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**University of Colorado**  
**482 UCB**  
**Boulder, CO 80309-0482**

## **Quick Response Report #145**

# **Risk Factors for Death in the 8 April 1998 Alabama Tornadoes**

**Yuichi Ono**

**Department of Geography**

**Kent State University**

**Kent, OH 44242**

**E-mail: [yuichiono@hotmail.com](mailto:yuichiono@hotmail.com)**

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## **INTRODUCTION**

Tornadoes on 8 April 1998 killed 34 people in Alabama, becoming the worst event in Alabama tornado history since the 21 March 1932 tornadoes that marked 271 deaths. I conducted a field survey to assess risk factors associated with the tornado deaths. Tornado deaths do not occur randomly. A high death rate occurs among people with higher vulnerability. Vulnerability is key to understanding the deaths caused by natural disasters, including tornado disasters. Efficient communication and quick access to a safe place are significantly important. Whatever situations that would disturb such actions can be considered risk factors. Risk is determined by people's response to a tornado. Behavioral

studies, therefore, have been the focus of researchers. Factors such as age, gender, and ethnicity seem to affect death rates (Schmidlin and King 1995, 1997; King, Hammer, Ono, and Schmidlin 1999). The location of people when the tornado hit is important. Inevitably, a housing structure is important because it affects the location and safety of people during tornado (Duclos and Ing 1989; Brenner and Noji 1995). This is related to long-term tornado preparedness. People in a tornado prone area may be more interested in installing a storm cellar or basement although there are regional/geographical differences in the use of storm cellars. Other parameters that may affect the death rate are income level, educational level, accuracy of forecast, communication systems, emergency rescue operation and transportation, medical equipment, community network, and so on.

The objectives of the present research are 1) to obtain information on persons who died in the 8 April 1998 Alabama tornadoes; 2) to obtain information on those people in terms of their housing structure, location during tornado, and F-scale assessed from the damage; and 3) to discuss a potential survival strategy.

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## RESEARCH QUESTION

What locations, personal attributes, or behaviors cause tornado deaths? Are there any ways to avoid being a victim?

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## THE 8 APRIL 1998 ALABAMA TORNADOES

One supercell thunderstorm that moved across central Alabama on the evening of Wednesday, 8 April 1998 produced three tornadoes. The first tornado began in Pickens County at 7:01 p.m. It moved toward the east, entered Tuscaloosa County at 7:05 p.m., and ended in the county at 7:29 p.m. The F-scale was rated 3, the path length was 28.0 km, and the path width was at most 228 m wide. There were no deaths but 2 people were injured.

Thirteen minutes after the first tornado diminished, the same supercell formed a second tornado in eastern Tuscaloosa County at 7:42 p.m. It moved toward the east-northeast and entered Jefferson County at 7:52 p.m. The tornado intensified to an F-5 category and devastated Oak Grove, Concord, Pleasant Grove, Edgewater, and McDonald's Chapel areas. It traveled 49.2 km and ended in Pratt City at 8:22 p.m. The maximum path width of this tornado was 800 m wide. Thirty-two people were killed, 256 people were injured, 1,177 homes were destroyed or damaged, 1 school was destroyed, 4 churches were damaged, 8 businesses were damaged, and 30 apartments were destroyed or damaged.

A third tornado began north of Moody in St. Clair County at 8:56 p.m. and moved toward the east-northeast all the way to Wattsville for 23.2 km and dissipated there at 9:15 p.m. The tornado was ranked F-2. Two people died in this path.

Tornado warnings were issued for Pickens County at 6:26 p.m. (warning lead time = 35 minutes), for Tuscaloosa County at 7:01 p.m. (warning lead time = 4 minutes), for Jefferson County at 7:45 p.m. (warning lead time = 7 minutes), and for St. Clair County at 8:49 p.m. (warning lead time = 7 minutes). The average warning lead time was 13 minutes and 42 seconds. People in each county had at least 4 minutes of warning lead time.

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## FIELD METHODS

I began to conduct field research in Birmingham on 13 April 1998, five days after the tornado disaster. Since my time was limited to three days, I focused my field research areas on the Oak Grove area on 13 April, Edgewater and Wattsville areas on 14 April, and Edgewater and McDonald's Chapel areas on 15 April. Prior to my field work, telephone contacts were made with local police and disaster relief agencies. The National Weather Service and various news Web sites were screened to obtain updated information.

I methodically drove or walked through the damage paths with street-level maps. A survey was given to neighbors or family members and relatives when obtaining information on persons who lost their lives. The survey asked the victim's age; gender; type of housing; degree of damage to the victim's home; location of the victim when hit by the tornado; whether the victim was aware of the approaching tornado; how the victim obtained tornado information; what action the victim took after sensing the approaching tornado; what object fell on the victim, if any; and other situations that limited the victim's actions.

In all other cases, direct interviews were conducted, and F-scales were assessed at each residence. Newspaper articles (The *Birmingham News* and *Birmingham Post-Herald*) were collected to obtain supplemental information.

## RESULTS AND CONCLUSIONS

Central Alabama has been hit by several devastating tornadoes in recent history. For example, the 16 April 1956 tornado hit the McDonald's Chapel area, one of the same areas as the 1998 tornado, killing 22, injuring 200, and destroying 50 homes. Because of past events, most people must have been aware that they lived in a tornado-prone area. The topography is hilly and located at the southernmost end of the Appalachians. Despite its location in the Deep South, many houses have a basement. There are many trees in the area, and houses are often shaded by the trees. Such an environment may prevent people from seeing an approaching tornado. The 8 April 1998 Alabama tornadoes hit after sunset in the evening hours of a weekday. The majority of people would have been at home, maybe in the living room just after finishing their dinner, watching TV, reading books, etc. Most people were still awake. Although time of day would not have allowed people to eyewitness the approaching tornado due to the darkness, it would have allowed people to obtain a weather warning easily through TV, radio, weather radio, siren, or phone calls from friends or family members/relatives.

As shown in Table 1, there were 13 male and 21 female fatalities caused by the 8 April 1998 Alabama tornadoes. The reason for this difference is unknown. There were 15 fatalities over age 60 accounting for 44.1% of the total. Although there were only 4 fatalities for males over age 60, there were 11 fatalities among females over 60. This is partly in accordance with Schmidlin's previous research on tornado fatalities in Ohio suggesting that elderly women had a relatively high death rate (Schmidlin 1993). The age groups 40s and 70s had the highest number of fatalities with 8. Younger people had a relatively low number of deaths.

**Table 1. Tornado Fatalities by Age and Gender (N = 34)**

Age Group	# of Male Fatalities	# of Female Fatalities	Total # of Fatalities
0 - 9	3	0	3
10 - 19	0	1	1
20 - 29	1	1	2
30 - 39	1	3	4
40 - 49	4	4	8
50 - 59	0	1	1
60 - 69	1	2	3
70 - 79	2	6	8
80 - 89	1	3	4
90+	0	0	0

Total	13	21	34
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Information on 21 fatalities was obtained by the survey. Everyone was inside of their home when hit by tornado. Among 21 deaths, 16 died in framed houses and 5 others died in mobile homes. Nine out of the 16 deaths in framed houses occurred in basements with windows. This is very ironic because those people did believe that the basement would provide the safest shelter for them. More analyses is added later. All the other 12 deaths occurred on the first floor of houses or mobile homes in a room with windows. Table 2 shows the fatalities by F-scale of damage to the home. There were 5 deaths caused by the F-2 strength, 1 death by the F-3, 13 deaths by the F-4, and 2 deaths by the F-5 strength. All 5 deaths caused by the F-2 strength occurred in two mobile homes, and the actual strength of the tornadoes might have been more powerful because the maximum F-scale to the demolished mobile home cannot be ranked higher than F-2 no matter how strong the wind speed would have been, according to the current system. The sharp difference in the number of deaths between F-3 and F-4 is interesting (1:13). All the deaths occurred instantly or within the same day of the tornadoes, except for an 8-year-old boy who died in a hospital 10 days later.

**Table 2. Tornado Fatalities by F-scales (N = 21)**

F - Scale	0	1	2	3	4	5
# of Fatalities	0	0	5	1	13	2

As shown in Table 3, the 21 deaths occurred at 9 sites (Sites A through I), 7 at framed houses (Sites A through G) and 2 at mobile homes (Sites H and I). Thirty-two people were present in these homes, and only 11 survived (survival rate = 37.5%).

**Table 3. Information on the Housing Sites of 21 Fatalities**

Site	# of People at the Site	# of Fatalities	# of Survivors	F-Scale at the Site	Type of Housing
A	7	6	1	4	framed house
B	2	2	0	4	framed house
C	3	3	0	4	framed house
D	2	1	1	5	framed house
E	2	2	0	4	framed house
F	2	1	1	3	framed house
G	5	1	4	5	framed house
H	5	2	3	2	mobile home

<b>I</b>	4	3	1	2	mobile home
<b>Total</b>	32	21	11	-	-

Table 4 and 5 show information on the 9 sites with the resident's location and behavior during the tornado. At Site A, 6 persons died, and this number was the largest. One of the victims spoke to her husband over the phone right before the tornado, warning him to be cautious about the bad weather. Victims had sensed a potential risk in the house because they all went down to the basement. The tragedy happened in the basement. The tornado removed the whole house above the basement instantly, sucking the 6 victims out of the basement and dumping them with other debris in the brush on the cliff 20-30 m behind the house. I searched the basement, and not much material or debris, except some heavy furniture, remained. Materials under the stairs were untouched by the tornado. One person survived in the basement, but details of that particular situation is unknown. Basements provide a safer room than above ground rooms, but they are not perfect. In this situation, the safest place in their basement was just under the stairs.

**Table 4. Location and Behavior of 21 Fatalities**

<b>Site</b>	<b>Location when victim(s) first became aware of tornado</b>	<b>Location when victim(s) were hit by tornado</b>	<b>Location when victim(s) were found after tornado</b>	<b>Distance if victim(s) blown away by tornado</b>	<b>Something victim(s) used to cover</b>	<b>Object hit or fell on victim(s)</b>
<b>A</b>	somewhere in home	basement with windows	outside in the bush	20-30 m	unknown	unknown
<b>B</b>	somewhere in home	room on first floor with windows	outside in the bush down the hill	more than 50 m	unknown	unknown
<b>C</b>	somewhere in home	basement with windows	collapsed basement	none	quilt to cover head	basement wall fell on the victims
<b>D</b>	bedroom on first floor with windows	bedroom on first floor with windows	outside	more than 100 m	none	unknown
<b>E</b>	bedroom on first floor with windows	bedroom on first floor with windows	outside	2 blocks away	unknown	unknown
<b>F</b>	kitchen on first floor with windows	kitchen on first floor with windows	kitchen on first floor with windows	none	none	walls and ceiling
	somewhere in	bedroom on first floor				

<b>G</b>	home	with windows	unknown	unknown	mattress	unknown
<b>H</b>	somewhere in a mobile home	somewhere in a mobile home	outside in the neighbor's yard	30-50 m	mattress and blanket	unknown
<b>I</b>	somewhere in a double wide mobile home	kitchen	outside in the ravine	90m	unknown	unknown

**Table 5. How Victim(s) Obtained Information on the Approaching Tornado and Their Vulnerabilities**

<b>Site</b>	<b>Whether victim(s) were aware of tornado warning</b>	<b>How victim(s) obtained the info</b>	<b>Time victim(s) had after warning until being hit</b>	<b>Whether victim(s) were awake</b>	<b>Physical or mental handicap if any</b>
<b>A</b>	yes	unknown	unknown	awake	no
<b>B</b>	unknown	unknown	unknown	awake	no
<b>C</b>	yes	phone call from husband	10 minutes	awake	no
<b>D</b>	no	-	0	asleep	deaf
<b>E</b>	unknown	unknown	unknown	unknown	one person had Alzheimer's disease and the other person was blind
<b>F</b>	no	-	0	awake	no
<b>G</b>	yes	unknown	unknown	awake	no
<b>H</b>	no	-	0	awake	no electricity at home
<b>I</b>	yes	TV	unknown	awake	no

Site B is just two houses away from Site A. The house did not have a basement, and an old couple were in a room with windows when the tornado hit. They must have known the risk before the tornado because one of them went outside to his van to get a flashlight. Their bodies were dismembered but were found in the bush down the hill 50 m from their house. The person's hand was still holding the flashlight when found. The two sites were unique because they were located on the top of the hill/cliff. The wind speed of tornado might have been locally stronger.

Another family took shelter in their basement at Site C. A victim was warned by her husband, who was away from home, over the phone. It was 10 minutes before the victims died in their basement by a collapsed concrete wall. Two children had been covered with quilts by their mother but more were found dead. The potential strategy for survival in this case would be to take cover under a sturdy material even in the basement, believed to be the safest location during

a tornado. Things could fall on people in the basement when hit by a tornado. To take cover under a sturdy material would also prevent persons from being sucked out of the basement.

The strong risk factor at Site D was the victim's physical vulnerability. The victim was deaf and sleeping when hit by the tornado. He was sleeping in his bedroom with windows on the first floor. Being hit by an F-5 strength tornado, the victim was blown away with the house for more than 50 m. In this case, the only way to survive would have been someone's assistance to relocate the victim to a safer place.

The strong risk factor at the Site E was also the victims' physical vulnerability. An elderly couple, a husband with Alzheimer's disease and his wife, who was blind, were very vulnerable in terms of sensing the risk and responding to it. They were believed to be in their first floor bedroom with windows when hit by the tornado. There is no other information about them, except their bodies were found two blocks away from their home. Again, there would have been no way for them to survive without someone's assistance.

At Site F, a victim did not know of the approaching tornado until she was hit. She was in the kitchen on the first floor. Although she was not blown away, the ceiling and walls fell on her. If she had sensed the risk, her destiny might have been different. The interior section of the house was not severely damaged.

At Site G, a victim was the only fatality among his five family members, most of whom were severely injured. Some debris hit hard on the victim's head. They knew the risk of an approaching tornado and hid under the mattress in a first floor bedroom with windows. The damage to the house was F-5, and they were all blown away a significant distance. Against F-5 wind speed, persons in the house would have been injured or killed anyway. A basement or installation of an underground or above-ground storm shelter would have been the only option for survival. It is not known if or when they had a warning. If they had enough time, taking a shelter in a neighbor's basement would have been the best option.

Site H was a mobile home. The strong risk factors were both social and constructional ones. According to a victims' friend, the victims had acknowledged the risk of being in a mobile home during a tornado, and they would have gotten out of the mobile home. The victims were not aware of the tornado warning. It is assumed that they went to the bedroom to take cover under the mattress with a blanket immediately before the tornado hit. The wind picked up the mobile home, smashed it into their neighbor's yard at a distance of 30-50 m. Both parents died but all three children survived with minor injuries. The children might have been given extra covers by their desperate parents. There were no sirens in the area. Yet, the main cause of their lacking the warning information was due to the fact that a power company had stopped their electricity as a result of their delayed payment. Although both parents were employed, one of their children had suffered a heart problem, having numerous expensive surgeries. The victims were socially vulnerable. There were many things that could avoid this misery. First, the power company should have sent electricity during tornado warning situations. The victims would also have received the warning if they had a battery operated weather radio.

Site I was another location of a mobile home. In this case, victims knew of the warning through TV, yet, they chose to stay in the mobile home. They were believed to be in the kitchen when hit by tornado. The three bodies of the victims were found with debris in the ravine, 90 m away from the original site. The only survivor had many lacerations. They were all tangled with the mobile home when found.

Table 6 shows information on vehicles parked near the victim's home. In total, 17 vehicles were identified at the sites, including 15 cars and 2 pick-up trucks. The degree of damage on each vehicle was assessed either major or minor, depending on the likelihood of potential passenger's safety. If a vehicle was tossed, rolled, or blown away, the moved distance was measured. At the Site A, 4 cars were blown away into the bush with housing materials. One of them fell off the cliff and ended up on its slope, severely damaged. Another car had a major damage, and 2 other cars and a pick-up truck had a minor damage. The pick-up truck had been parked behind the house against the moving direction of the tornado. The probability of survival rate, if victims took a shelter in a car, would have been 60% (3 out of 5 vehicles had a minor damage). There were 3 cars at the Site C. All of them received an only minor damage despite F-4 wind at the site. At the Site D, a car received a minor damage while a pick-up truck received a major damage. Both vehicles remained at the site against F-5 damage on the building. At the Site F, there was one car, and it received a

minor damage. The car remained at the site. At the Site H, there were two cars near the trailer. Both cars did not receive any damage while the mobile home was picked up by the wind, smashed into the neighbor's yard. No one would have been hurt at all if seeking a shelter in the vehicle. Four cars that had parked just beside the mobile home at the Site I did not receive any damage at all. Persons would have been saved if seeking a shelter in the car, instead of staying in the mobile home. This issue has been discussed by Schmidlin and King (1995). There was no vehicle at the Site E, and there was no information on vehicles at the Sites B and G.

**Table 6. Degree of Damage on Vehicles Parked Near the Victim's Housing Sites**

Site	F-scale	# of Vehicles	Type of Vehicle	Degree of Damage	Moved Distance
A	4	5	car car car car pick-up truck	major minor minor major minor	30 m 25 m 20 m 50 m 0 m
B	4	unknown	-	-	-
C	4	2	car car	minor minor	0 m 0 m
D	5	2	car pick-up truck	minor major	0 m 0 m
E	4	0	-	-	-
F	3	1	car	minor	0 m
G	5	unknown	-	-	-
H	2	2	car car	none none	0 m 0 m
I	2	4	car car car car	none none none none	0 m 0 m 0 m 0 m

Only 3 out of 17 (17.6%) identified vehicles received major damage at the nine fatality sites. The current research does not propose all persons should seek shelter in a vehicle during a tornado warning. Yet, vehicles provide a shield from tornadic winds with debris, occasionally standing with minor damage against even killer violent tornadoes as in this case. Vehicles parked near houses may receive a significantly lower wind speed than buildings themselves due to surface roughness caused by the buildings or trees. The lessons from the two mobile home sites should be further studied using more data for constructing better safety guidelines for mobile home residents.

If tornadoes with the same strength occurred 50 years ago, more lives would have been lost. It can be said that many lives were saved thanks to the early warnings, time of day, existence of numerous basements in the areas, as well as residents' proper actions during tornado. Yet, the results indicate that more lives are potentially saved by better actions. How many persons received the warning and took a shelter in an interior room without windows at the lowest floor in a framed house? This simple strategy should be reinforced to minimize the disaster.

The nine deaths that occurred in the basements indicate that persons still need to hide under heavy furniture even in a basement. Despite these deaths, there is no question that basements provide one of the safest places during tornado.

There were at least five deaths strongly linked to physical, mental, and social vulnerabilities. They could not have been avoided by individual actions. Societal help is needed for those. A good communication system would be key to saving those people who are somehow isolated from society.

The five deaths at the mobile home sites were avoidable if they sought shelter in a vehicle. These were classic cases that vehicles provide relatively safer environments than mobile homes as Schmidlin and King have been indicating since 1995 (Schmidlin and King 1995).

It seems that there is a relationship between the degree of injuries and the distance victim(s) were tangled with debris during the tornado. The longer the distance the victim is tangled with debris, the more likely that the victim has severe wounds. Further study is needed to verify this.

Over all, there were many similarities with previous Quick Response research reports conducted in Arkansas and Florida. The uniqueness with the present research area was that many houses had a basement. The safety of a basement against F-5 tornado was again tested and approved that it is still a very useful area. Yet, proper use of a basement as a tornado shelter is encouraged.

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[hazctr@spot.colorado.edu](mailto:hazctr@spot.colorado.edu)