Quick Response Report #106 RISK FACTORS FOR DEATH IN THE 22-23 FEBRUARY 1998 FLORIDA TORNADOES

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Abstract

Field surveys were made in the week after tornadoes killed 42 persons in central Florida, USA, on 22-23 February 1998. Surveys were completed for persons killed (n=42) and a sample of persons in the paths of the tornadoes but who survived (n=86) to determine whether there were differences in personal characteristics, behavior, or location between the two groups. All but one of the deaths were in mobile homes or parked recreational vehicles.

Risk factors for death included advanced age, being in an above-ground room with windows, being in a room where the roof, wall, or floor was blown away, being hit by debris, and being unmarried. The well-known vulnerability of mobile homes is emphasized in these results. A lack of underground shelters or sturdy above-ground shelters for mobile home residents contributed to the high death toll. In addition, the midnight occurrence and lack of community sirens meant few people received warning of the approaching tornado, in spite of 10 to 24 minutes warning from the National Weather Service.

Introduction

Tornadoes on the night of 22-23 February 1998 killed 42 people in central Florida. We conducted field research in the disaster areas 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 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 to those who were not killed, may be useful to evaluate tornado preparedness programs, safety rules, and warning methods (Sanderson, 1989). That information identifies high risk groups and high risk behaviors that could be used to improve tornado preparedness and warning.

White and Haas (1975, p. 276) observed that geographic differences in tornado death rates were not explained by differences in tornado occurrences. 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 (Moore, 1958; Centers for Disease Control, 1985; Carter, Millson, and Allen, 1989; Schmidlin and King, 1995), sex of the victim (Beelman, 1967; Glass et al, 1980; Schmidlin, 1993), and the victim's ethnicity (Moore, 1958, Perry et al, 1982; Aguirre, 1988). Previous experience with the hazard, access to warnings, and the location when the tornado struck 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). However, data from death certificates cannot provide information on the behavior of the victims as the tornado approached, type of warning received, or experience with tornadoes. Comparable information on those who were in the tornado path, but were not killed, is also not available years after the event.

To seek this detailed information on those who die in tornadoes and those who survive, we initiated a research project several years ago to collect data soon after tornado disasters. Collection of data soon after a disaster allowed us to gather and preserve information that will be lost in

coming years.

In the first case, we conducted field research one week after the Georgia and Alabama Tornadoes of March 1994 (Schmidlin and King, 1995). A survey was completed for those who died (n=20) and for a sample of survivors (n=31) of the tornadoes. Fifteen of the 20 deaths were in rural mobile homes. Those who died were older than survivors, more likely to be in a room above ground with windows, less likely to be listening to the television, had less warning time, and more likely to have been struck by an object than survivors. Although NWS warnings preceded all of the killer tornadoes and 2/3 of survivors had a radio or TV on in the hour before the tornadoes struck, 68% became aware of the approaching tornado only by seeing or hearing the tornado. This gave little time for action.

The research continued following the tornadoes that killed 26 in Arkansas in March 1997. Fourteen of those deaths were in mobile homes, four in frame homes, and the remaining eight in commercial buildings, cars, and outdoors. Surveys of fatalities (n=25) and survivors (n=73) showed risk factors for death were being in a room above ground with windows and being in a room that lost walls, roof, or floor. More of the deaths were divorced (22%) than were survivors (1%). About 61% first became aware of the tornado when they saw or heard the tornado, giving little time for protective action. We found vehicles parked outside damaged homes to be remarkably stable, even with extensive house damage (Schmidlin et al, 1998)

The purpose of the present research is to obtain information on persons who died in the February 1998 Florida tornadoes and those who survived, to build upon our 1994 field work in Georgia and Alabama (Schmidlin and King, 1995) and our 1997 field work in Arkansas (Schmidlin and King, 1997)

Research Question

What locations, personal attributes, or behaviors increase the risk of death to persons in tornadoes?

The 22-23 February 1998 Florida Tornadoes

At least seven tornadoes were produced by four supercell thunderstorms across central Florida during the night of 22-23 February 1998 (Figure 1). Four of the tornadoes caused fatalities. There were 42 deaths and about 260 persons injured. Tornado watches had been issued by the NWS Storm Prediction Center for central Florida at 13:44 on 22 February effective until 21:00 and at 20:13 effective until 03:00 on 23 February. Both watches mentioned that conditions were favorable for the development of supercell thunderstorms. Severe weather developed in central Florida by 16:00, prompting several severe thunderstorm warnings and special marine warnings.

The first deadly tornado (F2) struck just west of Daytona Beach in Volusia County from 22:55 to 23:05. It killed one person and injured three along an 11 km path. The National Weather Service (NWS) in Melbourne issued a tornado warning for Volusia County at 22:41 effective until 23:15.

Another supercell produced a tornado (F3) that struck along a 32 km path in Lake and Orange counties from 23:37 to 00:00. This tornado killed three in Winter Garden in western Orange County and injured 70 people. The NWS issued tornado warnings for Lake County at 23:27 effective until 00:30, for western Orange County at 23:37 effective until 00:40, and then Seminole County at 23:46, effective until 00:55.

The same supercell produced a second tornado in Seminole County that continued into Volusia County. It killed 13 in Seminole County and injured 36 others along the 22 km path from 00:10 to 00:28. Seminole County was under a tornado warning for this storm from 23:46 until 00:55.

A third supercell thunderstorm produced a tornado in Osceola County at

00:40 that traveled 56 km before lifting at 01:28 in Orange County. This storm struck across Kissimmee, killing 25 in Osceola County and injuring about 150 persons. A tornado warning was issued for Osceola County at 00:22 effective until 01:20. The other tornadoes that night did not cause any injuries or deaths.

All counties where fatalities occurred were under tornado warnings at the time the tornadoes struck, giving warning lead times of 10 to 24 minutes. There were no community tornado warning sirens in the areas struck by the tornadoes.

Field Methods

We entered the field on 25 February for four days of field work. Prior to traveling to Florida, we collected information on the fatalities from the *Orlando Sentinel* web-site and other media. Preliminary information on the tornado tracks was available from the National Weather Service - Melbourne web site. Clearance to enter the disaster area was coordinated through the Florida Emergency Management Agency with assistance from the Director of the Ohio Emergency Management Agency.

We traveled to Orlando with Kent State University Geography graduate student Barbara Hammer. Two other KSU Geography graduate students, Yuichi Ono and Heather Heckman, traveled to Florida with us on Yuichi's Quick Response grant. The two teams cooperated in field work. The first day of field work focused on western Orange County, the second day in Seminole County , the third day in Osceola County, and the fourth day in Volusia County. Passes were required and obtained to enter the worst-damaged areas of Osceola County.

A survey (Schmidlin and King, 1995; and available from TWS) was completed for fatalities (n=42) by obtaining information from medical examiners, funeral home directors, relatives, or neighbors. A survey was also completed for each survivor we encountered (n=86). Survivors were sought who were in the same structure with someone who died or at sites adjacent to the fatalities. Most surveys were completed in person. A

small number were completed by mail after we returned from the field work.
Damage at the sites of deaths was evaluated with the Fujita Tornado Intensity Scale using Grazulis (1993) as guidance. Mobile homes were ranked F2 if they were totally destroyed. Parked recreational vehicles were ranked F1 if they were totally destroyed.

Data Analysis

Data were entered into an Excel spread sheet. Statistical analyses were performed to test the null hypothesis that the responses to the survey questions did not differ between those who were killed and those who survived. 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 analysis. Some questions could not be evaluated because responses among most of the fatalities were "unknown." This was common in cases where everyone in the home was killed.

Results

There were no deaths in frame houses during the Florida tornadoes, in spite of widespread F3 damage to occupied frame homes. Thirty-one of the deaths (74%) were in mobile homes (also known as manufactured homes), ten deaths (24%) were in parked recreational vehicles, and one death (2%) was in a vehicle. The deaths in recreational vehicles all came in the Ponderosa Park Campground, and were mostly in travel trailers and motor homes parked there as winter seasonal homes. Among survivors in our sample, 70% were in a frame home, 29% in a mobile home, and 1% outdoors when the tornado struck.
There was a significant difference ($p = 0.025$) in average age between

fatalities (48 years) and survivors (39 years). Sixty percent of the fatalities were males with no significant difference in gender between fatalities and survivors. Thirty-nine (93%) of the fatalities were white, two (5%) Hispanic, and one (2%) was black. In the survivor sample, 45 (52%) were white, 36 (42%) Hispanic, and five (6%) were black. There were significantly more whites among the fatalities than among the survivors ($p < 0.001$). Among persons, 18 years and older, 56% of fatalities were currently married compared to 92% of the survivors. This is a significant difference ($p < 0.001$).

None of the fatalities or survivors were in a room below ground when the tornado struck. No basements or underground storm shelters were seen or known in the region. All of the fatalities in buildings were in a room above ground with windows. There was also a significant difference ($p < 0.001$) between deaths and survivors in whether a wall was gone, the roof blown off or collapsed, or the floor blown off or collapsed in the room they were in, and whether they were hit by debris. In rooms where deaths occurred, 100% lost the ceiling, 100% lost a wall, 100% had the floor blown away, and 100% of deaths were hit by debris. In rooms where survivors were located, 60% lost the ceiling, 44% lost a wall, 27% had the floor blown away, and 51% of survivors were hit by debris. Among the survivors, 47% were taking shelter behind or under furniture or a stairway and 39% used a rug or blanket to cover themselves when the tornado struck.

Most (68%) of the survivors first became aware of the tornado when they heard or saw the tornado, 10% first became aware of the tornado through a warning on the television, and 18% were told of the tornado by a friend, neighbor, or relative (typically a family member in the same house). Warning sirens did not exist in any of the communities we surveyed. No one reported use of radio or NOAA weather radio to first receive the warning, although 32% of survivors reported a weather radio in their home. Only 2% of the survivors had a radio on during the hour prior to the tornado, while 34% reported watching the television in the hour prior to the tornado. Although tornado warnings had been issued 10 to 24 minutes prior to the first touchdown of each fatal tornado, 88% of survivors reported less than one minute awareness before the tornado

struck. The remainder reported one to five minutes awareness. Twenty percent of survivors had practiced what to do if a tornado approached and 7% had been directly affected by a tornado before.

There was one death in a motor vehicle. A man died when his vehicle was destroyed in the parking lot of the Buenavista Lakes Shopping Center, an area with F3 damage. He was alone in the car and reportedly talking to his wife on a cellular telephone when the tornado struck. It is not known whether he was wearing a seat belt. Carter et al (1989) suggested that persons increase their chance of surviving a tornado in a vehicle by wearing a seat belt, even if the vehicle is rolled over by the wind. None of the survivors in our sample were in vehicles when the tornado struck.

Discussion

These results clearly indicate the importance of protection by a building in preventing deaths. All deaths to persons in buildings occurred when above ground rooms disintegrated or collapsed in mobile homes and parked recreational vehicles. As reported also in our earlier results (Schmidlin and King, 1995; 1997), survivors were more likely to be in an interior room without windows. However, few survivors took the recommended action of hiding under heavy furniture or covering with a blanket. We earlier reported that few survivors of the 1994 Georgia tornadoes and 1997 Arkansas tornadoes took these precautions, leading to the conclusion that these simple steps should be reinforced in tornado preparedness programs.

Government warnings preceded the tornadoes by 10 to 24 minutes and nearly all persons had access to radio and television. The occurrence of these tornadoes near midnight on a Sunday night reduced the effectiveness of radio and television in conveying tornado warnings to the public. Several persons told us they watched the late evening news for storm information but did not see any warnings for their county so went to bed. Without community warning sirens or NOAA weather

radio tone alerts, the only warning most people had was the noise of the approaching tornado and associated debris hitting their home. This left just a few seconds to gather family members and seek shelter.

Several large communities of mobile homes were struck by the tornadoes, leading to large numbers of deaths and injuries. Residents of these mobile home communities did not have nearby underground shelter. The local 'shelter' in many peoples' minds was the community activity building. However, the sheltering value of these buildings is doubtful as they have large-span roofs, large glass windows, and did not appear to have the capacity to hold all the residents of the area. Several elderly residents told us their 'tornado shelter' was the local school, several blocks away, but they stayed in their mobile homes because there was not time to reach the school and it would have been locked at midnight on a Sunday. They had apparently been instructed that the school was their 'hurricane shelter' and assumed it would also serve as a tornado shelter. Actions to be taken during hurricanes and tornadoes need better distinction among Florida residents, especially the elderly.

With one exception, mobile home residents we surveyed did not leave their home to lie in a ditch or depression when they heard the tornado approaching. When we inquired why they did not take this step recommended by the National Weather Service and Red Cross, they responded that it was dark, they were in their night clothes, trees and wires were falling, things were blowing around, there were no ditches, ditches had alligators in them, and so on.

The finding that persons of Hispanic ethnicity were at less risk of death than whites may be an artifact of the tornado path. The mobile homes struck by the tornadoes were largely occupied by whites, while there was a larger Hispanic population in the modern frame homes along the path. The most severely damaged frame homes lost roofs and some exterior walls (F3) but interior walls protected the occupants from death.

This research found several results similar to those we reported earlier from Georgia and Arkansas tornadoes and a few contrasts with those results. Differences may result from the geographic and temporal setting of the disasters. Continued collection of this 'quick response' data will provide a stable and reliable data-base from a variety of situations from

which general conclusions may be drawn.

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