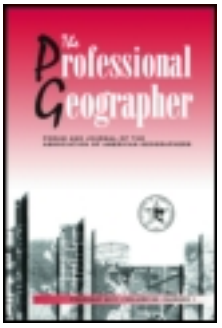

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Ethnic and Racial Differences in Tornado Hazard Perception, Preparedness, and Shelter Lead Time in Tuscaloosa*

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The 27 April 2011 EF4 Tuscaloosa tornado directly impacted more than 50,000 residents, causing forty-five fatalities within the city and sixty-five in total. It was a rare urban tornado with varying impacts on the three major ethnic and racial groups within the city. A hybrid survey and interview of open-ended and closed questions was conducted with 211 Tuscaloosa area residents in a two-week period after the tornado. Results indicate significant differences in risk perception, preparedness, and shelter lead time among the three ethnic and racial groups. Furthermore, results were still significant for perception after controlling for the effects of age, education, and experience. **Key Words: ethnicity, perception, preparedness, shelter, tornado.**

2011 年四月二十七日, 强度级数为 EF4 的龙捲风塔斯卡卢萨直接影响了五万名居民, 在城市中造成四十五人死亡, 总共导致了六十五人丧生。这是个很罕见的城市龙捲风, 对于城市中三个主要族裔与种族社群产生了不等的冲击。龙捲风过后, 本研究在两週内对二百一十一位塔斯卡卢萨地区的居民进行了包含开放式与封闭式问题的混合调查及访谈。研究结果显示, 三个族裔与种族社群对于风险的感知、准备以及避难前导时间有着显着的差异。此外, 在控制年龄、教育以及经验的影响后, 在感知方面的结果仍然相当显着。 **关键词: 族裔, 感知, 准备, 避难, 龙捲风**。

El tornado EF4 del 27 de abril de 2011, en Tuscaloosa, impactó directamente a 50.000 residentes, causando cuarenta y cinco fatalidades dentro de la ciudad, y sesenta y cinco en total. Se trató de un tornado urbano raro, con impactos variados sobre los tres principales grupos étnicos y raciales de la ciudad. Un estudio de campo híbrido y entrevistas de preguntas abiertas y cerradas fue efectuado entre 211 residentes del área de Tuscaloosa, durante las dos semanas posteriores al tornado. Los resultados muestras diferencias significativas en la percepción del riesgo, preparación y tiempo de acceso a los refugios entre los tres grupos étnicos y raciales. Más aún, los resultados se mantuvieron significativos en lo que se refiere a percepción, luego de tomar en cuenta los efectos de edad, educación y experiencia. **Palabras clave: etnicidad, percepción, preparación, refugio, tornado.**

The 27 April 2011 EF4 Tuscaloosa tornado was one of the strongest tornadoes to impact a densely populated urban area. There have been several urban tornadoes since the 1950s; however, factors such as urban sprawl (Hall and Ashley 2008; Paulikas and Ashley 2011) and ethnic diversity (Winders 2005) have transformed the dynamic of larger southern cities in the United States while exacerbating vulnerability to severe weather events (Emrich and Cutter 2011). As cities expand in area and in population, the probability of an atmospheric disaster increases within a metropolitan area. This is especially notable if newer residents are not accustomed to regularly occurring atmospheric hazards endemic to a particular region (Wang, Amati, and Thomalla 2012). In particular, the Southeastern United States has experienced a rapid increase in the Hispanic and Latino (H/L) population in the past two decades (Peralta and Larkin 2011). The recent influx and transient nature of H/L residents in Southeastern U.S. cities is juxtaposed with the more permanent African American (AA) and white (W) populations in the region. The influx of H/L residents into the region has possibly increased vulnerability to atmospheric hazards by accenting barriers to effective weather warning communication (Donner and Rodriguez 2008).

Research on hazard perception and warning communication in ethnic groups spans several decades. Studies that have analyzed ethnicity or race as a variable in warning perception and communication point to conflicting results that could be attributed to cultural or other differences. Although minorities might appear less likely to prepare, respond, or take protective action once a warning is issued (Perry, Lindell, and Greene 1982; Riad, Norris, and Barry 1999; Gladwin and Peacock 2000), it might be a result of warning misinterpretation or cultural differences in how the information is processed and disseminated (Perry and Mushkatel 1986; Perry and Nelson 1991; Blanchard-Boehm 1997; Peguero 2006). In most instances, forecasters of the ethnic or racial majority issue storm warnings that are unwittingly directed toward the cultural ethnic or racial majority (Perry and Mushkatel 1986; Aguirre 1988; Mileti 1999; Lindell and Perry 2004; Hayden et al. 2007). Furthermore, ethnic minorities might not value or trust government

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information or environmental health risks the same as the ethnic majority (Perry and Lindell 1991; Flynn, Slovic, and Mertz 1994; Finucane et al. 2000; Mitchem 2003; Barnshaw 2006; Eisenman et al. 2007; Elder et al. 2007; West and Orr 2007), or they might perceive and conceptualize risk differently (Lindell and Perry 2004). These possible ethnic and racial differences in warning communication and risk perception deserve increased attention, especially in the aftermath of the violent 2011 tornado season.

Previous studies have focused on how African Americans perceive and respond to tornado threat information. In a posttornado survey, Mitchem (2003) concluded that African Americans in Indiana were less likely to understand the differences between watches and warnings and thus possibly not fully comprehend the magnitude of risk compared to other groups. White respondents were slightly less likely, although not significantly so, to be aware of the existing tornado warning. Results regarding African Americans being less likely to receive warnings were reported by Paul et al. (2003) and Lindell and Perry (2004). In research scattered across Arkansas, Alabama, Georgia, and Florida, Schmidlin and colleagues (Schmidlin and King 1995, 1997; Schmidlin et al. 1998) did not attribute a greater number of fatalities to any particular ethnic group. Furthermore, Legates and Biddle (1999), in their analysis of the F5 April 1998 Oak Grove, Alabama, tornado also did not find any significant ethnic differences in the numbers of fatalities. Although it is possible that some African Americans might have a slightly different interpretation of watches and warnings, tornado fatalities appear to be the result of a direct hit on inadequate structures with little regard for ethnicity.

There is a dearth of previous research on tornado hazard perception and warning communication for H/L residents; however, research on flood evacuation behavior showed H/L residents to perceive less risk, be more skeptical about believing warning messages, and be less likely to take protective action than white residents (Perry, Lindell, and Greene 1982). Aguirre (1988) is one of the first researchers to draw attention to the potential communication problems faced by H/L populations after the 1987 F4 Saragosa, Texas, tornado. The Saragosa, Texas, tornado was an unusual and rapidly evolving violent tornado in the desert of western Texas that caused thirty fatalities. One of the problems associated with the Saragosa, Texas, tornado was a lack of Spanish-language warning information. Many locations in the United States do not have adequate Spanish-language media outlets. In the large metropolitan region of southern Florida this is not a problem. Gladwin and Peacock (1997) reported that 14 percent of their respondents listened to Spanish-speaking television and 32 percent to Spanish-speaking radio for Hurricane Andrew information. Aguirre (1988) argued for adaptation of warning systems to support multilingual and multicultural social structures to offset some of these deficiencies in less populated areas. Benavides and Arlikatti (2010) recently examined the Emergency Alert System's ability to transmit multilingual alerts and provided suggestions for improvement. Multilingual modifications would mark an improvement in the communication process; however, it should be noted that Perry and Mushkatel (1986), Perry and Nelson (1991), Blanchard-Boehm (1997), and Morrow (1997) all reported that H/L respondents rely more on social networks via communication with family and friends than other ethnic groups. Although the adaptation of warning systems is important, it is also valuable to understand the social network dynamics of marginalized and minority groups (Messias, Barrington, and Lacy 2012).

The Tuscaloosa tornado offered a rare opportunity to study perception and preparedness for a violent long-track tornado in a major urban area with a long (sixty-five-minute) warning lead time (National Weather Service Birmingham 2012). Although many tornadoes have impacted urban areas before, few tornadoes have impacted sections of cities that can be described as multiethnic (Figure 1). The tornado outbreak of 27 April 2011 was arguably the most hyped and best forecasted tornado outbreak in history. Nevertheless, for a variety of reasons, many people either did not take warnings and forecasts seriously enough, they did not believe it could happen to them, or they did not understand the potential risk. Thus, although much hazard and risk perception research is ongoing from this event, a specific novel focus of this research is placed on analyzing potential ethnic differences in preparedness and perception for the 27 April 2011 tornado in Tuscaloosa. It is important to study ethnicity independent of other variables because minority populations might be especially vulnerable to natural hazards due to potential obstacles with language, isolation, and housing construction (Fothergill, Maestas, and Darlington 1999).

This research has two primary questions: (1) Are there significant differences in tornado preparedness and perception between ethnic groups in Tuscaloosa? and (2) Are these potential differences still present when controlling for the influences of age, education, and years of Tuscaloosa residency? A two-part methods section explains the survey and interview procedures and statistical analysis. This is followed by results and discussion.

Data and Methods

Survey and Interview Development and Implementation

For a two-week period after 27 April 2011, our team of eight University of Alabama researchers conducted hybrid survey and interviews with affected residents in Tuscaloosa. The days after the tornado were chaotic as Tuscaloosa began to mobilize toward recovery and debris removal efforts. Several aid distribution points were established throughout the city. At these distribution points, teams of volunteers from various organizations assembled supplies and then drove out into the affected neighborhoods to find people in need. The city also opened numerous shelters for those

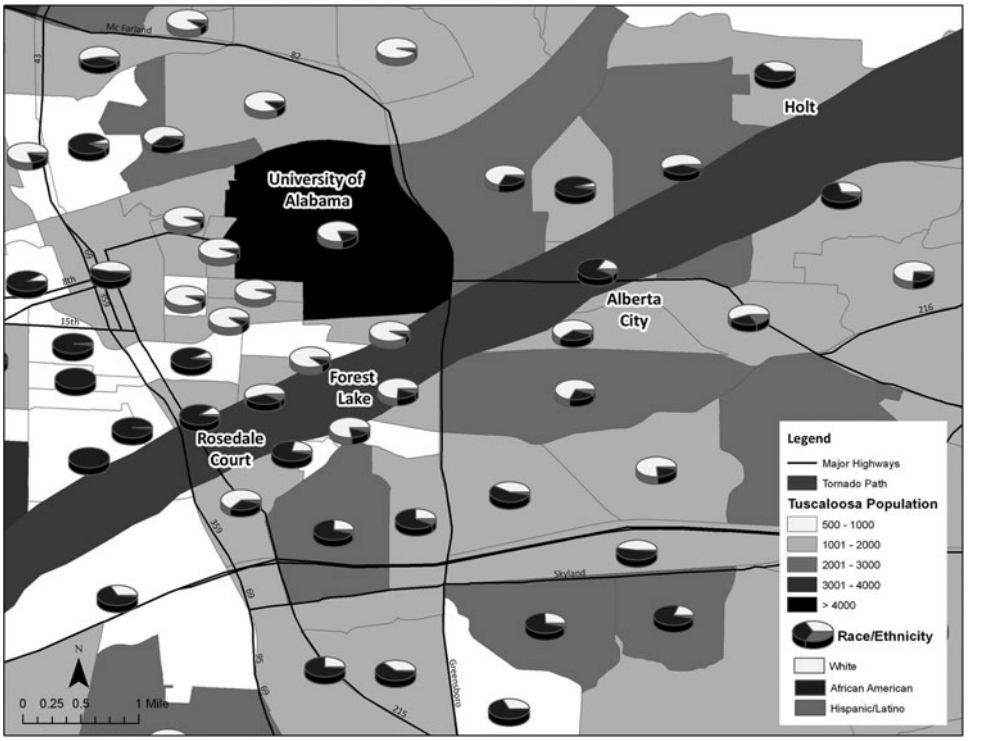

Figure 1 *Ethnic composition of census tracts within the city of Tuscaloosa. The swath of the tornado wind field is indicated in black.*

rendered homeless. Our team decided to adopt a strategy of targeting shelters and distribution points to find residents directly affected by the tornado. Half of the team rode into neighborhoods accompanying distribution teams, and the other half concentrated on residents in shelters. Most respondents answered questions while waiting in line for disaster relief assistance or food either at shelters or aid distribution stations. A small number answered questions while cleaning debris from their property. Although the data collected represent a convenience sample, this strategy provided our team with the best opportunity to connect with residents impacted by the tornado. Surveys and interviews with less affected residents also occurred at several locations around the Tuscaloosa area during the same two-week period in early May 2011. A total of 211 residents were surveyed, interviewed, and grouped according to how they labeled their ethnicity. A total of fourteen respondents either preferred not to provide their ethnicity or their ethnicity was so uncommon in Tuscaloosa that it was not included for analysis. This reduced the sample size to 197 in race and ethnicity categories.

A twenty-two-question hybrid survey and interview was developed with five open-ended questions and seventeen closed questions. An abbreviated version with only questions used in this research is presented (Table 1). To improve the efficiency of the questioning process, the survey and interview was converted to an HTML platform using Zoomerang (www.zoomerang.com) and offered to respondents via iPad. Respondents could easily navigate between questions, and all answers were stored on the Zoomerang server. Some respondents preferred to read and answer questions holding the iPad, whereas others preferred to have questions read to them. A research team member typed responses to open-ended questions on the iPad as the respondent spoke. These responses were also stored on the Zoomerang server.

Respondents were asked to identify their ethnicity in addition to demographic questions such as years lived in Tuscaloosa (experience), age, and education. The remaining questions asked respondents to label their threat perception on 27 April according to one of three categories and also to indicate whether or not they had a shelter plan (see Table 1). Respondents were asked about their shelter lead time prior to the impact of the tornado at their residence. They were also asked to discuss the severity of damage to their homes. The following paragraphs explain how these questions address preparedness and perception.

Preparedness has been defined in previous research as the stage of a disaster involving all preevent preparation activities and mitigation efforts in advance of a specific warning or actions taken before a disaster to reduce the expected ramifications (Fothergill, Maestas, and Darlington 1999; Zahran et al. 2008). Specific questions regarding preparedness as defined in the

Table 1 *List of questions used in this research*

Preparedness and perception questions	**Possible responses**
Did you have a shelter plan prior to April 27, 2011?	Yes No
How would you rate your perception of the tornado risk on April 27, 2011?	I was unaware of the tornado threat I was aware of the tornado threat but did not know how dangerous it could be I was aware of the tornado threat and knew how dangerous it could be
How much time elapsed (minutes) between you taking shelter and the tornado arriving at your location?	Continuous variable
How did the April 27 tornado impact your home?	Open-ended response
Demographic questions	**Possible responses**
What is your age?	**19–24** (sample = 27%, population = 31%) **25–34** (sample = 28%, population = 27 %) **35–44** (sample = 21%, population = 14%) **45–54** (sample = 14%, population = 10%) **55–** (sample = 10%, population = 19%)
What is your highest education attained?	**<High school** (sample = 14%, population = 12%) **High school** (sample = 27%, population = 24%) **Some college/associate's degree** (sample = 32%, population = 35%) **Bachelor's degree** (sample = 13%, population = 17%) **Graduate degree** (sample = 14%, population = 12%)
How many years have you live in Tuscaloosa?	4 or less 5–10 10–20 20+
What is your ethnicity?	**White** (sample = 46%, population = 53%) **African American** (sample = 28%, population = 42%) **Hispanic/Latino** (sample = 18%, population* = 3%) **Other or prefer not to answer** (sample = 8%, population = 2%)

Note: Comparisons between the percentages of our sample and the Tuscaloosa city population from the 2010 census are provided in parentheses. The actual Hispanic/Latino population is estimated to be higher than the 2010 census value.

previous sentence were not asked. Thus, our assessment of preparedness stems from responses to the question, "Did you have a shelter plan prior to the 27 April tornado?" A shelter plan is considered any protective action indicative of a plan instead of seeking shelter at the last minute or second, which many respondents did. Preparedness was assessed by using categorical counts of shelter plan (yes or no) among the three dominant ethnic or racial groups: W, AA, and H/L.

Perception was assessed by using responses to the question: "How would you label your perception of the tornado threat on 27 April?": (1) I was unaware of the tornado threat (unaware), (2) I was aware of the tornado threat but did not know how dangerous it could be (underestimation), and (3) I was aware of the tornado threat and knew how dangerous it could be (aware). Respondents were encouraged to discuss their personal experiences on this question so that responses could be more clearly classified into one of the three categories.

Perception and preparedness are not mutually exclusive terms. Respondents who had a shelter plan were assumed to be more prepared; however, that preparedness is not advantageous unless it is coupled with accurate perception of the potential risk. Therefore, a third hybrid area involving shelter lead time was evaluated by responses to the question, "How much time elapsed between taking shelter and the tornado arriving at your location?" Only respondents who experienced at least some damage at their residence were included in this analysis of sheltering lead time. This reduced the sample size for the analysis of shelter time: H/L, sixteen (41 percent); AA, forty-five (75 percent); and W, thirty-three (34 percent). This damage criterion was used because during our interviews respondents who experienced damage immediately recalled shelter time, whereas those that did not experience damage had to reflect on the exact time in minutes. To prevent potential loss of data from restricting damage criteria, additional analyses include residents who did not experience damage.

Most Tuscaloosa area residents in temporary shelters or at distribution points were willing to devote about five minutes of their time to speak with researchers while waiting for services. Thus, many were willing to answer the closed questions but were unwilling to offer much dialog when pressed for details on open-ended questions. The H/L population was the most difficult to reach; however, approximately 100 impacted H/L residents were located in a temporary shelter at Holy Spirit Catholic Church. The survey and interview were translated into Spanish and administered using paper copies instead of iPads. A single announcement about the research objectives was made in Spanish to all residents in the temporary

shelter because many were unable to read in Spanish. Thus, some survey and interviews were administered verbally, whereas other respondents preferred to read questions. Only one member from each family completed the survey and interview, and a total of twenty-five completed responses were gathered at Holy Spirit Church. The remaining fourteen responses were gathered at various businesses in Tuscaloosa that were frequently visited by H/L residents. Many H/L residents declined to be interviewed and this was at least partially attributed to fears about the Hammon-Beason Alabama Taxpayer and Citizen Protection Act, a controversial immigration law. This law, although not enforced until August 2011, was already a growing concern among the H/L community.

Statistical Analysis

Statistical analysis of categorical survey responses consisted of several different tests to assess potential differences in preparedness and perception. First, a 3×2 (3×3) contingency table with a chi-square statistic was used to test the association between preparedness (perception) among the three ethnic and racial groups. Count data from the binary variable of shelter plan were cross-tabulated with the three groups using a chi-square statistic for preparedness. Similarly, count data from the categorical variable perception were grouped into three subcategories and cross-tabulated with the three ethnic and racial groups using a chi-square statistic (Figure 2).

Following the two initial contingency table tests described in the preceding paragraph, the count data were reorganized for each ethnic and racial group into 2×2 formats so that additional tests could be performed (see Figure 2). Mantel-Haenszel (MH) tests (Cochran 1954; Mantel and Haenszel 1959) were used to determine whether the preparedness and perception results from the original chi-square tests were still significant when controlling for the influences of age, education, and years lived in Tuscaloosa (experience). Education and age were statistically significant predictors of residents likely to have shelter plans from Senkbeil, Mason, and Rockman (2012), so these two variables were used for the MH tests. Years lived in Tuscaloosa was also included as a proxy for previous tornado experience in Tuscaloosa. There had been numerous severe weather and tornado events in the past decade prior to the 27 April tornado in Tuscaloosa. This includes a weak tornado on 15 April 2011 and an F4 tornado in December 2000 (National Weather Service Birmingham 2012); therefore, Tuscaloosa respondents were very experienced with tornado warnings and tornadoes prior to the 27 April 2011 event.

A total of eighteen MH tests were performed (see Figure 2). Fisher's Exact (FE) tests were also used in conjunction with MH tests instead of chi-square tests because the expected values were small in many cases after stratifying results by subcategories of age, education, and experience. Reported p values indicate the total significance across all subcategories. Results are reported as significant if both MH and FE tests are less than 0.05, thus providing a more robust level of significance. For perception, the original categories of unaware and underestimated were combined into one underestimated category for MH tests. The categories were combined for the preferred simplicity of a 2×2 matrix in a MH test and also because of the small

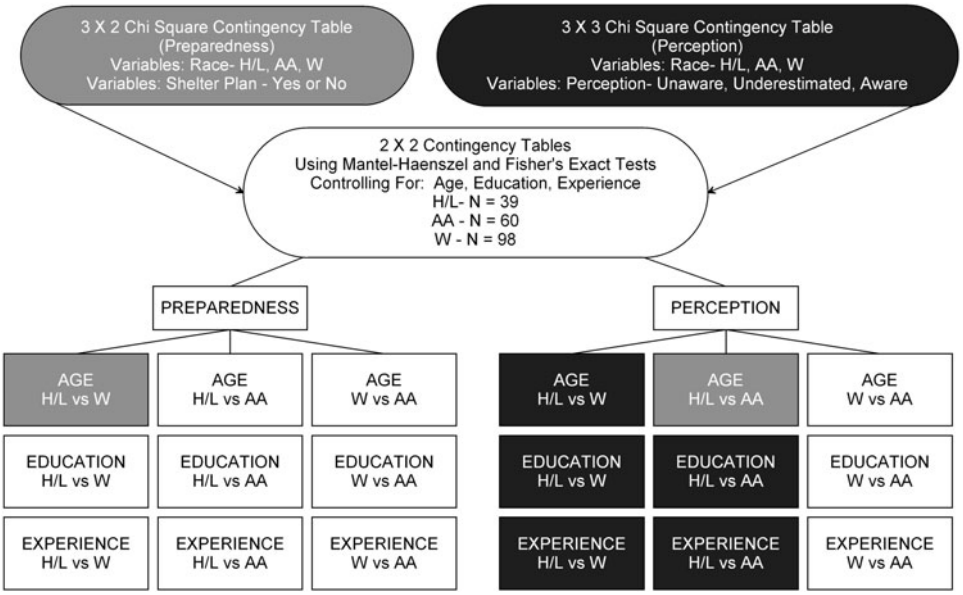

Figure 2 *Flowchart depicting methods used for statistical testing for differences in preparedness and perception. Black (gray) boxes indicate significance at the .01 (.05) level. Exact* p *values and test statistics for significant results are listed in Table 2.* Note: *H/L = Hispanic/Latino; AA = African American; W = white.*

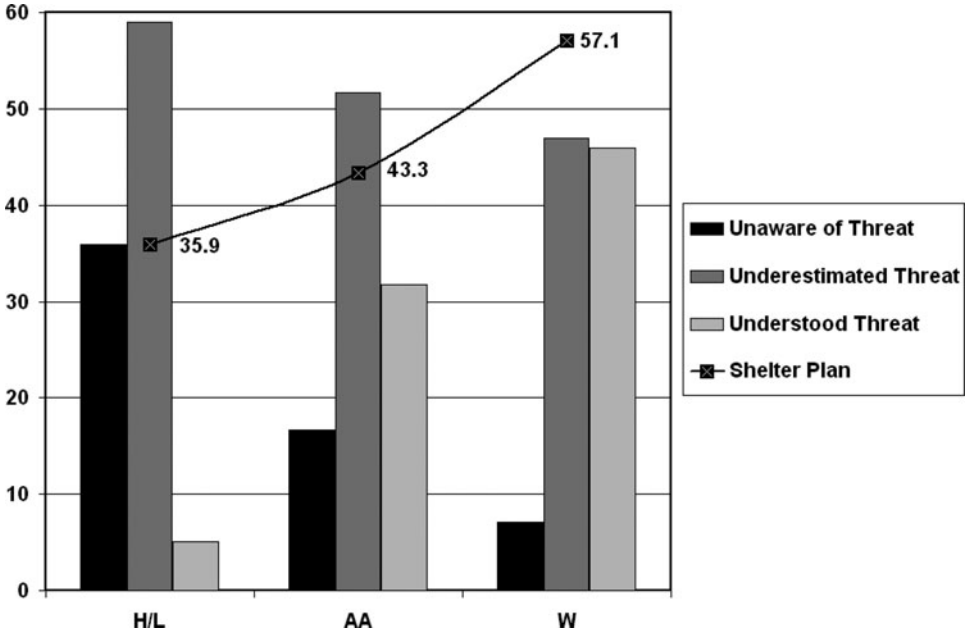

Figure 3 *Percentages of Hispanic/Latino (H/L), African American (AA), and white (W) respondents by subcategories of perception and preparedness (shelter plan).*

sample sizes with the unaware category and subcategories of age, education, and experience. A Kruskal–Wallis test was used to test for significant differences in shelter lead time among ethnic and racial groups.

A final statistical test was included to further evaluate the validity of these findings by producing a Pearson correlation matrix. The correlation matrix is important for the following reasons: (1) It shows the relationships among all variables while addressing potential data loss issues from 2 × 2 groupings in MH procedures, and (2) it allows for researchers to determine whether other models might fit the data and thus be more representative of the population in quantitative meta-analyses. Pearson's r was used because all of the variables in the correlation procedure are categorical and dummy-coded with the exception of shelter lead time. The sample size for shelter lead time was 177 respondents because many declined to answer that question. Some subcategories of damage, perception, and education were combined to increase sample sizes for correlations. Damage and perception were binary-coded into damage or no damage and understood or underestimated. Education was reduced from five subcategories to three.

Results

Count data from the binary variable of preparedness (shelter plan) were cross-tabulated with the three ethnic/racial groups using a chi-square statistic and a 3 × 2 contingency table to assess preparedness. There were significant differences in preparedness among the three groups, $\chi^2(2, N = 197) = 6.046$, $p = 0.05$ (Table 2). The largest differences between the observed and expected counts occurred among H/L respondents and W respondents. A lower percentage of H/L respondents indicated that they were prepared when compared to AA and W respondents (Figure 3).

Following the initial chi-square test, a total of nine MH tests were run for preparedness. Only one of the nine MH tests was significant. After controlling for age, H/L respondents were less prepared than W respondents (MH $p = 0.03$, FE $p = 0.04$; see Table 2). This result was also found in correlations W ($r = 0.15$, $p = 0.03$) and H/L ($r = –0.13$), albeit with little practical significance (Table 3). Thus, there do not appear to be many significant differences in preparedness among the groups. Differences in preparedness might exist in other aspects beyond having a shelter plan.

Similarly, count data from the categorical variable perception were used in a 3 × 3 contingency table with the three ethnic and racial groups using a chi-square statistic. There were significant differences in perception among the three groups, $\chi^2(4, N = 197 = 29.458)$, $p < .01$ (Table 2). The largest differences between the observed and expected counts once again occurred among H/L respondents. The highest percentage of unaware and underestimating respondents were H/L (see Figure 3).

Nine MH tests were also performed for perception with several significant results. After controlling for education, H/L respondents did not accurately perceive the tornado threat on 27 April when compared to W and AA respondents (MH $p < 0.01$, FE $p < 0.01$; see Table 2). Similar results were found for age and

Table 2 *Statistically significant results*

Purpose	Test	Variables	Test statistic	df	*p* value
Perception	Chi-square	Ethnicity and perception	$\chi^2 = 29.5$	4	< .01
Perception	Mantel-Haenszel and Fisher's Exact	H/L, W, perception, age	$\chi^2 = 18.6$	1	(<.01) (<.01)
Perception	Mantel-Haenszel and Fisher's Exact	H/L, W, perception, education	$\chi^2 = 8.98$	1	(<.01) (<.01)
Perception	Mantel-Haenszel and Fisher's Exact	H/L, W, perception, experience	$\chi^2 = 17.4$	1	(< .01) (< .01)
Perception	Mantel-Haenszel and Fisher's Exact	H/L, AA, perception, age	$\chi^2 = 5.87$	1	(0.015) (< .01)
Perception	Mantel-Haenszel and Fisher's Exact	H/L, AA, perception, education	$\chi^2 = 9.64$	1	(<.01) (<.01)
Perception	Mantel-Haenszel and Fisher's Exact	H/L, AA, perception, experience	$\chi^2 = 7.65$	1	(<.01) (<.01)
Perception	Mantel-Haenszel	H/L, W, perception, damage	$\chi^2 = 15.9$	1	(<.01)
Perception	Mantel-Haenszel	H/L, AA, perception, damage	$\chi^2 = 13.5$	1	(<.01)
Preparedness	Chi-square	Ethnicity and preparedness	$\chi^2 = 6.05$	1	0.05
Preparedness	Mantel-Haenszel and Fisher's Exact	H/L, W, preparedness, age	$\chi^2 = 5.04$	2	(.03) (.04)
Shelter time	Kruskal-Wallis	Ethnicity and shelter time (minutes)		1	0.04

Note: H/L = Hispanic/Latino; W = white; AA = African American.

experience. After controlling for age, H/L respondents once again did not accurately perceive the tornado threat when compared to W (MH $p < 0.01$, FE $p < 0.01$) and AA (MH $p = 0.02$, FE $p < 0.01$) respondents. H/L respondents were also significantly different after controlling for experience when compared to W and AA (MH $p \leq 0.01$, FE $p < 0.01$). Pearson correlations also reflect differences in perception with r values of W (0.24, $p < 0.01$), AA (–0.03), and H/L (–0.29, $p < 0.01$) for understanding the potential threat (see Table 3).

By combining the three categories of perception into two categories for MH and FE tests, bias was possibly introduced. For example, it was hypothesized that respondents who experienced some, significant, or total destruction of their homes would possibly respond that they were unaware or underestimated the tornado threat at a greater rate than respondents who experienced less damage. Results indicated that the significant differences in the preceding paragraph were not affected by this possible bias. After controlling for home damage, H/L respondents still had significantly different perceptions of the event when compared to W and AA respondents (DAMAGE MH $p \leq 0.01$, FE $p < 0.01$; see Table 2).

Shelter lead time is a third variable that represents aspects of both preparedness and perception. Shelter-seeking plans and shelter quality were addressed in Senkbeil, Mason, and Rockman (2012). As defined earlier, shelter lead time is the amount of time that elapsed between taking shelter and the tornado arriving at that location. A Kruskal–Wallis test indicated that there were significant differences in shelter lead time among the three ethnic and racial groups ($p = 0.04$; see Table 2). Pearson correlations reveal similar results indicating statistically significant relationships in shelter lead time among the three groups: W ($r = 0.18$, $p = 0.02$), AA ($r = -0.22$, $p < 0.01$), and H/L ($r = 0.05$; see Table 3). The mean shelter lead times were 13.7 minutes for W, 5.2 minutes for AA, and 8.4 minutes for H/L respondents. There was a considerable range within each group, with some respondents using only seconds of lead time and others using an hour. A 95 percent confidence interval was placed on the range of each group showing large variance in W and H/L lead time and relatively small variance in AA lead time. Although AA respondents were generally better prepared and had a better perception of the potential risk than H/L respondents, shelter lead time suggests that more AA respondents waited for confirmed evidence of a tornado before taking shelter. It should be noted that many respondents in each ethnic and racial group waited for visual confirmation, although exact numbers are not available. The role of previous tornado events and the active spring severe weather preceding 27 April 2011 certainly is worth more attention. Future research will attempt to explore the influence of false alarm and near-miss events in Tuscaloosa and surrounding areas.

Discussion and Limitations of Perception Results

The results suggest that differences in perception, shelter lead time, and preparedness exist between ethnic and racial groups in Tuscaloosa. The emphasis of this section is to discuss the authenticity and limitations of perception differences because those results were the strongest. It is not clear why these differences exist beyond obvious linguistic communication barriers associated with Spanish-speaking populations. One possible explanation is that the percentage of AA (75 percent) respondents experiencing at least some damage to their residences was greater than H/L (41 percent) and W (34 percent) respondents. Pearson

Table 3 *Correlation matrix of all variables*

							Ethnicity/Race			Age					Education			Experience		
	x̄	**s**	**Shelter time**	**Preparedness**	**Understood (perception)**	**Damage**	**W**	**AA**	**HL**	**19–24**	**25–34**	**35–44**	**45–54**	**55+**	**High school**	**Some college**	**Degree**	**0–4 yl**	**5–10 yl**	**10–20 yl**
Shelter time	19.40	36.30																		
Preparednes	0.49	0.50	**0.16**																	
Understood (perception)	0.34	0.47	**0.16**	***0.26***																
Damage	0.54	0.50	**−0.18**	**−0.17**	−0.12															
W	0.46	0.50	**0.18**	**0.15**	***0.24***	***−0.30***														
AA	0.28	0.45	***−0.22***	−0.08	−0.03	***0.40***	***−0.59***													
HL	0.18	0.39	0.05	−0.13	***−0.29***	−0.02	***−0.44***	***−0.30***												
19–24	0.26	0.44	0.09	−0.13	−0.06	−0.03	***0.18***	−0.14	−0.09											
25–34	0.28	0.45	0.00	−0.12	−0.05	−0.02	−0.09	0.02	0.05	***−0.37***										
35–44	0.21	0.41	0.07	0.12	−0.07	−0.11	−0.13	−0.04	**0.18**	***−0.31***	***−0.32***									
45–54	0.14	0.35	−0.14	0.01	0.08	0.05	−0.05	**0.17**	−0.09	***−0.24***	***−0.26***	***−0.21***								
55+	0.10	0.31	−0.06	***0.19***	**0.15**	**0.16**	0.09	0.03	−0.08	***−0.20***	***−0.22***	**−0.18**	**−0.14**							
High School	0.40	0.49	−0.13	***−0.21***	***−0.22***	***0.36***	***−0.44***	***0.25***	***0.36***	***−0.18***	0.08	0.01	0.05	0.07						
Some College	0.32	0.47	−0.08	0.06	0.01	−0.04	**0.14**	0.00	***−0.25***	***0.27***	−0.09	**−0.15**	−0.04	0.00	***−0.56***					
Degree	0.28	0.45	***0.23***	**0.17**	***0.23***	***−0.35***	***0.33***	***−0.28***	−0.13	−0.09	0.01	**0.15**	−0.01	−0.07	***−0.51***	***−0.43***				
0–4yl	0.23	0.42	−0.02	−0.12	***−0.20***	−0.05	0.03	**−0.15**	0.11	**0.16**	0.00	−0.03	−0.03	**−0.15**	−0.02	0.06	−0.04			
5–10yl	0.24	0.43	−0.02	−0.03	0.07	−0.12	0.05	***−0.26***	***0.22***	−0.03	***0.21***	0.01	**−0.17**	−0.08	0.01	**−0.15**	**0.14**	***−0.31***		
10–20yl	0.17	0.38	0.12	0.06	−0.08	−0.13	−0.04	−0.09	0.08	0.02	−0.09	**0.14**	0.03	−0.11	−0.06	−0.04	0.11	***−0.25***	***−0.26***	
20+yl	0.36	0.48	−0.07	0.08	***0.18***	***0.26***	−0.04	***0.43***	***−0.35***	−0.13	−0.12	−0.09	**0.15**	***0.30***	0.06	0.11	−0.18	***−0.41***	***−0.42***	***−0.34***

Note: Correlations significant at the .01 (.05) level are shown in bold italics (bold). The first two columns represent the mean and sample standard deviation for each variable. W = white; AA = African American; HL = Hispanic/Latino.

correlations also confirm this damage finding; AA ($r = 0.40$, $p < 0.01$) and W respondents were less affected ($r = -0.30$, $p < 0.01$; Table 3). This could have influenced AA respondents to answer that they underestimated the risk on 27 April at a greater proportion than W respondents. It should be noted, however, that there was not a strong relationship between damage and perception ($r = -0.12$; Table 3). Furthermore, the severity of damage to one's residence was not a significant predictor of intent to change a shelter plan in the future; however, ethnicity was a significant predictor of intent to change a shelter plan (Senkbeil, Mason, and Rockman 2012). Perhaps the potential underestimation bias from tornado impact on personal residence is mitigated by these findings and the collection of perishable data immediately after the event.

From our field discussions and responses to interview questions it is believed that the significant differences in perception between ethnic and racial groups are authentic. The most common comments heard from AA and W respondents were related to frequent near-miss and false alarm events. Many indicated that they did not think this would be any different than previous tornado warnings that did not produce anything. Others said that sirens go off all the time and nothing ever happens. In contrast, many H/L respondents were completely unaware of the tornado risk that day. Others who were aware indicated that they did not know what action to take. Several mentioned how they stood underneath a doorframe at their house or place of business, classic earthquake safety responses with which they were familiar. Despite the inadequate perception prior to the event, no H/L surnames were listed among the fatalities. This is either a very fortunate coincidence or it represents a disturbing social anomaly. The probability of no fatalities with an H/L surname is low given the path of the Tuscaloosa tornado through the neighborhood with the highest concentration of H/L residents in Tuscaloosa.

It is also possible that the differences in perception are attributed more to socioeconomics and individual socio-psychological processes and less to characteristics of ethnicity (Parker, Priest, and Tapsell 2009). The socioeconomic argument loses strength considering the representation of our multiethnic sample compared to the population of Tuscaloosa (see Table 1). Using median property values as a proxy for income, there are only modest income disparities among the three ethnic and racial groups across the tornado path. The path of the tornado impacted mostly lower income sections of Tuscaloosa populated by renters but interspersed with pockets of middle-income neighborhoods. There was only one small section of a wealthy neighborhood that was affected. Percentages of homeownership for each group were not asked.

Unfortunately, respondents were not asked any personal questions such as annual income, occupation, or whether they owned or rented their residence. Therefore, we cannot arrive at any firm conclusions on the role of socioeconomics on perception. The research was conducted immediately after the tornado, and the expedited institutional review board approval prohibited us from asking personal questions beyond those listed in Table 1.

Culture could also play a role in explaining how the various populations first perceived and then responded to the tornado that struck Tuscaloosa. An alternative approach to studying differential hazard perception and preparedness could perhaps best be found by using a cultural model. The most accurate cultural models take a great deal of time to construct using ethnographic methods. In this article, a proper elicitation of the cultural domain was not done due to the ephemeral nature of accurate data collection and the many exigencies involved. Nevertheless, this research seems to indicate that there are ethnic and racial differences in tornado hazard perception and preparedness that could be analyzed in future research by using a cultural model.

Conclusion

The 27 April 2011 Tuscaloosa tornado was one of the strongest tornadoes to ever impact a densely populated and multiethnic urban area. Among other topics, it provided a rare opportunity to study ethnic and racial differences in tornado hazard perception and preparedness. Two specific research questions emerged: (1) Are there significant differences in tornado preparedness and perception among ethnic and racial groups in Tuscaloosa? and (2) Are these potential differences still present when controlling for the influences of age, education, and years of Tuscaloosa residency?

Statistical results suggest that there are significant differences among ethnic and racial groups in both tornado perception and preparedness, which answers Question 1. The differences in preparedness disappear, however, with one exception after controlling for the influences of age, education, and experience. After controlling for age, significant differences were found in preparedness between H/L and W respondents. The differences in perception are exclusively between H/L respondents and W and AA respondents after controlling for all three influencing variables. There are no differences in perception between W and AA respondents. Thus, most H/L respondents appear to have had a poor perception of the potential risk on 27 April. A third analysis based on shelter lead time showed that AA respondents had the lowest mean shelter time and also the lowest variance in shelter lead time of the three groups. The severity of damage to one's home was not a significant variable in explaining differences in perception. Socioeconomic and cultural influences on perception and preparedness were not directly measured or tested but should be considered in future research. These results from Tuscaloosa are believed to be authentic representations of the larger population. Future research is needed to test that hypothesis on a larger spatial scale. These results suggest a need for meteorologists and emergency managers

to begin thinking about alternative forecasting and communication strategies for particular ethnic and English-as-second-language populations. ■

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