Emma O. Lew,[1] *M.D. and Charles V. Wetli,*[2] *M.D.*

Mortality from Hurricane Andrew

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ABSTRACT: Hurricane Andrew, a category 4 storm, made landfall in South Florida on August 24, 1992, and caused extensive structural and environmental damage. The Dade County Medical Examiner Department investigated 15 deaths directly related to the storm and another 15 natural deaths indirectly related to the storm. The aftermath of the hurricane continued to create circumstances that lead to 32 accidental deaths, five suicides, and four homicides over the next six months. Traffic fatalities due to uncontrolled intersections accounted for one-third of the post-storm accidental deaths. Dyadic deaths (homicide-suicide) doubled in rate for the six months following the storm. The limited number of direct hurricane deaths is attributed to advance storm warnings, its occurrence on a weekend, the storm's passage through less populated areas of the county, and the relatively modest amount of accompanying rainfall.

KEYWORDS: forensic science, forensic medicine, hurricane, weather, mortality, autopsy, homicide-suicide, natural disaster

Hurricane Andrew was the most recent major hurricane to strike South Florida, an area where the hurricane season spans the months of June through November. Hurricane Andrew, a category 4 storm by the Saffir/Simpson Hurricane Scale (1), made landfall at 5:05 A.M. on August 24, 1992, with sustained wind speeds of greater than 145 mph, gusts of at least 175 mph (Hurricane Specialist Max Mayfield, National Hurricane Center, Miami, Florida, personal communication, July 1995), and 93 decibels of sustained wind noise. Andrew has also been the most costly hurricane in the United States (2,3) as, four hours later, Dade County was left with 30 billion dollars in total damages, over 15 billion dollars in insurance claims, 103,200 homes damaged, 50,000 homes destroyed, and 68,000 new homeless people (Kathleen C. Hale, Director of the Metro-Dade Office of Emergency Management, personal communication, July 1995). The environmental, agricultural, and property damage created mountains of trash, 22 million cubic yards of which were removed at a cost of $540 million dollars. Despite these daunting statistics, the toll in human lives was not as great as feared, or as some continued to believe. This study documents the number and types of deaths associated directly and indirectly with Hurricane Andrew, and examines reasons why direct storm fatalities were relatively limited.

[1]Associate Medical Examiner, Dade County Medical Examiner Department, Miami, FL.

[2]Chief Medical Examiner, Suffolk County Medical Examiner Office, Hauppauge, NY.

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Methods

All hurricane-related deaths from the files of the Dade County Medical Examiner Department were divided into deaths that were directly related to the storm effects (direct deaths, 15 cases), natural deaths that occurred during the storm and over the next two weeks that were ascribed to storm-related activities (indirect deaths, 15 cases), and unnatural deaths attributed to hurricane-related activities. The basic criterion for all groups was "but for the hurricane, death would not likely have occurred." The two-week period for indirect deaths was chosen with the rationale that, after two weeks, the "acute excitement and response phase" would be over and storm effects stabilized. Despite the adverse circumstances of the post-storm period, medicolegal death investigations were carried out as thoroughly and completely as before the storm.

Results

Hurricane Andrew caused 15 accidental deaths directly as a result of its physical forces on land (12 deaths) and on the water (3 deaths) (Table 1). All 12 deaths on land involved victims who sought shelter inside a structure or vehicle. Among the land-based fatalities, eight died from injuries incurred as homes collapsed, and roofs and walls caved in, and four died of mechanical asphyxia from being crushed by falling debris. One of the asphyxiated victims was in the bed of a truck covered by a camper-top when a tree fell and pinned the man inside. Mobile homes and trailers were particularly susceptible to wind damage. Two of the four asphyxial deaths occurred in mobile homes, and two other people

TABLE 1—*Direct deaths.*

	On land (12):
Blunt Trauma (8)	
12 year old WF	Struck by falling roof beam
25 year old WM	Collapsing roof
74 year old WM	Ejected from turning trailer
49 year old WM	Ejected from turning trailer
46 year old WM	Collapsing home
49 year old WM	Collapsing barn (debris)
68 year old WF	Collapsing townhouse
54 year old WM	Collapsing roof
Mechanical Asphyxia (4)	
47 year old BM	Pinned by tree inside truck
62 year old WM	Found in destroyed mobile home
67 year old WM	Collapsed ceiling of retirement home
80 year old WF	Destroyed trailer
	On water (3):
37 year old WM	Struck by flying debris and knocked overboard
32 year old WM	Found in canal after trying to secure boat
56 year old WM	Washed overboard—body not recovered

died from blunt trauma as they were ejected from overturning trailers.

The water-based deaths involved two separate incidents. In one, three men were on a boat during the height of the storm when the door to the cabin flew open. One victim attempted to close the cabin door and was virtually decapitated by flying debris and thrown overboard; his body was found in the water six days later. The second victim was washed overboard as he attempted to help his friend; his body was never recovered. The third man stayed in the cabin and survived the storm. In the second incident, a man was seen attempting to secure his boat during the storm, and his body was recovered later in the day from the canal in which he drowned (but the boat was never found).

Circumstances engendered by the hurricane contributed to 15 natural indirect deaths during, and within the two weeks following, the storm (Table 2). During the storm, two individuals experienced symptoms, but could not be reached by rescue personnel. The first, a previously healthy 81-year-old female complained of gas pains and shortness of breath; the autopsy disclosed an acute myocardial infarct and occlusive coronary atherosclerosis. The second, a 22-year-old woman in her third trimester of pregnancy complained of severe headaches, and died from intracerebral hemorrhage associated with eclampsia. A third individual, a 63-year-old woman, appeared to have died of atherosclerotic heart disease during the hurricane. Her decomposing body was found in her dining room four days after the storm. Scene findings indicated that she was hiding in the bathtub until the window was blown in, whereupon she fled the bathroom, closing the door behind her.

The two weeks following the hurricane brought twelve additional cardiovascular deaths: four (aged 72 to 94 years) were related to evacuation from nursing homes; seven (aged 41 to 78 years) were associated with increased physical exertion during post-storm cleanup operations. An additional person, a 36-year-old schizophrenic, died suddenly following a psychotic hyperactivity episode during which he attacked his mother and sister because there was no ice available for his drinks. Autopsy disclosed no anatomic cause of death, and toxicological analyses were negative.

The six months following the hurricane saw 32 accidental deaths attributable to the aftermath of the storm (Table 3). Disruption of traffic light signals, and loss of stop signs, street signs and other traffic information posted at intersections resulted in 11 vehicular-related fatalities from nine separate incidents.

TABLE 2—*Indirect deaths (15).*

	During storm (3):
81 year old WF	Acute MI during evacuation
63 year old BF	Found in dining room after apparently fleeing bathroom
22 year old WF	Intracerebral hemorrhage due to eclampsia associated with third trimester pregnancy
Cardiovascular deaths during two week period after storm (12):	
67 year old WM	Chest pains while sealing a window
73 year old WM	Trimming trees
51 year old WM	Collapsed upon seeing damage to business
76 year old WM	Collapsed getting plywood
72 year old WM	During evacuation from damaged home
94 year old WF	During evacuation from damaged home
81 year old WF	During evacuation from damaged home
80 year old WF	During evacuation from damaged home
66 year old WM	Collapsed during cleanup
40 year old WM	Collapsed while driving to bring supplies
42 year old WM	Working 15 hrs/day for 13 days restoring electrical power
36 year old WM	Schizophrenic hyperactivity episode initiated by lack of ice

Complications from falls claimed six victims whose average age was 73 years. A 52-year-old man fell off a table, striking his head on the concrete floor, as he was attempting to repair his ceiling. A 68-year-old worker from out-of-state died of blunt trauma after falling off a roof. In separate incidents, a 74-year-old woman fell from her third floor balcony, and a 78-year-old legally blind man fell from a seventh floor balcony after portions of the balcony had been destroyed by the hurricane. A 74-year-old woman fell to the ground as she was trying to remove tape from her seventh floor window. An 89-year-old woman fell backwards off the sofa and sustained an impacted right femoral neck fracture while helping her husband put up a portrait. Although she was admitted to the emergency room within 15 minutes, the hospital had lost electrical power during the storm, disabling the air-conditioning unit, and the woman's course was complicated by heatstroke (body temperature 108°F).

Downed power lines left entire neighborhoods without electricity for many weeks and the corresponding use of generators, fires and candles lead to seven accidental deaths: a 47-year-old man was pouring gasoline when it was ignited by a pilot light, and he became engulfed by the flames; a 51-year-old man died in a fire caused by an electrical overload in the travel trailer in which his body was found; two sisters (9 years and 6 years) died in a house fire while they were using candles during the power outage; a 29-year-old laborer from out of state was sleeping in his truck when his campfire burned out of control, engulfing his vehicle. Two died from carbon monoxide poisoning from the use of gasoline operated generators indoors without proper ventilation: a 23-year-old man had been drinking heavily before he fell asleep in an outbuilding (a generator was in the room next to where his body was found); a 55-year-old business owner was anticipating intruders, so he slept upstairs in his warehouse while the generator was operating downstairs.

The three electrocution deaths involved men who were engaged in various repairs: a 44-year-old man was electrocuted when he rested an aluminum beam against a wall (damaged 110-voltage electrical conduits leading from a pump-driven electrical compressor into the building had energized the wall); a 31-year-old lineman was doing repairs in a "cherry picker," using a drill that was connected to a truck-mounted generator, when he was electrocuted; a 36-year-old man contacted a 220 volt line while re-installing a storm-damaged fan on a roof.

Two men died while cutting trees: a 22-year-old man was struck in the head by a large branch as he was cutting down a tree. The second, aged 52 years, was helping to trim an uprooted 12 to 15 foot diameter tree stump. The decedent was standing behind the root portion as a coworker cut off a substantial portion of the tree, thereby shifting the center of gravity and causing the stump to spring upright and pin the victim beneath the root mat.

Miscellaneous causes of three accidental deaths included: a 21-year-old man crushed in the neck by the falling bed of a defective dump truck; a 55-year-old man struck by lightning as he stood outdoors holding a portable radio; an 8-day-old infant that asphyxiated after becoming wedged in the side of a suspended rocking cradle at a shelter (the locking pin to stop the cradle from rocking was absent). Although sudden infant deaths have been associated with this type of cradle (4), it should be noted that the incident

TABLE 3—*Delayed indirect deaths (32).*

	Vehicular-related (11):
50 year old WF (passenger)	Downed stop sign
19 year old WM (passenger)	Downed stop sign
31 year old BM (motorcycle passenger)	Downed stop sign
25 year old BF (driver)	Inoperative signal light
28 year old WF (driver)	Collided with dump truck
29 year old WM (driver)	Collided with tow truck
35 year old BM (driver)	Downed stop sign
14 year old BM (passenger)	Downed stop sign
31 year old WM (driver)	Struck by tractor trailer
43 year old WM (motorcyclist)	Struck head on hurricane debris
43 year old WF (driver)	Stop light destroyed
	Falls (6):
52 year old WM	Fall from table to concrete floor while repairing ceiling
68 year old WM	Construction worker fell from roof
74 year old WF	Fall from damaged 3rd floor balcony
78 year old WM	Fall from damaged 7th floor balcony
74 year old BF	Fell while removing tape from 7th floor window
89 year old WF	Hip fracture complicated by hyperthermia due to loss of electrical power and air conditioning in hospital
	Fire (5):
47 year old WM	Burnt after pilot light ignited gasoline being poured
51 year old WM	Smoke inhalation in trailer fire due to electrical overload
29 year old WM	Campfire engulfed laborer sleeping in truck
9 year old BF	House fire from candles
6 year old BF	House fire from candles
	Carbon monoxide (2):
23 year old WM	Sleeping with generator in next room
55 year old WM	Sleeping above generator
	Electrocution (3):
44 year old WM	Storm-damaged electrical conduits
31 year old WM	Lineman working with electrical drill in cherry-picker
40 year old WM	Re-installing damaged roof fan
	Tree-cutting (2):
52 year old WM	Crushed by imbalanced tree stump
22 year old WM	Struck by large tree branch
	Miscellaneous (3):
21 year old WM	Neck crushed by bed of dump truck
55 year old WM	Struck by lightning while talking on hand-held radio
8 Day WM	Asphyxiated in rocking cradle at shelter

occurred in a hurricane-relief shelter and the cradle was loaned by a relief agency.

Reactive depression from loss of homes, businesses, and life-styles, compounded by insurance problems, prompted four men aged 52 to 63 years to commit suicide, three by self-inflicted gunshot wounds and one by hanging, all within 67 days of the storm.

Two homicidal incidents were related to Hurricane Andrew. A 16-year-old male robber was shot by an armed homeowner who was retrieving possessions from his destroyed home 20 days after the storm. The second incident involved a Florida National Guardsman (assigned to the relief effort) who fatally stabbed three students (two males aged 20 and 21 years and a 15-year-old female) after an evening of bar-hopping 36 days after the storm.

Incidents of dyadic deaths (homicide-suicide) claimed the lives of 26 people in the six months following the storm.

Discussion

Hurricane Andrew's limited direct mortality can be accredited to three main factors. Firstly, the National Hurricane Center provided storm warnings several days in advance, allowing an opportunity for the reinforcement of homes and evacuation of people from areas of potential flooding. Also, residents were able to take advantage of the weekend to prepare before Andrew made landfall in the early hours of Monday morning. This advance warning is a luxury not always possible in other types of natural disasters such as earthquakes. Secondly, Andrew had modest accompanying rainfall, $7^1/_2$ inches instead of a potential 40 inches, and was, in other words, a "dry" hurricane. Drowning is the main cause of hurricane deaths (5). Torrential rains and storm tidal surges that dump up to 20 feet of water along coastal regions cause sudden flooding and are more deadly than the hurricane force winds (5). Thirdly, Hurricane Andrew's path spared major metropolitan areas of Dade County. Had Andrew's path been 20 miles north of its actual route, it would have swept through Miami Beach, downtown Miami, and Hialeah, and crossed the west coast of Florida at Fort Myers instead of the Everglades.

Understandably, in view of Andrew's destruction, rumors were rampant, describing anywhere from tens to hundreds or thousands of victims buried in and under debris, the existence of mass graves,

secret morgues, and the clandestine removal of dead bodies by refrigerated trucks or military trains by night. The news media occasionally intensified rumors by reporting unsubstantiated findings. People who witnessed relief workers unloading dozens of body bags assumed the worst, and helped fuel accounts of many dead bodies. Odor from rotting fish in beached boats and decaying food and animals in decimated residences was ascribed to decomposing human victims. And, when various agencies could not verify such rumors, some alleged that the government, Medical Examiner Department and news media were participating in a massive coverup to allay the fears of the public in an effort to protect the tourist industry.

About one-third of the traumatic deaths were from motor vehicle crashes at uncontrolled intersections. Since volunteers cannot possibly be deployed to all intersections, broadcast warnings and/or temporary signs placed at busy but non-major intersections might reduce similar mortality in the future. Despite the lack of electrical power, deaths from fire and carbon monoxide (from gasoline generators) were relatively few. Again, recommendations for the use of flashlights rather than open-flame lamps and candles, and continued warnings about proper ventilation for gasoline generators should continue to keep such deaths to a minimum in future natural disasters. The news media can provide an important public service by alerting residents to the dangers of open flames and carbon monoxide-producing generators, as well as reporting on traffic flow in problem areas.

Two unexpected categories of death were related to Hurricane Andrew, and these may be worthy of consideration for areas likely to be affected by future storms. One was the unexpected increase in cardiovascular deaths in the elderly for the week following the storm. The medical examiner case load doubled (from an average of 10 cases per day to 20 or more per day) during that one week, with the increase due predominantly to "natural" cardiovascular disease in the elderly. Although these deaths could not be attributed directly or indirectly to the storm, their collective demise in temporal proximity may represent the toll of Hurricane Andrew's physical and psychosocial stresses on those with limited cardiovascular reserve. Studies support that acute emotional/psychological stress may indeed be associated with increased mortality in susceptible individuals (6). While additional efforts by local government or individuals may not further reduce the number of deaths directly attributable to the violence of hurricanes, some cardiovascular deaths could, conceivably, be prevented by educating the public about the dangers of cardiovascular stress from exertion and heat on sedentary individuals of middle age or older.

The second unexpected category of death was the doubling of dyadic incidents (homicide-suicide) where one partner in a relationship (usually the husband or boyfriend) kills the other partner (wife or girlfriend) before killing himself. The Dade County average of 1 dyadic death per month between January 1, 1988 and August 23, 1992 doubled in the six months following the hurricane, and, just as unexpectedly, returned to the pre-hurricane rate in the next six month period. Again, the only relationship to the storm is a temporal one.

That the abrupt but limited increase in cardiovascular and dyadic deaths may be the result of storm-associated stress is further supported by the general increase in domestic violence, child abuse and substance abuse which rose in the months after Hurricane Andrew (Kathleen C. Hale, Director of the Metro-Dade Office of Emergency Management, personal communication, July 1995). Anticipation of similar stress-associated events in future storms may prompt agencies involved with disaster management planning to take preventive action and provide additional psychosocial support and, in particular, medical support for the elderly.

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Address requests for reprints or additional information to
Emma O. Lew, M.D.
Dade County Medical Examiner Department
One Bob Hope Rd.
Miami, FL 33136-1133