure or ordering that has been shown to apply across all hazard or disaster preparedness contexts. It should be noted that demographic factors such as gender, socioeconomic status, and race/ethnicity can also be important predictors of hazard preparedness, though the relationships are not consistent across all hazards and all events (Bourque 2013).
2.4.1.1. Preparedness Information

Household preparedness should lessen the possibility of negative effects, whether harm to humans and animals or damage to buildings and material possessions (Paton 2001). There are several aspects of preparedness information that can influence whether a person adopts a certain preparedness approach. The information has to be understandable and actionable; that is, it must be received by a person and the content must be specific enough to spur action in the desired context (Wood et al. 2012). The dissemination of the information must also be widespread, sustained, and consistent in its content to maximize the likelihood of capturing the intended audience’s attention and minimize confusion (Wood et al. 2012).

Other research on information seeking and processing have highlighted the importance of information insufficiency; this is the perceived difference between a person’s existing knowledge about preparedness and the target hazard agent and a threshold of sufficiency wherein the person may cease to seek further information (Yang and Kahlor 2013). Yet another important factor is whether the information reception process is passive, interactive, or experiential; the latter two function similar to active learning and promote internalization of the information (Becker et al. 2012). This concept is related to additional information processing frameworks in which understanding of content hinges largely on the differences between systematic and heuristic processing of messages (Trumbo 2002).

Another factor related to preparedness information is trust, or the perception that information is accurate, complete, reliable, and communicated in good faith (Renn and Levine 1991; Becker et al. 2012; Wachinger et al. 2013). Trust is crucial for encouraging

2.4.1.2. Coping Strategies

Coping involves conscious actions to lessen the negative effects of a stressful event or process (Carter and Connor-Smith 2010). Coping can be active in the sense that a person directly engages with a problem or potential problem with both action and positive emotional responses, or it can entail disengaging from a problematic situation in order to avoid distress (Carter and Connor-Smith 2010). Coping strategies can be conceptualized as related to one’s personality (Carter and Connor-Smith 2010), but they can also be thought to stem from one’s appraisal of resources available to address a problem (Mulilis and Duval 1997). Typically, hazard preparedness action is thought to be associated with engagement coping, both instrumental and emotional (Mulilis and Duval 1997; Becker et al. 2012; Keller et al. 2012; Prior and Eriksen 2013).

2.4.1.3. Agency and Self-Efficacy

Agency and self-efficacy are related concepts, but should not be considered as synonyms. Agency (sometimes called perceived behavioral control) has to do with the amount of control a person has over their own behavior in a given situation or environment (Bandura 2012). Accordingly, there can be situations that are imposed upon a person, situations that a person chooses to participate in with the expectation of at least a modicum of control, and situations that are created specifically to enhance personal agency (Bandura 2012). A sense of responsibility informs whether a person feels any
obligation to undertake a behavior, and self-efficacy describes a person’s perceptions about their own abilities to act toward a certain goal or outcome (Bandura 2012; Becker et al. 2012; Miller, Adame, and Moore 2013). Hazard or disaster preparedness models typically assume that more personal agency, responsibility, and self-efficacy influence a greater likelihood of adopting preparedness measures (Becker et al. 2012; Prior and Eriksen 2013; Wachinger et al. 2013).

2.4.1.4. Risk Perception

Risk can be defined as the likelihood of some event or phenomenon (usually adverse) and the outcomes related to the magnitude or severity of the event (Haimes 2009). A simple understanding of risk perception therefore is that it is how a person views the probability of the risk object occurring and the probability of it being severe enough to produce negative consequences. Risk perception can be formed from objective measurement and analysis of risks, but it can also be formed subjectively based on comparisons of the risk context (Sjoberg 2000; Fischhoff 2009). Subjective formation of risk perception can also be a function of affect, which refers to subtle emotions and intuitive feelings (Slovic et al. 2004).

Beyond analytical and affective approaches to risk perception, a person may also derive risk meaning from socio-cultural factors. A person’s values and worldviews influence the levels of risk and the hazard agents that they focus on (Sjoberg 2000; Leiserowitz 2006). For example, individualistic people tend to fear objects or events that compromise personal freedom, hierarchical people more readily accept risks that have been approved by experts, and egalitarian people focus on risks imposed on a larger group by a smaller more powerful group (Rippl 2002; Leiserowitz 2006). The American
culture of individualism and a hierarchical worldview is most often embodied in risk perception as the white male effect, meaning that white males have a tendency to be more dismissive of risks than females, especially those from race/ethnicity minority groups (Finucane et al. 2000; Olofsson and Rashid 2011). This effect may be a manifestation of identity-protective behaviors wherein persons speak and behave in ways that they feel will reinforce their role in society (Kahan et al. 2007). An additional socio-cultural factor in risk perception is the amplification of risk. This can take place when perception of a risk in the minds of many citizens is much greater than objective analysis of the risk by experts might indicate, or conversely attenuation can occur if the perceived risk is generally lower than what experts might posit from a probability standpoint (Pidgeon, Kasperson, and Slovic 2003).

2.4.1.5. Response Efficacy and Outcome Expectancy

Not only do persons evaluate and perceive risk and their own abilities to prepare for and handle a risky situation, but they also evaluate the potential effectiveness of recommended preparedness actions (Wood et al. 2012). Perceived effectiveness is closely related to the concept of response efficacy which is a tenet of fear appeal messaging such as theorized in the Extended Parallel Processing Model (Maloney, Lipinski, and Witte 2011). For example, a person who lives in a typical single-family site-built home might plan to shelter in-place in a bathroom during a tornado because they expect this location to offer effective protection against wind-borne debris. Thus, increased perception of response efficacy is thought to enhance the likelihood of a person undertaking associated preparedness behaviors.
Another concept often included in preparedness models is outcome expectancy (Prior and Eriksen 2013) or outcome desirability (Keller et al. 2012). These are conceptually tied to response efficacy, though not exclusively. They implicitly include the possibility of ineffective preparedness actions, since an expected negative outcome of a risk event (as in Prior and Eriksen 2013) would often accompany the belief that the preparedness behaviors would be inadequate. Desirability likewise assumes effort toward a positive outcome which lessens the possibility or severity of impacts associated with the target risk. Watson and Spence (2007) characterized outcome desirability as congruence with a person’s goals and as generally pleasant or good.

2.4.2. Tornado Preparedness: Household Planning

Only a handful of studies have researched tornado preparedness in the context of sheltering plans. In a hypothetical tornado preparedness context, it has been suggested that those who feel personally responsible for preparation activities are more likely to engage in these activities, as long as personal or household resources are deemed sufficient to support the preparedness activities (Mulilis and Duval 1997). Mulilis and colleagues (2000) added that the appraisal process likely begins with available resources available to deal with the tornado threat, followed by how much responsibility a person assumes for preparedness, and then extending to actual preparedness behaviors. The final improvement in this hypothetical preparedness work suggested that when people feel they have a choice to prepare and are committed to the actions in order to produce a desirable outcome, then personal responsibility as a motivator for preparedness can be maximized (Mulilis et al. 2001). In accordance with these findings, experiencing a tornado directly or having tornado events occur nearby increases the propensity to engage
in preparedness (Mulilis et al. 2003; Senkbeil, Rockman, and Mason 2012; McCormick et al. 2014).

Other recent studies investigated tornado preparedness in terms of who would be more likely to prepare and have a sheltering plan. Mulilis et al. (2001) collected data that suggested female participants saw preparedness as more important than males, that they viewed tornadoes as more destructive, and that they rated themselves as more prepared. These conclusions were based on a very small sample however. Following the Tuscaloosa, Alabama tornado of April 2011, Senkbeil, Rockman, and Mason (2012) found that older and better educated residents were more likely to have sheltering plans prior to the event. Hispanic or Latino residents were less likely to have a sheltering plan (Senkbeil et al. 2014), and accordingly were the most likely to say they would make a plan after surviving the storm (Senkbeil et al. 2012). Interestingly, over half of all participants who stated they did not have a sheltering plan prior to the storm said they would change and have a plan, but did not know where their future sheltering location would be. Chaney and colleagues (2013) also found after the 2011 Alabama tornadoes that lower income residents were less likely to have a plan for seeking shelter.

Most relevant to the present study, it seems that mobile home residents also are less likely to engage in tornado preparedness by formulating a sheltering plan. Chaney and Weaver (2010) found evidence of this after the February 2008 tornado outbreak in Tennessee and again in Alabama after the April 2011 tornado outbreak in northern Alabama (Chaney et al. 2013). In both cases, residents rarely had access to an on-site shelter and many stated that their plan involved staying in their mobile home. Chaney and coauthors suggested that such a plan was invalid because it did not follow National
Weather Service and emergency management recommendations. They also cast negative light on some mobile home residents’ plans to drive to another building for shelter because the distances were too far. Schmidlin et al. (2009) noted that mobile home residents were reticent to plan to evacuate to nearby sturdier site-built homes because they did not know the homeowners and were hesitant to initiate contact.

2.4.3. Mobile Homes and Wind Hazard Structural Mitigation

2.4.3.1. Construction Codes

The inability of mobile homes to withstand wind hazards such as tropical cyclones and tornadoes became an issue as they began to proliferate across the US during the 1950s. The first major event that drew attention to the problem was Hurricane Donna which tracked from southern Florida to the eastern Carolinas in September of 1960, damaging or destroying a large number of mobile homes (Harris 1962). Early work on the promise of stricter building codes in reaction to Donna also suggested benefits with respect to tornadoes, especially in the southern US (Davies-Jones et al. 1973). In 1976, the US Department of Housing and Urban Development (HUD) issued a new construction standard for mobile homes to ensure a certain level of quality in the design and siting of the units (Simmons and Sutter 2008b). However, these standards proved inadequate when Hurricane Andrew struck in 1992 (FEMA 2007) and a large number of mobile homes were destroyed once again in southern Florida. Therefore, in 1994 HUD strengthened the 1976 standards for mobile homes sited within certain coastal zones prone to effects from tropical cyclones (FEMA 2007) (Figure 2.3). Outside of these zones in the southern and eastern US, the 1976 construction standards apply for the remainder of the contiguous US (FEMA 2007).
Figure 2.3. HUD wind zones for manufactured housing construction standards, image courtesy of the Manufactured Housing Institute (2015a).

There is some evidence that the more stringent construction codes, while largely spurred by hurricane events, have been effective in reducing damages and casualties from tornadic winds, especially in Florida. Simmons and Sutter (2008b) documented that mobile homes built between 1976 and 1994 fared better than those built prior to 1976 in their study of a deadly tornado event in central Florida during February of 2007. Their results further suggested mobile homes built after 1994 fared the best of all. Despite the improved construction codes in coastal areas and the improvement in construction quality over time, newer mobile homes can still be compromised and seriously damaged as a result of added rooms or structures (carports or porches) built onto the existing unit (Simmons and Sutter 2008b; Kerr et al. 2012). It should be noted that most of South Carolina remains in HUD wind zone I, which has essentially the same mobile home construction codes as were enacted in 1976.
2.4.3.2. **Tornado Shelters**

The second major strategy for structural mitigation to reduce tornado casualties in mobile homes is to have a sturdier structure on the premises where residents can retreat until a threatening storm passes. This has been the primary suggestion for mobile home parks in particular, due to the higher percentage of residents who are renters. Golden and Snow (1991) went as far as to suggest that legislation should require all mobile home parks to provide one or more common shelters for their residents, and this has been realized in at least one state (Minnesota) (Sutter and Poitras 2010). Schmidlin, Hammer, and Knabe (2001) collected data on the prominence of community shelters for 480 mobile home parks in eleven states. While their data suggested perhaps 75% of Kansas and Oklahoma mobile home parks had community tornado shelters at the time of the research, only about 12% of South Carolina and Georgia mobile home parks contacted indicated they had community shelters.

For those who own their mobile home, and who are less likely to live in mobile home parks, there is the possibility of purchasing a shelter specially designed to withstand tornadic winds. These are often installed as underground structures; above-ground shelters are also available (Simmons and Sutter 2006), but the expense for installation of an above-ground shelter would be prohibitive for residents of mobile homes because of the need to install a foundation (Levitan 2013). Merrell, Simmons, and Sutter (2005) suggested that tornado shelters purchased by mobile home residents are cost effective and worth the investment to reduce casualties. However, this study was specific to Oklahoma and did not consider other regions in the US with lower tornado frequencies. There is no known data on the prevalence of either below-ground or above-
ground tornado shelters owned by mobile home households in South Carolina. It can be surmised that the percentage is quite low, likely fewer than 10% of mobile home households, if recent post-event surveys in other southern states are any indication (see Schmidlin et al. 2009; Chaney and Weaver 2010; Chaney et al. 2013).

2.5. Warning Messages and Protective Action

Tornado preparedness actions, including structural mitigation and formulation of sheltering plans, are important and should take place well before any single event is imminent. Once a thunderstorm event is underway, human responses move from being motivated by general tornado risk perceptions and vague potential sheltering scenarios to more specific and immediate threats requiring specific and immediate protective behaviors. Thus, it is appropriate to briefly discuss the current state of the tornado warning system and then outline warning communication and behavioral response models relevant to this study, as well as recent empirical studies of tornado events which illustrated these concepts.

2.5.1. Integrated Warning System

According to Mileti and Peek (2000), a warning system should have a detection component, an emergency management component, and a public response component. Accordingly, warnings for tornadoes and other rapid-onset thunderstorm hazards are generated and disseminated through an integrated warning system including federally funded weather forecasting and detection entities, commercial weather forecasting and detection entities, the news media, and emergency management (Golden and Adams 2000).
Brotzge and Donner (2013) summarized this integrated warning process as having an institutional response process that links to individual persons who each go through their own response process in reaction to messages generated through the institutional response (Figure 2.4). The institutional response for a tornado event begins from an ongoing general weather prediction stage using numerical weather models on longer time scales (7-10 days) and empirical data from remotely sensed data and in-situ measurements on shorter time scales (6-24 hours). When forecasts and observations suggest the possibility of tornadic thunderstorms in a certain geographic area within a certain time frame, detection becomes paramount. Once events begin unfolding, networks of humans and technological systems are deployed to monitor whether ongoing thunderstorms show telltale signs of tornado formation. If a tornado is observed, or if one appears to be imminent, a decision is made by the local National Weather Service forecasting office whether or not to issue an official tornado warning. If a warning message is issued, it is then disseminated to persons in the threatened area quickly and widely through a variety of media sources. The following section provides further details about characteristics of effective warning messages.

2.5.2. Warning Message Characteristics

Drawing heavily from Mileti and Peek’s (2000) thorough exposition of the warning process for a nuclear power plant accident, warning messages should have certain content and style to be effective. Several of these aspects of warning content and style are relevant for tornado warnings as well. These are discussed below, using the text of an actual tornado warning from South Carolina as an example (Figure 2.5).
2.5.2.1. Content

There are at least five descriptive elements that help make warning messages clear and understandable (Mileti and Peek 2000). The message should describe the hazard agent, the location under threat, and the time frame during which the threat is expected to exist. Tornado warnings always state the hazard type, obviously, but do not always offer a description of specific dangers associated with a tornado that often cause serious injury such as flying debris or collapsing walls. There is a recent trend, however, to provide more information in tornado warnings on exactly how damage and injuries might be expected occur (Perreault, Houston, and Wilkins 2014; Ripberger et al. forthcoming).
These new warning formats have not yet been implemented nationwide as of early 2015 and are still considered experimental. The time that the tornado was detected is always given, as well as the ending time of the warning period (Figure 2.5). A generic description of the area under threat typically references portions of counties, while the initial approximate location of the tornado itself is typically described using miles for distance and cardinal or intermediate directions from a nearby reference city, town or water body. The warning messages also include an estimation of the speed and direction of movement in miles per hour, along with a list of locations which can expect potentially life-threatening weather conditions. Depending upon the situation, update messages with new location, direction, and temporal information can be issued at irregular intervals.

It is also imperative that the source of the warning message be clearly stated and that some guidance be provided as to the proper courses of action. Tornado warnings are only issued by the National Weather Service, and each message states which local forecast office in particular is transmitting the message. All tornado warning messages give guidance for sheltering in-place, including general directions to move away from windows and toward the center of the lowest floor of a building. Importantly, many tornado warning messages also include a recommendation for those in mobile homes to evacuate to a substantial shelter or lie flat in a nearby ditch (Figure 2.5). Contrary to Mileti and Peek’s (2000) recommendation of specific evacuation guidance as to the route and destination, tornado warnings do not and cannot include such information due to the ephemeral nature and rapid onset of the hazard.
Figure 2.5. Example of an official tornado warning, retrieved from online archive hosted by the Iowa Environmental Mesonet (2015).

2.5.2.2. Style

While the content of warning messages is critical, several aspects of the style in which the warnings are conveyed can be equally important. Mileti and Peek (2000) highlighted seven of these warning style considerations: clarity, sufficiency, specificity, certainty, accuracy, channel, and consistency. Tornado warnings from all NWS offices follow the same format and are written for clarity; they do not contain jargon, inscrutable
technical language, acronyms, or abbreviations. However, the original text is not always received by the public at-large because they are disseminated through a wide range of channels. Tornado warnings are often received via television (Sherman-Morris 2005; Sherman-Morris 2013), though increasingly tornado warnings are delivered directly to personal cellular phones via a variety of applications and the federal government’s wireless emergency alert system (Casteel and Downing 2013; Bean et al. 2015). The issuance of a tornado warning is often signaled by the sounding of outdoor siren systems which do not convey any details other than to alert those within earshot to danger (Brotzge and Donner forthcoming). Because warning messages are transmitted and interpreted multiple times via multiple formats, there is also difficulty with controlling consistency of the contents of the message.

The notions of specificity, sufficiency, certainty, and accuracy are intertwined. Tornadoes are very difficult to predict and sometimes even to detect at all. There is the possibility, therefore, of being too specific in the contents of a warning message to the detriment of its accuracy. Meteorologists are quite concerned with being accurate and therefore provide a level of specificity commensurate with the inherent uncertainty of where a tornado is located and where it is moving. Only about 40% of warnings include language that states a tornado has already been confirmed in progress (Blair and Leighton 2014). Still, even if one has incontrovertible evidence of its existence at one moment, it may dissipate within a matter of seconds. There is evidence that inaccurate warnings—those that are either false alarms or missed events that were not warned for—lessen trust in the NWS and therefore the propensity to take protective action (Ripberger et al. 2015). Simmons and Sutter (2009) demonstrated that more warning false alarms have been
associated with more tornado fatalities and injuries. Others have collected data that suggests the public can tolerate tornado false alarms without viewing the NWS as having reduced credibility (Schultz et al. 2010), or that members of the public can have a different conceptualization of false alarm than the NWS (Donner, Rodriguez, and Diaz 2012). The specificity of geographic language can likewise be critical for spurring protective action. In at least three recent studies, the geographic description of a tornado’s location and movement caused confusion among warning recipients as to whether or not they were in danger (Klockow 2011; Montz 2012; Nagele and Trainor 2012). The following section expands on the individual warning response process, the lower half of Brotzge and Donner’s (2013) warning process model (Figure 2.4).

2.5.3. Individual Warning Response

2.5.3.1. Individual Warning Response Process

Drawing principally from past works by Dennis Mileti, John Sorensen, Michael Lindell, and Ronald Perry, Brotzge and Donner (2013) presented a quasi-linear framework describing the main steps in a typical individual’s warning response process (Figure 2.4). The process begins with receiving the warning message and moves immediately into a belief stage where the credibility of the warning is evaluated. If a person believes the warning to be credible, then s/he tries to confirm the warning by seeking additional information. If the warning message is repeated by other trusted sources, then the warning also needs to be internalized and personalized; that is, the person should not only find the warning credible, but should recognize that it applies directly to them in their immediate place and time. If, after realizing the need for action
the person has the resources and/or ability to act appropriately vis-à-vis the warning message, then they are likely to respond accordingly.

2.5.3.2. Protective Action Decision Model

Lindell and Perry (2012) proposed their Protective Action Decision Model (PADM), which is discussed here in a warning response context, though it has many similarities to preparedness behavioral models presented earlier in this chapter and could be used in that context as well. PADM begins with several starting inputs (Figure 2.6), including the actual warning message(s), the person or institution who is the source of the information, the channel through which the information is transmitted (e.g. television, radio, etc.), available cues in the environment (tornado sounding like rushing water or a freight train), social cues (see neighbors getting in their shelter), and a catch-all input for the person(s) who is receiving all of this information.

According to Lindell and Perry (2012), the predecision processes of information exposure, attention, and comprehension are unconscious; they happen more or less automatically. The crux of the PADM is in three key interacting perceptions or beliefs. Perception of the threat is similar to risk perception in preparedness models, but in this context the perception is perhaps more immediate and event-specific. The second perception component relates to recommended or potential protective actions. As in the preparedness models, this encompasses notions of self-efficacy and response efficacy. The third perception is that of other relevant stakeholders in a warning system, including notions of responsibility, competence, and trust. The perception elements then inform the cognitive decision making process with another round of information inputs and both risk and protective action appraisals. A protective action response of some kind then follows,
tempered by factors unique to each situation which can enhance or impede the connection between intended actions and actual behavior. The following section provides further details about characteristics of effective warning messages.

![Protective Action Decision Model](image)

Figure 2.6. Protective Action Decision Model, reproduced from Lindell and Perry (2012), page 617.

### 2.5.4. Factors Affecting Tornado Warning Response: Recent Empirical Evidence

Previous experience with tornadoes continues to generate mixed results in studies on its influence on warning response. Perreault et al. (2014) suggested that more experience with severe thunderstorms increases the likelihood of seeking additional information when a warning is issued. Silver and Andrey (2014) demonstrated with their study in Goderich, Ontario that having a recent tornado experience can increase likelihood of engaging in protective behaviors during successive events. Conversely, Paul, Stimers, and Caldas (2014) found that residents who expressed greater past experience with tornadoes were less likely to comply with official tornado warnings in the 2011 Joplin tornado. Furthermore, Klockow, Peppler, and McPherson (2014) noted in Mississippi and Alabama that previous tornado experiences often were interpreted through the lens of local or folk explanations tied to the physical and built environments.
These interpretations of events were not always congruent with expert meteorological explanations, and in some cases warning responses based upon folk science understandings ran counter to expert recommendations during the 27 April 2011 tornado outbreak.

Several recent studies contributed to the existing understanding of female and male warning responses. Female study participants were found to be more likely to seek warning information (Perreault et al. 2014), take protective action (Sherman-Morris 2010; Paul et al. 2014; Silver and Andrey 2014) and perceive warning false alarm ratios to be lower than males (Ripberger et al. 2015). White residents in Tuscaloosa were more likely to take protective action during the 2011 tornado than non-white residents (Luo, Cong, and Liang 2015). Also, in a broader study across several events over the span of two years, Latino and non-white residents and those with lower educational attainment were more likely to believe that previous tornado events were not properly warned by the NWS (Ripberger et al. 2015). Reduced trust and credibility is often associated with reduced likelihood of protective action. In the same study, however, Ripberger and colleagues (2015) found that older respondents were more likely to believe tornado warnings to be accurate.

A few additional recent findings are worth noting here. In multiple tornado events, post-event data suggested that having a sheltering plan in place before the event increased the propensity to take protective action in response to a warning (Nagele and Trainor 2012; Cong et al. 2014). One hypothetical study showed evidence that the preferred warning lead time may be around 30 minutes (Hoekstra et al. 2011); longer lead times might not enhance warning response because people will wait to act when they are
confident that it is truly necessary. Donner, Rodriguez, and Diaz (2012) noted that some people may favor protective actions to mitigate damage to personal property rather than prioritizing personal or household safety. They also noted that some Gulf Coast residents might not respond appropriately to tornado warnings because they are accustomed to viewing hurricanes as the primary hazard of concern.

2.6. Evacuation Behavior

2.6.1. Key Concepts

2.6.1.1. Evacuate or Shelter-in-Place

Assuming that an individual or household has received and understood some kind of warning message, understands and personalizes some level of risk, and feels they are responsible and able to take action, the final decision is which protective action to implement. Sorensen, Shumpert, and Vogt (2004) presented two simple factors that are fundamental in an evacuation decision: whether sheltering-in-place will provide sufficient protection from the hazard, and whether there is time to complete an evacuation. The first question, in Sorensen and colleagues (2004) context of hazardous chemical releases, generally refers to the interaction between the lethality of exposure to a chemical, the duration of exposure, and the ability of a building to keep air exchange between the outside and inside to a minimum. Additionally, people sheltering-in-place can take actions which might lessen their exposure like shutting off cooling/heating units and sealing doors and windows, although these measures take precious time to complete. Similar factors are at play for other hazards; some evacuate while others choose to stay and defend against wildfires (Cova et al. 2009; Penman et al. 2013) or floods (Terpstra and Lindell 2013). For mobile home residents in the US, the official standing
recommendation of the NWS and FEMA is that mobile homes cannot withstand tornadic winds and residents should either evacuate to a nearby sturdy building or lie flat in a ditch. However, perhaps only one-third of mobile home residents have ever actually evacuated as recommended because of a tornado warning (Schmidlin et al. 2009).

The second evacuation factor given by Sorensen and coauthors (2004) is whether enough time is available to evacuate safely. This can be estimated by the geographic extent and movement of the hazard agent, such as the size of the toxic release cloud and the proximate atmospheric and topographical conditions. This can also depend upon the evacuation route(s); whether there is only one route or multiple feasible escape routes relative to the primary hazard, or whether the evacuation route(s) is unable to handle the volume of vehicles leaving at once (Trainor et al. 2012). It can also depend upon the amount of time a person or household needs to prepare for evacuation (Lindell, Kang, and Prater 2011). Tornadoes are somewhat unique in an evacuation context because they can sometimes be anticipated by up to an hour, with an even longer run-up time of up to several days with messages aimed at heightening awareness for an upcoming possible tornado event. More often, they happen rather unexpectedly with little or no forewarning. There is also very little skill in predicting before a tornado forms how long it will last, how large it will be, or how fast its wind speeds will be. Determination of sufficient time for evacuation for a tornado is therefore variable and highly uncertain.

While the two principal evacuation factors in Sorensen et al. (2004) are certainly relevant from an evacuation administrative viewpoint, social science research on evacuation behavior has uncovered many more complicating factors. From a socio-demographic standpoint, evacuation behavior has been demonstrated to differ across age,
gender, household size, the presence of children or the elderly, race, ethnicity, physical and mental health, income, vehicle access, housing type, education, and extent of one’s social network (Dash and Gladwin 2007; Trainor et al. 2012).

A final consideration in the evacuation versus shelter-in-place decision is the issuance of and compliance with official evacuation orders. In numerous hazard contexts—toxic release, nuclear accident, terrorist attack, hurricane, tsunami, coastal flood, river flood, wildfire—there is the possibility of a government agency, usually a local jurisdiction, proclaiming an evacuation order with clearly defined geographic boundaries and a date and time indicating when the evacuation should be complete (Dash and Gladwin 2007). There can be mandatory evacuation orders and voluntary orders, the latter of which might also be referred to as recommended evacuations. Frequently, even people in areas which are not required to leave but are in close proximity to those that are can complicate the situation by deciding to leave as well (Lamb et al. 2012). To the author’s knowledge, official mandatory evacuation orders are not issued regularly in advance of a tornado anywhere in the US, even for mobile home residents. The recommendation for mobile home residents to evacuate that accompanies many tornado warnings is the closest comparable product to an official voluntary evacuation order.

2.6.1.2. Evacuation and Geospatial Thinking

Geospatial thinking is essential for evacuation behavior, and there is evidence that geospatial thinking and map reading tasks are unique from other cognitive tasks and activate different centers in the brain (Gersmehl and Gersmehl 2007; Lobben, Lawrence, and Pickett 2014). Drawing from the work of Golledge and colleagues (2008), Gersmehl and Gersmehl (2007), and others, Lobben and Lawrence (forthcoming) contend that
geospatial thinking can be synthesized in a simple model with three axes: space, time, and attribute. This provides a framework for more complex geospatial concepts like distance, direction, path, proximity, and networks.

Because evacuation typically requires understanding of risk regions or zones, trip planning and routing, several past studies investigated aspects of evacuation related to geospatial thinking. Previous studies in hurricane and wildfire contexts have focused on identification of risk areas (Arlikatti et al. 2006), timing of departure (Sorensen 1991; Dennison, Cova, and Mortiz 2007; Larsen et al. 2011), and routing strategies (Dow and Cutter 2002; Trainor et al. 2012; Sadri et al. 2014). In hurricane evacuations, the destination for households is typically the home of a family member or a friend, though hotels/motels are also used heavily in some contexts (Whitehead et al. 2000; Mesa-Arango et al. 2013; Murray-Tuite and Wolshon 2013). As of this writing, there has been very little research on choosing a destination (Chaney and Weaver 2010; Chaney et al. 2013) in the context of evacuation for a tornado, and there has not been any social research on other geospatial aspects such as time of departure or choosing a route.

2.7. Chapter Summary

One of the goals of this dissertation is to identify key factors that either encourage or discourage mobile home residents to prepare for tornadoes by having an evacuation plan. Rather than choosing a conceptual model a priori and tailoring data collection to test the validity of the theorized relationships in one model, the author elected to conduct the research in an inductive and exploratory fashion. The paramount reason for such an approach is to allow for the possibility of new insights to supplement the solid knowledge base that already exists in understanding hazard preparedness, response, and evacuation
behaviors. In this way, the researcher can attempt to address idiographic factors specific to the study area or the hazard under investigation, while also contributing further data on nomothetic factors which might be generalized to other places or other hazards. The most critical concepts from the extant literature used in this research can therefore be summarized visually with no particular order or magnitude (Figure 2.7). These were incorporated into the interview guide and subsequently into the mailed questionnaires; Chapter 4 of this document explains the implementation of the research methodology in greater detail.

Figure 2.7. Conceptual context diagram for this research.
CHAPTER 3: RESEARCH SETTING

3.1. Overview

The research presented in the remainder of this document took place in South Carolina. Given the anticipated difficulties in recruiting interviewees and in obtaining mobile home address data for a mail survey, the author loosely identified the study area as the entire state of South Carolina at the outset. While such a strategy was not as simple as using one Metropolitan Statistical Area (for example, Columbia), it allowed the author to pursue potential contacts for recruitment anywhere within the state. The author intended, however, to collect the majority of data for this research from an eight county area in central and northeastern South Carolina: Calhoun, Darlington, Kershaw, Lee, Lexington, Orangeburg, Richland, and Sumter (Figure 3.1).

This was the particular region of focus for two main reasons. First, the author wanted to maximize the opportunity to include African-American participants and their perspectives in the research, which was more readily accomplished by focusing on counties generally south and east of Columbia, South Carolina rather than north and west. The second main reason was to include the path of SC’s deadliest tornado which occurred in 1924, and followed a path through the middle of the eight-county region depicted in Figure 3.1. If a similar tornado were to occur in 2015, thousands of persons residing in mobile homes would be in or near the path.

Though 70% of the total housing units located in these eight counties are in urban areas according to 2010 census data (Census Bureau 2011), the region includes a variety
of urban, suburban, and rural settings. Richland County is home to nearly 385,000 people who mostly live in or near Columbia, the capital city of South Carolina. Just over 90% of housing units in Richland are in urban areas, mostly clustered near Columbia and Fort Jackson, a large military installation east of downtown Columbia (Figure 3.1). Large uninhabited areas are located in southern and eastern Richland County where the Congaree and Wateree River flows decelerate in their transition from the Piedmont to the flatter coastal plain, particularly in the riverine wetlands of the Congaree National Park.

Lexington County is also densely populated with just over 262,000 persons, about 75% of which live in housing units in urban areas. The main urban areas are clustered in the northern and eastern portions of the county, south and east of Lake Murray and bordered to the east by the Congaree River. Sumter County also approaches the 70% mark for housing units in urban areas, and has a population of about 107,500 clustered principally around the city of Sumter and nearby Shaw Air Force Base. Western Sumter County is largely unpopulated due to the presence of the Wateree River and its flood plain.

The five remaining counties are more rural in nature. Darlington (population ~68,500) and Kershaw (population ~61,500) Counties, in the northern and northeastern part of the study area, have about 55% to 60% of their housing units in rural areas (US Census Bureau 2011) (Figure 3.1). In Kershaw County, many households are located in a swath connected to urbanized areas in northeastern Richland County that extends northeast near and north of Interstate 20 through the communities of Elgin and Lugoff to
Figure 3.1. Study area in central and northeastern South Carolina.

the city of Camden. In Darlington County, the most populated areas are in an arc from Hartsville to Darlington and southeastward to the border with Florence County. Orangeburg County has 92,500 residents, is 65% rural, and is the largest county (measured by land area) in the study area. The city of Orangeburg and surrounding communities, however, is one of the largest urbanized areas in the eight-county region. Lee County (population ~19,000) is largely rural (78%) and Calhoun County (population ~15,000) is completely rural (100%).

3.2. The Rise of Mobile Homes in the Southeastern United States

During the 1950s, mobile homes emerged as a booming affordable housing option, having evolved from earlier types of recreational trailers into larger and more
functional dwellings (Hart, Rhodes, and Morgan 2002). The production and shipment of mobile homes in the US increased dramatically through the 1960s from about 100,000 units annually to over 400,000, peaking in the early 1970s at nearly 600,000 units per year (Figure 3.2) (Manufactured Housing Institute 2015b). After a relatively stable period between 1975 and 1985 and a subsequent brief decline to below 200,000 units during the early 1990s, annual shipments increased again to about 350,000 units during the middle to late 1990s. Thereafter, mobile home shipments began a steady decline, falling to and maintaining annual production and shipment numbers closer to 50,000 since 2009—the lowest since the mobile home phenomenon began fifty years ago.

Though the industry has struggled more recently, mobile homes remain a fixture on the American landscape. According to the American Community Survey (ACS) (2013), there are just fewer than seven million occupied mobile homes in the US, constituting about 6% of all households. They are particularly prominent in retirement communities, large urban centers, mining and farming communities, and across the Piedmont region and coastal plain of the southeastern US (Hart, Rhodes, and Morgan 2002).

3.2.1. South Carolina in a National Context

South Carolina and its neighboring states were at the forefront of the fifty year proliferation of mobile homes. Using decennial census and American Community Survey data obtained from the National Historical Geographic Information System (NHGIS) (Minnesota Population Center 2014), the areal density of occupied mobile homes increased six-fold in South Carolina from about 1.6 units per mi$^2$ in 1970 to nearly regional density rose to 10 units per mi$^2$ while the US areal density peaked near 2 units
Figure 3.2. Annual shipments of manufactured homes in the United States, 1959 to 2013 (Manufactured Housing Institute 2015b).

per mi$^2$ in 2000. Mobile home areal densities remained level or decreased slightly from 2000 to 2010 across the southeastern states and for the entire US. As the raw number of mobile homes increased from 1970 to 2000, so did their portion share of the total housing stock. At the national level, mobile homes grew from about 3.3% of households to 7%. Simultaneously, South Carolina’s mobile homes vaulted from 6.8% to 20% of households, a national high in 2000 (Figure 3.4) (Minnesota Population Center 2014).

Using the 2008-2012 American Community Survey estimates (ACS 2013), South Carolina is situated within a broader region of states across the southern and eastern US where mobile homes are similarly prominent (Figure 3.5). South Carolina maintained the highest percentage of households as mobile homes in 2010 at nearly 17%, and ranked fourth in areal density trailing only Delaware, Florida, and North Carolina. The national
pattern is for mobile homes to be densely packed together in most of the major metropolitan areas, but make up a greater share of the housing stock in rural areas. This is true in the Carolinas as well, yet many rural counties in the region are in the top 25% for mobile home percentage as well as for areal density.

3.2.2. The Study Area in a Regional Context

The study area includes portions of central and northeastern South Carolina, situated along and just south and east of the physiographic transition zone between the Piedmont and the coastal plain. Using census tract level mobile home estimates from the ACS 2008-2012 (ACS 2013), the study area is within one of four main belts—oriented generally from southwest to northeast—where mobile home densities and percentages are high (Figure 3.6). In order geographically starting from the Appalachians: 1) beginning near Asheville, North Carolina (NC) and extending east toward Winston-Salem, NC; 2) beginning just northeast of Atlanta, Georgia (GA) and running northeast to near Greensboro, NC; 3) beginning near Augusta, GA and extending northeast across the study area to between Raleigh, NC and Greenville, NC; 4) beginning near Savannah, GA and extending intermittently northeast along the coastline to near New Bern, NC. The first two of these belts fall within the settlement region dubbed “Spersopolis” by Hart and Morgan (1995), which is characterized in part by heavy reliance on mobile homes for residential housing not only in cities, but across the sprawling suburban and exurban neighborhoods. The latter region’s proximity to the coast distinguishes it from the other three as a mix of local mobile home residents and amenity migrants who moved to the scenic coastal areas after retiring.
Figure 3.3. Areal density of occupied mobile homes, 1970 to 2010 (Minnesota Population Center 2014).

Figure 3.4. Mobile homes as percentage of all households, 1970 to 2010 (Minnesota Population Center 2014).
Figure 3.5. Mobile home areal density (mi²) and percentage of all households for 2010, classified by quartiles.

Figure 3.6. Mobile home areal density (mi²) and percentage of all households for 2010, classified by quartiles and with study area outlined in yellow.
The third mobile home belt—which overlaps with the study area—is unique from the other three in its social and economic characteristics. It is situated within a larger region of the southern US containing about one quarter of all African American persons, sometimes referred to as the “Black Belt” (Wimberley 2010). Residents of the Black Belt generally have a lower quality of life, and the region has some of the highest poverty and mortality rates in the US (Murray et al. 2006; Wimberley 2008; 2010). Increasingly, this region is also a destination for Latino migrants who often work in the farming industries, particularly in southern Georgia, eastern South Carolina, and eastern North Carolina (Winders 2005; Montz, Allen, and Monitz 2011).

Mobile homes are an integral portion of the housing stock in the Black Belt, and especially in the Carolinas. The study area in central SC has more than twelve mobile homes per mi², and about 17% of all households are mobile homes (Table 3.1). Nearly half, 46%, of mobile home heads of household are non-white residents, compared to 37% for the rest of SC and closer to one third in GA and NC. Almost one quarter of mobile homes in the study area are family households headed by single females, which is also somewhat higher than in the remainder of SC, as well as GA and NC. Approximately one third of mobile homes in the study area are rental units, and elderly heads of household (65 and over) make up roughly 15% all units. The study area has a slightly lower percentage of older mobile homes built prior to 1980 (16%) than the neighboring states.

Breaking the same list of mobile home and mobile home resident characteristics into the eight individual counties in the study area, it is clear that the study area is situated astride a cultural transition zone between the Piedmont’s Spersopolis region (Hart and
Table 3.1. Descriptive mobile home and mobile home resident statistics for the combined study area and adjacent states.

<table>
<thead>
<tr>
<th>Variables</th>
<th>South Carolina (Minus Study Area)</th>
<th>Combined SC Study Area</th>
<th>North Carolina</th>
<th>Georgia</th>
</tr>
</thead>
<tbody>
<tr>
<td>MHs per Square Mile</td>
<td>9.5</td>
<td>12.2</td>
<td>10.0</td>
<td>5.5</td>
</tr>
<tr>
<td>% Housing in MH</td>
<td>16.9%</td>
<td>16.8%</td>
<td>13.2%</td>
<td>9.0%</td>
</tr>
<tr>
<td>% MHs Rented</td>
<td>31.5%</td>
<td>33.4%</td>
<td>35.8%</td>
<td>35.0%</td>
</tr>
<tr>
<td>% MHs Built Before 1980</td>
<td>17.3%</td>
<td>15.5%</td>
<td>18.5%</td>
<td>19.8%</td>
</tr>
<tr>
<td>% MHs Householder Non-White</td>
<td>36.6%</td>
<td>46.3%</td>
<td>32.7%</td>
<td>31.3%</td>
</tr>
<tr>
<td>% MHs Householder 65 or Over</td>
<td>16.7%</td>
<td>14.7%</td>
<td>15.1%</td>
<td>16.3%</td>
</tr>
<tr>
<td>% MHs Householder Single Female</td>
<td>20.2%</td>
<td>23.1%</td>
<td>18.2%</td>
<td>18.2%</td>
</tr>
<tr>
<td>Persons per MH</td>
<td>2.8</td>
<td>2.8</td>
<td>2.7</td>
<td>2.8</td>
</tr>
</tbody>
</table>

Morgan 1995) and the so-called Black Belt of the inner coastal plain (Wimberley 2010). Lexington County, which is located on the western edge of the study area (Figure 3.6), has one of the highest mobile home areal densities in the US (27.4 per m$^2$) (Table 3.2). It also has the lowest percentage of non-white mobile home householders (23%) and single female mobile home householders (18%) in the study area. All other counties in the study area approach or exceed 50% except for Kershaw County (32%), which is also on the northwestern fringe of the study area and just outside of the core of the Black Belt. Richland County, which includes SC’s capital city Columbia, has the lowest percentage of mobile homes in the housing stock (5%) due to the large numbers of single-family homes and multifamily units in portions of the city. However, there are a large number of mobile homes in the county (almost 10 per m$^2$) and roughly 43% are rental units. Additionally, about one in five mobile homes in Richland County was built prior to 1980, the highest rate for older units in the study area. The presence of a military base in Columbia likely adds to the typical urban market for older, cheaper rental units.
Table 3.2. Descriptive mobile home and mobile home resident statistics for the study area counties.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Calhoun</th>
<th>Darlington</th>
<th>Kershaw</th>
<th>Lee</th>
<th>Lexington</th>
<th>Orangeburg</th>
<th>Richland</th>
<th>Sumter</th>
</tr>
</thead>
<tbody>
<tr>
<td>MHs per Square Mile</td>
<td>5.3</td>
<td>13.8</td>
<td>8.5</td>
<td>6.0</td>
<td>27.4</td>
<td>9.7</td>
<td>9.8</td>
<td>13.2</td>
</tr>
<tr>
<td>% Housing in MH</td>
<td>33.4%</td>
<td>29.2%</td>
<td>25.7%</td>
<td>37.2%</td>
<td>18.5%</td>
<td>31.0%</td>
<td>5.2%</td>
<td>22.3%</td>
</tr>
<tr>
<td>% MHs Rented</td>
<td>18.4%</td>
<td>29.3%</td>
<td>29.0%</td>
<td>28.5%</td>
<td>34.6%</td>
<td>30.2%</td>
<td>43.2%</td>
<td>37.9%</td>
</tr>
<tr>
<td>% MHs Built Before 1980</td>
<td>12.0%</td>
<td>14.0%</td>
<td>11.1%</td>
<td>11.4%</td>
<td>14.4%</td>
<td>18.3%</td>
<td>22.1%</td>
<td>15.1%</td>
</tr>
<tr>
<td>% MHs Householder Non-White</td>
<td>50.1%</td>
<td>47.3%</td>
<td>32.3%</td>
<td>72.3%</td>
<td>23.3%</td>
<td>64.2%</td>
<td>62.5%</td>
<td>61.5%</td>
</tr>
<tr>
<td>% MHs Householder 65 or Over</td>
<td>16.9%</td>
<td>14.8%</td>
<td>17.1%</td>
<td>11.7%</td>
<td>12.2%</td>
<td>18.3%</td>
<td>13.6%</td>
<td>15.3%</td>
</tr>
<tr>
<td>% MHs Householder Single Female</td>
<td>22.1%</td>
<td>19.9%</td>
<td>24.9%</td>
<td>34.9%</td>
<td>17.8%</td>
<td>27.7%</td>
<td>22.0%</td>
<td>28.4%</td>
</tr>
<tr>
<td>Persons per MH</td>
<td>2.5</td>
<td>2.7</td>
<td>2.8</td>
<td>3.0</td>
<td>2.7</td>
<td>2.8</td>
<td>2.8</td>
<td>2.9</td>
</tr>
</tbody>
</table>

3.3. Tornadoes, Tornado Hazards, and Warnings

3.3.1. South Carolina Tornado Climatology

The highest historical tornado frequencies in the US extend from Alabama and Mississippi westward to northern Texas and northward through the eastern plains and the Great Lakes (Figure 3.7). Though SC is not in the aforementioned area, the Piedmont and coastal plains regions of Georgia and the Carolinas are prone to tornadoes as well. About 800 total tornadoes occurred in SC on 385 separate days from 1950 through 2013 (Figure 3.8). The peak tornado season is from late March to early June, though tornadoes associated with tropical systems periodically occur, usually from June through September. Over the period 1950 to 2013, SC ranked 16th in the US for tornado frequency after adjusting for land area, with about 2.7 tornadoes per 100 mi² (Storm Prediction Center 2015b). Within SC, the density and length of observed tornado paths across most of the state are similar, with the exceptions being an area near the Atlantic coast and inland approximately 30-50 miles, and in north central SC just south of
Charlotte, NC (Figure 3.7). The latter two areas represent local minima in observed tornado frequency since 1950.

![Tornado paths in the central and eastern United States (1950-2013), classified by Enhanced Fujita Scale ratings, with the study area outlined in yellow.](image)

Figure 3.7. Tornado paths in the central and eastern United States (1950-2013), classified by Enhanced Fujita Scale ratings, with the study area outlined in yellow.

Most tornadoes—about 75% both nationally and in SC—are rather weak and cause only minor societal disruption. Yet, a mobile home can be destroyed by tornadoes with maximum wind speeds lower than 100 miles per hour (Edwards et al. 2013). Thus, if only tornadoes rated at the lowest two levels of the Enhanced Fujita scale (EF0 and EF1) are counted, SC ranks 13th (2.1 per 100 mi²). Another important factor is the time of day when a tornado occurs. Nocturnal tornadoes can be especially dangerous because people are often asleep during these hours and may not receive weather-related alert messages (Ashley, Krmenc, and Schwantes 2008). Of SC’s 800 tornadoes (1950-2013), roughly 20% struck between the hours of 9 PM and 6 AM—ranking 15th in the US—which is about half the rate that nocturnal tornadoes occur in the leading states located in
the lower Mississippi River valley. Recent literature on the relationship between
tornadoes and climate change in the US suggests that SC’s spring tornado season may
shift from a peak in April and May to become more concentrated in March and April
(Gensini and Mote forthcoming). Such a scenario would also likely raise the possibility
of tornadoes in late February while decreasing the possibility in June. Also, the
variability of tornado occurrence may increase such that a larger percentage of annual
tornadoes may occur on a smaller number of days (Brooks, Carbin, and Marsh 2014). As
of yet, there is no evidence of changes in nocturnal tornado rates.

3.3.2. South Carolina Tornado Casualties and Damage

Tornadoes are of concern primarily when they are a hazard to human activities,
causing harm to people, pets, and livestock, and damaging crops, buildings, and vehicles
(Boruff et al. 2003). The deadliest tornado in South Carolina history struck during the
late morning and early afternoon hours of 30 April 1924. It followed a northeastward
path across Aiken, Lexington, Richland (passing nine miles south of downtown
Columbia), Sumter, Lee, and Darlington counties, killing 53 persons (8 in Lexington
County, 24 in Richland, 20 in Sumter, and one in Lee) and injuring over 500 (Grazulis
1993). Tornadoes in Anderson County (9 deaths) and Florence County (14 deaths) on the
same day took an additional 23 lives within SC (Grazulis 1993).

More recently, South Carolina has been spared from large casualty tornado events
over the past several decades. From 1960-2013, there were 46 deaths and 1200 injuries
in total, using data from the Spatial Hazard Events and Losses Database for the United
States (SHELDUS) version 13.1, available from the Hazards & Vulnerability Research
Institute (HVRI) (2015). These figures are far from the worst in the US for total fatalities
Figure 3.8. South Carolina tornadoes and tornado days by month, as percentages of the total tornado count and total number of tornado days.

(18\textsuperscript{th}) or injuries (18\textsuperscript{th}) by state (accounting for land area) during the 54 year period; nor is SC’s $265 million (2013 dollars) in property damages impressive when compared to inflation-adjusted totals of many other southern, Midwestern, and plains states.

However, when the total fatalities and injuries are scaled by the total amount of property losses, as done by Simmons and Sutter (2011), a different picture emerges (Table 3.3). When considering the top thirty states in total tornado property damage over the period 1960-2013, SC is ranked 2\textsuperscript{nd} with 1.75 fatalities per $10 million in losses and 1\textsuperscript{st} with 45.3 injuries per $10 million in losses. When a tornado causes damage to structures or vehicles in SC, humans are harmed at a higher rate than in many states where the total number of tornadoes and tornado hazards are more frequent such as Alabama, Arkansas, Florida, Kansas, and Oklahoma.
Table 3.3. Tornado fatalities and injuries, scaled by property damage over the period 1960-2013 for top 30 states in total damage, with ranks in parentheses; data obtained from HVRI (2015).

<table>
<thead>
<tr>
<th>State</th>
<th>Fatalities per $10M Property Damage</th>
<th>Injuries per $10M Property Damage</th>
<th>Fatalities</th>
<th>Injuries</th>
<th>Property Damage (adj. 2013 $)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS</td>
<td>2.25 (1)</td>
<td>23.5 (7)</td>
<td>455 (2)</td>
<td>4749 (3)</td>
<td>$2,020,209,092 (11)</td>
</tr>
<tr>
<td>SC</td>
<td>1.75 (2)</td>
<td>45.3 (1)</td>
<td>47 (21)</td>
<td>1203 (21)</td>
<td>$265,516,836 (27)</td>
</tr>
<tr>
<td>TN</td>
<td>1.58 (3)</td>
<td>22.7 (8)</td>
<td>216 (8)</td>
<td>3101 (10)</td>
<td>$1,366,346,343 (14)</td>
</tr>
<tr>
<td>KY</td>
<td>1.4 (4)</td>
<td>26.8 (3)</td>
<td>137 (13)</td>
<td>2632 (10)</td>
<td>$980,552,574 (19)</td>
</tr>
<tr>
<td>LA</td>
<td>1.26 (5)</td>
<td>28.6 (2)</td>
<td>97 (17)</td>
<td>2204 (15)</td>
<td>$770,250,678 (21)</td>
</tr>
<tr>
<td>NC</td>
<td>1.25 (6)</td>
<td>24.3 (5)</td>
<td>125 (14)</td>
<td>2435 (14)</td>
<td>$1,003,951,156 (18)</td>
</tr>
<tr>
<td>PA</td>
<td>1.18 (7)</td>
<td>16.7 (13)</td>
<td>80 (18)</td>
<td>1133 (22)</td>
<td>$677,941,378 (22)</td>
</tr>
<tr>
<td>AR</td>
<td>1.12 (8)</td>
<td>18.5 (12)</td>
<td>255 (6)</td>
<td>4204 (4)</td>
<td>$2,269,464,843 (9)</td>
</tr>
<tr>
<td>OH</td>
<td>1.1 (9)</td>
<td>23.6 (6)</td>
<td>173 (10)</td>
<td>3714 (8)</td>
<td>$1,574,953,622 (13)</td>
</tr>
<tr>
<td>AL</td>
<td>1.06 (10)</td>
<td>13.1 (21)</td>
<td>638 (1)</td>
<td>7843 (1)</td>
<td>$6,000,916,035 (1)</td>
</tr>
<tr>
<td>IN</td>
<td>0.95 (11)</td>
<td>13.6 (19)</td>
<td>289 (5)</td>
<td>4117 (6)</td>
<td>$3,037,087,422 (12)</td>
</tr>
<tr>
<td>GA</td>
<td>0.85 (12)</td>
<td>16.4 (14)</td>
<td>154 (12)</td>
<td>2962 (12)</td>
<td>$1,809,454,568 (5)</td>
</tr>
<tr>
<td>TX</td>
<td>0.81 (13)</td>
<td>15.2 (15)</td>
<td>305 (3)</td>
<td>5728 (2)</td>
<td>$2,106,792,608 (10)</td>
</tr>
<tr>
<td>FL</td>
<td>0.8 (14)</td>
<td>14.5 (17)</td>
<td>168 (11)</td>
<td>3050 (11)</td>
<td>$3,775,534,995 (5)</td>
</tr>
<tr>
<td>SD</td>
<td>0.71 (15)</td>
<td>21.4 (9)</td>
<td>13 (27)</td>
<td>393 (27)</td>
<td>$183,533,639 (30)</td>
</tr>
<tr>
<td>IL</td>
<td>0.69 (16)</td>
<td>14.4 (18)</td>
<td>174 (9)</td>
<td>3647 (9)</td>
<td>$2,536,797,749 (8)</td>
</tr>
<tr>
<td>NY</td>
<td>0.67 (17)</td>
<td>6.5 (28)</td>
<td>31 (24)</td>
<td>294 (28)</td>
<td>$453,590,712 (23)</td>
</tr>
<tr>
<td>IA</td>
<td>0.67 (18)</td>
<td>18.7 (11)</td>
<td>77 (19)</td>
<td>2156 (16)</td>
<td>$1,155,412,386 (16)</td>
</tr>
<tr>
<td>MN</td>
<td>0.63 (19)</td>
<td>11.5 (22)</td>
<td>73 (20)</td>
<td>1341 (19)</td>
<td>$1,170,430,500 (15)</td>
</tr>
<tr>
<td>MO</td>
<td>0.57 (20)</td>
<td>8 (23)</td>
<td>299 (4)</td>
<td>4193 (5)</td>
<td>$5,217,692,933 (3)</td>
</tr>
<tr>
<td>VA</td>
<td>0.56 (21)</td>
<td>20.9 (10)</td>
<td>16 (26)</td>
<td>592 (25)</td>
<td>$282,871,074 (26)</td>
</tr>
<tr>
<td>MA</td>
<td>0.56 (22)</td>
<td>13.5 (20)</td>
<td>17 (25)</td>
<td>402 (26)</td>
<td>$296,992,427 (25)</td>
</tr>
<tr>
<td>WI</td>
<td>0.51 (23)</td>
<td>15.2 (16)</td>
<td>40 (22)</td>
<td>1208 (20)</td>
<td>$796,896,237 (20)</td>
</tr>
<tr>
<td>OK</td>
<td>0.46 (24)</td>
<td>7.5 (24)</td>
<td>244 (7)</td>
<td>3981 (7)</td>
<td>$5,313,424,306 (2)</td>
</tr>
<tr>
<td>KS</td>
<td>0.4 (25)</td>
<td>7.2 (25)</td>
<td>120 (15)</td>
<td>2130 (17)</td>
<td>$2,972,329,997 (7)</td>
</tr>
<tr>
<td>NE</td>
<td>0.39 (26)</td>
<td>7.2 (26)</td>
<td>40 (23)</td>
<td>719 (23)</td>
<td>$1,004,624,832 (17)</td>
</tr>
<tr>
<td>MI</td>
<td>0.22 (27)</td>
<td>4.2 (29)</td>
<td>98 (16)</td>
<td>1814 (18)</td>
<td>$4,368,824,187 (4)</td>
</tr>
<tr>
<td>MD</td>
<td>0.18 (28)</td>
<td>6.9 (27)</td>
<td>7 (28)</td>
<td>268 (29)</td>
<td>$387,314,141 (24)</td>
</tr>
<tr>
<td>CT</td>
<td>0.16 (29)</td>
<td>26.1 (4)</td>
<td>4 (29)</td>
<td>658 (24)</td>
<td>$251,915,317 (28)</td>
</tr>
<tr>
<td>UT</td>
<td>0.04 (30)</td>
<td>3.7 (30)</td>
<td>1 (30)</td>
<td>91 (30)</td>
<td>$243,247,444 (29)</td>
</tr>
</tbody>
</table>

3.3.3. Tornado Warnings in South Carolina

The NWS is organized geographically into over one hundred forecasting offices that serve their respective local areas. There are four office locations that are responsible for issuance of short-fuse weather warnings, including tornado warnings, for counties in South Carolina: Charleston, SC; Columbia, SC; Greenville, SC; and Wilmington, NC (Figure 3.9). All of the counties in the study area for this research are in the Columbia
warning area, except for Darlington County which is in the Wilmington warning area. According to the national warnings archive maintained by the Iowa Environmental Mesonet (2015), the Columbia NWS office issued 1,457 tornado warnings over the period 1986 to 2013, while the Wilmington office issued 1,010. Accounting for the areal size of each office’s area of responsibility, Columbia NWS issued 10.7 warnings per 100 mi² and Wilmington NWS issued 9.8 warnings per 100 mi².

Figure 3.9. National Weather Service forecast office areas of responsibility for Columbia, SC and adjacent offices, with the study area outlined in yellow.

From 1986-2013, there were 295 and 181 confirmed tornadoes respectively in the Columbia and Wilmington areas of responsibility. The official tornado warning probability of false alarm statistics (as defined in Barnes et al. 2009) are not available, and the calculations are intensive and beyond the scope of this research. Nevertheless, using a rough approximation it appears that, in the study area, about three out of four
warnings are not followed by an actual tornado. These figures suggest that the Columbia and Wilmington offices are near the national average for tornado warning verification statistics (Brotzge, Erickson, and Brooks 2011) and do not seem to over- or under-warn noticeably compared to other offices in the contiguous US.

3.4. Chapter Summary

This study addresses how mobile home residents prepare for and respond to tornadoes. This problem is especially relevant in the southeastern US, and central South Carolina is one of the core mobile home areas. The study area encompasses a range of urban and rural settings, allowing data collection with single-sited mobile homes and urban and suburban mobile home parks. South Carolina is not as readily associated with tornadoes as states like Kansas and Oklahoma, and it does not have the devastating tornado history of the Mississippi, Tennessee, and Ohio River valleys. However, South Carolina experiences tornadoes on a regular basis, and when tornadoes incur damage the human toll is high compared to the other tornado prone states in the US. Conducting the study with mobile home residents in South Carolina will add valuable and unique data to the existing body of literature on tornado hazard perception, preparedness, and response.
CHAPTER 4: RESEARCH METHODOLOGY

4.1. Overview

Commensurate with the inductive research design and in accordance with the research questions, the research methodology was a mixture of qualitative and quantitative approaches. This chapter describes how the research was accomplished, highlighting its strengths and shortcomings as appropriate.

4.2. Qualitative Methodology

The role of the qualitative research approach in this study was to gain insight into important perspectives that may be missing from other existing general models of hazard preparedness, protective action, and evacuation behaviors. Therefore, it was necessary first to speak with some mobile home residents in South Carolina and get their perspectives on a range of general and specific topics related to tornado preparedness, response, and evacuation.

4.2.1. Development of the Interview Guide

This research utilized a semi-structured approach to qualitative interviewing. The advantage of this format is that it allows for a loose structure that keeps each interview mainly focused on the topics of interest, while also providing latitude for unique follow-up questions specific to each participant’s responses (Patton 2002). In order to keep the topics and types of questions similar across all interviews, the author developed an interview guide (Ulin, Robinson, and Tolley 2005). Though many specific questions
were listed on the guide, the wordings of the questions were not repeated verbatim in every interview. Rather, the list of questions served as suggested entry points for relevant topics, and provided a general checklist that the author referenced to ensure critical topics were discussed.

The interview guide outlined five major themes or topics that were covered in every interview (Appendix A). The first topic included a few basic questions designed to allow the interviewee to describe where s/he lives and who lives there. The second theme began to touch on experiences and perspectives on disaster preparedness and planning at the personal, household, and community levels. The third group of questions was related to perspectives on weather information and warnings. Of particular interest was participants’ typical sources of information, their reasoning behind choosing those sources, and how much confidence they place in weather information and alerts from a number of different sources. Following the weather information questions, the fourth theme was perception of tornadoes and tornado risk. This group of queries centered on interviewees’ views on the physical nature of tornadoes and their predictability, their occurrence in South Carolina, and any prior experiences with tornadoes. The fifth and final theme on the interview guide focused on various aspects of response or evacuation during tornado events. These questions elicited opinions about personal and response efficacy and potential outcomes of a variety of sheltering or evacuation strategies, including how to know when or when not to evacuate for a tornado and where to go, and the perceived ability of manufactured housing to withstand damaging wind speeds.
4.2.2. Interview Methodology

4.2.2.1. Participant Recruitment

During the planning stages, the goal was to recruit twenty to thirty mobile home residents in central South Carolina for a Q Methodology project. Q Methodology consists of a series of interviews and card sorting activities with the end goal of identifying several common perspectives on a topic of interest as expressed by the participants (Addams 2000; Watts and Stenner 2005). Each participant was to be interviewed twice; the first being a semi-structured interview as described above, and the second being an activity where participants read and react to the anonymous statements of other interviewees. According to the Q Methodology research paradigm, the goal of participant recruiting is to capture a variety of different perspectives on the principal issues being studied (Brown 1993; Brannstrom, Jepson, and Persons 2011). Thus, the goal was to recruit purposively in order to include persons from a wide variety of demographic population segments who lived in a variety of mobile home settings (Table 4.1). The characteristics in the list were derived from the literature review in Chapter 2.

In practice, the recruitment methodology was not strictly purposive, but was a mix of purposive, convenience, and snowball approaches (Patton 2002; Phillips 2014). Interest in participation among potential recruits was generally quite low, and in some cases personal contacts were needed to gain access to mobile home occupants. In total, the author interviewed twenty residents during a five month period in 2013, beginning in late June and concluding in November. Six of the interviewees were recruited using convenience and snowball approaches. Of these six, four participants were recruited through the author’s professional contacts at the University of South Carolina. Two
additional participants were recruited by snowballing from one of the participants recruited from a professional contact. All six of these recruits lived in single-sited mobile homes rather than in a park, and five of these six were interviewed between June and September 2013. Beginning in September the author began to recruit purposively in mobile home parks in order to include perspectives from those living in park settings.

Table 4.1. Key characteristics and perspectives sought for interviews on tornado preparedness and evacuation.

<table>
<thead>
<tr>
<th>Characteristic of Interest</th>
<th>Key Perspectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>Younger adults (under 35), middle-aged adults (35-64), elderly (65 and over)</td>
</tr>
<tr>
<td>Children in Home</td>
<td>No children in home, young child or children in home, teenage child or children in home</td>
</tr>
<tr>
<td>Education</td>
<td>No high school diploma or GED, high school graduates, college graduates</td>
</tr>
<tr>
<td>Evacuation Experience</td>
<td>Evacuated mobile home previously for wind hazard, never evacuated before</td>
</tr>
<tr>
<td>Gender</td>
<td>Female, male</td>
</tr>
<tr>
<td>Household Size</td>
<td>Single occupant, two or three occupants, four or more occupants</td>
</tr>
<tr>
<td>Neighborhood Location</td>
<td>Mobile home in rural area, mobile home in suburban area, mobile home in urban area</td>
</tr>
<tr>
<td>Neighborhood Type</td>
<td>Isolated single-sited mobile home, clustered single-sited mobile homes, mobile homes in a park</td>
</tr>
<tr>
<td>Mobile Home Size</td>
<td>Double-section unit; single-section unit</td>
</tr>
<tr>
<td>Personal Mobility</td>
<td>Cannot walk easily or quickly; walks and moves with relative ease</td>
</tr>
<tr>
<td>Pets in Home</td>
<td>No pets in home, one pet in home, multiple pets in home</td>
</tr>
<tr>
<td>Race/Ethnicity</td>
<td>African-American, Latino or Hispanic, White</td>
</tr>
<tr>
<td>Religious Belief</td>
<td>Belief in deity, spiritual but not strictly religious beliefs, no belief in deity</td>
</tr>
<tr>
<td>Tenure</td>
<td>Renter, homeowner</td>
</tr>
<tr>
<td>Vehicle Access</td>
<td>Do not have vehicle, have at least one vehicle</td>
</tr>
</tbody>
</table>

There were two general types of mobile home parks that the author visited in central South Carolina: those with a central office and management on-site in the park and those without any on-site management presence. For the former type of park, the author would first try to contact the office via telephone to explain the ongoing research project and ask for permission to come on the premises for the purpose of recruitment. If the on-site park management could not be contacted by telephone, then the author went in
person to explain the research and ask for permission to recruit. In some cases, management asked the author to immediately vacate the premises and never return. However, several parks were amenable to the research. For those that granted permission, the author posted information flyers with contact details either inside the park office, on an outdoor park bulletin board, or near several of the large banks of mailboxes located in the park. When visiting parks without any central office or known contact information, the author simply posted the information flyers near one of the large mailbox banks, if possible.

The recruiting visits to mobile home parks were more successful than the convenience and snowball recruiting. Fourteen participants from parks were interviewed from late September to late November 2013. Four of these contacted the author after seeing one of the information flyers. The remaining ten participants were recruited as a result of visiting mobile home park offices and speaking with the management. In several cases, one or more of those working in the office lived in a mobile home themselves and agreed to participate in the study. Some of these persons lived within the mobile home park in which the author met them, while others lived in single-site mobile homes located elsewhere.

The geographic and demographic coverage of those recruited for interviews was satisfactory for covering the major perspectives thought to be of interest for the study (Table 4.1). Geographically, the original goal was to interview about four or five persons from each of six counties in and near Columbia, South Carolina (Aiken, Calhoun, Lexington, Orangeburg, Richland, and Sumter). Indeed, fifteen of the twenty interviewees lived in Lexington, Orangeburg, Richland, and Sumter counties (Figure
Due to the difficulty in recruiting participants from Aiken and Calhoun counties, the author branched out to other adjacent counties in order to take advantage of a few professional contacts outside of the originally planned study region. Two participants were recruited in York County and three additional recruits were from Chester, Darlington, and Fairfield counties, respectively (Figure 4.1). In total, there were twelve participants who lived in mobile home parks and eight who lived in single-sited mobile homes, though the coverage of neighborhood settings tended toward suburban (ten) and rural (seven) over urban (three).

The author interviewed persons from several different demographic segments based on age, race/ethnicity, family structure, and mobility. There are two demographic segments, however, from which perspectives on tornado preparedness and sheltering were not fully explored. The first is males as only three of twenty recruits were male. The author encountered many more potential male recruits, but they were generally dismissive of the idea of participation in this study. The second segment is persons of Latino or Hispanic ethnicity, particularly those who are not proficient English speakers. The author recognized the importance of this population segment, and there was a potential professional contact who was anticipated to assist in gaining access to one or two Latino residents in Aiken County. Unfortunately, this potential opportunity did not materialize as hoped.

4.2.2.2. Conducting the Interviews

The communication media and settings for the interviews were arranged according to the limitations and preferences of the participants. The author’s first priority was to collect the qualitative data without undue inconvenience to the mobile home residents.
According to recent empirical and conceptual arguments, keeping the medium of interviews constant across all participants is not essential to the integrity of a study and there is evidence that using multiple communication methods, whether telephone (Novick 2008; Holt 2011; Irvine, Drew, and Sainsbury 2013) and/or internet video chat (Sedgwick and Spiers 2009; Hanna 2012; Deakin and Wakefield 2013), does not fundamentally alter the meaning or critical content of responses. Therefore, half of the interviews took place via remote communication media and half took place in face-to-face settings.

Figure 4.1. Numbers and locations of interview participants within South Carolina.

Nine participants chose to speak via the telephone, and only one chose to speak via Skype, a free internet video chat service. One practical concern when using telephone and internet video chat for interviews is the potential for service interruptions or poor quality audio or video during the interviews. Fortunately, there were very few
interruptions during the interviews due to poor cellular or internet service. On the occasions when the interview was interrupted, the author was able to reestablish contact within a few minutes and resume the interviews. None of the participants expressed a desire to terminate the interview due to technological difficulties. One individual was forced to truncate the telephone interview to attend to children. The average length of telephone and Skype interviews was 47 minutes, and ranged from 26 to 62 minutes.

Ten of the twenty interviews were conducted in a face-to-face setting. Eight of the ten took place inside mobile home park offices, with six interviews being one-on-one between the author and the respective participant and one interview where the author spoke simultaneously with two participants. The dual interview was conducted in this manner at the participants’ request. The author was sensitive to the possibility that participants might feel inhibited if their answers could be overheard by others, and in one mobile home park office three consecutive interviews took place in a backroom office with the door closed. This allowed the participants to speak more freely and also provided a buffer from the steady noise and conversations that took place in the main portion of that park office.

In all other cases, the participants and the author were the only persons inside the office during the interviews, such that privacy and noise were not a concern. The other two in-person interviews were conducted in public buildings. One was in a meeting room at a public library which the author had reserved in advance, while the second was in a fast-food restaurant. Conducting an interview in a fast-food restaurant was not ideal, but the participant could not speak via telephone due to long distance charges and minute restrictions, and also requested not to drive very far from home. The eating establishment
was the best available location given the other limiting factors. On average, face-to-face interviews lasted 42 minutes and ranged from 27 to 61 minutes.

Regardless of the setting or medium, each interview began in the same fashion. The author briefly explained the purpose and scope of the study, his role in conducting the study, and the role of the National Science Foundation and multiple entities at the University of South Carolina in supporting the research. This was followed by a brief explanation of how the interview would be conducted, including the fact that the audio would be recorded for later transcription and analysis, and that any information given verbally or in writing by participants would not be divulged to any other parties. The recruits were made aware of efforts to protect the privacy and confidentiality of their responses and information contained therein, as well as their right to refuse to answer any question at any time or withdraw from the study at any time and for any reason. They were told that the compensation for interview participation would be $25, and that this compensation would be disbursed at the second of two interviews with the author. If recruits agreed to participate after hearing the above information, they were considered to have given their informed consent.

Interview audio was recorded using a hand-held Sony ICD-PX333 digital voice recorder. Audio files were saved in MP3 format and transferred via a USB cord to a password-protected file server at the University of South Carolina as soon as possible following each interview. The author utilized a semi-structured format in the interviews, following general topics and initial questions as established in the interview guide (Appendix A). The intended order of the questions was to begin with introductory questions regarding the interviewee and her/his household, and then transition to broad
questions about disaster/emergency preparedness and perception of day to day weather before continuing with more specific topics such as tornado experiences and perspectives on preparedness and evacuation of the mobile home. In several instances, interviewees moved quickly in their responses from general perspectives to very specific experiences or examples related only to wind storms such as hurricanes or tornadoes. In these instances, the author was flexible and followed the participants’ leads, insofar as they continued to speak about perspectives and experiences relevant to the topics outlined in the interview guide. For those interviews that were of longer duration, the author consciously steered the conversations toward conclusion once the elapsed time approached or exceeded one hour in keeping within the time limits promised to the participants.

4.2.3. Interview Data Processing

Once the twenty initial interviews were finished in late November 2013, the MP3 files were uploaded to the audio transcription company Verbal Ink. Within one week the author received all twenty interview transcriptions in the form of Microsoft Word documents. Verbal Ink made special notations within each document to indicate when the author or interviewee was inaudible or when it was difficult to distinguish what was being said with complete certainty. It was necessary, therefore, for the author to listen to the interview audio files while simultaneously reading the transcriptions to ensure their accuracy and fill in any passages left blank by the transcription service. During this quality check process, several instances were discovered where the transcriptions were completely inaccurate—and were not flagged as uncertain or indistinguishable by Verbal
Ink. Thus, the extended quality check and assurance process was critical not only for filling in gaps in the transcriptions but correcting a number of erroneous transcriptions.

4.2.4. Interview Data Analysis Methodology

4.2.4.1. Interview Coding

There were two main goals in analysis of the interview transcriptions. The first goal was to generate a list of opinion statements from which to choose several dozen to use in a second interview with the twenty participants. As part of the Q Methodology research design, participants were to read through the statements one-by-one, and sort them into a quasi-normal distribution based on their levels of agreement or disagreement. This activity would aid in identifying a small set of common perspectives on tornado preparedness, sheltering, and evacuation, thus addressing research question #1. The second goal was to highlight any perspectives or opinions relevant to tornado preparedness and response which were unique to this study and have not been documented previously. To organize the interview passages and facilitate analysis, the author developed coding categories which were organized by broad categories similar to those listed at the conclusion of Chapter 2 (Figure 2.7) and in the interview guide (Table 4.2). The categories are not mutually exclusive, as some passages pertain to multiple coding categories. However, the general categorization strategy was to separate out passages outlining perceptions or experiences about tornadoes or severe thunderstorms from passages related to other hazards (such as flooding or earthquakes) or emergencies (such as a house fire). Passages related to information seeking and sources for general disaster preparedness were also coded into a separate category than passages specific to
weather forecast and warning information. Organization of the transcribed interviews and the coding process was accomplished using NVivo version 10.

Table 4.2. Coding categories and sub-categories for analysis of interview transcriptions.

<table>
<thead>
<tr>
<th>Interview Coding Categories</th>
<th>Participant Self Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Emergencies and Disasters</strong></td>
<td>Household Characteristics</td>
</tr>
<tr>
<td>Agency &amp; Control</td>
<td>Mobile Home Characteristics</td>
</tr>
<tr>
<td>Education</td>
<td>Neighborhood Characteristics</td>
</tr>
<tr>
<td>Emergency Information</td>
<td>Personal Characteristics</td>
</tr>
<tr>
<td>Emergency Management</td>
<td></td>
</tr>
<tr>
<td><strong>Personal Experiences (Non-Meteorological Hazards)</strong></td>
<td><strong>Tornado Sheltering and Evacuation</strong></td>
</tr>
<tr>
<td>Preparedness</td>
<td>Preparing for Evacuation</td>
</tr>
<tr>
<td>Response</td>
<td>Shelter Location and Access</td>
</tr>
<tr>
<td><strong>Meteorological Hazards</strong></td>
<td>Shelter Type</td>
</tr>
<tr>
<td>Experiences with Meteorological Hazards</td>
<td></td>
</tr>
<tr>
<td>Physical Appearance of Tornadoes</td>
<td><strong>Weather Related Information</strong></td>
</tr>
<tr>
<td>Predictability of Hazard Events</td>
<td>Accuracy of Information</td>
</tr>
<tr>
<td>Relationship to Religious Beliefs or Philosophy</td>
<td>Clarity of Information</td>
</tr>
<tr>
<td>Safety Precautions During Thunderstorms</td>
<td>Desired Content</td>
</tr>
<tr>
<td>Tornado Frequency or Intensity</td>
<td>Frequency of Information Seeking</td>
</tr>
<tr>
<td><strong>Physical Appearance of Tornadoes</strong></td>
<td>Information Sources</td>
</tr>
<tr>
<td><strong>Predictability of Hazard Events</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Relationship to Religious Beliefs or Philosophy</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Safety Precautions During Thunderstorms</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Tornado Frequency or Intensity</strong></td>
<td></td>
</tr>
</tbody>
</table>

4.2.4.2. Difficulties Implementing the Research Design

The sorting activity portion of the Q Methodology research design could not be completed as planned. After the quality assurance and coding processes, the author chose several dozen opinion statements for sorting, developed the materials to carry out the activities, and began contacting participants in March 2014. However, the contact details—mostly phone numbers—given by seven of the twenty participants were no longer valid. Due to the time restrictions on the research funding, the author decided to forego the sorting activities and simply compensate and thank those interviewees who could be reached. After several months of effort, the author was able to find and pay all but five of the interview participants; sadly, the author learned one of those five had passed away.
Despite the theoretical and conceptual utility of Q Methodology in addressing the research questions, the method may not be suitable for such a transient population when multiple meetings are needed. Yet, the completed and transcribed interviews remained a valuable data source relevant to the research questions, and provided the basis for a larger quantitative Q Methodology-style analysis using the mailed questionnaires. The main drawback of omitting the repeated interviews and activities is that the author was not able to check the validity of the results with the study members, as is a standard practice in more typical Q Methodology studies.

4.2.4.3. Connecting the Qualitative Data to the Quantitative Methodology

Because the Q Methodology portion of the research was not completed, the author modified the research design in order to address the research questions. Rather than conducting the sorting activities with the twenty interviewees and using factor analysis to identify a few common perspectives, the author folded about two dozen of the opinion statements into the mail questionnaire; further details about the contents of the questionnaire are provided below in Section 4.3.1. The goal of asking survey respondents to express their level of agreement or disagreement with the statements is to use the answers to identify the most common typologies of perspectives and opinions on tornado sheltering. While the author preferred to identify the typologies with the Q sort activity and then assess the prevalence of these using the survey methodology, the modified methodology still provides a way to answer the research questions and gain insight into mobile home residents’ views regarding the possibility of evacuation during tornadoes. The full methodology behind the quantitative survey is described in detail in Section 4.3.
4.2.4.4. Reporting of Results from the Semi-Structured Interviews

Several themes relevant to the research topic and questions emerged during the interviews and the interview coding process. These themes influenced the development of the questions posed in the mail questionnaire, as stated in the previous subsection. Chapter 5 of this document describes several themes and provides interview excerpts where appropriate to illustrate how participants spoke about disaster preparedness and response, specifically in the context of tornadoes. To protect the identities of the interviewees, each person was assigned a number designation $n$ and was quoted as Participant $n$. The gender of the person being quoted was provided as well.

4.3. Quantitative Methodology

The purpose of the quantitative portion of this research is to better understand intended tornado sheltering behaviors of manufactured home residents in South Carolina by collecting and analyzing data from the population of interest through a formal survey. Previous examples of social science research designed to collect primary data specifically from manufactured home residents has been conducted in one of two ways: via face-to-face administration of questionnaires or by sending questionnaires through the mail. When the study area consists of a few mobile home parks encompassing dozens to a few hundred units across a relatively small area, a random sample can be obtained by door to door recruitment (Kusenbach, Simms, and Tobin 2010). Alternatively, tax assessor data can be obtained and a random sample generated in advance for an in-person recruitment campaign (Schmidlin et al. 2009). However, for larger geographical areas—several counties or an entire state—a mailing methodology is more feasible. Tax assessor data may be used to generate a random sample and address list for studies in which thousands
of questionnaires are mailed (Beamish et al. 2001; Aman and Yarnal 2010). Such a sampling and recruitment methodology represents a novel design in the hazards and disasters literature for targeted research with persons living in mobile homes.

Other survey media such as the internet and telephones were also considered during the planning stages of the research. However, it is much more difficult to target mobile home residents by telephone or the internet than by mail. Additionally, recent research suggests that mail surveys still result in equal or better response rates than web-based or telephone surveys (Smyth et al. 2010; Couper 2011; Millar and Dillman 2011).

4.3.1. Development of the Survey Instrument

The questionnaire was developed during the spring of 2014 as a four page document consisting of 52 numbered questions and over 100 total response items (Appendix B). The questions were designed to gather data relevant to the research questions regarding tornado preparedness, warning response, and evacuation perspectives and intentions. The first page (Figure B.1) consisted of questions pertaining mainly to individual and household demographics, physical characteristics of the mobile home, past experiences with tornadoes, and sources for emergency or weather-related information. Page two (Figure B.2) posed questions about potential tornado damage and injury outcomes, access to a specially constructed tornado shelter, and perspectives about several aspects of preparedness and response to disasters in general and tornadoes in particular. The perspective questions (22 lettered items under the heading of question #22) came from statements made by interviewees during the interview stage of the research. Pages three and four (Figures B.3 and B.4) primarily focused on questions about tornado sheltering or evacuation past experiences, household evacuation logistics,
and intentions for several hypothetical scenarios. The survey concluded on page four with five additional demographic items.

The visual design and layout of the questionnaire was adapted from the 2011 South Carolina Hurricane Evacuation Behavioral Study conducted by the Hazards and Vulnerability Research Institute at the University of South Carolina (Cutter et al. 2011). Due to cost constraints, the Tornado Preparedness Survey was printed in gray scale rather than in the original red and white color palette of the 2011 survey instrument. Where appropriate, the question formats from the hurricane evacuation questionnaire were retained and the wording was altered to reflect the interests of the current study. An example of this is on page one in questions #16 through #18 regarding information sources (Figure B.1). The question formats were a mix of multiple choices, yes or no, ranking of given choices, short answer, and Likert-type items.

4.3.2. Assembling a Manufactured Home Address Database

4.3.2.1. Secondary Data Collection

Thirteen counties in SC were contacted between September 2013 and March 2014 about the possibility of obtaining an address list specifically for mobile homes (Figure 4.2). Several methods of communication were used, including personal visits to tax assessment offices, telephone calls, and email correspondence. Five counties provided the requested data free of charge: Darlington, Kershaw, Orangeburg, Richland, and Sumter. An address list was generated for a sixth county—Lexington—by accessing the county’s tax assessment website (Lexington County Tax Assessor 2013). This website features an option to specifically search mobile home records, and a large sample was generated iteratively using the location field through manual searches for place names.
(e.g., West Columbia and Gaston) and generic odonyms (e.g., Street, Avenue, Lane, etc.).

The format of the search output was amenable to copying and pasting from a web browser into a Microsoft Excel spreadsheet for further processing.

![Map of South Carolina showing counties for manufactured home address data](image)

**Figure 4.2.** Counties from which mobile home addresses were requested.

Of the eight counties that did not provide data, six (Fairfield, Florence, Lee, Chester, Clarendon, and York) did not reply to multiple emails, nor was the appropriate contact person available via telephone on multiple attempts. Aiken County initially indicated they would be willing to provide the data, but after multiple attempts to follow up went unanswered this possibility was abandoned. Calhoun County was willing to
provide the data for $300, but the expense was deemed unnecessary given that Calhoun has the smallest number of mobile homes of the counties for which data were requested.

After address data were obtained from six counties, there were more than sufficient data from which to obtain a random sample and no further efforts were made to contact the remaining eight counties. In total, nearly 50,000 addresses associated with mobile homes were obtained from the six county tax assessment offices (Table 4.3); all addresses were from tax year 2013 except for Lexington County which were from 2012.

Table 4.3. Raw and usable numbers of addresses obtained by county.

<table>
<thead>
<tr>
<th>Data Description</th>
<th>Total</th>
<th>Darlington</th>
<th>Kershaw</th>
<th>Lexington</th>
<th>Orangeburg</th>
<th>Richland</th>
<th>Sumter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw Number of Obtained Records</td>
<td>48,534</td>
<td>6317</td>
<td>6788</td>
<td>9944</td>
<td>6747</td>
<td>9084</td>
<td>9654</td>
</tr>
<tr>
<td>Usable Addresses After Pre-processing</td>
<td>46,448</td>
<td>6230</td>
<td>6550</td>
<td>9944</td>
<td>6512</td>
<td>8103</td>
<td>9109</td>
</tr>
<tr>
<td>Usable Addresses Successfully Geocoded</td>
<td>38,929</td>
<td>5071</td>
<td>5398</td>
<td>9149</td>
<td>4808</td>
<td>7212</td>
<td>7291</td>
</tr>
<tr>
<td>Percent Usable Addresses Geocoded</td>
<td>84%</td>
<td>81%</td>
<td>82%</td>
<td>92%</td>
<td>74%</td>
<td>89%</td>
<td>80%</td>
</tr>
<tr>
<td>Owner Mailing Address or Unit Location Address</td>
<td>-</td>
<td>Owner</td>
<td>Both</td>
<td>Unit</td>
<td>Owner</td>
<td>Both</td>
<td>Both</td>
</tr>
</tbody>
</table>

4.3.2.2. Address Data Pre-processing

The address data were delivered in a variety of formats, and therefore the pre-processing tasks of cleaning and address standardization were required prior to the geocoding process. The most important task was identifying whether the addresses for each county were the owners’ mailing addresses or the addresses where the units were actually located. Darlington and Orangeburg provided only the owners’ mailing addresses. As a result, it was necessary to filter out owner mailing addresses that were not located in South Carolina or within the county of interest. Beyond these filtering
procedures, it was necessary to assume that the remaining owners’ mailing addresses in Darlington and Orangeburg coincided with the physical location of the unit. Kershaw, Richland, and Sumter counties provided data for both the owners’ mailing addresses and the units’ locations; the location addresses were used for these three counties. For Lexington County, the addresses obtained were the units’ physical locations, and no geographic filtering procedures were needed.

The other principal pre-processing task was to ensure that each address included a house number, a street, a city and state, and a zip code (five digit zip codes sufficed). This was most problematic for Lexington County as zip codes were not included in the output generated by the tax assessor search website. To fill in the zip codes, the author iteratively grouped the addresses by city and street, used Google Maps or Bing Maps to look up the zip code for one of the addresses in each group, and then applied that zip code to all other addresses with the same city and street. This procedure undoubtedly assigned incorrect zip codes to some of the Lexington addresses. However, the data could not be geocoded with empty zip code fields, and any errors that would render an address unable to be matched by the geocoding engine could be considered lost as part of the random sampling process. For the addresses in the other five counties, empty zip code, city, or state fields were imputed in a similar fashion to that used for the Lexington County addresses. Records that had no address information whatsoever were completely removed from the list. The pre-processing procedures eliminated approximately 2,000 records, leaving 46,448 records for entry into the address locator (Table 4.3).
4.3.2.3. Geocoding the Addresses

Addresses were geocoded in ArcGIS 10.0 using the Street Addresses United States address locator available from Esri. The default geocoding options were used; minimum match score was set at 85 and the spelling sensitivity was set at 80. The matching rates by county ranged from 74% to 92%, with an aggregate matching rate of 84% (Table 4.3). This overall rate was very close to 85%, a frequently cited benchmark indicating a reliable geocoding process (Ratcliffe 2004). Qualitative visual inspection of the results did not indicate any obvious systematic errors which might render the data unsuitable for random sampling (Figure 4.3). Therefore, no further tweaking of the geocoding spelling or match score settings was necessary and the geocoding process was deemed acceptable.

4.3.3. Address Sampling Procedure

At the outset, the goal was to obtain an effective response rate that would allow questionnaire item responses to be reported with a 5% margin of error at the 95% confidence level. With just less than 60,000 occupied mobile homes in the study area (American Community Survey 2013), the author needed to obtain approximately 400 usable responses. Assuming an effective response rate of 15% to 20%, 2,500 addresses were randomly selected from the 38,929 geocoded addresses.

4.3.3.1. Stratification by County and Tract

The author used proportionate stratified random sampling to generate a list of mobile home addresses for the questionnaire mailing. The county sampling proportions were determined using American Community Survey (ACS) five-year (2008-2012) estimates of occupied manufactured homes in the study area (Table 4.4) (American
Community Survey 2013). Proportions ranged from a high of 0.32 for Lexington County to a low of 0.10 for Kershaw County.

Figure 4.3. Geocoded manufactured home addresses.

Table 4.4. Number of mobile home addresses sampled by county.

<table>
<thead>
<tr>
<th>County</th>
<th>Occupied Mobile Homes</th>
<th>Proportion of Occupied Mobile Homes</th>
<th>Sample Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Darlington</td>
<td>7,752</td>
<td>0.13</td>
<td>323</td>
</tr>
<tr>
<td>Kershaw</td>
<td>6,144</td>
<td>0.10</td>
<td>257</td>
</tr>
<tr>
<td>Lexington</td>
<td>19,159</td>
<td>0.32</td>
<td>797</td>
</tr>
<tr>
<td>Orangeburg</td>
<td>10,730</td>
<td>0.18</td>
<td>447</td>
</tr>
<tr>
<td>Richland</td>
<td>7,442</td>
<td>0.12</td>
<td>310</td>
</tr>
<tr>
<td>Sumter</td>
<td>8,765</td>
<td>0.15</td>
<td>366</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>59,992</strong></td>
<td><strong>1.00</strong></td>
<td><strong>2,500</strong></td>
</tr>
</tbody>
</table>
Figure 4.4. Number of mobile home addresses sampled within each census tract.

After the county sample sizes were calculated, the sample was geographically stratified once more. The same procedure used to weight the sample by county was applied using the proportion of county total occupied mobile homes within each tract, again using the ACS 2008-2012 five-year estimates (American Community Survey 2013). This method accomplished the intended goal of spatially distributing the random sample of addresses so that a variety of urban, suburban, and rural settings were included (Figure 4.4).
4.3.3.2. Random Sampling and Quality Control of the Address List

Following the assignment of addresses to their corresponding census tracts, the sampling quotas were determined using a random selection process with a simultaneous quality control procedure. First, the addresses within each tract were assigned a random number using Microsoft Excel. Then, the addresses were sorted in ascending order by the random number column. According to the sampling quota within the tracts, the appropriate numbers of addresses with the lowest random numbers were highlighted. Then, each respective highlighted address was entered into Google Maps and both aerial photos and Street View images were used to ascertain if the dwelling at each address was indeed a mobile home. In some instances, the imagery available from Google Maps was inconclusive and Bing Maps aerial imagery was also consulted. If it could be determined that the dwelling at the address in question was obviously not a manufactured home, then that address was removed from the sample and an additional new record was added in its place. This process continued until each tract’s sampling quota was reached and all selected addresses had been checked against the available imagery.

The quality control method was certainly not without error—some of the street level imagery was as old as 2007—but did allow dozens of non-mobile home addresses to be removed. This was particularly useful for the addresses in Darlington and Orangeburg counties since these were owners’ mailing addresses; however, several addresses in other counties also appeared not to correspond to a manufactured home and were removed from the sampling frame. This quality control process was effective, if not particularly elegant, efficient, or completely objective in design. An automated methodology to cross reference geocoded addresses against high resolution remotely
sensed or in situ imagery could expedite future studies while also enhancing the repeatability of the research methodology. Development of such a methodology would have been well beyond the scope of this dissertation, however.

4.3.4. Mail Survey Implementation

The mail survey in this study was implemented generally following the procedures and guidelines of The Tailored Design Method (Dillman, Smyth, and Christian 2009). Dillman and colleagues claim that their survey design and implementation methods typically generate 50% to 70% response rates. However, given the population of interest, study area, subject matter, and the shortcomings in the quality of the address data, a much lower response rate was expected from this survey. For example, Cutter and coauthors (2011) generated a 21% response rate in their South Carolina hurricane evacuation survey. The study area for this survey about tornado preparedness and evacuation was adjacent to—but did not overlap directly with—the hurricane evacuation survey. Yet, the two survey instruments were of similar length and design, and followed similar modifications of the methods described in Dillman et al. (2009). Therefore, a 20% response rate was set as a reasonable goal for this survey.

4.3.4.1. Materials and Mailing Procedures

To attempt to maximize the response rate, a series of four contacts was planned for each of the 2,500 sampled manufactured home addresses, as in Dillman et al. (2009). All of the materials sent to study recruits were approved beforehand by the University of South Carolina’s IRB within the Office of Research Compliance. The first contact was a postcard announcing the study and stating that the questionnaire packet would arrive within one week. Approximately one week later, the questionnaire packets arrived in
participants’ mailboxes. The packet included an invitation letter with a short information sheet on the reverse side. The letter provided information about who was conducting and funding the study, the purpose of the questionnaire, instructions related to completion and return of the questionnaire, and assurances of protection of privacy and confidentiality for any information given by participants.

In order to randomize the recruitment of individuals, the letter requested that the questionnaire be completed by the adult (18 and older) in the household who had the most recent birthday. If a recruit chose to participate by returning a questionnaire, they were considered to have given their informed consent. The reverse side of the letter contained brief educational information on some key differences between a tornado and a hurricane, and on key differences between a tornado watch and a tornado warning. This information was provided in order to lessen the possibility of participants confusing essential characteristics of tornadoes and hurricanes—and watches and warnings—while recording their answers. A return envelope with postage already covered was provided so that a participant was not required to pay postage in order to return her/his questionnaire.

Roughly two weeks after the questionnaire packets were mailed out, a second postcard was sent as a reminder for those who had not returned their questionnaire to think about doing so; the reminder postcards were not mailed to addresses which had already replied. Finally, a second questionnaire packet was mailed out two weeks after the reminder postcards. The contents of the second packet were the same as the first packet, with the exception that the second letter specified a final deadline for return of the surveys. Again, the second round of packets went out only to addresses which had not
already replied. In addition, if any previous attempts at contact had been returned as undeliverable by the postal service, these addresses were eliminated from subsequent mailing lists. Due to cost constraints, this study did not use the fifth and final contact suggested by Dillman and coauthors (2009).

The first series of mailings went to 1500 of the sampled addresses in May and June 2014, while the second series of mailings went to 1000 additional sampled addresses in August and September 2014. There were 2500 sampled addresses overall with no duplication between the first and second groups of addresses since the initial 1500 addresses were removed during the sampling procedure for the next 1000 addresses.

4.3.4.2. Response Incentive

Originally, this study proposed and received approval from the university Institutional Review Board (IRB) to include a token incentive of one dollar within each initial questionnaire packet. Some recent research evidence suggested that such token incentives help to convince recruits of the legitimacy and importance of the study (Willcox, Giuliano, and Israel 2010; Millar and Dillman 2011). However, in April 2014 during the final stages of preparation for the first round of mailings, the university IRB contacted the author and informed that token incentives were not to be used. The primary reason for the decision was that many questionnaire packets—with dollar bills tucked inside—would likely be discarded into the garbage by potential recruits. Hence, it was not be desirable in the current political climate of hostility against the social sciences for the university to be seen as throwing away taxpayer money in this fashion.

Therefore, the author decided—with support from the IRB—to advertise a drawing for prizes for any participant who returned a questionnaire. Any participant who
returned a questionnaire was entered into the drawing, even if they did not answer a single item, to receive one of twenty $100 gift cards. In order to be able to contact the twenty participants whose names were drawn, a small contact information card was included in the questionnaire packet. To protect participants’ confidentiality and privacy, any information given on these cards was stored separately from answers provided in the questionnaire. The drawing was held in October 2014 and the gift cards were distributed during the spring 2015 academic term.

4.3.5. Questionnaire Response Characteristics

4.3.5.1. Response Rates

After the materials were mailed, a relatively small number of addresses were found to be unusable. In total, postcards and questionnaire packets for 68 of the 2500 (2.7%) addresses were returned as undeliverable by the postal service (Table 4.5). For most cases, one of four reasons was provided by the post office to explain why the materials could not be delivered: no mail receptacle, no such number, not deliverable as addressed, or vacant. The number of times each reason was given was roughly equal across the study area, and thus no systematic problems or errors with the mailing methodology were apparent. Darlington County had the highest undeliverable rate (5.3%); this was not surprising given that the addresses were sampled from a list of the manufactured home owners’ mailing addresses. Conversely, the addresses for Orangeburg County were also owners’ mailing addresses, yet the undeliverable rate there was only 2.0%. It is possible that the undeliverable rates in Orangeburg County and elsewhere were nearer to that observed in Darlington, but the appropriate notices never arrived back to the author’s campus mailbox. After subtracting the 68 total addresses
which were undeliverable, the effective number of addresses to which questionnaire packets were assumed to be delivered was 2,432.

Table 4.5. Numbers of undeliverable and completed questionnaires by county.

<table>
<thead>
<tr>
<th>County</th>
<th>Address Sample Size</th>
<th>Materials Returned as Undeliverable</th>
<th>Percent Returned as Undeliverable</th>
<th>Responded to Questionnaire</th>
<th>Effective Response Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Darlington</td>
<td>323</td>
<td>17</td>
<td>5.3%</td>
<td>22</td>
<td>7.2%</td>
</tr>
<tr>
<td>Kershaw</td>
<td>257</td>
<td>7</td>
<td>2.7%</td>
<td>20</td>
<td>8.0%</td>
</tr>
<tr>
<td>Lexington</td>
<td>797</td>
<td>13</td>
<td>1.6%</td>
<td>70</td>
<td>8.9%</td>
</tr>
<tr>
<td>Orangeburg</td>
<td>447</td>
<td>9</td>
<td>2.0%</td>
<td>51</td>
<td>11.6%</td>
</tr>
<tr>
<td>Richland</td>
<td>310</td>
<td>9</td>
<td>2.9%</td>
<td>36</td>
<td>12.0%</td>
</tr>
<tr>
<td>Sumter</td>
<td>366</td>
<td>13</td>
<td>3.6%</td>
<td>25</td>
<td>7.1%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2,500</strong></td>
<td><strong>68</strong></td>
<td><strong>2.7%</strong></td>
<td><strong>224</strong></td>
<td><strong>9.2%</strong></td>
</tr>
</tbody>
</table>

The overall effective response rate—not counting undeliverable addresses—was very low as only 224 of 2,432 responded by returning a survey (9.2%) (Table 4.5). Of the 224 households who responded to the questionnaire, seven either left it completely blank or indicated on the first page that they do not live in a mobile home. In compliance with the University of South Carolina IRB instructions, all 224 households who responded in some way to the mailed questionnaire packet were eligible to be chosen at random to receive one of twenty gift cards as an incentive for participation. However, for the purpose of data analysis, only 217 questionnaires were processed and transcribed.

The highest effective response rates were in Richland (12%) and Orangeburg (11.6%) counties, while Lexington County accounted for the highest number of completed responses (70) (Table 4.5). The most concentrated area of responses was in central and southern Lexington County, including mailing addresses within the cities of Lexington, West Columbia, Gaston, and Pelion (Figure 4.5). Additional clusters of responses were located north of Columbia near Blythewood, near the city of Orangeburg, and in the Cherryvale, Privateer, and Lakewood areas of central and southern Sumter.
County. Response rates were closer to 7% in Sumter and Darlington counties, the lowest of the six county study area. There were no responses from large areas within southern Darlington County, northeastern Sumter County, and northern and northwestern Lexington and Richland counties.

Despite these areal gaps, the geographic distribution of the responses among the six counties was similar to the overall distribution of manufactured homes in the study area. Using difference of proportions tests, only Orangeburg County had a percentage of the total survey responses (22% of 224) that was significantly different from its percentage of the total mobile homes (17%) using ACS data (z-value 1.84, sig. at 90% confidence level). This means that Orangeburg County mobile home residents were slightly overrepresented in the sample. While Richland County responses also made up a slightly larger percentage of the total than in the ACS data (16% versus 12%), the difference was not statistically significant. The author concluded that the questionnaire responses were not severely biased toward any one county.

In trying to understand why the response rates were so low across the study area, there are likely several contributing factors. One factor is the salience or relevance (as in Stewart et al. 2012) of the topic, tornado preparedness and response, to mobile home residents. As stated earlier, South Carolina is not especially associated with tornadoes relative to other states, and if the recent SC hurricane evacuation survey (Cutter et al. 2011) drew only a 21% response rate, in hindsight one might have expected not to approach the same level of interest with tornadoes. Another factor that likely interacts with the salience of the topic is income. While mobile home residents are a diverse population segment, there is a part of that segment that struggles daily with having
enough income and resources to maintain a decent quality of life. When one is preoccupied with these concerns, it is understandable that a rather exotic phenomenon such as tornadoes would be far from the mind. Furthermore, the survey took some time to complete; four pages and 100 response items were probably perceived as asking for too much of some residents’ time.

Other factors could have contributed further to the lack of robust response. There were likely some surveys received by households with very limited English language proficiency, particularly for recent Latino/Hispanic migrants. Related to this point, though not exclusively, the response from renters was quite low. This could have been in part because of the high turnover rates in occupancy; some who received the survey may have not bothered to complete it because they do not plan to be in the same unit for much longer. There are also levels of distrust in larger public institutions stemming from at least two sources. Generations of discrimination against black or African-American persons have undermined the credibility even of institutions of higher education such as the state’s flagship university, limiting the ability to engage with that community. Finally, there exist segments of the population who are suspicious of any government sponsored activities on the basis of their conservative political views. It is likely that all of the factors listed above played at least some part in producing the low overall response rate.

4.3.5.2 Demographic Representativeness of the Sample

Several of the questionnaire items asked about demographic characteristics, and it is standard survey procedure to compare the sample against a reference dataset to
Figure 4.5. Locations of questionnaires that were completed and returned.

determine whether any demographic segments are under- or overrepresented in the survey data. There is not a census or survey that regularly collects demographic data exclusively from those residing in manufactured homes, but the American Community Survey (ACS 2014) provides multiple tables with demographic characteristics broken down by units in structure. These tables contain some data specific to mobile homes, though the mobile home data are often grouped together with citizens residing in recreational vehicles and house boats. Nevertheless, these data tables, in tandem with demographic comparisons using data from the general population, provide the context to understand the sources of potential biases in the sample. The reference data used in this
section are county level five-year ACS estimates from 2009-2013, aggregated across the entire six-county study area. Statistical significance in the differences between the tornado preparedness survey and the ACS is determined using difference of proportions tests, as suggested by the US Census Bureau (American Community Survey 2014). Unfortunately, the survey response rate was not robust enough to allow demographic analysis for each respective county.

Demographic characteristic comparisons can be separated into those describing individual persons and those describing households. The percentages of survey responses by sex, age, and race/ethnicity of the individual who completed the questionnaire are compared to the ACS percentages in the general population age 18 and above (Table 4.6). In relation to the ACS reference data, female perspectives are clearly overrepresented and male perspectives are underrepresented in the tornado preparedness survey. Approximately two-thirds of the participants are female, in contrast to a more typical equitable split nearer to 50%. In terms of the age of participants, the youngest was 20 and the eldest 88, and there was good representation of middle aged adults between 35 and 54 years. However, in the remaining age groups there was a severe response bias toward the two older population segments, as those over the age of 55 were oversampled by a factor of nearly two. The youngest age group—18 to 34 years—comprised only 11% of responses despite making up nearly one third of the general population in the study area.

The percentages of responses from participants identifying as white alone, black or African-American alone, or Latino or Hispanic are relatively similar to the corresponding percentages in the general population, though the latter two approach
Table 4.6. Demographic representativeness by sex, age, race/ethnicity, and education.

<table>
<thead>
<tr>
<th>Demographic Variables</th>
<th>Sample Estimate (90% CI)</th>
<th>ACS Estimates 2009-2013</th>
<th>Diff. of Proportions Test Z-Value</th>
<th>Representative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>66.20% +/- 5.3%</td>
<td>52.40%</td>
<td>4.293***</td>
<td>Over</td>
</tr>
<tr>
<td>Male</td>
<td>33.80% +/- 5.3%</td>
<td>47.60%</td>
<td>-4.293***</td>
<td>Under</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18 to 34 years</td>
<td>11.30% +/- 3.6%</td>
<td>33.20%</td>
<td>-9.994***</td>
<td>Under</td>
</tr>
<tr>
<td>35 to 54 years</td>
<td>31.40% +/- 5.2%</td>
<td>34.90%</td>
<td>-1.072</td>
<td>Yes</td>
</tr>
<tr>
<td>55 to 64 years</td>
<td>26.30% +/- 5.0%</td>
<td>15.80%</td>
<td>3.437***</td>
<td>Over</td>
</tr>
<tr>
<td>Older than 65 years</td>
<td>31.00% +/- 5.2%</td>
<td>16.10%</td>
<td>4.701***</td>
<td>Over</td>
</tr>
<tr>
<td>Race/Ethnicity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White Alone</td>
<td>61.30% +/- 5.5%</td>
<td>57.40%</td>
<td>1.161</td>
<td>Yes</td>
</tr>
<tr>
<td>Black or African-American Alone</td>
<td>30.70% +/- 5.2%</td>
<td>35.80%</td>
<td>-1.626</td>
<td>Yes</td>
</tr>
<tr>
<td>Hispanic or Latino</td>
<td>2.40% +/- 1.7%</td>
<td>3.80%</td>
<td>-1.381</td>
<td>Yes</td>
</tr>
<tr>
<td>Highest Education Completed</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less Than HS</td>
<td>11.90% +/- 3.7%</td>
<td>13.50%</td>
<td>-0.707</td>
<td>Yes</td>
</tr>
<tr>
<td>High School/GED</td>
<td>64.30% +/- 5.4%</td>
<td>49.70%</td>
<td>4.413***</td>
<td>Over</td>
</tr>
<tr>
<td>Associate/Bachelor Degree</td>
<td>21.00% +/- 4.6%</td>
<td>26.30%</td>
<td>-1.903*</td>
<td>Under</td>
</tr>
<tr>
<td>Graduate Degree</td>
<td>2.80% +/- 1.9%</td>
<td>10.50%</td>
<td>-6.538***</td>
<td>Under</td>
</tr>
</tbody>
</table>

Asterisks denote confidence levels: *90%, **95%, ***99%

Statistically significant underrepresentation. Using reference groups depicting the highest level of educational attainment of the general population aged 25 and up, there are fewer responses from those with college and particularly graduate degrees than expected and perhaps an overrepresentation of those with only a high school diploma or General Education Development (GED) certificate. However, it may be misleading in the case of educational attainment to compare the mobile home survey percentages to those from the general population. If specific data were available describing the educational attainment of mobile home residents older than 24 years, the percentages might resemble more closely those observed in the tornado preparedness survey.
Moving on to the household demographic comparisons (Table 4.7), there are similar problems using all occupied housing units as a reference population to gauge the distribution of income responses from mobile home residents. The data suggest an oversampling of participants reporting less than $25,000 annual household income and an underrepresentation of households reporting $50,000 income or greater. This questionnaire item is more prone to non-response bias, however, as can be expected when inquiring about income. It is unknown the extent to which the deficit in the higher income groups can be explained by non-response bias. Perhaps it is simply unrealistic to expect that 30% of mobile home households in the study area carry an annual income greater than $75,000. In another comparison using a reference group of all types of occupied housing units, the availability of vehicles in the ACS data corresponded well to the data from the tornado preparedness survey.

The final three demographic comparisons used ACS data specific to mobile homes (Table 4.7). Only 16% of tornado preparedness survey respondents indicated they rent their unit, a far lower percentage than the nearly 36% estimated from the ACS. This bias toward owned units is not surprising, however, given that these were systematically more likely to be sampled due to the nature of the address data obtained from county assessor offices. The tornado survey responses are also skewed toward those who have lived in their mobile home for a longer period of time, especially for those living in the same unit since at least 1989. Those households who first moved in to their mobile homes since 2005 are underrepresented when compared to the ACS data. Finally, household size is somewhat evenly represented, though statistically significant
discrepancies are noted for two (overrepresented) and three (underrepresented) person households.

Table 4.7. Demographic representativeness by income, vehicles, tenure, duration of residence, and household size.

<table>
<thead>
<tr>
<th>Demographic Variables</th>
<th>Sample Estimate (90% CI)</th>
<th>ACS Estimates 2009-2013</th>
<th>Diff. of Proportions Test Z-Value</th>
<th>Representative</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Household Income</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than $25K</td>
<td>56.00% +/- 5.8%</td>
<td>26.60%</td>
<td>8.311***</td>
<td>Over</td>
</tr>
<tr>
<td>$25K to $50K</td>
<td>30.00% +/- 5.3%</td>
<td>26.50%</td>
<td>1.088</td>
<td>Yes</td>
</tr>
<tr>
<td>$50K to $75K</td>
<td>8.50% +/- 3.2%</td>
<td>18.70%</td>
<td>-5.194***</td>
<td>Under</td>
</tr>
<tr>
<td>More than $75K</td>
<td>5.50% +/- 2.7%</td>
<td>28.20%</td>
<td>-13.583***</td>
<td>Under</td>
</tr>
<tr>
<td><strong>Vehicles Available</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zero</td>
<td>7.90% +/- 3.0%</td>
<td>6.80%</td>
<td>0.586</td>
<td>Yes</td>
</tr>
<tr>
<td>One</td>
<td>37.70% +/- 5.4%</td>
<td>34.80%</td>
<td>0.880</td>
<td>Yes</td>
</tr>
<tr>
<td>Two</td>
<td>33.90% +/- 5.3%</td>
<td>37.60%</td>
<td>-1.134</td>
<td>Yes</td>
</tr>
<tr>
<td>Three or more</td>
<td>20.50% +/- 4.5%</td>
<td>20.80%</td>
<td>-0.110</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Housing Tenure</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Owned Mobile Homes</td>
<td>84.00% +/- 4.3%</td>
<td>64.10%</td>
<td>7.38***</td>
<td>Over</td>
</tr>
<tr>
<td>Rented Mobile Homes</td>
<td>16.00% +/- 4.3%</td>
<td>35.90%</td>
<td>-7.192***</td>
<td>Under</td>
</tr>
<tr>
<td><strong>Year Moved Into Unit</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2005 or Later</td>
<td>33.30% +/- 5.5%</td>
<td>44.90%</td>
<td>-3.331***</td>
<td>Under</td>
</tr>
<tr>
<td>2000 to 2004</td>
<td>18.40% +/- 4.5%</td>
<td>16.70%</td>
<td>0.620</td>
<td>Yes</td>
</tr>
<tr>
<td>1990 to 1999</td>
<td>23.40% +/- 4.9%</td>
<td>26.20%</td>
<td>-0.921</td>
<td>Yes</td>
</tr>
<tr>
<td>1980 to 1989</td>
<td>18.40% +/- 4.5%</td>
<td>9.30%</td>
<td>3.281***</td>
<td>Over</td>
</tr>
<tr>
<td>1979 or Earlier</td>
<td>6.50% +/- 2.9%</td>
<td>3.00%</td>
<td>1.957*</td>
<td>Over</td>
</tr>
<tr>
<td><strong>Household Size</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>One person</td>
<td>25.40% +/- 4.9%</td>
<td>27.00%</td>
<td>-0.535</td>
<td>Yes</td>
</tr>
<tr>
<td>Two persons</td>
<td>38.00% +/- 5.5%</td>
<td>29.50%</td>
<td>2.485**</td>
<td>Over</td>
</tr>
<tr>
<td>Three persons</td>
<td>11.70% +/- 3.6%</td>
<td>18.30%</td>
<td>-2.826***</td>
<td>Under</td>
</tr>
<tr>
<td>Four persons</td>
<td>13.60% +/- 3.9%</td>
<td>13.50%</td>
<td>0.028</td>
<td>Yes</td>
</tr>
<tr>
<td>Five or more</td>
<td>11.30% +/- 3.6%</td>
<td>11.70%</td>
<td>-0.174</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Asterisks denote confidence levels: *90%, **95%, ***99%

4.4. Chapter Summary

This research employed both qualitative and quantitative approaches. The author interviewed twenty mobile home residents across eight counties in central and northern
South Carolina about tornado preparedness and response. The interviews, ranging in length from half an hour to an hour, generated a large volume of material from which the author gleaned several key themes. Some of these are presented in Chapter 5 and others were used in the mail questionnaire for which analyses are presented in Chapters 6 and 7. The most important limitations of the interviews were that very few men participated—only three out of twenty—and that the author was not able to interview more Latino participants who might have shed light on unique linguistic and cultural aspects that influence their tornado preparedness and response perspectives and behaviors. Despite these shortcomings, the interviews were successful enough to address the research questions and inform the quantitative portion of the research.

Over 200 usable questionnaires were collected across six counties in central and northeastern South Carolina. The response rate was just under 10%, though enough were returned to complete the research and draw some useful conclusions about mobile home resident tornado preparedness and response in South Carolina. However, responses appeared to be over-representative of a few population segments including female residents, persons aged 55 and older, owner-occupied mobile homes, and households who lived in their mobile homes since before 1989. There is a possibility that the over-representation is an artifact of the way the county data are aggregated across the study area and reported here. Finer analysis for individual counties might have revealed that certain areas are driving the statistically significant over-representation noted above, but there are insufficient numbers of participants in several counties. Nevertheless, the caveats about the representativeness of the sample should be kept in mind while reading and interpreting the quantitative results in Chapters 6 and 7.
CHAPTER 5: QUALITATIVE ANALYSIS AND RESULTS

5.1. Overview

In analyzing and coding the interview transcriptions, several themes emerged which provided insights into how mobile home residents in South Carolina think about tornadoes and the potential need to leave their mobile home for shelter just before or during a tornado warning. This chapter describes seven factors that elucidate why residents might conclude that evacuating their mobile homes for safety from a tornado is either not necessary or presents overwhelming levels of uncertainty that counteract notions of responsibility, self-efficacy, response efficacy, and agency.

5.2. Perspectives on the Nature of Tornadoes

5.2.1. Confusion about the Differences between Tornadoes and Hurricanes

During the interviews, it was evident that some residents do not readily distinguish tornadoes as different phenomena that can occur separately from hurricanes. The following passage is one of many examples from participants who mentioned tornadoes and hurricanes together throughout the interview; this particular response was preceded by a prompt to speak about how the person views tornado warnings that end up being false alarms:

So just because it didn’t come today don’t mean it won’t come tomorrow. I feel you should at least give it three weeks, and you should at least have a three-week plan set in stone for your family. Okay, it didn’t happen this week. What if
they’re still talking about it that Friday? Prepare for it, even if the weatherman stops talking about it and says, “The hurricane turned around, the tornado turned around.” Me, I’m still going to prepare for it because they said that before.

(Participant #6, female).

A different female interviewee, Participant #3, also did not distinguish the difference between tornadoes and hurricanes. When asked whether she had previously experienced a tornado, she replied, “No, not yet. I guess that I—with the aftermath of Hugo, you could say that was a tornado, right?” In a similar example, another interviewee recalled Hurricane Hugo after being asked to talk about whether tornadoes are a concern in South Carolina:

But it’s very seldom we have that here as far as a tornado. Now hurricanes come through a little bit, just according to how big they are and stuff like that. Hugo, when it come through, I don’t know if you was around then, but when Tornado Hugo come through, it come all the way off the coast, all the way in. It went far as like Rock Hill and Charlotte, up in that area somewhere. (Participant #4, male).

Not every interviewee had trouble distinguishing between tornadoes and hurricanes; many were able to speak easily about both without any confusion or conflation of the phenomena. Yet, there were others, in addition to the examples above, who used the terms tornado and hurricane almost interchangeably.

5.2.2. The Unpredictability of Tornadoes

Another theme related to the nature of tornadoes is their seemingly unpredictable nature. Some interview participants made reference to the seemingly apparitional manner in which tornadoes form, appearing unexpectedly from out of nowhere. This passage
was a reply given when asked to express an opinion on the ability to forecast where a tornado might strike:

I’m not exactly sure if that is possible or not. However I think it would be sort of a hard thing to predict considering that a lot of times tornadoes just form suddenly. (Participant #9, female).

Another aspect of the perceived unpredictability of tornadoes was manifest in comments about their supposedly erratic movement. This excerpt began with a response to a question about trying to confirm a tornado threat by looking outside and ended with a statement on the capricious nature of how they move:

I think I would recognize a tornado. Yeah. Then I would hot-foot it, especially if it was coming in this direction. Well, with tornadoes they actually have no direction. They can be coming down the road 100 miles an hour and then stop and turn right, or left, or back. (Participant #10, male).

Finally, multiple residents made reference to the fact that tornadoes are not only unpredictable in where they form and how they move, but that this unpredictability is increasing over time. These views were elicited by prompts asking participants to discuss whether tornadoes are a threat in South Carolina. For example:

Had you asked me that about six, seven, eight years ago, I probably would have said no, but like lately, I guess maybe over the last five or six years, seven years, I mean you see cyclones up in New York. You see, I mean, even tornadoes in South Carolina now. And I don’t know, it’s just so much more unpredictable, and so many places now are having weather that they’re not used to. (Participant #1, female).
Ironically, many who made statements similar to the passage above also noted that technology is improving over time and is making weather observations and predictions more accurate.

5.3. Perspectives on Tornado Warning Protective Actions

From reading the relevant literature reviewed in Chapter 2, there are several potential factors that might encourage or discourage a person(s) to evacuate a mobile home and find more suitable shelter from a tornado. While perception of one particular hazard agent, tornadoes, is one of those factors, the perception of other hazard agents and need to protect property rather than life can take priority over tornado preparedness and response behaviors (Donner, Rodriguez, and Diaz 2012). Alternatively, residents may be convinced that their home actually can withstand a tornado, counter to official narratives from meteorologists, engineers, and emergency management. Others may be discouraged from leaving their homes by the range of uncertainties or problems related to the timing of departure, the accessibility and effectiveness of the chosen evacuation destination, and the safest route to that destination. The following five subsections present participants’ comments on these factors.

5.3.1. Multiple Environmental Hazards

Each of the residents that the author interviewed expressed that tornadoes are of some concern given that they live in mobile homes. However, it was apparent in the conversations that some focus equally, if not more so, on the multitude of other hazards that can accompany thunderstorms. Lightning is a very common thunderstorm hazard in South Carolina, and the potential for damage from lightning strikes was mentioned by
several interviewees. One participant described her aversion to lightning and what her household does during thunderstorms:

   One time it did, I wasn’t over here, number one, but somebody that was living over here, lightning had struck they [sic] air conditioner and everything. And it blew it up. But I don’t play with lightning. If I even hear it, I cut the TV off, sit down, be quiet and we just wait ‘til it get over. (Participant #14, female).

More than one participant mentioned unplugging appliances and electronics, getting the entire family in one room, and sitting quietly until a thunderstorm passes. According to one interviewee, this is a Southern tradition, particularly in African-American households:

   When we were little and living down here [in South Carolina], whenever there was a storm out—not just rain, but it had to be a storm—everything in the house had to be unplugged, all the lights turned out. And we had to sit quietly because during thunderstorms, electrical storms, it was said, “God is doing his business.” And so that was a tradition here in the South. I don’t know if it was among the whites or not. But among the black community, everything from the refrigerator to the stove to the TV, everything was unplugged. All the lights were out and everybody sat still and quiet because “God was doing his business.” And I find out that some people still do that to this day. (Participant #15, female).

While some focused on lightning and the potential to lose appliances and electronics to electrical surges, others expressed concerns about flooding from excessive rainfall. In one instance, a resident spoke about her worry that the route to her tornado sheltering
place—a nearby family member’s site-built frame home—would be impassable due to flood waters:

And we made sure it [the route to the home] was on roads that don’t flood because we—the last, about three weeks ago, we had—I mean it was flooded bad. It was so flooded that cars were stuck in the middle of the road and they had to call […] fire trucks to get these cars out of the water. And I was like, “What if that was my car? What if that was me in that car?” (Participant #5, female).

There are also non-meteorological environmental hazards that residents consider when thinking about their best tornado sheltering options. One resident, whose vehicle is rather unreliable and cannot easily drive to another location during a tornado, revealed one of her reservations about lying down in a ditch or ravine during a tornado warning:

So like I say [sic] if I had a blanket […], some kind of plastic thing that I could put on the ground and lay on it. And not just lay in there. Because you never know, there might be a snake in there. There might be bugs. South Carolina is known for black snakes. Black snakes come out when it rains. So I don’t want to get bit. So I got to be prepared for that. (Participant #14, female).

Thus, the interviews revealed that mobile home residents are cognizant of multiple environmental hazards—some meteorological and others not—and that they sometimes focus on these other hazards and place little emphasis on preparing and enacting a response strategy for tornadoes.

5.3.2. The Ability of the Mobile Home to Withstand a Tornado

Wind engineers, the NWS, and FEMA take the position that mobile homes are unsafe during tornadoes because they are likely to be severely damaged or destroyed
when struck directly by a tornado (McPeak and Ertas 2012; Ready.gov 2015; NWS 2015). In this study, most mobile home residents echoed this general sentiment, but several also spoke further about how their mobile home has physical characteristics that give it a better chance of surviving damaging tornado winds than a typical mobile home. One characteristic that was mentioned by several residents is the size of the unit, especially whether it is a double-wide unit rather than a single-wide unit. Another characteristic is the material used in the skirting or façade along the lower portion of a mobile home to hide the undercarriage and chassis upon which it is mounted. The following excerpt contains both of these examples in addition to the idea that the home has been on the property long enough that it is firmly affixed to the earth beneath it:

I think because the house has been there since 1984, and it’s not only pinned down but it has cinder block underpinning underneath it, I guess that minimizes wind being able to get up underneath it and do anything with it. But I always say it’s been sitting here for so long, it’s just attached to the ground now. And it’s never suffered any damage in any major storm that has come through […] The community that I live in there are mostly frame homes, I don’t know if those frame homes would be any more sturdy than—I live in a double wide unit […] so it’s kind of large and it’s heavy. (Participant #15, female).

Another interviewee referred to the general sturdy quality of her mobile home as indicated in part by its ability to muffle outside noises:

You know my home is—I have weathered several weather [sic] out here and it’s held pretty good. They’ll [neighbors] ask me, “Did you hear that weather last night?” I said, “No.” It’s pretty well structured. Yeah. This home was brought in
from somewhere else and it was placed here. And it’s well made, it’s well insulated. It’s well kept up by the previous owner, so yeah. The roof is intact […] That’s all I could say because I really don’t hear what’s going on outside. (Participant #12, female).

The quality of the roofing construction and material was cited by another participant as potentially important for the unit to survive a tornado:

I’m not sure like how the roof would hold up. It’s not like—this is a nicer mobile home. It’s not one of the like cheaper, older ones that has like the tin roof. It’s got a nice shingled roof on top of it. (Participant #2, female).

Residents spoke about several other features that can mitigate the potential for wind damage. Several referenced the strength of the bolts that tie or anchor the entire unit to the ground. One (Participant #10, male) stated that he had reinforcing straps that he intended to fasten to his unit in the case of a hurricane or tornado. Participant #1 (female) spoke about one bedroom in her home in which the walls had been reinforced with stronger building materials. In her words, “So if push came to shove, that would—that room would probably still be standing, if nothing else [would still be standing], maybe.”

A few other participants stated they would be most likely to shelter in a room without windows because glass panes would be the most likely component of the home to be damaged.

5.3.3. Deciding When to Leave to Seek Shelter Elsewhere

The residents the author spoke with understood the recommendation from the NWS, FEMA, and the South Carolina Emergency Management Division is that they should abandon their homes during a tornado warning and go to a nearby sturdy building.
However, there is confusion over when exactly they should leave. A number of participants answered with references to their visual and auditory senses and environmental cues. They will know it is time to leave and seek shelter when the sky looks ominous, the wind starts to roar, or they simply can see a tornado approaching. One participant described his thinking as follows:

I would maybe kind of watch its [tornado] direction and keep track of it on the report from weather, or if I was out—you can’t see them at night too much, but if it’s like in the daytime and I can see it and I know it was actually coming my way, I would—yeah, I’d actually get out of the way. But if I seen [sic] it was going in another direction, I would just watch it and make sure if it passed or what it’s doing, and I’d keep my eye on it. (Participant #4, male).

Another resident spoke about knowing when to enact her sheltering plan by listening for the infamous freight train sound:

Well, they tell you that you know when there’s the sound of a train coming, which might not be so helpful because I live—the train tracks run through my backyard. So I’d have to stick my head out and be like, “Okay, is that an actual train?” I know it sounds a little different than an actual train. But yeah, obviously when you start to hear it, I think it’s close enough that you need to take shelter.

( Participant #2, female).

Tornado sirens were not a widely referenced social cue. Only one participant identified tornado sirens as being a clue to think about leaving, and this person conceptualized the siren as a first cue to think in terms of whether her family would have time to arrive at their chosen sheltering destination:
In the past, when we heard sirens, I guess depending on how much time we have, I’ve always thought to myself, okay, would I take the family and have enough—if I had enough time, I’d try to get down to [town name] fire department right here.

( Participant #18, female).

One of the other interviewees also commented on the timing aspect in the context of receiving social cues in the form of warning messages on television or on mobile devices:

I mean if we had time [we would go elsewhere]. But most of the time when those things [tornadoes] come through you have very—I mean you’re within minutes. And there’d be no way we could get out of there [her mobile home] within minutes. ( Participant #13, female).

Finally, it is noteworthy that none of the residents indicated that they interpret a tornado warning message as an evacuation order for mobile home residents within the potential path. Several mentioned that they would know when to leave during any kind of hazard event like a hurricane, wildfire, or tornado when police officers, firefighters, or similar official emergency personnel come directly to their neighborhood and direct people to leave.

5.3.4. Deciding Which Route to Take

If the chosen short-term evacuation destination is far enough away to require driving, then a person may need to decide which route to take. Some of the participants envisioned this being potentially problematic. One resident commented:

The other thing is like maybe even knowing which direction you need to go because the tornado could be over by the school [her sheltering destination] and you don’t […] We just need to know what way to go. (Participant #1, female).
Another interviewee recalled a previous experience when this situation occurred:

‘Cause sometime when you leave home in the storms, sometime you make a mess, if it worse than when you try to stay home. And I done did that too, try to like outrun the storm. […] When I got half of where I was going, the storm was coming up to meet me on the highway. And I turned around and went back the other way. So sometimes it be [sic] better to stay put. (Participant #11, female).

Another source of confusion in choosing a direction or a route for tornado sheltering can be the official hurricane evacuation routes, which are marked with signs on the side of some roadways. One resident commented specifically about this:

We live right off the freeway. I see a sign on the road that says, “Evacuation Route” coming. Okay well that’s great, but that’s only on one road that I’ve seen, you know? Like I said, fabulous, but once you get to a certain area it kind of stops. Okay, well, where do you go from there? (Participant #20, female).

This mobile home resident was not alone in her general frustration about planning an escape route and destination. Several participants commented that there needs to be a concerted effort from local and state governments and the manufactured housing industry to help those who live in mobile homes know not just that they may need to leave when tornadoes threaten, but when to leave, where to go, and how to get there.

5.3.5. Deciding Where to Go for Shelter

Following on from the previous subsection, the participants contributed several interesting perspectives about where they might go for shelter. Since there are very few structures in South Carolina built specifically as tornado shelters (underground shelters or above-ground safe rooms), residents would need to find some kind of nearby sturdy
building that they believe will provide better protection than their mobile home. A few mobile home parks have some site-built structures which could be used for shelter. One interviewee discussed this possibility:

I would probably head for one of these cement apartments we have here, because they’re pretty solid and they’re pretty well insulated and they’re pretty well firmly set into the ground. (Participant #10, male).

Several residents spoke about going to a nearby family member’s site-built frame home for shelter. For instance, after being asked about potential places that would be safer than a mobile home, one participant stated:

I’d probably have to go somewhere else. My sister’s house. […] She have [sic] a big house with a whole big basement to the bottom. About five minutes [to get there] […] I have a key to get in, so I can go whenever I want. (Participant #5, male).

Another resident mentioned the possibility of going to her landlord’s nearby site-built frame home:

If we were up watching TV and there were some storms and it came across a tornado warning, or a tornado in the area, we would probably—I would call my landlord real quick and say, “Hey, I’m bringing the kids down to the house,” (Participant #9, female).

Those who do not have family members or other acquaintances with sturdier housing nearby expressed more uncertainty and even frustration as they spoke about planning where they might go. One participant was exasperated by the lack of information about where to go for shelter:
When severe weather comes around, or tornadoes, threats of tornadoes—things like that—where do you go? I mean, there’s no information out there to tell anybody, “Okay, this is what you should do to prepare. If you want to seek cover, these are options of where you can go.” (Participant #20, female).

For those who did not mention any personal contacts as possible sheltering destinations, the potential destinations that were discussed were generally larger structures present in most communities. For example, several participants assumed they would be able to access school buildings as public shelters during a tornado warning. When asked where she and her family might go, one resident said:

Probably to one of the schools. I was thinking more, ‘cause I know a lot of the schools will open up for shelters and stuff in disasters. (Participant #13, female).

Churches were also mentioned by multiple interviewees as sturdy places with people there willing to help. As one resident stated:

We would go to the church down the street because it’s like a big—it’s old, but it’s a brick church so I believe we’ll be safe there because it’s better than where we at [sic], because we in a trailer.[...] It ain’t nothing but a three minute drive, it’s like right up the street. [...] The pastor stay [sic] right across the street and if he know something was going on, we just knock on his door and let him know what’s going on and then he open [sic] the door because he’s a friendly guy. (Participant #16, female).

A variety of additional buildings were mentioned during the interviews as potential evacuation destinations, including grocery stores, motels, gas stations, and fire stations.
Others spoke about possibly getting underneath their mobile home or getting into a ditch, although these sheltering behaviors were typically spoken of in terms of a last resort.

5.4. Chapter Summary

This chapter presented evidence from the twenty qualitative interviews that aids in understanding why mobile home residents might choose not to evacuate to a sturdy building during a tornado warning. From the transcriptions, it seemed that some residents do not clearly distinguish tornadoes from hurricanes. This is understandable as South Carolina is certainly subject to both hazards, and sometimes tornadoes form in association with hurricanes or tropical storms. However, given the important differences in geographic scale between tornadoes and hurricanes, it is important that some residents do not internalize this in the same manner as experts. One way to address such basic knowledge gaps could be to improve hazard education for elementary and secondary students in South Carolina and across the southeastern US.

Furthermore, tornadoes have something of a mythic quality even for those who more clearly cognize them as a specific hazard. They are seen as being unpredictable in important ways; their formation and movement are regarded as capricious and unable to be anticipated. Even when residents receive warning messages about tornadoes with what would be considered by experts as specific, credible, and accurate scientific information, their perceptions of the physical nature of the hazard are anchoring points with the potential to counteract expert recommendations.

Another consideration is that other environmental hazards can receive priority over tornadoes. Very few thunderstorms actually produce tornadoes, and residents are cognizant of the dangers of more common thunderstorm hazards of lightning and flash
flooding. Other environmental hazards, such as snakes and insects, make refuge in a ditch quite uninviting, and many residents are hesitant to drive when visibility and road conditions might be compromised. Mobile home residents also realize that not all units are equal in their construction quality. They may shun evacuation recommendations because they live in a large double-section unit with brick skirting that is practically indistinguishable from a site-built home. Alternatively, they invoke a persistence argument; their home has been at the same site for ten, twenty, or thirty years without a hint of wind damage. Why should they evacuate what has proven to be a reliable structure?

Lastly, even if a household were favorably disposed to evacuating during a tornado warning, there are compounding uncertainties related to routing decisions. When exactly is the time to leave, where can one go that is likely to be accessible and satisfactory as a short-term sheltering refuge and what is the best route to take to get there without being exposed to the stormy elements while in a vehicle? Many interviewees expressed a level of bewilderment in the face of such a multi-faceted decision. The following chapter describes quantitative results that will be used in tandem with those presented in this chapter to address the research questions.
CHAPTER 6: A TYPOLOGY OF PERSPECTIVES ON TORNADO PREPAREDNESS AND PROTECTIVE ACTION

6.1. Overview

Many of the themes that emerged from the qualitative interviews were melded into the mailed questionnaire. Integration of these themes into the quantitative analysis allowed for a formal rendering to identify specific key factors that define how mobile home residents in the study area think about tornado sheltering. This is important because such a rendering facilitates additional analysis to link perspectives to demographic, geographic, and experiential characteristics. It also provides the opportunity to confirm findings from the qualitative portion of the study with new participants in order to provide greater confidence in any conclusions that are drawn. Therefore, this chapter presents a typology of mobile home resident perspectives on tornado preparedness and protective action and demonstrates how key perspectives relate to participants’ demographic, geographic, and experiential characteristics.

6.2. Identification of Tornado Sheltering Perspective Typologies

6.2.1. Data and Methods

6.2.1.1. Input Variables

The data used in the cluster analysis is from page two of the mailed questionnaire, questions 22a through 22v (Table 6.1). Respondents were instructed to choose the box that best described how much s/he agreed or disagreed with the statement presented in each item. Answers were indicated using a discrete ordinal scale with five choices,
labeled at the respective extremes as strongly agree and strongly disagree. The answers were coded such that strong disagreement was -2 and strong agreement was +2, with the three intervening boxes assigned values of -1, 0, and +1 in their respective orders.

Question 22j was omitted from the analysis because nearly all respondents gave the same

Table 6.1. Questionnaire items used in cluster analysis.

<table>
<thead>
<tr>
<th>Question Number</th>
<th>Question Text</th>
</tr>
</thead>
<tbody>
<tr>
<td>22a</td>
<td>Tornadoes are not predictable.</td>
</tr>
<tr>
<td>22b</td>
<td>Weather forecasters on TV make thunderstorms sound more dangerous than they really are.</td>
</tr>
<tr>
<td>22c</td>
<td>Tornadoes hit the same places again and again.</td>
</tr>
<tr>
<td>22d</td>
<td>I believe God has control over the weather.</td>
</tr>
<tr>
<td>22e</td>
<td>I worry more about hurricanes than tornadoes.</td>
</tr>
<tr>
<td>22f</td>
<td>I expect to hear a tornado siren if a tornado is coming my way.</td>
</tr>
<tr>
<td>22g</td>
<td>Weather radar helps me to know if I'm in the path of a thunderstorm.</td>
</tr>
<tr>
<td>22h</td>
<td>I often think about what I might do in case of a disaster.</td>
</tr>
<tr>
<td>22i</td>
<td>Owners of manufactured home parks should provide tornado shelters.</td>
</tr>
<tr>
<td>22k</td>
<td>I think people waste time and money preparing for every possible type of disaster.</td>
</tr>
<tr>
<td>22l</td>
<td>Tornadoes in South Carolina are weak and don't cause much damage.</td>
</tr>
<tr>
<td>22m</td>
<td>I don't like driving in thunderstorms.</td>
</tr>
<tr>
<td>22n</td>
<td>I am concerned about the threat of a tornado.</td>
</tr>
<tr>
<td>22o</td>
<td>I usually unplug my TV during thunderstorms to protect it from electrical surges.</td>
</tr>
<tr>
<td>22p</td>
<td>I pay close attention to the weather every day.</td>
</tr>
<tr>
<td>22q</td>
<td>When I hear a tornado warning for my area on TV, I take cover right away.</td>
</tr>
<tr>
<td>22r</td>
<td>Tornadoes are likely to happen in South Carolina.</td>
</tr>
<tr>
<td>22s</td>
<td>The government should provide tornado shelters for manufactured home residents in South Carolina.</td>
</tr>
<tr>
<td>22t</td>
<td>I think I could afford to buy a tornado shelter.</td>
</tr>
<tr>
<td>22u</td>
<td>I believe God can protect me from dangerous weather.</td>
</tr>
<tr>
<td>22v</td>
<td>When they show weather radar on TV, I don't understand what I'm seeing.</td>
</tr>
</tbody>
</table>

* Question 22j was omitted from the analysis.
answer; they strongly agree that tornadoes are a natural part of weather systems on Earth. This question was originally intended to be a counterpart to questions about the relationship of deity to weather phenomena, and an attempt to discern those who might view weather in religious terms from those who might take more mystical or karmic views or from those who might ascribe certain weather events to governmental or military geoengineering. In hindsight, however, the question was poorly worded and was therefore discarded.

Very few of the 21 remaining items were highly correlated. The author computed a polychoric correlation matrix (Appendix C) using the ‘polycor’ package (Fox 2010) in the program R which approximates Pearson’s $r$ for ordinal data. Items 22d and 22u, both related to the relationship of weather to deity, were correlated at 0.71; this was the highest correlation among all 21 items. Three additional pairs were correlated higher than 0.5; items 22m and 22n, 22h and 22n, and 22p and 22q. Because the levels of correlation in the matrix were generally low to moderate, there was no statistical justification for excluding any further items from the analysis. In total, there were 212 questionnaires that were complete enough to use in analysis of these 21 items. Missing values were imputed on an item by item basis and the imputations used the mode, the most frequently given answer. Imputed values comprised less than 5% of the total response items.

6.2.1.2. Model Based Cluster Analysis

The author investigated several cluster analysis algorithms prior to settling on the final procedure. All clustering methods suffer from similar problems: how to partition or join groups of observations, how to justify the number of clusters chosen, and how to
validate whether the clustering solution can be generalized outside the sample. Test analyses using widely accepted methods such as hierarchical clustering, k-means, and self-organizing maps did not result in a number of clusters that could be cross-validated using training and validation samples as recommended by Lattin, Carroll, and Green (2003). Even using a dimension reduction technique appropriate for ordinal data—polychoric principal components analysis—did not resolve the cluster validation issue. Therefore, a more robust approach was needed to increase confidence that the numbers of clusters extracted reflected latent groups with common perspectives on tornado preparedness and response that were likely to exist beyond the sampled residents.

Two specific problems needed to be addressed: the sophistication of the clustering algorithm employed and the possibility of the clustering solution being over-fit to the sample data. The first problem was addressed by utilizing a model-based clustering algorithm employing Gaussian mixture models and an iterative form of maximum likelihood estimation called expectation-maximization (Bouveyron and Brunet-Saumard 2014). This clustering method was chosen because it has been shown to consistently outperform traditional clustering methods (Fraley and Raftery 1998; Haughton, Legrand, and Woolford 2009). An optimum number of clusters and the corresponding optimum ellipsoid mixture model are identified. There are multiple ellipsoid model possibilities, all combinations of different ellipsoid shapes, volumes, and orientations in n-dimensional space (Fraley and Raftery 2007). Diagonal models are oriented parallel to the coordinate axes of the input data, whereas ellipsoidal models are oriented parallel to eigenvectors capturing a maximum amount of variance in the input data (Fraley and Raftery 2007) (Table 6.2). The basis for identifying the optimum model and number of clusters is the
Bayesian Information Criterion (BIC), which applies a penalty function to the maximum likelihood estimator based on the number of parameters estimated and the sample size (Fraley and Raftery 2007).

Table 6.2. Types of mixture models used in the mclust R package.

<table>
<thead>
<tr>
<th>Model Type</th>
<th>Ellipsoid Type</th>
<th>Shape</th>
<th>Volume</th>
<th>Orientation</th>
</tr>
</thead>
<tbody>
<tr>
<td>EEE</td>
<td>Ellipsoidal</td>
<td>Equal</td>
<td>Equal</td>
<td>Equal</td>
</tr>
<tr>
<td>EEI</td>
<td>Diagonal</td>
<td>Equal</td>
<td>Equal</td>
<td>Varying</td>
</tr>
<tr>
<td>EEV</td>
<td>Ellipsoidal</td>
<td>Equal</td>
<td>Equal</td>
<td>Varying</td>
</tr>
<tr>
<td>EII</td>
<td>Spherical</td>
<td>Equal</td>
<td>Equal</td>
<td>Equal</td>
</tr>
<tr>
<td>EVI</td>
<td>Diagonal</td>
<td>Varying</td>
<td>Equal</td>
<td>Varying</td>
</tr>
<tr>
<td>VEI</td>
<td>Diagonal</td>
<td>Equal</td>
<td>Varying</td>
<td>Varying</td>
</tr>
<tr>
<td>VEV</td>
<td>Ellipsoidal</td>
<td>Equal</td>
<td>Varying</td>
<td>Varying</td>
</tr>
<tr>
<td>VII</td>
<td>Spherical</td>
<td>Equal</td>
<td>Varying</td>
<td>Equal</td>
</tr>
<tr>
<td>VVI</td>
<td>Diagonal</td>
<td>Varying</td>
<td>Varying</td>
<td>Varying</td>
</tr>
<tr>
<td>VVV</td>
<td>Ellipsoidal</td>
<td>Varying</td>
<td>Varying</td>
<td>Varying</td>
</tr>
</tbody>
</table>

Model-based clustering and other sophisticated clustering algorithms are slowly supplanting more traditional cluster analysis methods. For example, in social science applications model-based clustering is becoming a mainstream statistical technique in the form of Latent Class Analysis (Magidson and Vermunt 2004). Latent class models have been used in recent audience segmentation approaches to climate change communication research (e.g. Maibach et al. 2011; Barnes, Islam, and Toma 2013) to accomplish goals similar to those of this analysis. The model-based clustering algorithm applied in this study was implemented in the statistical software R (R Core Team 2014) using the package ‘mclust’ (Fraley and Raftery 2002; Fraley et al. 2012). The package ‘foreign’ (R Core Team 2015) was used to import the raw data from an SPSS file into the R programming environment. The R code used to complete this analysis is provided in Appendix D.
The ‘mclust’ algorithm was set to search for the optimum clustering solution across possible cluster sizes ranging from two up to ten. It may well be that in reality there are more than ten different classes of mobile home resident perspectives related to tornado preparedness and response. Yet, this possibility must be balanced with the ability to succinctly describe and differentiate so many groups, as well as the geographic and demographic biases and sample size limitations inherent to the questionnaire data. Bearing these caveats in mind, the optimum clustering solution identified by ‘mclust’ using the maximum value of the BIC was three clusters determined via a VEI Gaussian mixture model (Figure 6.1). This simply means that the three groups were best modeled using three ellipsoids of equal shape and varying volume that were oriented parallel to three of the original data axes. Because the input data was ordinal and not ratio level, it was appropriate that the optimum model was diagonal and axis-aligned.

The second cluster analysis problem to be addressed was over-fitting the model to the data; the strength of the model-based clustering approach in capturing patterns in the observed sample data can also be its weakness. There are two aspects to this problem. First, the sample size of 212 in this study is relatively small if it is to be segmented into several similarly sized groups. There is a possibility that the locally optimum clustering solution—that which was fit to the data—may not generalize well beyond the sample analyzed here (Bouveyron and Brunet-Saumard 2014). The second aspect is that the mclust algorithm initializes using results of a basic agglomerative hierarchical clustering algorithm. It is therefore sensitive to the pair of data points used to begin forming clusters. To address these problems, the author used bootstrap resampling and simulation. The dataset of n=212 observations was randomly resampled 999 times, such
Figure 6.1. Scatterplot showing number of clusters on the x-axis and the Bayes Information Criterion on the y-axis for ten different mixture models. There were 999 datasets each with n=212 observations that were randomly chosen from the original n=212 observations. The resampling was done with replacement, and therefore it was possible for an observation to be included more than once or not at all in each of the 999 datasets of size n=212. The bootstrap resampling procedure thereby reduced the sensitivity of the clustering algorithm to a few outlier respondents and allowed the cluster initialization pairs to vary over 999 iterations.

The output was 999 optimum cluster solutions specifying the number of clusters, the type of mixture model, and the optimum value of the BIC. After tabulating the
simulation results, the author generated a smoothed scatterplot showing all 999 BIC values and optimum numbers of clusters. The optimum number of clusters (three) and the BIC value (-15160) from the results obtained with the original dataset were then compared to the bootstrapped bivariate distribution of models (Figure 6.2). Any solution with between two and six clusters and BIC values between about -14850 and -15250 has similar optimum properties to the majority of the solutions produced by the simulation.

The original results are therefore a reasonable solution and do not represent an obvious

Figure 6.2. Smoothed scatterplot demonstrating the location of the original clustering results relative to 999 simulations of the mclust algorithm using case-wise bootstrap resampling.
outlier model solution. It should be noted here, however, that the clustering results are somewhat nebulous; an unequivocal signal of the exact number of clusters did not emerge. The following subsection provides further description of the three groups.

6.2.1.3. Brief Primer on Mosaic Plots

Sections 6.2 and 6.3 in this chapter make extensive use of mosaic plots. Mosaic plots were first introduced in the early 1980s (Hartigan and Kleiner 1984) and then developed further by Friendly (1994; 2002). They use the relative area of rectangles to visualize frequencies from contingency tables for ordinal or categorical data. The plots were generated using the statistical software JMP version 11 and the following explanation draws heavily from JMP’s online documentation (JMP 2015). The main visualization area on is the left side of mosaic displays. It has two axes: the x-axis scales the categories according to the number of observations in each grouping; the wider (narrower) the rectangle, the greater (fewer) the frequency. The y-axis functions similarly, with the height of the tiles being proportional to the number of observations in each y-axis grouping. The relationship between the independent variable (y-axis in mosaic plots) and the dependent variable (x-axis) can be visualized through the relative sizes of the tiles or rectangles. Also, to the right of the main plot area is another y-axis, which proportionally depicts the number of total observations in each category of the independent variable. This serves as another reference point to compare with the heights of the tiles in the main plot area to gauge the effect when the two variables of interest are interacted.
6.2.2. Cluster Analysis Results

The three clusters identified by the model-based algorithm are presented in order according to the number of respondents assigned to each group. The first two clusters are of roughly equal size (n=79 and n=75 respectively), while the third is somewhat smaller (n=58). To better understand which of the 21 questionnaire items were most important in distinguishing the three clusters, the author used two measures of association: uncertainty coefficients and Pearson chi-square tests (Table 6.3). The uncertainty coefficient is calculated by the software JMP (version 11) as the ratio of the negative log likelihood to the corrected total of the negative log likelihood, and is labeled as R Square (U) (Table 6.3). This value is an entropy measure which is interpreted in this application as the

Table 6.3. Associations and statistical significance between questionnaire items and clusters, in descending order according to value of the uncertainty coefficient (U).

<table>
<thead>
<tr>
<th>Item</th>
<th>-Log Likelihood</th>
<th>-Log Likelihood Corrected Total</th>
<th>R Square (U)</th>
<th>Chi-Square</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>22f</td>
<td>104.51</td>
<td>231.09</td>
<td>0.452</td>
<td>177.50</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>22a</td>
<td>47.52</td>
<td>231.09</td>
<td>0.206</td>
<td>85.05</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>22s</td>
<td>30.86</td>
<td>231.09</td>
<td>0.134</td>
<td>57.03</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>22q</td>
<td>28.57</td>
<td>231.09</td>
<td>0.124</td>
<td>54.20</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>22h</td>
<td>27.87</td>
<td>231.09</td>
<td>0.121</td>
<td>49.86</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>22p</td>
<td>23.14</td>
<td>231.09</td>
<td>0.100</td>
<td>44.76</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>22m</td>
<td>21.25</td>
<td>231.09</td>
<td>0.092</td>
<td>39.11</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>22i</td>
<td>21.07</td>
<td>231.09</td>
<td>0.091</td>
<td>39.95</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>22k</td>
<td>19.87</td>
<td>231.09</td>
<td>0.086</td>
<td>36.60</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>22g</td>
<td>18.87</td>
<td>231.09</td>
<td>0.082</td>
<td>34.83</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>22o</td>
<td>18.47</td>
<td>231.09</td>
<td>0.080</td>
<td>35.67</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>22b</td>
<td>15.20</td>
<td>231.09</td>
<td>0.066</td>
<td>28.75</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>22r</td>
<td>13.31</td>
<td>231.09</td>
<td>0.058</td>
<td>21.48</td>
<td>0.006</td>
</tr>
<tr>
<td>22a</td>
<td>11.97</td>
<td>231.09</td>
<td>0.052</td>
<td>23.08</td>
<td>0.003</td>
</tr>
<tr>
<td>22t</td>
<td>11.28</td>
<td>231.09</td>
<td>0.049</td>
<td>18.65</td>
<td>0.017</td>
</tr>
<tr>
<td>22d</td>
<td>8.62</td>
<td>231.09</td>
<td>0.037</td>
<td>16.81</td>
<td>0.032</td>
</tr>
<tr>
<td>22e</td>
<td>6.78</td>
<td>231.09</td>
<td>0.029</td>
<td>13.11</td>
<td>0.108</td>
</tr>
<tr>
<td>22l</td>
<td>5.59</td>
<td>231.09</td>
<td>0.024</td>
<td>10.59</td>
<td>0.226</td>
</tr>
<tr>
<td>22v</td>
<td>4.46</td>
<td>231.09</td>
<td>0.019</td>
<td>9.22</td>
<td>0.324</td>
</tr>
<tr>
<td>22u</td>
<td>4.39</td>
<td>231.09</td>
<td>0.019</td>
<td>8.70</td>
<td>0.368</td>
</tr>
<tr>
<td>22c</td>
<td>3.35</td>
<td>231.09</td>
<td>0.014</td>
<td>6.71</td>
<td>0.568</td>
</tr>
</tbody>
</table>
proportion of uncertainty in the clusters explained by each questionnaire item (Theil 1970; Agresti 2013).

Figure 6.3. Three clusters (blue, red, green dots) plotted by the three most distinguishing questionnaire items (22f, 22n, and 22s), with ellipsoids encompassing 25% of each cluster’s data points.

Item 22f (expect to hear tornado sirens) is by far the most important item in distinguishing the three clusters, with 22n (concerned about tornadoes) and 22s (government should provide tornado shelters) second and third most important respectively. Visualizing these three dimensions together with cluster membership indicated by color best illustrates how the mixture of ellipsoidal models fit the data (Figure 6.3). The first two clusters (blue dots-blue ellipse, red dots-gold ellipse) are located mostly in the negative region (disagreement) of the axis corresponding to item 22f, whereas the third cluster (green dots-red ellipse) is located in the positive region. Clusters two and three are located mostly in the positive regions of both item 22n and
22s, with cluster one spread more evenly and centered near zero for 22n and just inside the negative region for 22s. It should be noted that the ellipsoids drawn in Figure 6.3 were not the actual ellipsoids used by the optimum VEI model, but represent approximations for illustrative purposes only. They were drawn to encompass 25% of the data points within each cluster. The following three subsections discuss more substantively the characteristics of the three clusters.

6.2.2.1. Cluster 1: Relatively Unconcerned

The first cluster (n=79) included about 37% of mobile home residents who responded to the mailed questionnaire. The broadest defining characteristic of this cluster was that they were the least concerned of the three about tornadoes, severe weather information, daily weather information, and disaster preparedness in general (Figure 6.4). For example, 40% of this cluster answered on item 22n (Figure 6.4b) that they were neutral or unsure about being concerned about the threat of a tornado. Additionally, on item 22p (Figure 6.4f) less than half agreed that they pay close attention to the weather on a daily basis, while less than half also answered that they often think about what they might do during a disaster situation (Figure 6.4e). The lower level of concern manifested in the more specific questionnaire items as well. Very few residents in this cluster indicated that they take cover right away when they receive a tornado warning via television (Figure 6.4d), and compared to the other two clusters fewer answered that radar helps them know when a storm is moving into their area (Figure 6.5d). They were somewhat less averse to driving in thunderstorms (Figure 6.5a) and the least likely cluster to unplug their television to protect it from electrical surges during thunderstorms (Figure 6.5e).
Another defining characteristic of this cluster was that they were less apt to expect help from government entities and mobile home park owners in providing tornado shelters or disseminating warning messages. Over 40% said they disagree that government should provide tornado shelters for mobile home residents (Figure 6.4c), and two-thirds strongly disagreed that they would expect to hear tornado sirens if a tornado was moving toward their area (Figure 6.4a). They were, however, more supportive of the

Figure 6.4. Mosaic plots with distributions of answers expressed as percentages within each of the three clusters for questionnaire items 22f, 22n, 22s, 22q, 22h, and 22p.
idea that mobile home park owners should provide shelters for their residents with less than 20% disagreeing with this proposition (Figure 6.5b). Still, this cluster expressed far less agreement with the latter item than the other two clusters, and was slightly less disagreeable about whether they could afford to buy a tornado shelter (Figure 6.6c).

Finally, this relatively unconcerned cluster was also the least certain whether tornadoes are predictable or not (Figure 6.6b) and least likely to agree that deity (God) controls the weather (Figure 6.6d).

Figure 6.5. Mosaic plots with distributions of answers expressed as percentages within each of the three clusters for questionnaire items 22m, 22i, 22k, 22g, 22o, and 22b.
6.2.2.2. Cluster 2: Concerned and Informed

Cluster 2 (n=75) had vastly different characteristics than cluster 1. The 35% of respondents who were in this cluster were much more concerned about tornadoes in particular and disasters in general (Figure 6.4b and 6.4e). More than 80% responded that they think preparing for disasters is not a waste of time and money (Figure 6.5c), and almost two-thirds answered that tornadoes are likely to happen in South Carolina (Figure 6.6a). In being more concerned and willing to plan ahead, this cluster seeks and uses information more readily than the other two clusters. About 70% pay close attention to the weather on a daily basis (Figure 6.4f). More specifically, 65% of cluster 2 disagreed that television weather forecasters exaggerate danger associated with thunderstorms (Figure 6.5f), and over 80% agree that weather radar helps them know whether a storm is moving in their direction (Figure 6.5d). There was, however, some tension in this cluster.

![Mosaic plots](image)

Figure 6.6. Mosaic plots with distributions of answers expressed as percentages within each of the three clusters for questionnaire items 22r, 22a, 22t, 22d.
between the need for information and action relating to tornadoes and the need to protect life and property from other thunderstorm hazards. Almost 40% agreed that they often unplug their television during thunderstorms, nearly double the rate of cluster 1 (Figure 6.5e). Additionally, cluster 2 was about twice as likely as cluster 1 to agree that they do not like to drive during thunderstorms (Figure 6.5a).

Another major distinguishing characteristic of this second cluster of residents was their views on tornado shelters. An overwhelming percentage (96%) answered that they do not think they can afford to buy a tornado shelter (Figure 6.6c). Not surprisingly, more than two-thirds agreed the government should provide tornado shelters for mobile home residents (Figure 6.4c). Interestingly, an even greater percentage (89%) agreed that responsibility for providing tornado shelters in mobile home parks should rest with the owners of the parks (Figure 6.5b). Finally, cluster 2 almost unanimously (97%) disagreed that they expect to hear sirens if a tornado approaches their community.

6.2.2.3. Cluster 3: Anticipating Warnings and Taking Action

Clearly, the most important questionnaire item that separates the 27% of residents in cluster 3 (n=58) from the other two clusters was that 84% of cluster 3 agreed that they expect to hear the wail of a tornado siren as a warning when one is expected in their respective communities (Figure 6.4a). This was in sharp contrast to clusters 1 and 2 which strongly disagreed that they expect to hear tornado sirens. Another important distinguishing characteristic was that about 70% of cluster 3 agreed that they usually unplug their television to protect it from electrical surges during thunderstorms (Figure 6.5e). This was double the rate of agreement for cluster 2 and five times that of cluster 1. Cluster 3’s views on shelters were similar to those of cluster 2. About 86% disagree that
they can afford to buy a shelter (Figure 6.6c), and 82% agree that mobile home park owners should provide tornado shelters (Figure 6.5b). The difference between clusters 2 and 3 on shelters was in their views on whether government should provide tornado shelters for mobile home residents. Cluster 3 tended to agree (79%) with this proposition whereas agreement was somewhat lower for cluster 2 (68%) (Figure 6.4c).

Beyond the items discussed above, cluster 3 is very similar to cluster 2 for most of the items pertaining to concern, preparedness, and information seeking. Nearly everyone in cluster 3 (93%) agreed that they are concerned about tornadoes (Figure 6.4b), most pay attention to the weather daily (77%) (Figure 6.4f), and most did not agree that preparing for disasters is a waste of time and money (70%) (Figure 6.5c). Almost half of cluster 3 agreed that they take cover immediately when they receive a tornado warning via television, the highest of the three clusters; however, there was a large minority (32%) within the cluster that disagreed with this statement (Figure 6.4d). There is a similar split over whether television meteorologists hype or exaggerate the danger associated with thunderstorms (Figure 6.5f). Agreement that deity (God) can control the weather was above 75%, which was higher than either of the other two clusters.

6.3. Three Perspectives and Individual, Household, and Geographic Attributes

This subsection addresses research questions #2 and #3 by interrogating the relationships between the three tornado preparedness and response clusters identified in the previous section and a host of demographic, household, and geographic attributes. The analyses are presented below in four clusters of attributes: demographic and household, telecommunications, mobile home, and geographic. The dependent variable for all tests was a nominal variable using integers to denote whether a respondent fell into
cluster 1 (relatively unconcerned), cluster 2 (concerned and well informed), and cluster 3 (anticipating warnings and taking action). Independent variables were a mix of binary categorical data and continuous data. Relationships between the dependent variable and categorical variables were tested using Pearson’s chi-square tests, while tests with the continuous data were bivariate nominal logistic models. Both test types generated similar output: a chi-square value, an associated p-value, a negative log likelihood value, and an uncertainty coefficient expressed as an R-square. The analysis in this section concludes by incorporating all four attribute subsets into one nominal logistic model to demonstrate which attributes best explain membership in the preparedness and response clusters.

6.3.1. **Demographic and Household Attributes**

There were four demographic and household attributes that had statistically significant associations with the three preparedness and response clusters. The first was race; specifically, those respondents who identified as African-American (Table 6.4). This effect was seen mostly in clusters 1 and 3, as the former had fewer African-American respondents than expected and the latter had more than expected (Figure 6.7a). If using respondents who identified as white alone as the dummy variable, the interpretation is similar in that cluster 1 (3) had a disproportionately high (low) number of white members. The sample sizes for races and ethnicities other than white or African-American were too small for statistical inference. Income was also significantly associated with the three main perspectives on tornado preparedness and response (Table 6.4). The effect was most clearly seen by creating a binary variable with income clusters split at $50,000 annual household income (Figure 6.7b). About 60% of those with income greater than $50,000 fell into cluster 1, and clusters 2 and 3 had smaller shares.
than expected. The data also suggested that questionnaire respondents with less than $25,000 annual household income were focused in cluster 3, though the effect size was marginally significant (Table 6.4; figure not shown).

Table 6.4. Associations and statistical significance between demographic questionnaire items and three preparedness and response clusters, in descending order according to value of the uncertainty coefficient (U).

<table>
<thead>
<tr>
<th>Independent</th>
<th>N</th>
<th>Test Type</th>
<th>Chi-Square Value</th>
<th>P-Value</th>
<th>R-Square (U)</th>
</tr>
</thead>
<tbody>
<tr>
<td>African American</td>
<td>207</td>
<td>Pearson Chi-Square</td>
<td>10.850</td>
<td>0.004***</td>
<td>0.023</td>
</tr>
<tr>
<td>Income More 50K</td>
<td>196</td>
<td>Pearson Chi-Square</td>
<td>9.508</td>
<td>0.009***</td>
<td>0.021</td>
</tr>
<tr>
<td>Household Size</td>
<td>208</td>
<td>Logistic Model</td>
<td>8.019</td>
<td>0.018**</td>
<td>0.018</td>
</tr>
<tr>
<td>Female</td>
<td>211</td>
<td>Pearson Chi-Square</td>
<td>8.052</td>
<td>0.018**</td>
<td>0.017</td>
</tr>
<tr>
<td>White Alone</td>
<td>207</td>
<td>Pearson Chi-Square</td>
<td>7.798</td>
<td>0.020**</td>
<td>0.017</td>
</tr>
<tr>
<td>Kids Under 6</td>
<td>212</td>
<td>Pearson Chi-Square</td>
<td>6.835</td>
<td>0.033**</td>
<td>0.016</td>
</tr>
<tr>
<td>Kids Under 18</td>
<td>212</td>
<td>Pearson Chi-Square</td>
<td>6.678</td>
<td>0.035**</td>
<td>0.014</td>
</tr>
<tr>
<td>Income Less 25K</td>
<td>196</td>
<td>Pearson Chi-Square</td>
<td>5.799</td>
<td>0.055*</td>
<td>0.014</td>
</tr>
<tr>
<td>Rent Home</td>
<td>210</td>
<td>Pearson Chi-Square</td>
<td>4.019</td>
<td>0.134</td>
<td>0.009</td>
</tr>
<tr>
<td>Post High School Ed</td>
<td>208</td>
<td>Pearson Chi-Square</td>
<td>3.001</td>
<td>0.223</td>
<td>0.007</td>
</tr>
<tr>
<td>Age</td>
<td>208</td>
<td>Logistic Model</td>
<td>2.057</td>
<td>0.358</td>
<td>0.005</td>
</tr>
<tr>
<td>High School Ed</td>
<td>208</td>
<td>Pearson Chi-Square</td>
<td>1.939</td>
<td>0.379</td>
<td>0.004</td>
</tr>
<tr>
<td>Own Home</td>
<td>210</td>
<td>Pearson Chi-Square</td>
<td>1.844</td>
<td>0.398</td>
<td>0.004</td>
</tr>
<tr>
<td>College Ed</td>
<td>208</td>
<td>Pearson Chi-Square</td>
<td>1.029</td>
<td>0.598</td>
<td>0.002</td>
</tr>
<tr>
<td>Have Pets</td>
<td>208</td>
<td>Pearson Chi-Square</td>
<td>0.848</td>
<td>0.654</td>
<td>0.002</td>
</tr>
<tr>
<td>Adults Over 64</td>
<td>212</td>
<td>Pearson Chi-Square</td>
<td>0.701</td>
<td>0.704</td>
<td>0.002</td>
</tr>
</tbody>
</table>

Asterisks denote confidence levels: *90%, **95%, ***99%.

Gender was also related to the three perspective clusters. Just over 40% of female respondents were identified with the concerned and informed cluster (2), while 50% of
male respondents were in the unconcerned cluster (1) (Figure 6.7c). The fourth household attribute associated with the clusters identified in Section 6.2 was household size (Table 6.4). This attribute was largely a function of the number of children in the home. A dummy variable for the presence of children under 18 years of age demonstrated that mobile home respondents with at least one child under 18 living in the household were more likely to be in cluster 3 and less likely than expected to be in cluster 2 (Figure 6.7d). Variables representing housing tenure, age, educational attainment, and the presence of pets in the home were all unrelated to the preparedness and response perspectives in this analysis.

Figure 6.7. Mosaic plots with distributions of answers expressed as percentages within each of the demographic segments (x-axis; 0=no and 1=yes) and by membership in three preparedness and response clusters (y-axis).
6.3.2. Communication Technologies

The presence or absence of certain communication technologies could also be related to perspectives on tornado preparedness and response, particularly regarding receipt of forecasts and warning messages. Binary variables were therefore created for the presence or absence of cable television service, internet service at home, cell phone service, and internet data on a cell phone. Only one of these, however, significantly distinguished between the three preparedness and response clusters (Table 6.5). Those who answered that they have internet service at home were more likely to be in cluster 1 and less likely to be in cluster 3 (Figure 6.8a). Those without internet at home were more likely to be in clusters 2 or 3 and less likely to be in cluster 1.

6.3.3. Mobile Home Physical Attributes

A number of variables pertaining to the physical attributes of participants’ mobile homes were also tested (Table 6.5). Respondents who live in a double wide mobile home tended to be in the least concerned cluster (nearly 46% in cluster 1) and were less often in clusters 2 and 3 (Figure 6.8b). Those with single wide units were more concentrated in clusters 2 and 3, and less so in cluster 1. Similarly, residents who indicated that their mobile homes have features that make them more wind resistant (such as anchors, straps, and brick skirting) fell into cluster 1 at a higher rate than would be expected and into cluster 3 at a lower rate (Figure 6.8d). Yet, variables that were created and tested specifically for each of these characteristics (anchoring or straps, and brick skirting) were not significantly related to any cluster, nor was the age of the unit within which each respondent lives (Table 6.5).
### Table 6.5. Associations and statistical significance between questionnaire items on communication, mobile home, and geographic attributes and three preparedness and response clusters, in descending order by the uncertainty coefficient (U).

<table>
<thead>
<tr>
<th>Independent</th>
<th>N</th>
<th>Test Type</th>
<th>Chi-Square Value</th>
<th>P-Value</th>
<th>R-Square (U)</th>
</tr>
</thead>
<tbody>
<tr>
<td>County</td>
<td>212</td>
<td>Pearson Chi-Square</td>
<td>16.517</td>
<td>0.086*</td>
<td>0.040</td>
</tr>
<tr>
<td>Home Internet</td>
<td>209</td>
<td>Pearson Chi-Square</td>
<td>9.122</td>
<td>0.011**</td>
<td>0.020</td>
</tr>
<tr>
<td>% Urban Smoothed</td>
<td>212</td>
<td>Logistic Model</td>
<td>8.025</td>
<td>0.018**</td>
<td>0.017</td>
</tr>
<tr>
<td>MH 1 Mile Radius (Log)</td>
<td>212</td>
<td>Logistic Model</td>
<td>6.964</td>
<td>0.031**</td>
<td>0.015</td>
</tr>
<tr>
<td>Double Wide MH</td>
<td>203</td>
<td>Pearson Chi-Square</td>
<td>6.568</td>
<td>0.038**</td>
<td>0.015</td>
</tr>
<tr>
<td>Lived Outside SE US</td>
<td>201</td>
<td>Pearson Chi-Square</td>
<td>6.002</td>
<td>0.050*</td>
<td>0.014</td>
</tr>
<tr>
<td>Wind Resistant Features</td>
<td>209</td>
<td>Pearson Chi-Square</td>
<td>5.313</td>
<td>0.070*</td>
<td>0.012</td>
</tr>
<tr>
<td>Lived Outside SC</td>
<td>212</td>
<td>Pearson Chi-Square</td>
<td>4.300</td>
<td>0.117</td>
<td>0.009</td>
</tr>
<tr>
<td>Cell Phone</td>
<td>209</td>
<td>Pearson Chi-Square</td>
<td>3.822</td>
<td>0.148</td>
<td>0.009</td>
</tr>
<tr>
<td>MH 1/4 Mile Radius (Log)</td>
<td>212</td>
<td>Logistic Model</td>
<td>4.048</td>
<td>0.132</td>
<td>0.009</td>
</tr>
<tr>
<td>Year MH Built</td>
<td>171</td>
<td>Logistic Model</td>
<td>2.807</td>
<td>0.246</td>
<td>0.008</td>
</tr>
<tr>
<td>% Urban Raw</td>
<td>212</td>
<td>Logistic Model</td>
<td>2.799</td>
<td>0.247</td>
<td>0.006</td>
</tr>
<tr>
<td>Years in Current MH</td>
<td>196</td>
<td>Logistic Model</td>
<td>2.105</td>
<td>0.349</td>
<td>0.005</td>
</tr>
<tr>
<td>Years in SC</td>
<td>195</td>
<td>Logistic Model</td>
<td>1.451</td>
<td>0.484</td>
<td>0.003</td>
</tr>
<tr>
<td>Internet on Cell Phone</td>
<td>208</td>
<td>Pearson Chi-Square</td>
<td>0.813</td>
<td>0.666</td>
<td>0.002</td>
</tr>
<tr>
<td>Cable TV</td>
<td>210</td>
<td>Pearson Chi-Square</td>
<td>0.392</td>
<td>0.822</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Asterisks denote confidence levels: *90%, **95%, ***99%

### 6.3.4. Geographic Attributes

Several types of attributes related to where each respondent has lived previously and where s/he currently lives were tested. There was no indication of any spatial pattern in cluster membership (Figure 6.9a). Yet, looking at cluster frequencies by county, some
types of preparedness and response perspectives were focused in certain counties within the study area (Table 6.5). For example, over half of respondents from Richland County were in cluster 1, and less than 12% were in cluster 2 (Figure 6.9b). Kershaw County was split evenly between clusters 1 and 2, but only a few respondents were in cluster 3. Darlington and Sumter counties had greater numbers of respondents in clusters 2 and 3 and fewer in cluster 1. Orangeburg County was most concentrated in cluster 2 and lower than expected in cluster 3. Lexington County was the closest match to the overall proportions for cluster membership, not surprisingly, because the largest portion of all respondents came from that county.
Figure 6.9. Map showing a) respondent locations by cluster membership, and b) mosaic plot demonstrating cluster membership (y-axis) percentages by county (x-axis).
In addition to differences according to the county which each respondent lives in, there was a possibility for differences across urban and rural contexts. Two variables were created for testing whether any relationship existed between the preparedness and response perspectives and the population densities near each respondent’s location. Using the 2010 Census Summary File 1 data, the author calculated the proportion of housing units marked as urban in each census tract. This approach allowed for greater variance than a binary urban/rural classification. A second variable was created by applying spatial rate smoothing (using the program GeoDa) to all of the tracts in the state of SC; the neighbors were defined by the rook criterion and the smoothing bandwidth was first order neighbors. The smoothing was applied statewide so that tracts on the outer perimeter of the study area would not systematically have fewer neighbors. The smoothed urban housing proportion variable was significantly associated with the preparedness and response clusters (Table 6.5). The main difference was seen between clusters 2 and 3 (Figure 6.10a); respondents living in tracts with lower values of the smoothed urban indicator were more likely to fall into cluster 2 than cluster 3, and this relationship reversed for those living in more urbanized tracts. The effect size of the relationship was rather small, however, and the unsmoothed urban variable was not significant (Table 6.5).

Another factor considered in this analysis was whether a respondent lives in an area with a large number of mobile homes. The mail questionnaire included a question on page one that asked whether the respondent lived in a mobile home park or a more rural area dominated by mobile homes. This variable was not significantly related to the
Figure 6.10. Dot density plots showing percentage of housing units in urban areas (a) and the log of the mobile home count within a 1 mile radius of each respondent’s location (b), both stratified by membership in three preparedness and response clusters.

However, the author constructed two additional variables that used the mobile home address database built from county assessor’s data. The number of mobile homes within both a quarter mile and one mile circular buffer were tabulated for
each respondent’s geocoded home location to represent the local density of mobile homes. Both variables were log transformed to approximate normality and used to predict cluster membership using logistic models; the quarter mile variable did not predict cluster membership with statistical significance. The one mile variable did (Table 6.5), however, as mobile home density was higher near cluster 3 locations than both clusters 1 and 2 (Figure 6.10b). Again, the effect size was relatively small.

The final set of geographic attributes tested whether cluster membership was associated with a respondent’s duration living in their location, and whether they have previously lived outside of SC. The only significant variable was a binary indicating whether the person had ever lived outside of the southeastern United States (US) (Table 6.5), which was defined as including the following states: Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia. The main differences were between clusters 1 and 2 (Figure 6.8c); those who previously lived outside the southeastern US were concentrated in cluster 1 whereas those who had not were more concentrated in cluster 2.

6.3.5. Previous Tornado Experiences

The way that respondents think about tornado preparedness and response can also be influenced by their prior experiences. There were two questionnaire items related to previous tornado experiences; one asked residents to estimate the closest they have ever been to a tornado, and the other asked residents to estimate how many times they have been in a tornado warning. These questions were on page 1 of the survey instrument (Figure B.1). A binary variable was created for the first item based on whether respondents had ever been within five miles of a tornado. Using a Pearson chi-square
test, this variable was significantly associated with the three preparedness and response perspectives ($\chi^2=12.145$, p-value=0.002). Those who answered they had been within five miles of a tornado before (coded as 1) were more likely to be in clusters 1 and 2 and far less likely to be in cluster 3 (Figure 6.11a). A second binary variable separated those who answered that they had been in a tornado warning ten times or less previously while living at their current address from those who estimated they had been in more than ten tornado warnings while living at their current address. Those who answered they had been in fewer tornado warnings were significantly more likely to be in cluster 2 and less likely to be in clusters 1 and 3 ($\chi^2=8.634$, p-value=0.013) (Figure 6.11b).

Figure 6.11. Mosaic plots with distributions of answers expressed as percentages within each of the two experience segments (x-axis; 0=no and 1=yes) and by membership in three preparedness and response clusters (y-axis).
6.4. Combined Logistic Model to Predict Cluster Membership

While the previous subsections presented the results for demographic, household, communications, mobile home, geographic, and experiential characteristics, each in turn, this section presents results when all of these characteristics are combined in a single logistic model to predict membership in the three preparedness and response clusters. Eight variables were significant predictors of cluster membership (Table 6.6). The most significant predictor of cluster membership was whether a respondent had internet at home. This attribute was very strong in distinguishing cluster 1 from clusters 2 and 3 (Table 6.7). Those who answered they do not have internet were about half as likely (odds ratios 0.602 and 0.474) to be in cluster 1 compared to clusters 2 and 3. Home internet service was not, however, a highly significant predictor of membership when comparing clusters 2 and 3. The second most important predictor in the overall logistic model was the number of people within (or the size of) the household (Table 6.6). This was particularly useful for separating clusters 2 and 3. For example, for every increase of one person in the household, respondents were 52% more likely to be in cluster 3 compared to cluster 2 (Table 6.7). Household size also was significant in distinguishing clusters 1 and 2. For every increase of one person in the household, respondents were 37% more likely to be in cluster 1 compared to 2.

County of residence was important as well, as those who live in Richland County were 2.5 times as likely to be in cluster 1 compared to cluster 2 and also twice as likely to be in cluster 3 compared to cluster 2. Gender was a statistically significant predictor across the entire logistic model, with the greatest effect between the first two clusters. Male respondents were 77% more likely to be in cluster 1 compared to cluster 2.
Table 6.6. Variables used to predict preparedness and response cluster membership in logistic regression model, with statistical significance levels.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Likelihood Ratio Chi-Square</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home Internet</td>
<td>12.703</td>
<td>0.002***</td>
</tr>
<tr>
<td>Household Size</td>
<td>8.477</td>
<td>0.014**</td>
</tr>
<tr>
<td>Richland County</td>
<td>8.423</td>
<td>0.015**</td>
</tr>
<tr>
<td>Female</td>
<td>7.300</td>
<td>0.026**</td>
</tr>
<tr>
<td>African American</td>
<td>7.096</td>
<td>0.029**</td>
</tr>
<tr>
<td>Rent Home</td>
<td>6.518</td>
<td>0.038**</td>
</tr>
<tr>
<td>MH 1 Mile (Log)</td>
<td>5.853</td>
<td>0.054*</td>
</tr>
<tr>
<td>Less than 5 Miles Closest Tornado</td>
<td>5.749</td>
<td>0.056*</td>
</tr>
</tbody>
</table>

Asterisks denote confidence levels: *90%, **95%, ***99%

However, gender was just outside the margin of significance for distinguishing between cluster 1 (more likely to be male) and cluster 3 (more likely to be female). Race/ethnicity was important mostly for distinguishing cluster 3 from the others. Respondents who did not identify as African-American were almost 75% more likely to be in cluster 1 compared to cluster 3, and nearly 60% more likely to be in cluster 2 compared to 3.

Owners of their mobile home units were more than twice as likely to be in cluster 1 versus cluster 2 and 66% more likely to be in cluster 3 versus cluster 2. Those in cluster 3 lived in areas with more mobile homes within a 1 mile radius than cluster 2, but this variable was not significant in distinguishing cluster 1 from cluster 2 or cluster 3. Those who had never been within five miles of a tornado were significantly less likely to be in either cluster 1 or cluster 2 compared to cluster 3. Overall, the logistic model was significant (n=195, \( \chi^2 = 70.513 \), p-value<0.0001), but correctly predicted cluster membership for only 55% of the respondents used in the model. Clusters 1 and 2 were predicted with about 60% success, and cluster 3 was most difficult to predict with only 43% correct. While this analysis demonstrated several variables that are significant
predictors of cluster membership when used together in one model, the resulting model is not a particularly good predictor of cluster membership.

Table 6.7. Variables used to predict preparedness and response cluster membership in logistic regression model, broken down by models for clusters 1 versus 2, 1 versus 3, and clusters 2 versus 3, and with odds ratios and statistical significance levels.

<table>
<thead>
<tr>
<th>Term</th>
<th>Estimate</th>
<th>Odds Ratio</th>
<th>Chi-Square</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cluster 1 vs Cluster 2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>-0.836</td>
<td>0.433</td>
<td>0.776</td>
<td>0.378</td>
</tr>
<tr>
<td>African American [0]</td>
<td>0.097</td>
<td>1.102</td>
<td>0.164</td>
<td>0.685</td>
</tr>
<tr>
<td>Richland [0]</td>
<td>-0.951</td>
<td>0.386</td>
<td>7.411</td>
<td>0.007***</td>
</tr>
<tr>
<td>Household Size</td>
<td>0.315</td>
<td>1.371</td>
<td>3.837</td>
<td>0.050*</td>
</tr>
<tr>
<td>Female [0]</td>
<td>0.569</td>
<td>1.767</td>
<td>7.161</td>
<td>0.008***</td>
</tr>
<tr>
<td>MH_1_Mile (Log)</td>
<td>0.068</td>
<td>1.070</td>
<td>0.144</td>
<td>0.704</td>
</tr>
<tr>
<td>Home Internet [0]</td>
<td>-0.508</td>
<td>0.602</td>
<td>6.290</td>
<td>0.012**</td>
</tr>
<tr>
<td>Rent home [0]</td>
<td>0.750</td>
<td>2.116</td>
<td>5.785</td>
<td>0.016**</td>
</tr>
<tr>
<td>Less than 5 Miles</td>
<td>0.093</td>
<td>1.097</td>
<td>0.208</td>
<td>0.648</td>
</tr>
<tr>
<td>Closest Tornado [0]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cluster 1 vs Cluster 3</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>2.063</td>
<td>7.873</td>
<td>3.415</td>
<td>0.065*</td>
</tr>
<tr>
<td>African American [0]</td>
<td>0.551</td>
<td>1.734</td>
<td>6.009</td>
<td>0.014**</td>
</tr>
<tr>
<td>Richland [0]</td>
<td>0.025</td>
<td>1.025</td>
<td>0.009</td>
<td>0.924</td>
</tr>
<tr>
<td>Household Size</td>
<td>-0.180</td>
<td>0.836</td>
<td>1.541</td>
<td>0.214</td>
</tr>
<tr>
<td>Female [0]</td>
<td>0.327</td>
<td>1.387</td>
<td>2.225</td>
<td>0.136</td>
</tr>
<tr>
<td>MH_1_Mile (Log)</td>
<td>-0.336</td>
<td>0.714</td>
<td>2.521</td>
<td>0.112</td>
</tr>
<tr>
<td>Home Internet [0]</td>
<td>-0.747</td>
<td>0.474</td>
<td>11.434</td>
<td>0.001***</td>
</tr>
<tr>
<td>Rent home [0]</td>
<td>0.187</td>
<td>1.205</td>
<td>0.314</td>
<td>0.575</td>
</tr>
<tr>
<td>Less than 5 Miles</td>
<td>-0.467</td>
<td>0.627</td>
<td>3.882</td>
<td>0.049**</td>
</tr>
<tr>
<td>Closest Tornado [0]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cluster 2 vs Cluster 3</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>3.142</td>
<td>23.142</td>
<td>8.068</td>
<td>0.005***</td>
</tr>
<tr>
<td>African American [0]</td>
<td>0.463</td>
<td>1.589</td>
<td>4.479</td>
<td>0.034**</td>
</tr>
<tr>
<td>Richland [0]</td>
<td>0.788</td>
<td>2.200</td>
<td>5.401</td>
<td>0.020**</td>
</tr>
<tr>
<td>Household Size</td>
<td>-0.423</td>
<td>0.655</td>
<td>7.655</td>
<td>0.006***</td>
</tr>
<tr>
<td>Female [0]</td>
<td>-0.193</td>
<td>0.824</td>
<td>0.699</td>
<td>0.403</td>
</tr>
<tr>
<td>MH_1_Mile (Log)</td>
<td>-0.486</td>
<td>0.615</td>
<td>5.433</td>
<td>0.020**</td>
</tr>
<tr>
<td>Home Internet [0]</td>
<td>-0.349</td>
<td>0.706</td>
<td>2.592</td>
<td>0.107</td>
</tr>
<tr>
<td>Rent home [0]</td>
<td>-0.507</td>
<td>0.602</td>
<td>3.159</td>
<td>0.076*</td>
</tr>
<tr>
<td>Less than 5 Miles</td>
<td>-0.522</td>
<td>0.593</td>
<td>4.876</td>
<td>0.027**</td>
</tr>
<tr>
<td>Closest Tornado [0]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Asterisks denote confidence levels: *90%, **95%, ***99%
6.5. Chapter Summary

This chapter identified three types of perspectives on tornado preparedness and response. One perspective can be characterized as the relatively unconcerned cluster. Residents who were in this cluster expressed in their questionnaire answers that they are less inclined to think about disaster preparedness, do not pay attention to the weather on a regular basis, and are not really concerned about tornadoes (Table 6.8). Following from these main descriptors, members of cluster 1 tend not to take warnings as seriously, take less initiative to seek out additional information, and do not expect government interventions such as tornado sirens or programs to provide tornado shelters for mobile home residents. Respondents in this cluster were also less likely to ascribe control of the weather to God.

Demographically, persons in clusters 1 were more likely to be male and identify as white (Table 6.9). They were also more likely to have a higher income, and consequently to be a homeowner, live in a double-section mobile home, have internet service at home, and indicate that their home has wind resistant features such as brick skirting, better roofing, and anchors. Interestingly, respondents in this unconcerned cluster were more likely to indicate they had previously been within five miles of a tornado and been in more than ten tornado warnings. These respondents were also more likely to have lived outside the southeastern US, live in a more urban census tract, and live in Richland County.

The second perspective was characterized by much more concern and information seeking. Mobile home residents classified in this cluster stated they think about what to do in case of a disaster and that preparedness is not a waste of time and money (Table
Table 6.8. Three perspectives on tornado preparedness and response, with questionnaire items listed in order of importance for distinguishing the three clusters.

<table>
<thead>
<tr>
<th>Question Number</th>
<th>Question Text</th>
<th>Cluster 1: Relatively Uncconcerned (37.3%)</th>
<th>Cluster 2: Concerned and Informed (35.4%)</th>
<th>Cluster 3: Anticipating Warnings and Taking Action (27.3%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>22f</td>
<td>I expect to hear a tornado siren if a tornado is coming my way.</td>
<td>Disagree 81%</td>
<td>Disagree 97%</td>
<td>Agree 85%</td>
</tr>
<tr>
<td>22n</td>
<td>I am concerned about the threat of a tornado.</td>
<td>Not Sure 41%</td>
<td>Agree 88%</td>
<td>Agree 93%</td>
</tr>
<tr>
<td>22s</td>
<td>The government should provide tornado shelters for manufactured home residents in South Carolina.</td>
<td>Disagree 43%</td>
<td>Agree 68%</td>
<td>Agree 79%</td>
</tr>
<tr>
<td>22q</td>
<td>When I hear a tornado warning for my area on TV, I take cover right away.</td>
<td>Disagree 62%</td>
<td>Not Sure/Agree 41%</td>
<td>Agree 48%</td>
</tr>
<tr>
<td>22h</td>
<td>I often think about what I might do in case of a disaster.</td>
<td>Agree 47%</td>
<td>Agree 85%</td>
<td>Agree 81%</td>
</tr>
<tr>
<td>22p</td>
<td>I pay close attention to the weather every day.</td>
<td>Agree 44%</td>
<td>Agree 87%</td>
<td>Agree 78%</td>
</tr>
<tr>
<td>22m</td>
<td>I don't like driving in thunderstorms.</td>
<td>Agree 52%</td>
<td>Agree 85%</td>
<td>Agree 90%</td>
</tr>
<tr>
<td>22i</td>
<td>Owners of manufactured home parks should provide tornado shelters.</td>
<td>Agree 56%</td>
<td>Agree 89%</td>
<td>Agree 79%</td>
</tr>
<tr>
<td>22k</td>
<td>I think people waste time and money preparing for every possible type of disaster.</td>
<td>Disagree 52%</td>
<td>Disagree 88%</td>
<td>Disagree 72%</td>
</tr>
<tr>
<td>22g</td>
<td>Weather radar helps me to know if I'm in the path of a thunderstorm.</td>
<td>Agree 53%</td>
<td>Agree 80%</td>
<td>Agree 83%</td>
</tr>
<tr>
<td>22o</td>
<td>I usually unplug my TV during thunderstorms to protect it from electrical surges.</td>
<td>Disagree 48%</td>
<td>Agree 39%</td>
<td>Agree 71%</td>
</tr>
<tr>
<td>22b</td>
<td>Weather forecasters on TV make thunderstorms sound more dangerous than they really are.</td>
<td>Disagree 37%</td>
<td>Disagree 65%</td>
<td>Disagree 43%</td>
</tr>
<tr>
<td>22r</td>
<td>Tornadoes are likely to happen in South Carolina.</td>
<td>Not Sure 42%</td>
<td>Agree 63%</td>
<td>Agree 59%</td>
</tr>
<tr>
<td>22a</td>
<td>Tornadoes are not predictable.</td>
<td>Agree 47%</td>
<td>Agree 60%</td>
<td>Agree 52%</td>
</tr>
<tr>
<td>22t</td>
<td>I think I could afford to buy a tornado shelter.</td>
<td>Disagree 77%</td>
<td>Disagree 96%</td>
<td>Disagree 86%</td>
</tr>
<tr>
<td>22d</td>
<td>I believe God has control over the weather.</td>
<td>Agree 51%</td>
<td>Agree 73%</td>
<td>Agree 78%</td>
</tr>
</tbody>
</table>

6.8. They think tornadoes are likely to occur in South Carolina and they are concerned about them. They pay attention to the weather every day, and are more apt to look at weather radar to try and follow paths of storms. This cluster in particular expressed that
Table 6.9. Three perspectives on tornado preparedness and response, with demographic, mobile home, geographic, and experiential attributes.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Cluster 1: Relatively Unconcerned (37.3%)</th>
<th>Cluster 2: Concerned and Informed (35.4%)</th>
<th>Cluster 3: Anticipating Warnings and Taking Action (27.3%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Demographics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>More Likely Male</td>
<td>More Likely Female</td>
<td></td>
</tr>
<tr>
<td>Income</td>
<td>Likely Higher</td>
<td>Likely Lower</td>
<td></td>
</tr>
<tr>
<td>Race</td>
<td>More Likely White</td>
<td>More Likely African-American</td>
<td></td>
</tr>
<tr>
<td>Children Under 18 in Home</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tenure</td>
<td>Less Likely Renter</td>
<td>More Likely Renter</td>
<td></td>
</tr>
<tr>
<td>Internet at Home</td>
<td>More Likely</td>
<td>Less Likely</td>
<td>Less Likely</td>
</tr>
<tr>
<td></td>
<td>Home Characteristics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Size</td>
<td>More Likely Double-Wide</td>
<td>More Likely Single-Wide</td>
<td></td>
</tr>
<tr>
<td>Wind Resistance</td>
<td>More Wind Resistant</td>
<td>Less Wind Resistant</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Geographic Attributes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mobile Home Density (1 Mile)</td>
<td></td>
<td>Likely Lower</td>
<td>Likely Higher</td>
</tr>
<tr>
<td>County</td>
<td>More Likely Richland</td>
<td>More Likely Darlington</td>
<td>Less Likely Kershaw</td>
</tr>
<tr>
<td>Previous Residence</td>
<td>More Likely Lived Outside SE US</td>
<td>Less Likely Lived Outside SE US</td>
<td></td>
</tr>
<tr>
<td>Percentage Urban in Tract</td>
<td>Likely Higher</td>
<td>Likely Lower</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Previous Experiences</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Been Within 5 Miles of Tornado</td>
<td>More Likely</td>
<td>More Likely</td>
<td>Less Likely</td>
</tr>
<tr>
<td>Number of Previous Tornado Warnings</td>
<td>More Warnings Likely</td>
<td>Fewer Warnings Likely</td>
<td></td>
</tr>
</tbody>
</table>

owners of mobile home parks should provide tornado shelters for their residents, though they also expressed that the government also bears some responsibility for this. They almost unanimously expressed that they do not expect to hear tornado sirens to warn their communities when a tornado threatens.
In terms of demographics, participants in cluster 2 were more likely to be female (Table 6.9). Members of this cluster were more likely to be renters, live in single-wide mobile homes, and less likely to have internet service at home. Participants in cluster 2 were, like cluster 1, more likely to indicate they had previously been within five miles of a tornado; however, in contrast to cluster 1, cluster 2 indicated they had experienced fewer tornado warnings. They were also less likely to have lived previously outside of the southeastern US. Finally, members of this cluster were more likely to live in less urban census tracts, have fewer mobile homes within a one mile radius, and live in Darlington County.

Mobile home residents who were categorized in the third perspective were also quite concerned and diligently seek information about dangerous weather, but their answers suggested more anticipation of warnings and readiness for protective actions. For example, the third cluster strongly expects to hear tornado sirens as a signal that a tornado is approaching their communities. Also, this cluster has the strongest tendency to unplug their televisions during thunderstorms to avoid damage from electrical surges. More than the other two clusters, they think that mobile home park owners and the government should both provide tornado shelters for mobile home residents, though their answers were somewhat stronger in placing this responsibility on government. Finally, this cluster is more likely than the others to believe that God controls, or can control, the weather.

Mobile home residents in cluster 3 were more likely to identify as African-American and more likely to have children under 18 in the household. Their income was likely to be lower, especially compared to cluster 1, and they were less likely to have
internet service at home and less likely to indicate that their mobile home has wind resistant features such as brick skirting, strong anchoring, or better roof materials. They were the only cluster that was less likely to say they had previously been within five miles of a tornado. Members of this cluster were more likely to live in areas with a higher number of mobile homes within a one mile radius of their location, and were least likely to reside in Kershaw County.

In Chapter 8, further discussion is provided of how these results relate to the literature reviewed in Chapter 2 and what some of the implications for theory and practice the results might hold.
CHAPTER 7: QUANTITATIVE MODELING OF INTENDED PROTECTIVE ACTIONS

7.1. Overview

The ultimate goal of this study is to better understand how many mobile home residents might attempt to evacuate to a sturdy building during a tornado warning, and to elucidate the factors that encourage or discourage this behavior. Whereas the previous chapter identified important perspectives on tornado preparedness, communication, and response, this chapter focuses specifically on intended protective actions during a tornado warning. To this end, the author presented questionnaire participants with several hypothetical scenarios and asked them to indicate their most likely course of action. The following section presents the data collected from these hypothetical scenarios, and then presents data collected on several related topics such as information sources and channels, potential sheltering locations, and damage and injury expectations of respondents.

7.2. Dependent and Independent Variables

7.2.1. Dependent Variables

The six dependent variables considered in this chapter are constructed from items 46a, 46b, 46c, 47a, 47b, and 47c on page 4 of the mailed questionnaire (Figure B.4). The author’s instructions were for respondents to choose the one behavior they would most likely do given several tornado warning scenarios: evacuate to a sturdy building, flee the path of the storm in a vehicle, evacuate their mobile home and lie flat in a ditch, take
shelter inside the mobile home, or do nothing at all for protection. Six scenarios were presented across varying warning lead time and daylight conditions: three during the daytime at 5, 15, and 45 minutes lead time, and three during the night with the same three categories for lead time.

Evacuation to a sturdy building was the most commonly marked answer in five of the six warning scenarios (Figure 7.1). In the daytime 5 minute scenario, going to a sturdy building for shelter (38%) was chosen at about the same rate as sheltering in the mobile home (36%). For the nighttime 5 minute scenario, sheltering in the mobile home (42%) was the top answer with evacuation to a sturdy building the second most chosen answer (34%). In each of the 15 minute and 45 minute scenarios, evacuation to a sturdy building was the most given answer and marked by over half of respondents. In general, the propensity to evacuate to a sturdy building increased at each step from 5 to 15 to 45 minutes of lead time (Figure 7.1). Likewise, a greater percentage of respondents chose fleeing the path of a storm in a vehicle as lead time increased. Concordantly, sheltering at home and lying flat in a ditch were chosen less frequently as lead time increased. In all cases, less than 5% of participants indicated they would do nothing at all to protect themselves during a tornado warning. Also, the main difference between daytime and nighttime scenarios was that sheltering at home was chosen relatively more often for the nighttime cases and both evacuation to a sturdy building and fleeing the storm’s path in a vehicle were chosen somewhat less frequently.
Unfortunately, several respondents marked multiple answers, and therefore the author chose to focus on whether or not respondents marked that leaving home to seek shelter in a sturdy building was a behavior they would be likely to do. The six independent variables were coded as binaries: 1 signifies that the respondent answered they would leave home and seek shelter in a sturdy building and 0 signifies that they did not mark this answer. While information about other possible sheltering choices was not directly considered with this coding method, it allowed the author to focus on the behavior of greatest interest and address the principal research question.

7.2.2. Independent Variables

Most of the items in the questionnaire (Appendix B) were candidates to be independent variables in the logistic regression models to predict intention to evacuate to a sturdy building during a tornado warning. The demographic characteristics presented
in Chapters 4 and 6, the physical characteristics of each respondent’s mobile home, their communications technologies, variables capturing the geographic context of their residences, and experiential variables were all included. Similarly, the three tornado preparedness and response clusters identified in Chapter 6 were also used in the analysis, along with the individual questionnaire items from Table 6.1. There are several other questionnaire items which—based on the extant literature—could reasonably be hypothesized to influence whether a resident is more inclined to shelter in place or to evacuate. The following subsection describes these items relating to channels of information for tornado warnings, trust in emergency and tornado-related information sources, expectations of damage and injury levels were a tornado to strike residents’ own mobile homes and potential shelter sites, and several shelter characteristics such as the type of building, estimated travel time, direction from residents’ homes.

7.2.2.1. Tornado Warning Information Channels and Sources

On the first page of the questionnaire, there are three sets of items related to the communication of emergency information (Figure B.1). Question #16 asked respondents to indicate on a diverging four point scale the likelihood of receiving a tornado warning via eight different types of communication channels: radio, television, computer, landline telephone, cell phone, word of mouth, outdoor tornado sirens, and NOAA weather radio. The answers were originally coded as follows: -2 for very unlikely, -1 for unlikely, 1 for likely, and 2 for very likely. Respondents were instructed to provide an answer for each of the eight items on question #16, but only 129 of 217 (~60%) did so. Yet, only one of 217 left all eight items completely blank, and therefore the results of each item are presented in Figure 7.2 with the appropriate n noted in the column labels. Also, to simply
interpretation of the results, the coding was adapted to a binary scheme: respondents who indicated they were very unlikely or unlikely to receive a warning via a channel were placed in one category and those who said they were very likely or likely were placed in a second category.

The communication item with the most responses was television, with 60% very likely to receive a tornado warning via this channel and an additional 23% likely. Respondents were less unanimous with regard to radio, as 60% marked likely or very likely to receive a warning via radio. About 53% indicated they would be likely or very likely to receive a warning from a cell phone, while about 56% marked they would be likely or very likely to get a tornado warning by word of mouth. Taking into account the margins of error of roughly six percentage points for these relatively small samples, these latter two methods of delivery are relevant for approximately half of mobile home households in the study area. The other four information channels were generally indicated to be unlikely methods of receiving a tornado warning. Over 80% answered they were unlikely or very unlikely to receive a tornado warning by hearing an outdoor tornado siren, and a similar percentage of respondents indicated they would not likely be warned of a tornado via a landline telephone. About 20% of participants marked they would be very likely to receive a warning via NOAA weather radio, but almost 70% would be unlikely or very unlikely. Likewise, over 60% said they would be unlikely to receive a tornado warning via a computer.
Figure 7.2. Percentages of respondents’ answers for the likelihood of receiving a warning via each of eight potential information channels.

To facilitate interpretation of the responses to these items in prediction of intended evacuation behavior, the author used the binary coding scheme represented in Figure 7.2. For example, if the participant marked either likely or very likely for cell phone, then the variable was coded as a 1; if the participant marked unlikely or very unlikely, the variable was coded as a 0. Unfortunately, only television had enough responses to be included in the regression modeling presented in section 7.3. The other seven had so many missing values that imputation could not be justified.

7.2.2.2. Trust

Following the rating of warning channels, questions #17 and #18 instructed respondents to rate their levels of trust of several potentially relevant information sources on a four-point sequential Likert-type scale: not much (coded as 1), a little (2), fair amount (3), or a great amount (4). There were seven response items for each question: local radio station, local television station, local government, National Weather Service, national television station, family/friends, and neighbors. The first question pertained to
emergency related information, and the second question pertained specifically to tornado-related information. Preliminary inspection of the results revealed that the emergency information responses were extremely similar to the tornado information response, and thus only the tornado information responses are discussed and used in this analysis.

As with question #16, respondents did not address every item as instructed and therefore the volume of responses for each item as well as the distribution of ratings should be considered in interpretation of the answers. Out of 217 questionnaires, 159 (~73%) gave an answer for all seven items on question #18. Responses were coded as a binary; if participants indicated they had not much trust or a little trust, they were assigned as a 0 and if they indicated they had a fair or great amount of trust, they were coded as a 1.

Once again, television elicited the most responses—particularly local television stations—and 90% place a fair or great amount of trust in tornado information from local television outlets (Figure 7.3). Although fewer participants gave an answer for their trust in local radio and national television outlets, about 80% of those who did expressed that they trust tornado information communicated from both a fair or great amount. Trust in tornado information from the National Weather Service closely rivaled local television, whereas respondents expressed somewhat less trust in tornado information emanating from local government entities with 68% indicating a fair or great amount. The lowest levels of trust for tornado information were for family/friends, and neighbors, with both garnering about 60% to 65% of participants indicating a fair or great amount of trust. Unfortunately again, only local television had enough responses to be included in the
regression modeling presented in section 7.3. The other six had so many missing values that imputation could not be justified.

![Figure 7.3. Percentages of respondents’ answers for amount of trust for seven potential tornado warning information sources.](image)

7.2.2.3. Potential Tornado Sheltering Locations

The tornado preparedness questionnaire also included several questions regarding mobile home residents’ potential sheltering locations in the event they would evacuate because of a tornado warning. Two of these items were #24 and #25 on page 2 of the questionnaire (Figure B.2). The first question asked whether the mobile home resident has access to a tornado safe room or an underground storm shelter within 100 yards of the home, and the second question repeats this request for a distance of five miles. The author combined the answers for safe rooms and underground shelters for an estimate of the percentage of residents who have access to specially constructed tornado shelters in the study area. Only about 12% stated they have access to a tornado shelter within 100 yards of their home, and about 24% stated they have access to a tornado shelter within five miles of their residence (Figure 7.4).
Figure 7.4. Percentages of respondents’ with and without access to a tornado shelter.

It was anticipated that most residents would not have access to a tornado shelter and would need access to some kind of sturdier building if evacuating just before or during a tornado warning. Therefore, question #36 on page 3 of the survey (Figure B.3) instructed respondents to rank six common types of buildings according to how likely they would be to use these for shelter from a tornado. A seventh option was an “Other” category which allowed residents to write in answers which were not one of the provided options. Three options were marked most often as the most likely destinations (Figure 7.5). Over half indicated their most likely sheltering place would be the home of a friend or relative with an additional 15% marking this option as their second choice. Just over 40% answered that a school would be their first choice, and another 32% marked school as the second or third choice. Slightly under 40% stated a church would be their top choice; notably, another 25% answered that a church would be their second choice.

The respondents’ workplaces were the least likely place to take shelter from a tornado; over 50% ranked this option as last or next to last. Retail store and motel or
hotel were also considered unlikely sheltering destinations, though the rankings of motel or hotel were distributed rather uniformly between 10% and 20%. Very few respondents indicated an “Other” option and therefore the results were omitted from Figure 7.5. For the purpose of this analysis, the author constructed a binary variable for each of the six possible destinations. The variable was coded 1 if a respondent ranked a given evacuation destination as either their first or second choice, and was coded 0 if they answered otherwise.

![Figure 7.5. Percentages of respondents’ answers by evacuation destinations.](image)

In addition to potential sheltering locations, the questionnaire also asked respondents to estimate the travel time and direction to their first and second ranked sheltering choices. Answers ranged from less than one minute up to two hours. The mean travel time to the first sheltering choice was 11.3 minutes (+/- 1.4 minutes) and the median was 10 minutes. For the second sheltering choice, the mean travel time was 13.9 minutes (+/- 1.7 minutes), although the median was also 10 minutes. The distributions of estimated travel directions to the first and second sheltering choices were very similar.
(Figure 7.6). South was the most frequently answered direction, followed by north, east, and then west; the intercardinal directions were chosen less frequently than the cardinal directions. Perhaps most interesting is that the most frequently chosen answer was that the participant did not know the direction of travel to their likely sheltering destinations; 25% answered they did not know the direction to their first sheltering choice and 22% did not know the direction to their second sheltering choice.

Figure 7.6. Directions of travel to shelter destinations by percentages of responses.

7.2.2.4. Damage and Injury Expectations

The final types of variables that were used to predict whether respondents would evacuate to a sturdy building were those capturing their expectations of damage and injury. On page 2 of the questionnaire (Figure B.2), questions #20 and #21 instructed participants to rank potential outcomes that might result from a direct tornado strike to their respective mobile homes. Using a scale from 1 (most likely) to 4 (least likely),
respondents ranked the likelihood of four damage outcomes: no damage; minor damage, livable; major damage, unlivable; total destruction. Four injury outcomes were ranked using the same ranking scheme: no injuries; minor injuries, no hospital; severe injuries, hospital stay; extreme injuries, maybe death. As with other previously discussed questionnaire items, many participants did not assign a ranking to each potential outcome. Many marked only one outcome using 1 to signify the most likely result in their opinion. Despite these inconsistencies, it is clear that a majority of residents think that major damage or destruction of their mobile homes are the most likely outcomes of a direct tornado strike (Figure 7.7a). Concordantly, over 80% answered that the least likely outcome would be no damage at all. The responses for the injury outcomes were very similar, with severe or extreme injuries being the most likely outcome and no injuries the least likely outcome (Figure 7.7b).

To gauge whether mobile home residents viewed their potential sheltering options as able to withstand a tornado, questions #39, #40, #43, and #44 asked respondents to rank the same damage and injury outcomes for their first and second sheltering locations. Over 60% who marked minor damage answered that would be the most likely outcome if a tornado struck their first or second sheltering locations (Figure 7.7c, Figure 7.7e). Total destruction was seen as the least likely outcome. The results for potential injury outcomes were very similar for both first and second sheltering locations (Figure 7.7d, Figure 7.7f). Nearly 60% of those who marked an answer for minor injuries said that was the most likely outcome. No injuries and severe injuries were marked as the next most likely outcomes, while extreme injuries or even death was the least likely outcome.
Figure 7.7. Respondent rankings of potential damage and injury outcomes for their mobile home (a and b), their first sheltering location (c and d), and second sheltering location (e and f).

Because so many respondents gave incomplete answers to the damage and injury items, the author created binary variables in an attempt to capture the essence of the responses. If the participant answered the damage (injury) question by marking either
major damage (severe injuries) or total destruction (extreme injuries) as the most likely outcome, then the binary variable was coded as a 1. If the participant answered the damage (injury) question by marking either no damage (no injuries) or minor damage (minor injuries) as the most likely outcome, the binary variable was coded as a 0. If the participant ranked every outcome at the same level of likelihood, then the binary variable was coded as a 0. If a participant did not provide an answer for any of the potential outcomes, it was marked as missing and neither a 0 or 1. This binary coding scheme allowed the author to separate respondents who stated they expect major or severe impacts to themselves and their home or sheltering place from those who did not. To link respondents’ damage and injury expectations for their homes and their first shelter choices, the author constructed one final binary variable. If the participant answered that major damage or total destruction was most likely from a tornado strike to their home, and answered that no damage or minor damage was most likely from a tornado strike to their first shelter choice, then the binary variable was coded as a 1. The same coding procedure was applied to construct a binary variable for injury expectations as well.

7.2.3. Statistical Methodology

7.2.3.1. Logistic Regression Models

Research question #4 is answered using the results of six logistic regression models. This statistical method is appropriate since the predictand variables are all coded as binaries, with 1 signifying that a respondent indicated s/he would be likely to evacuate their mobile home and go to a nearby sturdy building in the given scenario. As explained in previous sections, most of the items from the questionnaire that are used to predict intended behavior are binary variables derived from a mix of ordinal and nominal
question formats. A few of the predictor variables are count or ratio level data types. The same group of nearly one hundred predictor variables was utilized for all six regression models. All of the logistic regression models were estimated using the statistical software SPSS version 22.

Variable selection was accomplished using a forward stepwise procedure, which is an iterative selection process that begins with an empty model and adds predictor variables. Using maximum likelihood estimation, the forward stepwise algorithm searches all candidate predictor variables for the one that most significantly improves prediction of the independent variable at each step. As long as the likelihood ratio test statistic exceeds a critical chi-square threshold at each iteration, the algorithm continues to add variables and improve the model. Once the critical significance threshold fails to be met, the model is finalized. For the six models presented in this chapter, the critical significance threshold for variable inclusion corresponded to the 95% confidence level, while the threshold for removing a variable from a model corresponded to the 90% confidence level.

The results of the overall model were interpreted using three key diagnostics. First, the significance of the entire model was assessed using the Hosmer-Lemeshow goodness-of-fit test. As long as the chi-square value in the test did not exceed the critical value (given the degrees of freedom), the model was assessed to adequately fit the data (Hosmer, Lemeshow, and Sturdivant 2013). The predictive ability of a model was assessed using the Nagelkerke R Square value and the misclassification rate. For those variables included in each of the six models, the strength and direction of their relationships to the predictand variable were interpreted using the odds ratios. For binary
independent variables, an odds ratio greater than 1 meant that the likelihood of evacuating to a sturdy building was greater when the binary was affirmative (1) than when it was null (0). For continuous independent variables, an odds ratio greater than 1 meant that the likelihood of evacuating to a sturdy building increased as the value of the predictor variable increased. When the odds ratios were less than 1, the author inverted the values and interpretation (Osborne 2006). For inverted odds ratios, those greater than 1 meant that the likelihood of evacuating to a sturdy building was greater when the binary was null (0) than when it was affirmative (1). Similarly, for continuous variables inverted odds ratios greater than 1 meant that likelihood of evacuation decreased as the value of the predictor variable increased.

7.2.3.2. Missing Data

Nearly every questionnaire item had at least a few missing values where respondents failed to provide an answer. For some variables, the lack of an answer might be interpreted as a negative answer; however, the author did not want to make any assumptions as to why some items were left blank. Instead, very simple imputation methods were used to fill in some of the missing data. For categorical or ordinal formats, the answer most frequently given (the mode) was applied for the missing values. For count or continuous variables, the mean was used to fill in missing values. The author applied these imputation techniques only to items that had less than 10% of the values missing. Variables with more than 10% of the cases missing were omitted from the regression analyses. These imputation guidelines applied only to independent variables; the six dependent variables had relatively small numbers of missing values (less than 3%) and were therefore not subjected to imputation.
7.3. Logistic Models of Intention to Evacuate to a Sturdy Building

There are three models for daytime scenarios with three different warning lead times: five minutes, fifteen minutes, and forty-five minutes. These same three lead time scenarios were also presented to participants in a nighttime context.

7.3.1. Daytime Scenarios

7.3.1.1. Five Minutes Lead Time

Following the forward stepwise logistic regression procedure outlined above, eight independent variables were retained as significant predictors of whether a respondent answered that s/he would evacuate to a nearby sturdy building given a tornado warning during the daytime with five minutes lead time (Table 7.1). The three most significant predictor variables were related to the potential shelter location. Respondents who stated they have access to an underground tornado shelter or safe room within five miles of their mobile home were over five times more likely to choose evacuation as an option on short notice than those without a nearby specialized tornado shelter. Another factor that increased the likelihood of evacuating was when participants did not know the direction from the respondent’s mobile home to their first sheltering choice. Those who did not know were more than four times more likely to evacuate than those who stated they did know the direction to their first sheltering choice. Furthermore, those who chose a church or place of worship as one of their top two sheltering choices were nearly three times more likely to evacuate than those who did not.

Participants who stated that severe or extreme personal injury would be likely if a tornado struck their home were over three times more likely to evacuate than those who expected minor injuries would be the outcome. However, one factor that influenced
Table 7.1. Logistic regression results for five minute lead time during daylight scenario, with reference category provided in brackets for binary independent variables.

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Influence on Intention to Evacuate</th>
<th>Wald Statistic</th>
<th>P-value</th>
<th>Odds Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tornado Shelter Within 5 Miles [1]</td>
<td>Increase</td>
<td>16.189</td>
<td>&lt; 0.001</td>
<td>5.464</td>
</tr>
<tr>
<td>Do Not Know Which Direction to Shelter [1]</td>
<td>Increase</td>
<td>13.394</td>
<td>&lt; 0.001</td>
<td>4.587</td>
</tr>
<tr>
<td>Evacuation Destination is Church [1]</td>
<td>Increase</td>
<td>9.184</td>
<td>0.002</td>
<td>2.978</td>
</tr>
<tr>
<td>Severe/Extreme Injuries Likely at Home [1]</td>
<td>Increase</td>
<td>8.763</td>
<td>0.003</td>
<td>3.542</td>
</tr>
<tr>
<td>Hear Warning, Take Cover Right Away [1]</td>
<td>Increase</td>
<td>8.507</td>
<td>0.004</td>
<td>2.961</td>
</tr>
<tr>
<td>Anyone Staying Behind [1]</td>
<td>Decrease</td>
<td>7.395</td>
<td>0.007</td>
<td>4.386</td>
</tr>
<tr>
<td># MHs Within 1 Mile Radius (Log)</td>
<td>Increase</td>
<td>6.499</td>
<td>0.011</td>
<td>2.812</td>
</tr>
<tr>
<td>Evacuated MH Before Multiple Times [1]</td>
<td>Increase</td>
<td>4.024</td>
<td>0.045</td>
<td>2.526</td>
</tr>
</tbody>
</table>

Model Diagnostics, n=207

Hosmer and Lemeshow Test: Chi-square=11.043, p-value=0.199
Nagelkerke R Square= 0.378
Classification Accuracies: Overall 76.3%, Evacuate 59.5%, Not Evacuate 86.7%

against evacuation was whether any one of the household members was apt to stay behind rather than evacuate. Those who answered that at least one person would stay behind were four times more likely not to evacuate. Those who were more likely to take cover immediately upon hearing a tornado warning were three times more likely to evacuate with only five minutes notice. Similarly, those who responded that they had evacuated multiple times before were more likely to intend to do so again on short notice. Finally, those who live in areas with more mobile homes in close proximity (1 mile) were
more likely to evacuate than those who live in areas with fewer mobile homes nearby. For every increase of ten mobile homes nearby, the likelihood of evacuation increased by a factor almost three. The model correctly predicted about three quarters of respondents’ answers, but achieved only about 60% accuracy for predicting evacuation.

7.3.1.2. Fifteen Minutes Lead Time

For the fifteen minute lead time daytime scenario, overall prediction accuracy was again near 75%, with negative evacuation responses being more difficult to classify correctly (66% accuracy) (Table 7.2). Twelve variables were significant, with several demographic attributes being highly significant. Participants who self-identified as African-American, who rent their mobile home, who have children under the age of six in the household, or who have pets were all more likely to evacuate than those who self-identified as white or Latino, who own their mobile home, who do not have children under six years old, or who do not have pets. An increase in one year of age of the participant was also associated with a 3.6% increase in the likelihood of choosing evacuation as a sheltering strategy with fifteen minutes notice.

As in the five minute notice daytime scenario, those who tend to take cover immediately when they hear warnings are issued also were more likely to choose evacuation as a sheltering strategy with fifteen minutes of lead time. In addition, those who have talked with members of the household about an evacuation plan and those who agreed that evacuating a mobile home during a tornado warning is generally a good idea were three and two times more likely to choose evacuation with fifteen minutes notice in a daytime setting. Those likely to choose a church as their sheltering location were more likely to choose evacuation than those not likely to choose a church. Also, those who
rated their first shelter choice as prone to major damage from a tornado were still more likely to evacuate than those who did not believe their sheltering location would be heavily damaged in a tornado. However, an increase of ten minutes in the expected travel time to a shelter meant a participant was nearly four times less likely to choose evacuation in this scenario.

Table 7.2. Logistic regression results for fifteen minute lead time during daylight scenario, with reference category provided in brackets for binary independent variables.

<table>
<thead>
<tr>
<th></th>
<th>Influence on Intention to Evacuate</th>
<th>Wald Statistic</th>
<th>P-values</th>
<th>Odds Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>African-American [1]</td>
<td>Increase</td>
<td>13.119</td>
<td>&lt; 0.001</td>
<td>4.919</td>
</tr>
<tr>
<td>Rent Home [1]</td>
<td>Increase</td>
<td>10.708</td>
<td>0.001</td>
<td>8.257</td>
</tr>
<tr>
<td>Children Under 6 [1]</td>
<td>Increase</td>
<td>9.743</td>
<td>0.002</td>
<td>8.834</td>
</tr>
<tr>
<td>Have Pets [1]</td>
<td>Increase</td>
<td>9.287</td>
<td>0.002</td>
<td>3.430</td>
</tr>
<tr>
<td>Talk About Evacuation Plan [1]</td>
<td>Increase</td>
<td>8.596</td>
<td>0.003</td>
<td>3.179</td>
</tr>
<tr>
<td>First Shelter Choice Likely to Suffer Major Damage [1]</td>
<td>Increase</td>
<td>6.498</td>
<td>0.011</td>
<td>2.891</td>
</tr>
<tr>
<td>Age</td>
<td>Increase</td>
<td>6.354</td>
<td>0.012</td>
<td>1.036</td>
</tr>
<tr>
<td>Evacuation Destination is Church [1]</td>
<td>Increase</td>
<td>6.140</td>
<td>0.013</td>
<td>2.410</td>
</tr>
<tr>
<td>Mean Travel Time to Shelter (Log)</td>
<td>Decrease</td>
<td>5.901</td>
<td>0.015</td>
<td>3.774</td>
</tr>
<tr>
<td>Hear Warning, Take Cover Right Away [1]</td>
<td>Increase</td>
<td>5.636</td>
<td>0.018</td>
<td>2.553</td>
</tr>
<tr>
<td># MHs Within 1 Mile Radius (Log)</td>
<td>Increase</td>
<td>3.891</td>
<td>0.049</td>
<td>2.244</td>
</tr>
<tr>
<td>Evacuation During Warning a Good Idea [1]</td>
<td>Increase</td>
<td>3.374</td>
<td>0.066</td>
<td>2.006</td>
</tr>
</tbody>
</table>

Model Diagnostics, n=206

Hosmer and Lemeshow Test: Chi-square=5.604, Sig.=0.691
Nagelkerke R Square= 0.433
Classification Accuracies: Overall 74.3%, Evacuate 80.3%, Not Evacuate 66.3%
7.3.1.3. Forty-five Minutes Lead Time

With a longer lead time of forty-five minutes, the most significant predictor of intended evacuation is the presence of children younger than six years in the household (Table 7.3); the presence of this factor increased the propensity to choose the evacuation strategy by almost nine-fold. Additional socio-demographic factors were being female, which increased evacuation likelihood by 2.5 times over being male, and age, with an increase of one year in age increasing likelihood to evacuate slightly. Interestingly, those with internet service at home were two times less likely to choose evacuation with forty-five minutes notice than those without internet.

As in the shorter notice daytime scenarios, respondents who would be more likely to evacuate to a church and those who have evacuated several times before were more likely to choose evacuation those not indicating a church as a shelter destination and those who have never evacuated for a tornado previously. Another interesting result is that those who tend to unplug their television during thunderstorms because of electrical surges were 2.5 times more likely to say they would evacuate than those who reported typically leaving their TV plugged in during stormy weather. Overall, this model correctly predicted intention to evacuate to a sturdy building for 70% of participants. Yet, only 60% of those not choosing evacuation were correctly classified.

7.3.2. Nighttime Scenarios

7.3.2.1. Five Minutes Lead Time

The three nighttime evacuation scenario models were somewhat less successful than the daytime models. For the five minute scenario, the logistic model correctly
Table 7.3. Logistic regression results for forty-five minute lead time during daylight scenario, with reference category provided in brackets for binary independent variables.

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Influence on Intention to Evacuate</th>
<th>Wald Statistic</th>
<th>P-value</th>
<th>Odds Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children Under 6 [1]</td>
<td>Increase</td>
<td>12.343</td>
<td>0.000</td>
<td>8.955</td>
</tr>
<tr>
<td>Evacuation Destination is Church [1]</td>
<td>Increase</td>
<td>8.975</td>
<td>0.003</td>
<td>2.631</td>
</tr>
<tr>
<td>Age</td>
<td>Increase</td>
<td>7.826</td>
<td>0.005</td>
<td>1.035</td>
</tr>
<tr>
<td>Unplug TV to Protect from Electrical Surges [1]</td>
<td>Increase</td>
<td>7.586</td>
<td>0.006</td>
<td>2.509</td>
</tr>
<tr>
<td>Female [1]</td>
<td>Increase</td>
<td>7.589</td>
<td>0.006</td>
<td>2.576</td>
</tr>
<tr>
<td>Evacuated MH Before Multiple Times [1]</td>
<td>Increase</td>
<td>4.175</td>
<td>0.041</td>
<td>2.582</td>
</tr>
<tr>
<td>Have Internet at Home [1]</td>
<td>Decrease</td>
<td>4.089</td>
<td>0.043</td>
<td>1.946</td>
</tr>
</tbody>
</table>

**Model Diagnostics, n=209**

**Hosmer and Lemeshow Test:** Chi-square=8.040, Sig.=0.430

**Nagelkerke R Square** = 0.297

**Classification Accuracies:** Overall 69.9%, Evacuate 77.0%, Not Evacuate 59.8%

classified 74% of respondents, but most of the success was in predicting those who would not evacuate (Table 7.4). Only 43.7% of those who indicated they would evacuate at night with five minutes lead time were correctly predicted by the model. There were six variables that were significant predictors. The most significant variable was the expected travel time to the first shelter choice; an increase of ten minutes in travel time decreased the likelihood of evacuation by three times. Respondents who reported having access to a specialized tornado shelter within five miles of their home were more than twice as likely to evacuate as those without close access. Also, participants who did not know the direction to their top sheltering choice were actually twice as likely to evacuate as those who said they did know which direction their sheltering choice was.
Expectation of being injured while in the mobile home during a tornado also increased intention to evacuate. Respondents who stated they would be likely to suffer severe or extreme injuries if caught in a tornado at home were 2.5 times more likely to choose evacuation than those who did not expect such injuries. The expectation of hearing a siren if a tornado was threatening also increased the likelihood of evacuation by two times. As in the daytime condition, those who take cover immediately upon hearing a warning were almost twice as likely to say they would evacuate to a nearby sturdy building.

Table 7.4. Logistic regression results for five minute lead time during nighttime scenario, with reference category provided in brackets for binary independent variables.

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Influence on Intention to Evacuate</th>
<th>Wald Statistic</th>
<th>P-value</th>
<th>Odds Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travel Time to Shelter First Choice (Log)</td>
<td>Decrease</td>
<td>12.510</td>
<td>&lt; 0.001</td>
<td>3.165</td>
</tr>
<tr>
<td>Severe/Extreme Injuries Likely at Home [1]</td>
<td>Increase</td>
<td>5.588</td>
<td>0.018</td>
<td>2.593</td>
</tr>
<tr>
<td>Do Not Know Which Direction to Shelter [1]</td>
<td>Increase</td>
<td>5.192</td>
<td>0.023</td>
<td>2.594</td>
</tr>
<tr>
<td>Expect to Hear Siren [1]</td>
<td>Increase</td>
<td>4.413</td>
<td>0.036</td>
<td>2.167</td>
</tr>
<tr>
<td>Tornado Shelter Within 5 Miles [1]</td>
<td>Increase</td>
<td>4.140</td>
<td>0.042</td>
<td>2.176</td>
</tr>
<tr>
<td>Hear Warning, Take Cover Right Away [1]</td>
<td>Increase</td>
<td>3.087</td>
<td>0.079</td>
<td>1.830</td>
</tr>
</tbody>
</table>

Model Diagnostics, n=206

**Hosmer and Lemeshow Test:** Chi-square=11.139, Sig.=0.194
**Nagelkerke R Square** = 0.210
**Classification Accuracies:** Overall 74.3%, Evacuate 43.7%, Not Evacuate 90.4%

7.3.2.2. Fifteen Minutes Lead Time

In the fifteen minutes lead time scenario, respondents who self-identified as African-American were three times more likely to choose evacuation than those who did
not identify as African-American (mostly white) (Table 7.5). Similar to the five minute scenario above, those who believed they would suffer severe or extreme injuries were three times more likely to evacuate, and those who take quick action when warnings are issued were more 2.5 times more likely to choose evacuation. Also, believing that evacuation during a tornado warning is a good idea and having a church as a likely shelter destination increased the likelihood of evacuation. Once again, an increase of 10 minutes of expected travel time decreased the probability of evacuating about four-fold. The overall classification accuracy for evacuate and not evacuate was 69%, but only 61% for correct classification of respondents who did not say they would evacuate.

Table 7.5. Logistic regression results for fifteen minute lead time during nighttime scenario, with reference category provided in brackets for binary independent variables.

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Influence on Intention to Evacuate</th>
<th>Wald Statistic</th>
<th>P-value</th>
<th>Odds Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe/Extreme Injuries Expected at Home [1]</td>
<td>Increase</td>
<td>8.557</td>
<td>0.003</td>
<td>3.241</td>
</tr>
<tr>
<td>Evacuation Destination is Church [1]</td>
<td>Increase</td>
<td>7.211</td>
<td>0.007</td>
<td>2.377</td>
</tr>
<tr>
<td>Mean Travel Time to Shelters (Log)</td>
<td>Decrease</td>
<td>8.201</td>
<td>0.004</td>
<td>3.831</td>
</tr>
<tr>
<td>Hear Warning, Take Cover Right Away [1]</td>
<td>Increase</td>
<td>6.802</td>
<td>0.009</td>
<td>2.549</td>
</tr>
<tr>
<td>Evacuation During Warning a Good Idea [1]</td>
<td>Increase</td>
<td>6.481</td>
<td>0.011</td>
<td>2.394</td>
</tr>
</tbody>
</table>

Model Diagnostics, n=202

Hosmer and Lemeshow Test: Chi-square=5.202, Sig.=0.736
Nagelkerke R Square= 0.269
Classification Accuracies: Overall 69.3%, Evacuate 75.9%, Not Evacuate 61.1%
7.3.2.3. Forty-five Minutes Lead Time

Overall classification accuracy for this scenario was nearly 75%, but was much lower for participants who did not state they would evacuate (51%) (Table 7.6). The Table 7.6. Logistic regression results for forty-five minute lead time during nighttime scenario, with reference category provided in brackets for binary independent variables.

| Prediction of Evacuation to Sturdy Building Scenario: Nighttime with 45 Minutes Lead Time |
|---------------------------------------------|---------------------------------|-----------------|-----------------|-----------------|
| **Independent Variables**                  | **Influence on Intention to Evacuate** | **Wald Statistic** | **P-value** | **Odds Ratio** |
| Children Under 6 [1]                       | Increase                          | 12.960           | < 0.001       | 9.868           |
| Unplug TV to Protect from Electrical Surges [1] | Increase                          | 11.047           | 0.001         | 3.311           |
| Do Not Like Driving in Thunderstorms [1]   | Increase                          | 7.412            | 0.006         | 2.934           |
| Evacuation Destination is Church [1]       | Increase                          | 6.162            | 0.013         | 2.297           |
| Evacuation During Watch a Good Idea [1]    | Increase                          | 5.818            | 0.016         | 2.352           |
| Trust Local TV Tornado Information [1]     | Increase                          | 5.621            | 0.018         | 4.378           |

Model Diagnostics, n=206

Hosmer and Lemeshow Test: Chi-square=4.931, Sig.=0.668

Nagelkerke R Square= 0.342

Classification Accuracies: Overall 74.8%, Evacuate 89.7%, Not Evacuate 51.2%

most important predictor of intention to evacuate at night with a long lead time was having children less than six years of age in the household. Those respondents were nearly ten times more likely to choose to evacuate to a sturdy building than those without very young children living in the home. As in the longest lead time daylight scenario, participants who usually unplug their television during thunderstorms were three times more likely to leave their mobile homes than those who do not typically unplug their television to avoid damage from electrical surges. Another consideration in this scenario
was the prospect of driving in a thunderstorm in the darkness of night. Respondents who expressed that they do not like driving in thunderstorms were nearly three times more likely to choose evacuation with 45 minutes of lead time as those who did not express dislike of driving in thunderstorm conditions.

In this scenario, two variables were significant that were not in any other scenario. Residents who answered that they think evacuation during a tornado watch is a good idea were twice as likely to say they would evacuate then residents who did not think leaving during a watch was a good idea. Also, expressing more trust in tornado information given by local television stations increased likelihood of evacuation four-fold over those who did not express trust in local television. Finally, having a church as a likely evacuation destination enhanced the intention to evacuate during a tornado warning.

7.4. Chapter Summary

This chapter presented data from multiple questionnaire items related to tornado warning protective actions including information sources and channels, potential destinations for short-term evacuation to a sturdy building, resident expectations of the potential for damage and injuries at their home and at potential evacuation destinations, and protective action intentions in several hypothetical tornado warning scenarios. Television is by far the most likely medium by which residents expect to receive a tornado warning, with radio and cell phones the other two most likely media. Mobile home residents in central South Carolina place the most trust in local television and the National Weather Service when it comes to tornadoes.

In terms of protection from tornadoes, most mobile home residents in the study area do not have ready access to any kind of specially constructed tornado shelter, above
or below ground. They understand that mobile homes generally do not fare well during tornadoes and that this fact puts them at serious risk of injury, as evidenced by the majority expecting major damage or destruction and severe or extreme injuries if a tornado were to strike their homes. When asked where they might be able to go for protection during a tornado warning, most respondents stated that a home of a relative or friend, a church, or a school would be their most likely choices. On average, residents expressed they would drive about ten to fifteen minutes to arrive at one of these sheltering destinations. However, approximately one quarter did not even not exactly which direction their preferred sheltering destinations were from their home.

When given only five minutes of lead time during a tornado warning, residents were evenly split between evacuating to a nearby sturdy building and sheltering-in-place inside their mobile home; although at night more residents indicated they would stay at home. Those who would leave were more likely to have a sturdy sheltering option relatively close to their home and were more likely to have evacuated for a tornado warning before. They were also more likely to state they take action quickly when warnings are issued and they feel immediacy to act because they believe damage and injuries are likely if they stay at home. However, if any other member of the household was likely to stay behind, this deterred the respondent from leaving.

In hypothetical situations with fifteen and forty-five minutes of lead time, more than half of the participants expressed they would likely evacuate to a sturdy building. Being favorably disposed to the idea of evacuation, having done so before, and lower travel times to shelter were all important factors for the longer lead time situations, just as in the five minute scenarios. Interestingly, there was also a consistent relationship
between intending to evacuate and having a church as a preferred destination. A variety of demographic factors were significant predictors of intention to evacuate, some with counterintuitive interpretations. The following chapter will include further discussion of these findings, their relationship to the research questions, and their implications for existing theory and recent empirical findings.
CHAPTER 8: ANSWERING THE RESEARCH QUESTIONS
AND DISCUSSION OF THE RESULTS

8.1. Research Question #1

What types of perspectives exist among mobile home residents about tornado preparedness and protective action responses?

8.1.1. Summary of Results

The first research question was originally intended to be answered using the results of a Q Methodology research design. However, the author altered the research design due to difficulties contacting interviewees for the second meeting to complete the sorting activities that would have provided the expected format of the results. Thus, research question #1 was addressed using questionnaire items for a cluster analysis methodology similar to existing social science methodologies such as latent class or audience segmentation analyses. Using this approach, three unique perspectives regarding tornado preparedness and protective action responses were identified with mobile home residents in South Carolina.

The largest cluster comprises 37.3% of respondents and can be characterized as the relatively unconcerned cluster. Based on the responses given by cluster 1, they are not greatly concerned about tornadoes and do not see them as a high probability threat in South Carolina. Nor do they seem especially preoccupied with avoiding or mitigating potential harm from other thunderstorm hazards; for example, they are less risk averse to electrical surges from lightning and to driving during a thunderstorm. They view disaster preparedness in general as far less important than the other two clusters, and accordingly
do not strongly favor government or mobile home park to provide tornado shelters for residents.

The second largest cluster includes 35.4% of respondents who are more concerned and seek information relevant to disaster and tornado preparedness and response. This cluster sees tornadoes as likely to happen in South Carolina; they are more diligent in paying attention to the weather, are less likely to view television weather forecasters as overhyping danger from thunderstorms, and more likely to look for sources of weather radar to judge whether they will be affected by a storm. Cluster 2 places the onus for providing tornado shelters on mobile home park owners, but sees the government as responsible for providing shelters as well. This cluster does not expect to hear a tornado siren if a tornado threatens their communities.

The third and smallest cluster (27.3%) is very similar to the second cluster in terms of concern and information seeking for tornadoes and disasters in general. Yet, this cluster is more likely than the other two clusters to anticipate warnings and react quickly upon receiving a tornado warning. The two most defining characteristics of the third cluster are that they expect to hear tornado sirens as a signal that their community is under threat from an approaching (possible) tornado, and that they often unplug their television during thunderstorms to protect them from electrical surges. Additionally, this cluster places responsibility for providing shelters more on the government than on mobile home park owners, and they are more likely to profess belief that God has control over the weather.
8.1.2. Theoretical Implications of the Three Sheltering Perspectives

The identification of three perspectives on preparedness and protective action presents several opportunities to discuss existing theory vis-à-vis the results of this study. The first cluster, those not very concerned with tornado preparedness and response, might be explained principally by lower risk perception. They see tornadoes as somewhat unlikely to happen in SC and are therefore not as concerned about them. With reduced perceived need for concern about tornadoes, there is less motivation to seek new preparedness information. This is in agreement with Yang and Kahlor’s (2013) description of the concept of information insufficiency, which places the perceived need for knowledge of a risk and appropriate preparedness actions as a main driver of information seeking. On a related note, this perspective is also somewhat more cynical than the other two about whether television weather coverage overhypes danger. In addition, this relatively unconcerned cluster tends not to take action immediately when a warning is issued for their location. Thus, lower levels of trust could also be a factor. Alternatively, this group’s lower levels of concern could be associated with a propensity to engage in milling behavior (Wood et al. 2012). This refers to consultation of other information sources to confirm whether danger is real and action is required.

The second perspective on tornado preparedness and protective action, those that expressed more concern and more actively seek out relevant information, can be tied to theory in essentially the opposite fashion as cluster 1. This second cluster sees tornadoes as likely to happen in SC, is concerned about them, takes warnings seriously, places a level of trust in television forecasters not to overhype events, and tries to use radar to better understand when they might be in the path of a threatening storm. Openness to
preparedness information and behaviors seems to increase with the credibility this cluster ascribes to local information sources, and is concordant with higher risk perception and negative outcome expectancy. In congruence with their apparent trust in television weather information, this group is very unlikely to unplug their television during thunderstorms. Self-efficacy and response efficacy may be compromised, however, by this cluster’s dislike of driving a vehicle during a thunderstorm. This could potentially counteract the previously discussed preparedness and evacuation motivating factors.

The third perspective on tornado preparedness and response offers perhaps the most intriguing insights into factors that are not well theorized in existing preparedness and protective action frameworks. Cluster 3 anticipates warnings and indicates strong willingness to take protective action, but is also the most averse to driving during thunderstorms and is most likely to unplug their television to protect from electrical surges caused by lightning strikes. Both of these are examples of behaviors which prioritize actions related to other thunderstorm hazards or protection of property (rather than life) that could reduce the ability to receive time-sensitive information about tornadoes (by unplugging the television) or travel effectively to an evacuation destination (Donner, Rodriguez, and Diaz 2010).

The existing hazard preparedness and protective action frameworks reviewed in Chapter 2 do not explicitly account for these types of competing hazard preparedness and response behaviors. Isolating social and psychological behaviors within one hazard context misses the opportunity to understand decision-making and perception of hazards that occur concurrently in space and time. It may therefore be theoretically fruitful to interact concepts of risk ranking (Fischhoff and Morgan 2012; Howe et al. 2013) with
preparedness and/or protective action frameworks such as Lindell and Perry’s (2012) Protective Action Decision Model.

The third cluster presents another problem which could result in failure to take adequate protective action for a tornado. Members in this cluster, in contrast to those in the other two, anticipate warnings and expect to hear a tornado siren if a tornado is bearing down on their communities. However, there are virtually no tornado sirens within the study area in the Midlands regions of South Carolina, nor in adjacent areas of the coastal plain nearer to the coastline, as documented in recent news items published by local television stations in Columbia and Charleston (Bedenbaugh 2013; Jain 2013).

While this study did not collect data that can directly explain why a segment of mobile home residents seem to depend on hearing sirens as a warning channel, there is a plausible explanation. One of the lasting images and sounds typically shown in actual or dramatized video presentations of both historical and fictional tornado events is the piercing wail of a siren. This holdover from the civil defense air raid warning system seems to have become an amplified component of the integrated tornado warning system. This is similar to the way in which certain risks (like nuclear power plant accidents) can become amplified through events that are highly visible in the news media and that capture the public’s attention (Pidgeon, Kasperson, and Slovic 2003). Even in places where tornado sirens are never used and do not even exist, some portion of residents will likely continue to expect that sirens will herald the soon arrival of a tornado.

There is a final point to be explored with regard to the perceived role of deity in controlling the weather and the three tornado sheltering perspectives. In the analysis from Chapter 6, the relatively unconcerned cluster (1) was the least likely to agree with
the assertion that God has control over the weather. In contrast, clusters 2 and 3, which indicated much more concern and interest in information pertaining to preparedness and protective action behaviors, were more likely to agree that God has control over the weather. A second proposition asked whether respondents agree whether God can protect them from dangerous weather. This item, however, was not significantly different between the three clusters identified.

These results suggest that the majority of respondents who ascribed control over the weather to God also valued preparedness and heeding warning messages. Thus, ascribing control of the weather to God does not necessarily discount the role of human agency in influencing the outcome of hazard events, especially for tornadoes. This interpretation of the results aligns with the findings of Mitchell (2000), who noted similar attitudes in surveys about hazard mitigation conducted with clergy from several Christian denominations in South Carolina. This research did not provide strong evidence for or against Sims and Baumann’s (1972) assertion that fatalism associated with religious beliefs can influence persons to react passively to hazardous environmental agents. This research also did not address the potential for perspectives specific to different religious traditions (Christian, Buddhist, Muslim, etc.), nor to agnostic or atheistic viewpoints.

8.2. Research Questions #2 and #3

Do different demographic segments of mobile home residents or those with prior tornado experiences tend to identify with certain types of perspectives about tornado preparedness and response?

Do mobile home residents living in different geographic contexts (e.g. urban/rural or mobile home park/single-site), or those living in larger mobile homes, identify with different types of perspectives about tornado preparedness and response?
8.2.1. Summary of Results

The three tornado preparedness and response clusters had statistically significant relationships with several demographic, experiential, geographic, and physical mobile home attributes. Rather than answer these research questions #2 and #3 separately, this section addresses them simultaneously. Cluster 1, those least concerned, had more members who were male and also more who were white. This cluster’s annual household income was generally higher; they were more likely to have internet service at home, to live in a double-section mobile home, and to perceive their home as having wind resistant features. Members in cluster 1 were more likely than those in the other clusters to have lived previously outside of the southeastern US. They were also more likely to live in census tracts with higher percentages of housing units in urban areas, and accordingly were more likely to live in Richland County. In terms of previous tornado experiences, members in the unconcerned cluster were more likely to state they have been within five miles of a tornado and that they have been in more than ten tornado warnings while living at their present home.

Cluster 2, the concerned and informed cluster, was more likely to have members who are female and who live in rented mobile homes. They were less likely to have internet service at home and more likely to live in a single-section mobile home. In terms of geographic context, they tended to live in census tracts with lower percentages of housing units classified as urban and also tended to have fewer mobile homes nearby, if using a search radius of one mile. Compared to the other two clusters, those in the concerned and informed cluster were less likely to have ever lived outside the southeastern US, were more likely to report having previously been within five miles of a
tornado, and to have experienced fewer tornado warnings while living at their current location.

The third and final cluster was characterized by the expectation of hearing tornado sirens, unplugging the television to guard against electrical surges, and the propensity to act immediately upon hearing of a tornado warning. This cluster’s members were more likely to identify as African-American, have children under 18 in the household, have a lower annual household income, and less likely to have internet service at home. Members were also more likely to live in areas with greater numbers of nearby mobile homes, although they were less likely to state that their mobile homes are wind resistant and less likely to say they have been close to a tornado in the past.

8.2.2. Theoretical Implications of the Demographic and Experiential Characteristics in Relation to the Three Sheltering Perspectives

In terms of demographics, the typology of three perspectives on tornado preparedness and protective action shows evidence of the so-called white male effect. Cluster 1, those who were relatively unconcerned about tornadoes, had significantly more males and more respondents who identified as white. This aligns with existing literature asserting that males are typically less concerned about risks and therefore less willing to engage in preparedness behaviors (Finucane et al. 2000; Kahan et al. 2007).

Furthermore, this cluster had higher income, was more likely to have internet service, was more likely to live in a double-section mobile home, and more likely to assess their homes as having wind resistant qualities.

One potential explanation of why the white male effect is apparent in this cluster is the cognitive dissonance induced by the tension between the cultural normative expectation of males as providers (Diener 2002; Hyde and Else-Quest 2013) and the
ignominy of being told repeatedly that one’s home is inferior, unsafe, and should be abandoned in order to survive a tornado. Such an explanation is bolstered by language observed during the qualitative interviews. Some mobile home residents expressed that their mobile homes had qualities such as larger size, extra rooms, or brick skirting that gave them confidence their mobile home was not as susceptible to wind damage as a typical mobile home. Thus, the relative unconcern of cluster 1 may be explained in terms of lower risk perception stemming from lower appraisal of tornado frequency and greater appraisal of the ability of the mobile home to withstand a tornado. These beliefs may be rooted in a defensive mechanism to protect one’s own male (and often, but not exclusively, white) cultural self-identity as a good and successful provider as much as in the cognitive appraisals often invoked in risk perception studies.

An additional point about the relatively unconcerned cluster (1) is that its members noted recalling more tornado warnings for their location and previously having at least one tornado occur within five miles. The previous research reviewed in Chapter 2 indicated mixed results as to whether experience enhances or detracts from motivation for preparedness and protective action. In this study, the most experienced cluster—according to respondents’ best estimations of past instances of actual tornadoes and tornado warnings—was the least concerned. This may be related to the fact that this cluster also states they do not act immediately upon receipt of a tornado warning. There is not clear evidence, but altogether this might be interpreted as something of a false alarm effect. Another related possible explanation is that this cluster is most prone to confirmation seeking or milling behavior, looking for more information before committing to action (Wood et al. 2012). The questionnaire did not probe the quality and
nature of previous tornado experiences in enough depth to make more definitive statements on this subject.

The statistically significant demographic characteristics of cluster 2, whose members were very concerned about tornadoes and open to information relevant to preparedness and protective action, were a greater likelihood of being female, being a renter, a greater likelihood of living in a single-wide mobile home, and a reduced likelihood of having internet access at home. The first result is consistent with the recent literature demonstrating that women are more likely to appraise risks as higher and engage in preparedness and protective action behaviors (Mulilis et al. 2001; Sherman-Morris 2010; Paul et al. 2014; Perreault et al. 2014; Silver and Andrey 2014).

This second cluster can be tied to theory in another fashion. The fact that this cluster tends to rent and live in single-wide units is concordant with higher risk perception, negative outcome expectations, and motivation to seek information. As previously discussed, cluster 2 perceives tornadoes as likely to occur. Rental units are often older and less well maintained than owned units, single-wide units are obviously smaller. As demonstrated in Chapter 5, some residents use mobile home size and age as a heuristic proxies for sturdiness with respect to wind. Thus, one would expect this cluster to expect more negative outcomes, motivating the need for more information on preparedness and response behaviors. Furthermore, it is logical that this cluster with more renters indicated they are unlikely to be able to buy a tornado shelter and placed more responsibility on mobile home park owners to provide tornado shelters.

In terms of experience, cluster 2 was more likely to indicate they had been within five miles of a tornado before, but they also recalled being in fewer tornado warnings.
This finding is in agreement with that of Ripberger and colleagues (2015), as they suggested that women perceived fewer false alarms than men. This cluster retains a high level of concern and does not seem to perceive that they have experienced a large number of warnings. A separate and more complete analysis matching respondent locations with actual past tornado warning polygons could improve interpretation of these results.

For the third cluster, those that anticipate warnings and engaging in protective behaviors, their high levels of concern and interest in preparedness may be attributed to higher risk perception and negative outcome expectancy. This cluster was more likely to identify as African-American and also more likely to have minors living in the household. The higher level of concern is therefore congruent with literature suggesting that minority race/ethnicity groups (Finucane et al. 2000; Kahan et al. 2007) and households with children (Solis, Thomas, and Letson 2010; Hasan et al. 2011) show propensities for higher risk perception and higher likelihood of responding to warnings, respectively. In addition, this third cluster was less likely to have higher income and less likely to indicate that their mobile home has wind resistant features. This would further strengthen the motivation to prepare and respond due to increased risk perception. The apparent eagerness of this cluster to heed warnings by taking cover immediately may further be related to their perceived lack of experience of tornadoes, as indicated by the lesser likelihood of answering they had been within five miles of a tornado on a previous occasion.

Another intriguing point of discussion with regard to cluster 3 and demographics is the propensity to unplug electronic appliances during thunderstorms. This cluster tended to have households with lower annual incomes, who therefore may live in older
homes with faulty wiring. Unfortunately, the ages of the mobile homes are not known; the questionnaire included a question on the year the respondent’s unit was built, but many did not know or provide an answer. Lower income households also may be less likely to have surge protectors than higher income households.

Yet, there also seem to be cultural connections to the practice of unplugging appliances during thunderstorms. As presented in Chapter 5, one interviewee told the author that it is a longstanding tradition in African-American households in South Carolina to unplug all electronics and appliances during a thunderstorm and gather all household members in one room until the storm passes. The results of the questionnaire support the interviewee’s assertion; cluster 3 was more likely to engage in the unplugging behavior and its members were more likely to identify as African-American. Unfortunately, the historical origins of this behavior and the geographic extent across which it occurs are not known at this time. Still, it is possible that African-American mobile home residents in South Carolina and adjacent states may engage in the unplugging and congregating behavior out of habit more so than conscious attempts to mitigate damage to electronics. It is also possible that this behavior is actually more related to age and income than race/ethnicity, and that the statistically significant relationship between identifying as African-American and the unplugging behavior is an artifact induced by the specific geography and demography of the study area. More thorough research is needed to establish the veracity of these relationships.

8.3. Research Question #4

Which factors are most important for explaining whether mobile home residents are willing to evacuate to a nearby sturdy building during a tornado warning?
8.3.1. Summary of Results

Questionnaire respondents expressed their willingness to evacuate to a sturdy building during a tornado warning under day versus night conditions and also with a short, average, and long lead time; six total scenarios were explored. There are not large differences between the daytime and nighttime scenarios; slightly more residents were willing to evacuate during the daytime with five (38% versus 34%) or fifteen minutes notice (57% versus 55%), and this reversed with forty-five minutes notice (59% versus 61%). Time is obviously a critical factor, especially the difference between short notice and average notice situations. Roughly 36% were willing to leave with five minutes notice, but about 56% were willing to evacuate with fifteen minutes of lead time. There was a much smaller jump in willingness to evacuate from fifteen minutes to forty-five minutes (about 56% to about 60%).

In this study, the most important factors in explaining mobile home resident willingness to evacuate to a sturdy building were those related to the planning and logistics of the evacuation itself and household characteristics. These relationships were somewhat contingent on the time of day and warning lead time conditions, however. For example, several aspects of an evacuation plan were important in the five minute daytime scenario (Table 8.1); residents were more likely to evacuate if they have a specially built tornado shelter nearby, if the destination was a church, and if they had evacuated before. If anyone in the home was deemed likely to stay behind, this would lessen the likelihood of evacuation for everyone in the home. In the nighttime scenario, residents were more likely to evacuate if they had an actual tornado shelter nearby or stay home if travel time to their shelter was longer. They were also more likely to evacuate in the short lead time
night scenario if they expected that a tornado would likely cause them severe or extreme injury if one struck their home, if they expected to hear sirens, and if they take cover quickly upon receiving a warning. Curiously, residents were more likely to evacuate in both five minutes scenarios if they did not know the direction from their home to their most likely sheltering location. None of the household variables were significant predictors of evacuation in the five minute lead time scenarios (Table 8.1).

Moving to the fifteen minutes scenarios, some aspects of the evacuation itself were still important, but household variables also became significant predictors especially for the daytime condition (Table 8.1). Evacuation destination (church), shorter travel time, talking with others in the household about evacuation, and viewing evacuation as a reasonable option all increased the likelihood of choosing evacuation over other sheltering options. From the demographic and household variables, a host of variables were relevant: identifying as African-American, renting the mobile home, having children under the age of 6, increasing age, and having pets were all associated with a greater inclination to evacuate in the daytime. Of this list, only African-American respondents were also more inclined to evacuate in the nighttime scenario. As in the five minute scenario, taking warnings seriously and expecting major damage or injuries were also associated with choosing evacuation.

With forty-five minutes of lead time during the daytime, household factors such as having children under age 6, being of older age, and being female were associated with being likely to evacuate. Having internet service at home was an indicator of being more likely to stay home in the daytime condition. Interestingly, other thunderstorm hazards became relevant at forty-five minutes. However, rather than discouraging evacuation,
Table 8.1. Factors that are significant predictors of willingness to evacuate to a sturdy building during a tornado warning across six different scenarios.

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>5 Minutes Influence</th>
<th>15 Minutes Influence</th>
<th>45 Minutes Influence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Daytime</td>
<td>Nighttime</td>
<td>Daytime</td>
</tr>
<tr>
<td>Tornado Shelter Within 5 Miles</td>
<td>Evacuate</td>
<td>Evacuate</td>
<td></td>
</tr>
<tr>
<td>Not Know Direction to Shelter</td>
<td>Evacuate</td>
<td>Evacuate</td>
<td></td>
</tr>
<tr>
<td>Evacuation Destination Church</td>
<td>Evacuate</td>
<td>Evacuate</td>
<td>Evacuate</td>
</tr>
<tr>
<td>Anyone Staying Behind</td>
<td>Evacuate</td>
<td>Evacuate</td>
<td></td>
</tr>
<tr>
<td>Evacuated More than Once Before</td>
<td>Evacuate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Talk About Evacuation Plan</td>
<td>Evacuate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Travel Time to Shelter</td>
<td>Evacuate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Evacuation During Warning Good Idea</td>
<td>Evacuate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Evacuation During Watch a Good Idea</td>
<td>Evacuate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Evacuation during Warning Good Idea</td>
<td>Evacuate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>African-American Rent Home</td>
<td>Evacuate</td>
<td>Evacuate</td>
<td></td>
</tr>
<tr>
<td>Have Children Under 6</td>
<td>Evacuate</td>
<td>Evacuate</td>
<td>Evacuate</td>
</tr>
<tr>
<td>Have Pets</td>
<td>Evacuate</td>
<td>Evacuate</td>
<td>Evacuate</td>
</tr>
<tr>
<td>Age</td>
<td>Evacuate</td>
<td>Evacuate</td>
<td>Evacuate</td>
</tr>
<tr>
<td>Female</td>
<td>Evacuate</td>
<td>Evacuate</td>
<td>Evacuate</td>
</tr>
<tr>
<td>Have Internet at Home</td>
<td>Evacuate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Warning</td>
<td>Evacuate</td>
<td>Evacuate</td>
<td>Evacuate</td>
</tr>
<tr>
<td>Heat Warning, Take Cover Immediately</td>
<td>Evacuate</td>
<td>Evacuate</td>
<td>Evacuate</td>
</tr>
<tr>
<td>Expect to Hear Siren</td>
<td>Evacuate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trust Local TV Tornado Info</td>
<td>Evacuate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Damage</td>
<td>Evacuate</td>
<td>Evacuate</td>
<td>Evacuate</td>
</tr>
<tr>
<td>Svr/Ext Injuries Likely at Home</td>
<td>Evacuate</td>
<td>Evacuate</td>
<td>Evacuate</td>
</tr>
<tr>
<td>First Shelter Major Damage Likely</td>
<td>Evacuate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Thunderstorm Hazards</td>
<td>Evacuate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unplug TV</td>
<td>Evacuate</td>
<td></td>
<td></td>
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<tr>
<td>Not Like Driving in Thunderstorms</td>
<td>Evacuate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Geographic Context</td>
<td>Evacuate</td>
<td></td>
<td></td>
</tr>
<tr>
<td># MHs in 1 Mile Radius</td>
<td>Evacuate</td>
<td></td>
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</tbody>
</table>

those who dislike driving in thunderstorms or unplug their television due to lightning were more likely to evacuate. Finally, in the longest lead time nighttime scenario, greater
trust in weather information from local television became a significant predictor of being willing to evacuate.

8.3.2. Implications of the Factors that Influence Evacuation Intentions

Several other theoretical considerations emerged from both the qualitative interviews and the analysis of evacuation intentions. One important issue was that of tornado warning lead time. As warning lead times have continued to increase over the past several decades, there is a point at which continued efforts to increase lead time may garner diminishing returns. This study provided evidence to suggest that the willingness to evacuate—in hypothetical scenarios—increased markedly from five minutes to fifteen minutes for mobile home residents. The explanation for this is likely that the average travel time to the first potential evacuation choice in this study was just over ten minutes. A fifteen minute hypothetical lead time therefore provided an appropriate, if tight, window for mobile home residents to envision enacting an evacuation plan. Increasing the lead time from fifteen to forty-five minutes did not result in a similar increase in evacuation willingness. It seems that many residents understand the uncertainty inherent in such a long warning lead time and are likely to wait until the situation becomes more certain before committing to an evacuation.

Residents’ answers regarding lead time and expected travel times to evacuation destinations demonstrated their ability to reason and weigh options based on time considerations. However, based on comments from the qualitative interviews and subsequent answers to questionnaire items, other geographic aspects of evacuation during a tornado warning were not as well cognized as the time element. For example, interviewees described difficulty in knowing exactly when they should leave if they were
going to evacuate because of a tornado. Contrary to an evacuation order during an impending hurricane or toxic release, there is no official evacuation order with clearly defined spatial and temporal boundaries. Compounding the problem, some expressed they did not know whether they might put themselves in more danger by leaving their mobile home than if they just sheltered-in-place. In the questionnaire, it was also clear that direction was problematic. When asked, about 25% did not even know which direction their preferred evacuation destination (e.g. home of relative, church, school) was from their home.

It is disconcerting that in the five minutes warning scenarios, residents who did not know the direction of their preferred evacuation destination were more likely to indicate that they would evacuate. Perhaps the destinations were so close to their homes that the direction was inconsequential. Still, leaving one’s home with five or even fifteen minutes lead time during a tornado warning and not knowing which direction one is travelling suggests a high likelihood for increasing danger rather than increasing safety. As demonstrated in Chapter 7, the details of the evacuation plan relative to the scenario, such as the travel distance and/or time, and the destination were among the most important predictors of the willingness to evacuate to a sturdy building.

These types of geospatial details are frequently treated as perfunctory in sociological and psychological warning response and protective action models, understandably so given the traditionally disciplinary nature of academic research. For example, in the Protective Action Decision Model (Lindell and Perry 2012) where would geospatial hazard information and geospatial thinking be placed in a tornado context? There is certainly geospatial information in the warning messages, including both written
and graphical representations of the area under threat. The receiver of the warning message has her/his own geospatial characteristics that may or may not intersect the geospatial characteristics of the outlined threat area. But there is no clear linkage of these geospatial factors in the model, nor the uncertainty inherent in representing and cognizing their potential interaction, nor how they relate to threat, protective action, and stakeholder perceptions and ultimately to decision making and actual behavior. Clearly, one stumbling block for mobile home residents, even in hypothetical evacuation scenarios, is trying to cognize in abstraction the uncertain current and near-future geographies of the hazard and its potential overlap with their own local geographies. Either new protective action models with geospatial representation and cognition concepts at their core are needed, or at least a more thorough rendering and integration of geospatial concepts into the existing models.

The results of the logistic regression models used to predict evacuation intentions in Chapter 7 were, for the most part, readily interpretable and followed what has been found in previous research. For instance, gender (female) increased likelihood of evacuation at the longest lead time, consistent with female residents being more willing to engage in preparedness activities and take protective action when necessary (Mulilis et al. 2001; Sherman-Morris 2010; Paul et al. 2014; Perreault et al. 2014; Silver and Andrey 2014). There was also some evidence from previous research that older residents might be more apt to evacuate for a tornado owing to a greater likelihood of having a plan (Senkbeil, Rockman, and Mason 2012). The results of this study likewise showed that increasing age was associated with increased likelihood of evacuating, but only in the 15 and 45 minutes daytime scenarios. Having an evacuation plan or having evacuated for a
tornado before also significantly increased likelihood of evacuation. One might expect there would be an upper age limit above which evacuation would become less likely due to health problems and reduced mobility. In this study, the dummy variable created to represent whether any household members were over age 65—a commonly used age threshold—was not a significant predictor of evacuation intentions in any of the modeled scenarios.

Several additional variables displayed significant relationships with evacuation intentions that fit well with previous literature. The presence of very young children under the age of six in households increased the likelihood of evacuation in the 15 and 45 minute scenarios. This fits with recent results in hurricane evacuation studies that suggested the presence of children encourages evacuation due to the desire to protect them from harm (Solis, Thomas, and Letson 2010; Hasan et al. 2011).

The presence of children between under the age of 18 in households was also significantly associated with intention to evacuate, but in the stepwise variable selection procedure the variable capturing the youngest age group (under 6) was more significant. The presence of children was not, however, a significant predictor in the five minute scenarios; it appears that respondents understood the dangers inherent in evacuating under such a short notice situation. Having pets in the household was also a significant predictor that influenced respondents to choose evacuation in the 15 minute daytime scenario. The explanation for this relationship is that pets are usually considered to be family members (Walsh 2009) and larger households (usually with children) are more likely to have pets (Edmonds and Cutter 2008). The same inclination for protective behaviors that applies for children therefore also applies for pets.
Another result that aligns with previous research but is somewhat difficult to explain in detail is that African-American residents were more likely to choose evacuation in the hypothetical fifteen minutes scenarios. In other risk contexts, racial/ethnic minority groups have been found to have higher risk perception (Finucane et al. 2000; Olofsson and Rashid 2011). Thus, it is not surprising that they were more likely to choose evacuation in this study. Yet, what is the deeper explanation for this? One possible explanation is that race is capturing differences in income and subsequently homeownership and the size and construction quality of the respondent’s mobile home.

Another potential explanation may be derived from the qualitative interviews. A couple of African-American interviewees invoked the tragic impacts of Hurricane Katrina in 2005. It was well documented that human impacts for residents who stayed during Katrina, especially in and near New Orleans, were much greater for African-American residents (Cutter and Smith 2009). The interviewees in this study who invoked Katrina did so in the context that it served as a lesson that when an evacuation is issued for one’s location, it is best to take the initiative to find a way to get out.

Therefore, part of the explanation why African-American respondents were more likely to intend to evacuate their mobile homes in this study may be theorized by a combination of social amplification of risk (Pidgeon, Kasperson, and Slovic 2003), a disjoint model of agency (Stephens et al. 2009), and cultural-identity protection (Kahan et al. 2007). Many media observers framed the behavior of those who evacuated during Katrina as highly agentic and independent, exercising control over their environment and taking positive protective action (Stephens et al. 2009). While such a model of agency is disjoint in that it does not recognize the many other ways that residents who stayed might
have acted with agency, this frame was crystallized and socially amplified by the vivid scenes broadcast after the storm and the disproportionate number of African-American who were among those who died by staying in New Orleans. Thus, the greater evacuation intentions in this study may be explained as African-American mobile home residents protecting their cultural identity as agentic and independent in accord with the widely publicized disjoint narrative of agency applied to African-Americans in New Orleans and the similar narrative often applied to mobile home residents in general. This is speculation of course, albeit informed by the study participants’ answers and the existing literature.

Finally, one of the most consistent results in Chapter 7 was that having a church building as an evacuation destination increased the likelihood of leaving, regardless of lead time or day/night scenarios. There are several possible explanations for this. South Carolina had one of the highest rates (42% attended weekly) of attendance for religious services in the US (Newport 2015). Therefore, the respondents could very well have been referring to a church at which they are a member and therefore familiar with the church building and those who work and worship there. If this is the case, it is also likely to be located relatively close to the respondent, keeping travel time lower. Alternatively, they may have simply chosen a church as a likely evacuation destination due to their own personal affiliation with a religious organization. Evacuating to a church building may also involve beliefs about the relative safety of the structure due to divine intervention. Yet another explanation is that in more rural areas a church might be the most prominent sturdy structure within several miles. This study did not collect data detailed enough to
provide full explanation for the reasoning behind this relationship between evacuation intentions and destination.
CHAPTER 9: CONCLUSIONS AND FUTURE RESEARCH

9.1. Conclusions

The basic key findings of this research can be summarized as follows:

- There are three distinct perspectives about tornado preparedness and protective action among mobile home residents in central South Carolina:
  - Relatively Unconcerned
  - Concerned and Informed
  - Anticipating Warnings and Taking Action

- The following demographic and experiential variables are significantly associated with the three perspectives listed above:
  - Gender
  - Race
  - Income
  - Presence of Children Under 18
  - Housing Tenure
  - Tornado Experience

- The following mobile home and geographic variables are significantly associated with the three perspectives above:
  - Mobile Home Areal Size
  - Mobile Home Perceived Wind Resistance
  - Neighborhood Mobile Home Density
  - Urban/Rural Context
  - County of Residence
  - Previous State(s) of Residence

- The length of warning lead time prior to a tornado is significantly associated with evacuation intentions:
  - 5 Minutes: 36% would evacuate
  - 15 Minutes: 56% would evacuate
  - 45 Minutes: 60% would evacuate
There are not significant differences in evacuation intentions for daytime scenarios compared to nighttime scenarios, when holding lead time constant.

Depending upon the time of day and the amount of lead time, evacuation intentions are significantly influenced by the following variables:

- Travel Time/Distance to Destination
- Evacuation Destination
- Direction to Destination
- Previous Tornado Evacuation Experience
- Having an Evacuation Plan
- Race
- Gender
- Age
- Housing Tenure
- Presence of Children Under 6
- Presence of Pets
- Information Source and Channel
- Expectation of Damage and/or Injuries
- Perception of Other Thunderstorm Hazards
- Urban/Rural Context

9.2. Practical Considerations

There are a number of practical considerations from this research that would be of interest for emergency managers and the NWS in South Carolina, especially in the study area. The official recommendation is for mobile home residents to evacuate their homes and go to a nearby sturdy building for shelter, and about 67% of respondents stated that they agree that the recommendation is a good idea. However, the percentage of residents who reported actually doing so at least one time previously is only about 26%. This is similar to the estimate given by Schmidlin and colleagues (2009) of the percentage of mobile home residents that evacuated during tornado events in several states. Thus, it appears that the generally low level of compliance with this recommendation is not unique to South Carolina.
Even if only one quarter to one third of mobile home households evacuate during any given tornado warning, this can still represent dozens to hundreds of extra vehicles leaving their homes and driving to their short-term shelter location. On average, residents estimated that they will drive about ten to twelve minutes to their chosen tornado sheltering location, with some indicating travel times as long as 20-30 minutes. Given that the average warning lead time is ten to fifteen minutes and many residents need more time to reach one of their chosen sheltering locations, it would be useful to encourage residents to consider leaving before their home and their shelter location are actually within the area being warned for a tornado. Some residents expressed concern about the dangers of driving in thunderstorms, and therefore leaving a few minutes earlier might alleviate these concerns.

According to the interview and questionnaire data collected in this study, there are three tornado evacuation destinations that residents are likely to try to drive to. The first is a home of a friend or relative; it would be beneficial to remind mobile home residents in preparedness materials and leading up to days when tornadoes are forecasted to be a possibility that they should coordinate with friends and family to make sure they will be able to access the home which will serve as the sheltering location. The two other types of locations are larger buildings: schools and church buildings. In some cases, the school that residents had in mind might be an officially designated public shelter intended for use during a hurricane. It is very unlikely that these would be used as official tornado shelter, whether during the daytime when students usually occupy the building or at night when it is closed. It would be helpful for emergency management and media partners to
reinforce regularly that schools are not public shelters in the case of a tornado. In cases where schools are available, there should be clear public messaging to make this known.

Churches in areas with high numbers of mobile homes might be able to serve a useful public function by working with emergency management and engineers to determine whether any part of the building could be used for the purpose of sheltering mobile home residents during severe thunderstorms. If so, the capacity could be determined in order to avoid overcrowding. There are myriad potential problems with churches serving as shelters, not the least of which is liability in case of injury. Such an initiative would need to be approached with caution and thoughtful planning.

Approximately 25% of the respondents in this study indicated that they expect to hear a tornado siren if a tornado is approaching their location. However, in much of South Carolina, including the study area, tornado sirens are not used systematically, if at all; in fact, most communities do not even have them. Thus, state and local emergency management, the NWS, and local media partners need to stress that residents should never wait to hear tornado sirens before taking action. This is part of the larger problem that many residents’ default impression of evacuation is of a highly publicized and managed event with definitive public statements and specific directives for action. If the NWS and emergency managers truly desire for mobile home residents not to remain in their homes when tornadoes threaten, then public information and education campaigns need to clearly define the differences between the personal kind of planning and threshold for action required for tornadoes and that used in official evacuations for hazards such as hurricanes, tsunamis, floods, nuclear plant accidents, or toxic releases.
While community, county, or even statewide emergency management initiatives and adult education programs might be used to address some of the practical issues raised in this chapter, another important consideration is the role of geography and hazards education in K-12 settings. Basic knowledge of major environmental hazards, their characteristics, how they interact with humans and human systems, and how to prepare for and respond to them can be taught to children and teenagers, equipping them for dealing with these hazards later in life (Mitchell 2009). Such synthesis of natural and social sciences is lacking in hazards education in many southeastern US states, including South Carolina (Mitchell 2009). As seen in mobile home residents’ frustration over knowing when to leave and where to go during a tornado, geospatial concepts related to disasters could also help in this regards (Mitchell, Borden, and Schmidtlein 2008; Sharpe and Kelman 2011). Between two-thirds and three-fourths of residents in many SC counties are native born (American Community Survey 2014), thus using the education system holds long-term promise for increasing knowledge of geography and environmental hazards for a large proportion of the population.

9.3. Limitations of the Research

The ability to draw more specific conclusions or generalize findings from this research is limited by several factors. Geographically, the research was limited to a six county area in central and northeastern South Carolina; conclusions drawn from this research are most likely to be valid in South Carolina and adjacent areas of North Carolina and Georgia with similar climatological, historical, and demographic contexts. The findings are also limited demographically because not enough males, renters, and persons aged 18-34 were recruited into the study to be representative of the population.
The conclusions drawn in this study were also limited by incomplete answers on the questionnaire as a result of misunderstandings in the format; this was especially true of the questions asking residents to provide rankings of multiple answers such as those regarding information sources, damage expectations, and potential sheltering locations. An obvious limitation is that the warning response and evacuation behaviors studied here were in hypothetical scenarios. Certainly, stated intentions of behaviors in scenarios are no replacement for documentation of actual behaviors. However, given the rarity of tornado events and difficulty of collecting data within hours or days of a storm, studies such as these provide insights into the perspectives and thought processes related to the behavior(s) of interest.

9.4. Future Research Directions

There are many opportunities for future research extending from this dissertation. First, while this research identified that potentially critical concepts such as risk ranking or prioritization and geospatial thinking are not well accounted for in preparedness and protection action conceptual models, it is not clear exactly how the models should be restructured and improved. Thus, one avenue for research is to develop a new framework and attempt to test it empirically with a larger, more geographically diverse dataset. The quantitative operationalization of a new framework likely would require structural equation modeling in order to better account for causality chains from exogenous variables to mediating endogenous variables to outcome variables such as evacuation intentions.

Another important next step is to more explicitly integrate geography into preparedness and protective action models. Most of the frameworks used in this study
were intended to model sociological and psychological aspects of risk perception, decision making, and information processing, with geospatial concepts vaguely conceptualized as just one of many other possible factors. There may be promise to putting geography at the core of tornado preparedness and response models (not only for mobile home residents) by using an approach similar to recent publications that developed wildfire evacuation trigger models (Dennison et al. 2007; Larsen et al. 2011) combined with an existing framework such as Lindell and Perry’s (2012) Protective Action Decision Model. These approaches could potentially be synthesized together and operationalized using concepts from psychological distance and geospatial thinking research (Trope and Liberman 2010; Liberman and Trope 2013; Lobben and Lawrence forthcoming).

A third future research direction would explore two further issues. First, whereas this research gathered data only with mobile home residents, it is important to gather data from residents of site-built homes and from church staff and leadership about their perspectives on hosting mobile home residents during severe thunderstorm events. It may be beneficial to approach this in the future from the perspective of social capital of mobile home residents. Then, using probabilities of whether mobile home residents will evacuate and where they might go combined with probabilities of whether the sheltering location will be accessible, an agent-based simulation could be used to determine the kinds of situations when evacuation is more likely to enhance safety and the kinds of situations when evacuation might lead a large number of mobile home residents decreasing their safety by driving out into a tornadic thunderstorm.
9.5. Concluding Remarks

In conclusion, this dissertation made three principal contributions. First, this research work contributed qualitative and quantitative evidence about mobile home residents’ perspectives on tornado preparedness and response, including the possibility of short-term evacuation and potential destinations. The second contribution was the identification of three common perspectives on tornado preparedness and response expressed by mobile home residents within the study area in South Carolina. These can be used to better target outreach campaigns to enhance tornado preparedness and response amongst a highly exposed and socially vulnerable population segment. The third contribution was in demonstrating the factors that were most likely to encourage mobile home residents to choose to evacuate (or discourage them from evacuating) during a tornado warning using several hypothetical situations. Again, the author hopes these findings might be used to enable safe and responsible responses to tornadoes for mobile home residents in the southeastern United States.
REFERENCES


APPENDIX A – INTERVIEW GUIDE

The following two pages (Figures A.1 and A.2) display images of the interview guide used in the qualitative portion of this research.
Interview Guide

Opening Statement
The goal of this study is to identify common perspectives about tornado preparedness and sheltering in the manufactured home communities of South Carolina. This is important because identifying these perspectives can help meteorologists and emergency managers to provide useful information to better educate residents about what to do and to provide better and more useful information to residents during dangerous weather events.

Household Description
- Tell me about where you live and how long you have lived there.
  - SC, Town or City, Neighborhood?
- Describe your living situation in terms of the people who live with you.
  - Very young children, adults of advanced age, pets?

Emergency/Disaster Preparedness and Planning
- Please describe any disaster situations you have experienced before.
- How much thought do you give to what you would do in case of a disaster?
  - What kinds of discussion have taken place within the household?
- Among those living in the house, who is involved in planning for safety or a disaster?
  - Tell me about the different roles those in the house expect to play during a disaster.
- What types of problems are anticipated? What types of problems are not?
- Where do you get information about emergency or disaster preparedness or response?
- What is your opinion of emergency preparedness in your community?
  - Neighborhood, city, county, or state
- How do you think emergency preparedness could be improved?

Weather Information and Warnings/Alerts
- Describe for me what kinds of weather information you use on a daily basis.
- Where do you get your information? Which sources?
  - What about that source appeals to you?
- What type of information do you look for during a weather emergency?
  - What are some of the words you listen for?
  - What are some of the visual aids that help you understand the situation?
- Where do you get your information? Which sources?
- Talk about your level of trust in the people you see and the information they give.
  - How might your trust be increased or decreased?
- How is it different to receive an alert on your phone compared to seeing/hearing it on TV/radio?
- What do you usually do right after receiving a weather warning?
- How much information sharing is there between you and your family/friends/neighbors during a weather emergency?
- How can communication be improved between meteorologists, emergency personnel, and the manufactured home community?
Perception of Tornadoes and Tornado Risk
- When you hear the word tornado, what images come to mind? What other words? Feelings?
- What, in your opinion, is the most dangerous aspect of tornadoes? Scariest aspect? Least scary aspect?
- What time of year do you associate with tornadoes?
- How would you compare the potential for tornadoes to happen in South Carolina to other places in the US?
  - Potential to cause casualties or damage?
  - Timing?
- What do you think is the relationship between tornadoes (or any bad weather or “natural” disaster) and religious beliefs?
- Please describe any experiences you have had with tornadoes.
- Do you think it is possible to know when or where a tornado might strike before it happens?
- What would you consider to be a ‘false alarm’?

Tornado Sheltering Plan and Perception of Potential Sheltering Behaviors
- In your opinion, what is the best way to keep from getting injured by a tornado?
  - How is this different from what family/friends/neighbors say?
- Please tell me what you plan to do when there is a tornado warning for your area
  - Think about details...how much time do you need to get ready? Pets?
- How might your plan be different at night time rather than during the day time?
- When it comes to tornadoes, how is taking shelter different for residents of manufactured homes than for residents of more substantial construction?
- Tell me about what you would consider to be positive outcomes of sheltering.
  - Negative outcomes?
- Please describe your access to a vehicle(s). How do you feel about driving a vehicle in general?
- What are advantages/disadvantages of staying in your home versus getting in a vehicle to go elsewhere for shelter?
  - How might access to information be different?
- How would you know when to leave?
- What is the most important piece of information that would convince you to leave?
- What factors would help you decide where to go?
- What are advantages/disadvantages of staying in your home versus lying down in a ditch for shelter?
- If you had to stay in your home, what would you do? Where inside would you go? How do you think you would feel about doing that?
- In your opinion, how strong and resistant to the wind your home is compared to other manufactured homes?
- What do you think is the relationship between the potential for damage or injury and religious beliefs?
- How can the decision about when and where to go be made easier for manufactured home residents?
APPENDIX B – TORNADO PREPAREDNESS QUESTIONNAIRE

The following pages (Figures B.1, B.2, B.3, and B.4) display images of the four pages—in numerical order—from the questionnaire used in the 2014 Tornado Preparedness Survey.
Questions 1-23 are about your household. Please give just one answer, unless the question asks for multiple answers.

2. Which one of these statements best describes the place where you currently live?  
   - In a manufactured home park or complex  
   - Not in a park, most neighbors in manufactured housing  
   - Not in a park, most neighbors not in manufactured housing  

3. Do you own or rent your home and the land where it sits? Choose all answers that apply to you.  
   - Own Land  
   - Own Home  
   - Rent Land  
   - Rent Home

4. How long have you lived in:  
   a. Your manufactured home? ________ years  
   b. South Carolina? ________ years

5. Including yourself, how many people live in your home?  
   a. How many are under 6? ________  
   b. How many are between 6 and 18? ________  
   c. How many are between 65 and 89? ________  
   d. How many are over 89? ________

6. How many automobiles do you have in your household?  
   - None  
   - 1  
   - 2  
   - 3 or more

7. Do you currently have cable television or a satellite service at home?  
   - Yes  
   - No

8. Do you have internet service at home?  
   - Yes  
   - No

9. Which of the following phone services do you have in your home? Choose all answers that apply to you.  
   - Landline  
   - Cell Phone  
   - I don’t have phone service

10. Is your home a single-wide or double-wide unit?  
    - Single  
    - Double  
    - Don’t know

11. What is the size of your home in square feet? ________

12. What year was your manufactured home built? ________

13. Does your home have any special features to help it resist strong winds?  
    - No  
    - Yes  
    - I don’t know

Questions 14-22 are related to your experiences with tornadoes and your opinions about getting information and taking shelter during severe weather.

14. What is the closest you have ever been to a tornado?  
    - Less than 100 yards  
    - Less than 1 mile  
    - Less than 5 miles  
    - Less than 10 miles  
    - More than 10 miles  
    - I don’t know

15. How many times have you been in a tornado warning since you started living at your current address? (Best guess)  
    - Never  
    - 1-3  
    - 4-5  
    - 6-10  
    - More than 10  
    - I don’t know

16. How likely are you to receive a tornado warning from the following sources?  

   - Very unlikely  
   - Unlikely  
   - Likely  
   - Very likely

   - Radio  
   - Television  
   - Computer  
   - Landline telephone  
   - Cell phone  
   - Word of mouth  
   - Outdoor tornado siren  
   - NOAA weather radio

17. How much do you trust emergency-related information that you receive from the following sources?  

   - Not much  
   - A little  
   - Fair amount  
   - Great amount

   - Local radio station  
   - Local TV station  
   - Local government  
   - National Weather Service  
   - National TV station  
   - Family/Friends  
   - Neighbors

18. How much do you trust tornado-related information that you receive from the following sources?  

   - Not much  
   - A little  
   - Fair amount  
   - Great amount

   - Local radio station  
   - Local TV station  
   - Local government  
   - National Weather Service  
   - National TV station  
   - Family/Friends  
   - Neighbors

19. In your opinion, where is the safest place inside your home to take cover during a tornado?  
    - Bathroom  
    - Kitchen  
    - Closet  
    - Hallway  
    - Bedroom  
    - I don’t know
20. What would happen if a tornado struck your home? Rank the following options with 1 being the most likely to happen and 4 being the least likely.

- No damage
- Major damage, unliveable
- Total destruction

21. What would you do if a tornado struck? Rank the following options with 1 being the most likely and 4 being the least likely.

- No injuries
- Some injuries, no hospital needed
- Extreme injuries, hospital stay

22. Please check the box that best describes how much you agree or disagree with the statements below.

a. Tornadoes are not predictable.
   - Strongly agree
   - Strongly disagree

b. Weather forecasters on TV make thunderstorms sound more dangerous than they really are.
   - Strongly agree
   - Strongly disagree

c. Tornadoes hit the same places again and again.
   - Strongly agree
   - Strongly disagree

d. I believe God has control over the weather.
   - Strongly agree
   - Strongly disagree

23. I worry more about hurricanes than tornadoes.
   - Strongly agree
   - Strongly disagree

24. I expect to hear a tornado siren if a tornado is coming my way.
   - Strongly agree
   - Strongly disagree

25. Weather radar helps me to know if I’m in the path of a thunderstorm.
   - Strongly agree
   - Strongly disagree

26. I often think about what I might do in case of a disaster.
   - Strongly agree
   - Strongly disagree

27. Owners of manufactured home parks should provide tornado shelters.
   - Strongly agree
   - Strongly disagree

28. Tornadoes are a natural part of the weather systems on earth.
   - Strongly agree
   - Strongly disagree

29. I think people waste time and money preparing for every possible type of disaster.
   - Strongly agree
   - Strongly disagree

30. Tornadoes in South Carolina are weak and don’t cause much damage.
   - Strongly agree
   - Strongly disagree

31. I don’t like driving in thunderstorms.
   - Strongly agree
   - Strongly disagree

32. I am concerned about the threat of a tornado.
   - Strongly agree
   - Strongly disagree

33. Usually unplug my TV during thunderstorms to protect it from electrical surges.
   - Strongly agree
   - Strongly disagree

34. I pay close attention to the weather every day.
   - Strongly agree
   - Strongly disagree

35. When I hear a tornado warning for my area on TV, I take cover right away.
   - Strongly agree
   - Strongly disagree

36. Tornadoes are likely to happen in South Carolina.
   - Strongly agree
   - Strongly disagree

37. The government should provide tornado shelters for manufactured home residents in South Carolina.
   - Strongly agree
   - Strongly disagree

38. I think I could afford to buy a tornado shelter.
   - Strongly agree
   - Strongly disagree

39. I believe God can protect me from dangerous weather.
   - Strongly agree
   - Strongly disagree

40. When they show weather radar on TV, I don’t understand what I’m seeing.
   - Strongly agree
   - Strongly disagree

Questions 41-47 are about evacuating your home to take shelter from a tornado.

23. Has your household or family talked about what you might do if you had to evacuate your home for a tornado?
   - Yes
   - No
   - Don’t know

24. Do you have access to either of the following within 500 yards of your home?
   a. Tornado safe room?
   b. Underground storm shelter?

25. Do you have access to either of the following within five miles of your home?
   a. Tornado safe room?
   b. Underground storm shelter?

Figure B.2. Page 2 of the 2014 Tornado Preparedness Survey.
26. How likely would you be to take the following actions if a tornado were coming toward you?
   a. Evacuate your home and lie down flat on the ground
      Very likely □ □ □ □ □ Not likely at all
   b. Evacuate your home and lie down in a ditch
      Very likely □ □ □ □ □ Not likely at all

27. What would happen if a tornado struck your location while you were lying down in a ditch? Rank the following options with 1 being the most likely and 4 being the least likely:
   □ No injuries
   □ Severe injuries, hospital stay
   □ Minor injuries, no hospital
   □ Extreme injuries, maybe death

28. Do you think leaving a manufactured home for shelter in a sturdy building during a tornado warning is a good or bad idea? Indicate your opinion on the scale below.
   Very good idea □ □ □ □ □ Very bad idea

29. Do you think leaving a manufactured home for shelter in a sturdy building during a tornado warning is a good or bad idea? Indicate your opinion on the scale below.
   Very good idea □ □ □ □ □ Very bad idea

30. How many times have you ever evacuated from a manufactured home to a sturdy building just before or during a tornado warning?
   □ Never □ 1-2 □ 3-5 □ 6-10 □ More than 10

31. Would anyone in your household stay at home during a tornado warning even if everyone else would leave?
   □ Yes □ No □ Don’t know
   If yes, how many people in your household would probably stay at home?
   □ Yes □ No □ Don’t know
   If yes, what kind of assistance would this person(s) require?
   □ Add a ride
   □ Need help walking or moving
   □ Need special care or medical equipment
   □ Other (please specify) __________________________
   □ Don’t know

32. Would anyone in your household need assistance from outside the household in order to evacuate?
   □ Yes □ No □ Don’t know
   If yes, what kind of assistance would this person(s) require?
   □ Add a ride
   □ Need help walking or moving
   □ Need special care or medical equipment
   □ Other (please specify) __________________________
   □ Don’t know

33. Would you leave home without your pet(s) to take shelter elsewhere before or during a tornado warning?
   □ Yes □ No □ I don’t have any pets

34. What are the top three factors that would encourage you to evacuate to a sturdy building just before or during a tornado warning?
   a. __________________________
   b. __________________________
   c. __________________________

35. What are the top three factors that would discourage you from evacuating to a sturdy building just before or during a tornado warning?
   a. __________________________
   b. __________________________
   c. __________________________

36. If you were going to evacuate before or during a tornado warning and go to another building, where would you most likely go? Rank the following options with 1 being the most likely place and 4 being the least likely place.
   □ Home of friend or relative
   □ Church or place of worship
   □ Retail store
   □ School
   □ Motel or hotel
   □ Workplace
   □ Other (please specify) __________________________

For questions 37-40 below, use the place you ranked 1 in question 36.

37. How much time would it take you to travel to your 1st ranked sheltering place? _____ minutes

38. Which direction would you travel to get to your 1st ranked sheltering place?
   □ North □ South □ Northeast □ Southwest
   □ East □ West □ Southeast □ Northwest
   □ Don’t know

39. What would happen if a tornado struck your 1st ranked sheltering place? Rank the following options with 1 being the most likely to happen and 4 being the least likely.
   □ no damage
   □ Minor damage
   □ Major damage
   □ Total destruction

40. What would happen if a tornado struck your 2nd ranked sheltering place while you were inside? Rank the following with 1 being the most likely and 4 being the least likely.
   □ No injuries
   □ Severe injuries, hospital stay
   □ Minor injuries, no hospital
   □ Extreme injuries, maybe death

For questions 41-44 below, use the place you ranked 2 in question 36.

41. How much time would it take you to travel to your 2nd ranked sheltering place? _____ minutes

42. Which direction would you travel to get to your 2nd ranked sheltering place?
   □ North □ South □ Northeast □ Southwest
   □ East □ West □ Southeast □ Northwest
   □ Don’t know
43. What would happen if a tornado struck your 1st ranked sheltering place? Rank the following options with 1 being the most likely to happen and 4 being the least likely.
   - No damage
   - Major damage
   - Minor damage
   - Total destruction

44. What would happen if a tornado struck your 2nd ranked sheltering place while you were inside? Rank the following with 1 being the most likely and 4 being the least likely.
   - No injuries
   - Minor injuries, hospital stay
   - Minor injuries, no hospital
   - Extreme injuries, maybe death

Questions 45-47 ask what you would do in daytime and nighttime situations.

45. What are the top three factors that might cause you to act differently when evacuating for a tornado late at night compared to during the daytime?
   a. ______________________
   b. ______________________
   c. ______________________

46. It is daytime and you are at home with all members of the household present. You hear a warning that says a tornado is approaching your area. What would you most likely do?
   a. If you have 5 minutes before the tornado will arrive.
      - I would do nothing to protect myself
      - I would evacuate, I would take shelter in my home
      - Leave home and lie flat on the ground or in a ditch
      - Leave home and drive out of the path of the tornado
      - Leave home and seek shelter in a sturdy building
   b. If you have 15 minutes before the tornado will arrive.
      - I would do nothing to protect myself
      - I would evacuate, I would take shelter in my home
      - Leave home and lie flat on the ground or in a ditch
      - Leave home and drive out of the path of the tornado
      - Leave home and seek shelter in a sturdy building
   c. If you have 45 minutes before the tornado will arrive.
      - I would do nothing to protect myself
      - I would evacuate, I would take shelter in my home
      - Leave home and lie flat on the ground or in a ditch
      - Leave home and drive out of the path of the tornado
      - Leave home and seek shelter in a sturdy building

47. It is late at night and you are at home with all members of the household present. You hear a warning that says a tornado is approaching your area. What would you most likely do:
   a. If you have 5 minutes before the tornado will arrive.
      - I would do nothing to protect myself
      - I would evacuate, I would take shelter in my home
      - Leave home and lie flat on the ground or in a ditch
      - Leave home and drive out of the path of the tornado
      - Leave home and seek shelter in a sturdy building
   b. If you have 15 minutes before the tornado will arrive.
      - I would do nothing to protect myself
      - I would evacuate, I would take shelter in my home
      - Leave home and lie flat on the ground or in a ditch
      - Leave home and drive out of the path of the tornado
      - Leave home and seek shelter in a sturdy building
   c. If you have 45 minutes before the tornado will arrive.
      - I would do nothing to protect myself
      - I would evacuate, I would take shelter in my home
      - Leave home and lie flat on the ground or in a ditch
      - Leave home and drive out of the path of the tornado
      - Leave home and seek shelter in a sturdy building

We value responses from many different perspectives. Questions 48-52 are a few questions to help us understand a little about your background.

48. What is your age? ______

49. What is your gender? ☐ Female ☐ Male

50. What do you consider to be your race or ethnic background?
You may select more than one option.
☐ Black or African American
☐ White
☐ Latino or Hispanic
☐ Asian
☐ American Indian or Alaska Native
☐ Other (please specify: ______________________)

51. What is the highest level of education you have completed?
☐ Less than high school
☐ High school graduate or GED
☐ Technical or vocational school
☐ College (Associate or Bachelor degree)
☐ College (Masters or Doctoral degree)

52. Which of the following best describes your total household income in 2013?
☐ Less than $15,000
☐ $15,000 - $45,000
☐ $45,000 - $74,999
☐ $75,000 or more

Thank you for completing our survey! Your answers will help to improve tornado preparedness and safety in South Carolina.
APPENDIX C – POLYCHORIC CORRELATION MATRIX OF QUESTION #22 ITEMS

This appendix contains two tables of matrices of polychoric correlations for the 21 items used in the analysis presented in Chapter 6.

Table C.1. Polychoric correlations for question #22, items a through k.

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<td>-0.17</td>
<td>0.09</td>
<td>0.13</td>
</tr>
<tr>
<td>22s</td>
<td>-0.10</td>
<td>-0.17</td>
<td>-0.18</td>
<td>-0.23</td>
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<tr>
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</table>
APPENDIX D – R CODE FOR MODEL-BASED CLUSTER ANALYSIS

This appendix contains the R code used to produce the Gaussian mixture model clustering results and to generate 999 simulations using bootstrap resampling.

# code for Gaussian mixture model cluster analysis
# load packages foreign, Mclust
> library(foreign)
> library(mclust)

# import SPSS file with raw data into R; command will open window allowing to choose file
> data<-read.spss(file.choose(),to.data.frame=TRUE)

# run model to find optimum clustering solution and mixture model between 2 and 10 clusters
> Q22.mclust <- Mclust(data, G=2:10)

# print summary of results
> summary(Q22.mclust)

# take note of optimum number of clusters (3), optimum model (VEI), and accompanying BIC value (-15160.5)
# then need to compare optimum model to other possible optimum models given 999 bootstrap resamplings of the original data
# set number of iterations for simulations
> R=999
# set optimum outputs and model name respectively as numeric and character vectors

> G.values=numeric(R)  # numbers of clusters

> models=character(R)  # names of models

> opt.bics=numeric(R)  # optimum values of BIC

> opt.loglik=numeric(R)  # optimum values of log likelihood

# define parameters for progress bar

> pb <- txtProgressBar(min=0, max=R, style=3)

# program ability to see how long it took to complete all simulations

> system.time(

Rprof(

# begin for loop of 999 bootstrap resamples and simulations of Mclust

> for (i in 1:R) {

+ Sys.sleep(0.1)  # needed to set up progress bar

+ setTxtProgressBar(pb, i)  # needed to set up progress bar

+ BSdata=data[sample(1:nrow(data), 212, replace=T),]  # draw random sample of n=212 and length=21 variables from original data, with replacement

+ G.values[i] = Mclust(BSdata, G=2:10)$G  # save optimum number of clusters for each run of Mclust

+ models[i] = Mclust(BSdata, G=2:10)$modelName  # save optimum model name for each run of Mclust

+ opt.bics[i]=Mclust(BSdata, G=2:10)$bic  # save optimum BIC value for each run of Mclust

Mclust

)
+ opt.loglik[i]=Mclust(BSdata, G=2:10)$loglik  # save optimum log likelihood value for each run of Mclust
+ }  # close for loop
+ })
+ )  # end tracking of processing time
> close(pb)  # close progress bar

# print optimum number of clusters, BIC and log likelihood values, and model names for all 999 simulations
> G.values
> models
> opt.bics
> opt.loglik

# generate smoothed scatterplot showing BIC values and numbers of clusters in simulations
# make legend for smoothed density values
> DensLegend<-function(){
+ xm<-get('xm', envir=parent.frame(1))
+ ym<-get('ym', envir=parent.frame(1))
+ z<-get('dens', envir=parent.frame(1))
+ colramp<-get('colramp',parent.frame(1))
+ image.plot(xm,ym,z,col=colramp(256),legend.only=T,add=F)
+ }
> par(mar=c(5,4,4,5)+.1)
# set the smoothing bandwidth

> bw<-c(0.5, 50)

# make the scatterplot with legend and axis labels

> smoothScatter(G.values, opt.bics, nbin=256, bandwidth=bw, nrpoints=0,
postPlotHook=DensLegend, xlab="Optimum Numbers of Clusters", ylab="Optimum
Values of the Bayesian Information Criterion")

# compare BIC value and cluster solution from original model; if the original model-
based solution is not an extreme outlier compared to the bivariate distribution in the
scatterplot, then proceed using results from original model (3 clusters using a VEI model)

# print summary of results

> summary(Q22.mclust)

# print probabilities of each observation belonging to each cluster

> Q22.mclust$z

# retrieve cluster membership assignments for each observation

> Q22.mclust$classification

# print uncertainty index for each observation

> Q22.mclust$uncertainty