Risk Factors for Death in the 27 March 1994 Georgia and Alabama Tornadoes

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Abstract

Field surveys were made one week after tornadoes killed 40 persons and injured over 300 in rural regions of Alabama and Georgia USA on 27 March 1994. Surveys were completed for samples of persons killed (N=20) and persons in the paths of the tornadoes but survived (N=31) to determine whether there were differences in personal characteristics, behavior, or location between the two groups. Persons who died were significantly older than persons who survived, more likely to be in mobile homes or in rooms above ground with windows, less likely to be watching television before the tornado, and were aware of the approaching tornado for less time than survivors. There was no difference in age, gender, race, marital status, education, disability, or previous experience with tornadoes prior between those who died and survivors.

Introduction

Tornadoes on 27 March 1994 killed 22 people in northeast Alabama and 18 in northern Georgia. We conducted field research in the disaster area following the storms to assess risk factors associated with death among persons in the tornado paths.

Adverse health effects of natural disasters do not occur randomly within a population but occur in a somewhat predictable pattern clustered in time, in space, or in certain groups of persons (Binder and Sanderson, 1987). Knowledge of the attributes of persons killed by tornadoes, their behavior as the tornado approached, and the circumstances of death, when compared with those persons who were not seriously injured, may be useful to evaluate tornado preparedness programs, safety rules, and warning methods (Ferguson, Ostby, and Leftwich, 1987; Sanderson, 1989). That information identifies high risk groups and high risk behaviors that could be used to improve tornado preparedness programs and tornado warning procedures.

White and Haas (1975, p. 276) observed that geographic differences in death rates were not explained by differences in tornado occurrence. They suggested that regional differences in death rates could be caused by differences in tornado severity, urbanization, building construction, preparedness, hospital facilities, warning systems, and the distinctive behavioral characteristics of individuals.

Previous studies of weather disasters have shown fatality rates varied with age of the victim (Moore, 1958; Centers for Disease Control, 1985; Sanderson, 1989; Carter, Millson, and Allen, 1989), sex of the victim (Beelman, 1967; Glass et al, 1980, Ferguson, Ostby, and Leftwich, 1987) and the victim's ethnicity (Moore, 1958; Perry et al, 1982, Aguirre, 1988). Previous experience with the hazard, access to warnings, and location when the tornado stuck have also been shown to affect risk of death.

An analysis of 155 tornado deaths occurring over a forty-year period in Ohio revealed that young boys and elderly women had a relatively high rate of death (Schmidlin, 1993). Information from death certificates showed 73% of victims were in a house, apartment, or commercial building when the tornado struck, 13% were in motor vehicles, and 9% in mobile homes. The primary (74%) cause of death was head or chest injuries or multiple trauma. However, data from death certificates

cannot provide information on behavior of the victim as the tornado approached, type of warning received, or experience with tornadoes. Comparable information on those who were not seriously injured is also not accessible years after the event.

The purpose of this research was to obtain information on persons who died in the tornadoes and those who survived. Field research in the weeks after the disaster allowed us to gather and preserve information which will be lost in coming years.

The Tornadoes of 27 March 1994

Severe weather developed over northern Alabama and Georgia during the afternoon of Sunday 27 March 1994 (Centers for Disease Control, 1994). Six major tornadoes and several smaller tornadoes touched down over an eight-hour period giving a total path length of about 400 km (Fig. 1). Four tornado watches were issued for the affected area by the National Severe Storms Forecast Center on 27 March and there were numerous tornado warnings issued by the National Weather Service (NWS) offices at Birmingham, Atlanta, and Athens. All but one death occurred in counties under tornado warnings at the time the tornado struck. Time between NWS issuance of a warning and death was typically 10 to 20 minutes. Forward motion of the tornadoes was about 80 km/hr.

The region affected by the tornadoes in the southern Appalachian mountains is hilly, wooded, and rural with a low population density (about 20 persons km^{-1}). Median age in the affected counties was about 32 years, 56% of the population over 25 years old had graduated from high school, and 30% of the occupied housing units were mobile homes (U.S. Bureau of the Census, 1993a, 1993b). There were no tornado warning sirens in the rural regions struck by the tornadoes. Most of the deaths occurred in areas near the margins or out of the range of NOAA Weather Radio broadcast stations.

No cities were struck by tornadoes although the tornado paths were just 75 km from Atlanta. Most of the damage was through forests and agricultural land. Many mobile homes were struck by the tornadoes, along with isolated rural frame houses, farm buildings, subdivisions of modern frame homes, and several rural churches.

Maximum strength of the tornadoes was difficult to judge where the path was only through forests and mobile homes as total destruction of these warrants no more than an F2 rating on the Fujita scale (maximum wind 180-250 km hr^{-1}) (Grazulis, 1991). Several of the tornadoes struck frame homes, however, and strengths of

F3 (maximum wind 250-330 km hr^{-1}) or F4 (over 330 km hr^{-1}) were indicated.

In the greatest tragedy, 20 persons died in the partial collapse of the Goshen Church struck by a tornado in Cherokee County, Alabama. Of the other 20 deaths in Alabama and Georgia, 15 persons were in mobile homes when the tornado struck, two were in frame houses (one without a foundation), two were outside, and one was in a destroyed motor vehicle. In addition to the deaths, there were 157 persons injured in Alabama and 147 injured in Georgia (John Bryan, FEMA, communication with authors).

Field Methods

Information on the tornado tracks and fatalities was collected from newspapers and county coroners prior to entering the field. During the period 4-8 April 1994 we visited the sites where 37 of the 40 fatalities occurred in Alabama and Georgia. A visit with the county coroners provided information on those who died in the tornadoes and names of relatives and other persons who could assist us in completing the field research.

Questionnaires modeled after that used by Carter, Millson, and Allen (1989) were completed for two samples, (1) persons who died from tornado injuries and (2) persons who were in the path of the tornadoes but survived with minor injuries. (Copies of the questionnaire are available from author Schmidlin). Most (84%) surveys were completed in person. The remainder were completed by telephone. Information to complete the questionnaires for the fatalities was obtained from county coroners, neighbors, or relatives. Several questions on behavior of the victims prior to the tornado remain unanswered because everyone in the structure was killed.

Surveys were completed for all 18 deaths in Georgia and the two deaths in Alabama that did not occur in the Goshen Church. Surveys were not completed for the 20 persons killed in the Goshen Church. Those persons were killed under a collapsed concrete block wall so differences in location, experience, age, gender, and other personal or cultural characteristics were not likely to be significant factors in determining risk of death in the church.

To obtain a sample of survivors, we drove along roads that intersected the paths and stopped to speak with persons found home or working outdoors in the areas of destruction. By this method, 31 surveys were completed for persons who were in the path of the tornadoes but survived with only minor injuries.

Statistical Analyses

Data were analyzed with SPSS (release 4.1, 1990) to test the null hypothesis that responses to the survey questions did not differ between those who were killed (N=20) and those who survived (N=31). A t-test was used to test for a difference in age between the two groups and the chi-square test was used on the categorical data. The hypothesis of no difference was rejected if $p < 0.10$. Responses of "refused" or "unknown" were considered missing in the analyses. There were few responses of "refused" in the survey but many responses of "unknown", especially for those who were killed. This reduced the sample size in many survey questions.

Results

There was a significant difference ($p = 0.04$) in age between those who died (mean 55.6 years, standard error 5.5 years) and those who survived (42.4, 3.7). There was no significant difference in marital status or gender between those who died (47% presently married, 55% female) and survivors (62% presently married, 61% female). Education levels were not different between the two groups. All persons surveyed, both fatalities and survivors, were white, except one survivor who was Asian-American. This is not surprising since 90% to 98% of the population is white in the counties where two or more deaths occurred (U.S. Bureau of the Census, 1993a, 1993b). Among the survivors in this study, 84% required no medical attention after the tornado, 10% were treated and released, and 6% were hospitalized.

There was a significant difference ($p = 0.001$) in the location of the respondent when the tornado struck. Among the fatalities, 75% were in a mobile home and 10% in a frame house, while only 23% of survivors were in mobile homes and 74% in frame houses. The others were outside or in a motor vehicle. This reinforces previous findings that persons in mobile homes are more vulnerable to death from tornadoes than persons in frame houses.

Among survivors, 29% first became aware of the tornado when they heard the roar of the storm, 23% saw it approaching, 16% heard the warning on television, 16% were told by a relative, friend, or neighbor, and 13% heard the warning on radio, and 10% did not know it was a tornado until it struck. The method of first becoming aware of the tornado was unknown for 80% of the fatalities so comparisons with the survivors were not possible.

Telephones, televisions, and radios were present in all of the homes where persons died and in homes of

all survivors. Only the few persons outside were not in a location with these sources of information. Only one home was found to have a NOAA weather radio. Information on whether a radio or television was on during the hour before the tornado struck was obtained for only 20% of the persons who died. There was no difference between the two groups in the percentage with a radio on but there was a significant difference ($p = 0.08$) in the percentage with the television on between those who died (25%) and survivors (70%).

Survivors were aware of the approaching tornado for a longer time ($p = 0.002$) than those who died. Of the seven fatalities for which this information was available, all became aware of the tornado less than one minute before it struck. Among survivors, 32% first became aware of the tornado less than one minute before it struck, 45% were aware of the storm one to five minutes before it struck, and 23% were aware a tornado was coming more than 15 minutes before being struck.

For persons in a building when the tornado struck, there was a significant difference ($p = 0.0004$) in position within the building. All persons who died were in a first-floor room above ground with windows. Among survivors, 37% were in a first-floor room above ground with windows, 33% were in a first-floor room above ground without windows (hallway or closet), 20% were in a room below ground without windows (basement or storm shelter), and 10% were in a room below ground with windows (walk-out basement).

All persons who died in buildings were in rooms where the floors, walls, and ceiling were blown away. In contrast, only 27% of survivors were in rooms with one or more walls blown away, 33% were in rooms with a collapsed or removed ceiling, and 10% of survivors were in a room where the floor was blown away. All persons who died were struck by an object during the tornado while only 30% of survivors were struck by objects during the tornado. These differences between persons who died and those who survived were all significant ($p < 0.0001$) and illustrated the importance in the integrity of the structure in protecting persons from death.

Sample sizes among those who died outdoors (N=2) and in a motor vehicle (N=1) were too small to analyze statistically. One person died of multiple injuries from flying debris while pulling a boat out of a lake. Another died under a collapsed tree while attempting to get into her house. Only one of the 40 deaths occurred in a motor vehicle. This man was ejected from a minivan when it was destroyed by the tornado. Three

other members of the family were injured but wore seat belts and were not ejected from the vehicle.

There was no significant difference between those who died and survivors in whether someone else warned them a tornado was coming. Significantly ($p = 0.03$) more of the survivors (35%) tried to warn or protect someone else than did those who died (0%). This was surprising since it had been suggested in the past that persons may put themselves at risk to protect others (Centers for Disease Control, 1988). However, a response to this question among those who died was generally available only for those who died alone and therefore had no opportunity to warn or protect someone else. None of those who died were known to have attempted to protect a pet or move property or possessions. None of the survivors or fatalities were known to have experienced a tornado before. Among survivors, 45% reported practicing what to do if a tornado struck but this information was generally not available for those who died. There was no significant difference in the presence of a mental or physical impairment among those who died (25%) and survivors (10%). The most common reported impairment was 'condition causing slow movement.'

Only 13% of survivors reported hiding under something in a building, such as furniture or a stairway, and 20% of survivors reported covering themselves with a rug, blanket, or another person. This information was not available for the fatalities.

Discussion

The importance of a substantial, well-anchored building in protecting occupants from death is evident from this research. All deaths of persons in buildings occurred when first-floor rooms disintegrated in the wind, most often in mobile homes (Fig. 2). Most survivors took the recommended action of going to an underground basement or storm shelter or, in homes without a basement, to a first-floor room without windows that protected them from being ejected from the building and gave protection from flying debris (Fig. 3). Few survivors took the recommended steps of hiding under heavy furniture or covering themselves with a blanket. Persons killed outside were crushed under trees or killed by flying debris. The single death in a vehicle came after ejection from the vehicle. These conclusions generally agree with Carter, Millson, and Allen (1989) and others. In contrast to some other tornado disaster studies, we found no differences in gender, education, or race between persons who died and survivors in this sample.

Government warnings preceded the deadly tornadoes by 10 to 20 minutes and nearly all persons had access to radio and television. However, the transfer of the warnings to residents in this rural region was inefficient. Although 61% of survivors had a radio on during the hour before the tornado and 70% had television on, only 29% of survivors became aware of the tornado through radio or television and 68% became aware of the tornado by seeing or hearing the storm or being told by another person. This may have been due to confusion from the repeated warnings issued for many counties over an eight-hour period, due to power failures in storms that preceded the tornadoes, or to lack of attention to radio or television on this holiday Sunday.

Our observations cast doubt on the recommendation that occupants of mobile homes and vehicles should get out and lie in a ditch. A common observation after the 27 March 1994 tornadoes was vehicles sitting with minor damage within 10 m of the location where a mobile home was destroyed and its occupants killed. The vehicles remained upright while the mobile home was blown 50 m or more.

Until a thorough study is made of tornado injuries and deaths in vehicles, residents of mobile homes should enter their vehicle and drive to a substantial building. Even if they do not reach a building, our observations indicate they are safer in their vehicle than in the mobile home. Although there have been some cases of multiple tornado deaths in vehicles (Glass, et al., 1980), most recent tornado disasters have had few deaths in vehicles. Carter, Millson, and Allen (1989) found that being ejected from a vehicle was a risk factor for serious injury or death in a tornado and suggested that widespread use of seat belts may improve survivability in vehicles. We suggest persons may be at lower risk belted in a vehicle than outdoors where ditches may not be available and flying debris and lightning can be lethal. Risk factors associated with vehicles in tornadoes need additional research.

Only one family was found to have a storm shelter. This family built a 3 m by 3 m concrete block underground shelter 12 years earlier and left their mobile home for the shelter during all severe thunderstorms. The family of four was in the storm shelter for 15 minutes before the tornado on 27 March destroyed their mobile home. Their survival in the mobile home was unlikely. Just 150 m away, a family of six was killed when their mobile home was destroyed. They did not have a storm shelter but a vehicle remained upright at the site of the six deaths. A

simple effective underground storm shelter should be encouraged for residents of mobile homes.

This study of persons who died and persons who survived the tornadoes of 27 March 1994 was only the second of its kind and provides some new information on risk factors for death in tornadoes. Like most studies of individual tornado disasters, it had a small sample size in a particular situation, a Sunday afternoon in the rural southern Appalachians. Continued field research of this type, collecting information on deaths and survivors soon after the disaster, will lead to improved preparedness and warnings.

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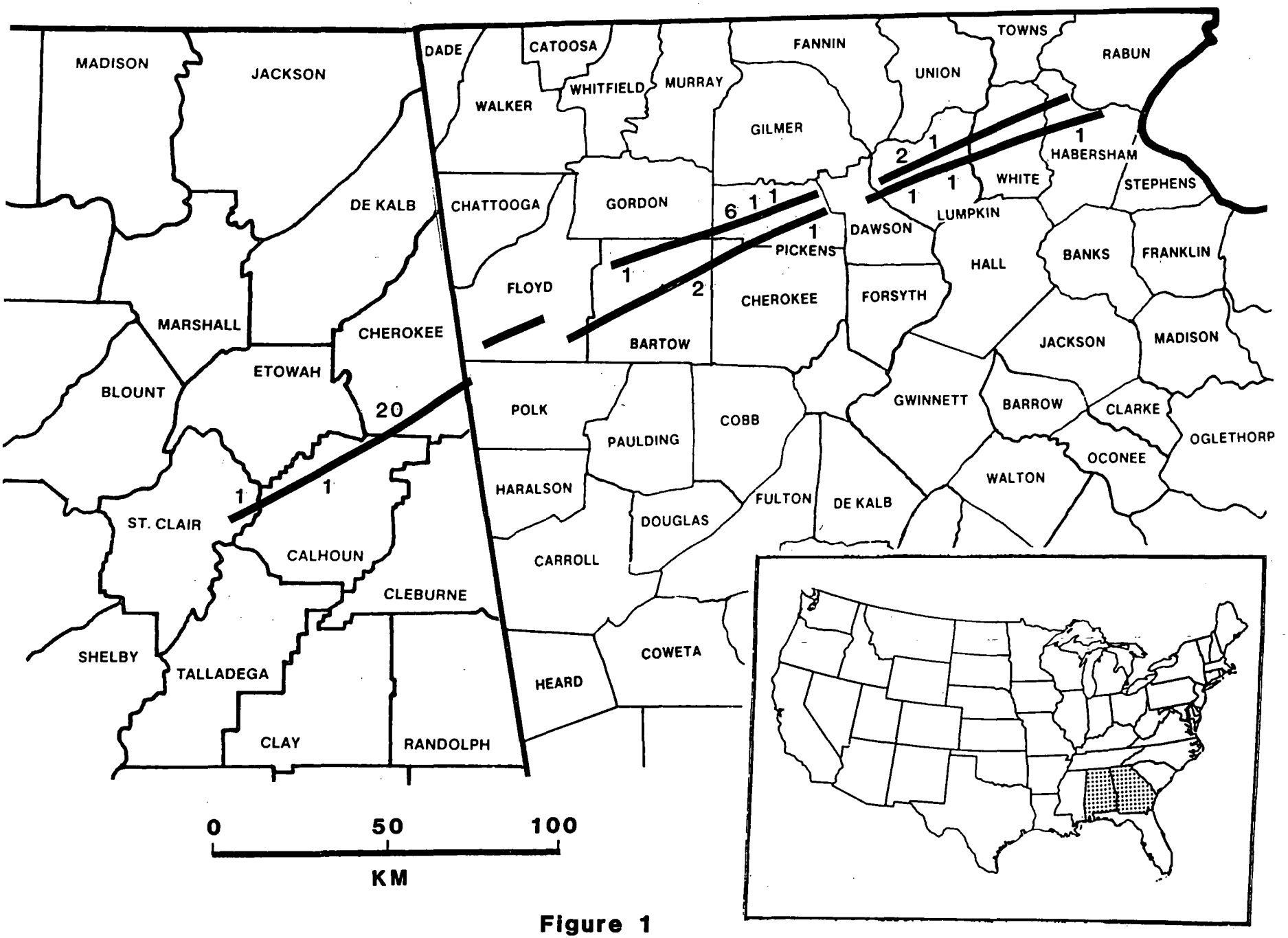
Figure Captions

1. Paths of major tornadoes in Alabama and Georgia on 27 March 1994. Several smaller and short-path tornadoes are not shown. Locations of fatalities and the number of persons killed in each location are shown by numbers along the paths.

2. Remains of a mobile home struck by a tornado in Bartow County. Two persons died as the home was blown about 20 m into trees, visible in the upper right. The unmortared cement block foundation is shown in the foreground. A 'tie-down' strap designed to anchor the home in high winds is visible in the center, still anchored in the ground but broken as the home was torn away. Other tie-down straps on this home were pulled out of the ground.

3. A destroyed frame home in Lumpkin County. Five persons took shelter in the hallway at the center of the house and survived without injury. The hallway, visible with white walls in the center, lost its ceiling but the walls remained intact and protected the occupants.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STEPHENS
LUMPKIN
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Figure 1

Figure 2

Figure 3