Deaths Directly Caused by Hurricane Katrina

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Abstract

Objective: Previous studies have used multiple death databases to estimate the death toll of Louisiana residents from Hurricane Katrina; however, these studies did not incorporate autopsy reports as a data source.

Methods: Autopsy reports from Katrina were used in combination with the Disaster Mortuary Operational Response Team's list of confirmed victims and death certificate data to re-estimate the number of deaths of Louisiana residents, and to identify more accurately the cause and location of death of Katrina victims. Using 2000 U.S. Census data, age, sex and race specific death rates were calculated for victims from Orleans and St. Bernard Parish, where 86% of Katrina deaths occurred.

Results: Hurricane Katrina was responsible for the death of up to 1,170 persons in Louisiana; the risk of death increased with age. Most deaths were caused by acute and chronic diseases (47%), and drowning (33%). The disease death rate was higher in Orleans Parish; the drowning death rate was higher for St. Bernard Parish. Moreover, in Orleans Parish, men were 1.47 times more likely to die than women. Most victims died in private residences (35%).

Conclusions: This study shows the importance for emergency disaster plans to consider the needs of elders, which have the highest risk of drowning and disease deaths. Furthermore, residents in healthy condition should be encouraged to evacuate for future hurricanes and be warned of the risks due to drowning and disease complications if they stay at home.

Key Words: Hurricane Katrina, Louisiana, mortality, drowning, flooding, disaster preparedness, data sources, coroner autopsy reports, vulnerable populations.

Introduction

Hurricane Katrina was one of the deadliest hurricanes ever to strike the United States. The secondary effects of the storm, especially flooding of 80% of New Orleans and surrounding parishes of up to depths of 20 feet (Knabb, 2005), caused unprecedented public health challenges for the Gulf Coast region.

Hurricanes are the most common natural disaster that the Gulf Coast incurs, especially as the population in the coastal areas increases and the wetland surface decreases. In order to improve the public health response to hurricane disasters, it is important to understand the burden and causes of death of Hurricane Katrina victims as well as victim demographics and location of death. Knowledge of this information will help both individuals and medical facilities improve evacuation recommendations in preparing for future hurricanes.

Brunkard, Namulanda, and Ratard (2008) published Katrina-related death totals and causes of death of Louisiana residents. Their data sources include the Hurricane Katrina Disaster Mortuary Operational Response Team (DMORT) data base and death certificates of Louisiana residents who either died in state, or Louisiana residents who moved, but died as a direct result of Hurricane Katrina injuries. Since the publication of this data, Louisiana autopsy reports from Katrina have become available - allowing the increase of the estimate of the number of Katrina-related deaths of Louisiana residents from 986 to 1170. These reports permit the identification of the cause and location of death of more Katrina victims.

Methods

Data Sources: Data sources for this study include the same Hurricane Katrina DMORT database and Louisiana and out-of-state Louisiana resident's death certificates that were used by Brunkard et al. (2008). Additionally, this study had access to 717 coroner autopsy reports.

Classification: Coroner reports were matched to existing reports in the Microsoft Access ® database used by Brunkard et al. (2008) on coroner case numbers, secondarily on personal identifiers (names, date of birth). Autopsy report data that could not be matched to existing reports were added to the database. The same definition of place and time as Brunkard et al.(2008) was used. Deaths occurred between 8/29/2005 and 9/30/2005, or the bodies were found during this time period.

Each Katrina victim was assigned a cause and location of death. Causes of death classifications include disease, drowning, hospice/terminally ill, suicide, trauma (firearm, poisoning, electrocution, traffic related, burns, electrocution, exposure to the elements, other trauma deaths), or unknown. The disease classification includes all persons that died of either acute or chronic disease. The terminally ill classification means that the victim was under care of a hospice facility; these individuals were listed separately from disease deaths.

All victims were also classified by location of death: home, hospital, residence, public, nursing home, hospice, or unknown. "Public place" was used for victims found in a public location such as street or parking lot, Convention Center, Superdome, or airport. "Hospital" was used for inpatient but not for victims brought to a hospital mortuary after death.

Analysis: Statistical software used were SAS ® 9.1 and EpiInfo 3.4.3.

Results

It appears that there could be 1155 deaths as a direct result of Hurricane Katrina, 184 more than had been previously recorded by Brunkard et al. (2008).

Victim Demographics: The distributions of cases by gender, race and age group are presented in Table 1, comparing data of this study with that of Brunkard et al. The overall distributions are similar in both studies.

Table 1: Comparison of deaths from Brunkard and present study

Results		Brunkard et al (2008)	This study
Number of deaths	Katrina-related deaths (LA)	971	1155
	Katrina-related deaths (other states)	15	15
	TOTAL DEATHS	**986**	**1170**
Gender	Male	512 (53%)	621 (54%)
	Female	437 (45%)	524 (45%)
	Missing	22 (2%)	10 (1%)
Race (Ethnic Group)	Black (non-Hispanic/Latino)	498 (51%)	610 (53%)
	White (non-Hispanic/Latino)	403 (42%)	443 (38%)
	Hispanic/Latino	18 (2%)	26 (2%)
	Other (American Indian, French Islander, and Asian)	9 (1%)	10 (1%)
	Missing	42 (4%)	66 (6%)*
Age	Average	69.0	68.6
	Range	0-102	0-106
	Age ≥75	472 (49%)	538 (47%)
	Age ≥45 and <75	392 (40%)	461 (40%)
	Age <45	85 (9%)	105 (9%)
	missing	22 (2%)	51 (4%)*

Table 1. This table summarizes demographic data from our study as compared to Brunkard et al (2008).
*Some victims were unknown in the original (Brunkard et al., 2008) database and some unknowns were added in our supplementary one. Therefore, there may be a few duplicates of the unknown victims.

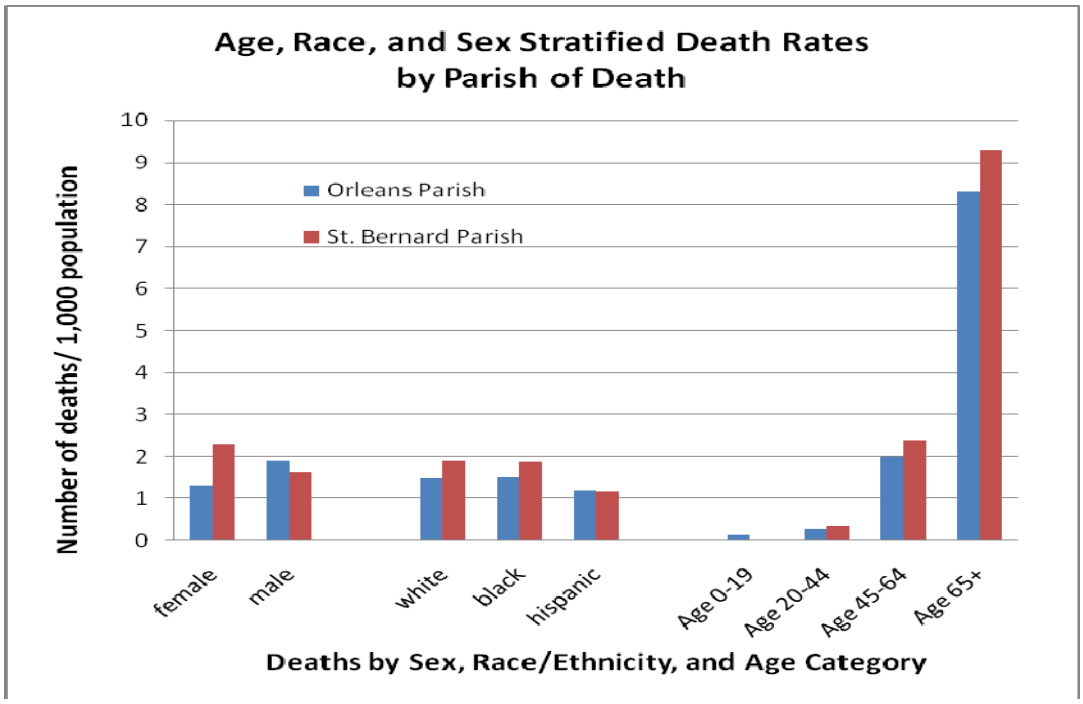
Age, race, and gender specific mortality rates per 1,000 population are presented in Table 2, focusing on Orleans and St. Bernard parishes because these were the most affected parishes. The overall death rates were 1.6 in Orleans and 2.0 in St. Bernard. Rates were higher in males in Orleans and in females in St. Bernard. There were no significant differences by race (Odds ratios close to 1 and confidence intervals overlapping 1 in all categories).

Table 2: Death rates per 1,000 population for the selected period

All victims (n= 1155)		Orleans Parish (n= 769)				St. Bernard Parish (n= 132)			
	# deaths	# deaths (%)	Rate /1,000	Odds Ratio* (CI)	p-value	# deaths (%)	Rate /1,000	Odds Ratio* (CI)	p-value
All	1145	767	1.641	---	---	132	2.01	---	---
Female	524	334 (44)	1.297	Ref.	Ref.	79	2.274	Ref.	Ref.
Male	621	433 (56)	1.907	**1.47** (1.27, 1.70)	<0.001	53	1.631	0.72 (0.50, 1.03)	0.06
White	443	211 (29)	1.505	Ref.	Ref.	116 (88)	1.925	Ref.	Ref.
Black	610	502 (68)	1.525	1.01 (0.86, 1.19)	0.87	10 (8)	1.892	0.98 (0.49, 1.93)	0.96
Hispanic	26	18 (2)	1.214	0.81 (0.48, 1.33)	0.38	4 (3)	1.168	0.61 (0.19, 1.70)	0.32
0-19 Black White	27 15 1	23 (3) 14 (2) 1 (0)	0.158	Ref.	Ref.	0 (0) 0 (0) 0 (0)	0	-----	----
20-44 Black White	77 54 21	55 (7) 48 (6) 7 (1)	0.304	**1.93** (1.16, 3.23)	0.01	10 (8) 1 (1) 8 (6)	0.346	Ref.	Ref.
45-64 Black White	305 194 104	201 (27) 160 (21) 40 (5)	1.982	**12.56** (8.02, 19.83)	<0.001	36 (27) 6 (5) 29 (22)	2.372	**6.86** (3.28, 14.74)	<0.001
≥65 Black White	694 341 340	470 (63) 280 (37) 181 (24)	8.296	**52.56** (34.05, 81.85)	<0.001	86 (65) 3 (2) 83 (63)	9.285	**26.85** (13.53, 54.91)	<0.001

On the other hand, there was a huge increase with age in both Orleans and St. Bernard. Those 65 years and older had the highest odds ratios, 52 in Orleans and 27 in St. Bernard (Figure 1).

Figure 1: Mortality rates by gender, race and age group in Orleans and St Bernard parishes.



Cause of Death: Data on cause of death are only available for 1040 victims - 240 more than published in Brunkard et al. (2008). Death rates by cause of death are presented in Table 3.

Table 3: Death rate per 1,000 population by death causes for Orleans and St. Bernard parishes

Age Range (Years)	Orleans Parish Death Rates by Cause Per 1,000 population			St. Bernard Parish Death Rates by Cause Per 1,000 population		
	Drowning	Disease	Other	Drowning	Disease	Other
Less than 5	0.03	0.06	0.84	0	0	0
5-9	0.03	0	0.027	0	0	0
10-14	0.13	0	0.02772	0	0	0
15-19	0.10	0	0	0	0	0
20-24	0.08	0	0.15	0	0	0
25-34	0.11	0.02	0.11	0.11	0	0.12
35-44	0.19	0.09	0.12	0.65	0	0.09
45-54	0.72	0.54	0.34	1.07	0.32	0
55-59	0.71	0.95	0.38	3.08	0.31	0.31
60-64	1.50	1.32	0.54	3.08	0.39	0.771
65-74	1.17	1.86	0.62	1.89	0.95	0.19
75-85	3.65	5.42	1.48	9.69	3.44	0.31
85+	6.21	11.07	2.97	29.49	3.85	1.28

The mechanism of injury of the trauma deaths were: firearm (8), poisoning (6), burns (2), from exposure to the elements (2), traffic accident (4, mostly pedestrians), and other trauma (11). With the exception of an 85 year-old White male, all deaths from firearms occurred in African-Americans less than 52 years of age. Only one firearm death was of a female. Six persons died as a result of poisoning; half were a result of carbon monoxide and half were drug- related. The average age of poisoning deaths was 48.2 (range: 30 to 66 years old) and two thirds of the deaths occurred in males. All but one death occurred in Caucasians.

Age specific mortality rates (drowning, disease, and other) were calculated for St. Bernard and Orleans Parishes.

Figure 2: Age specific death rate by cause of death among Orleans residents

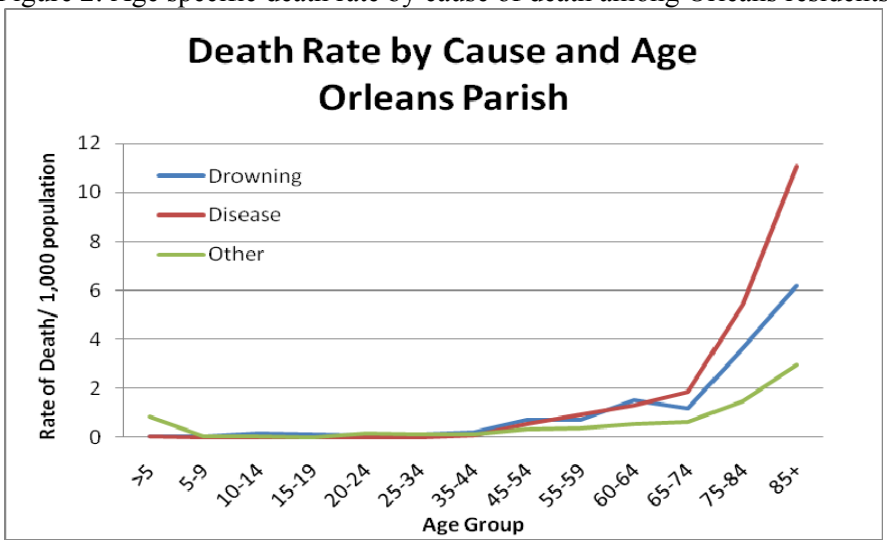
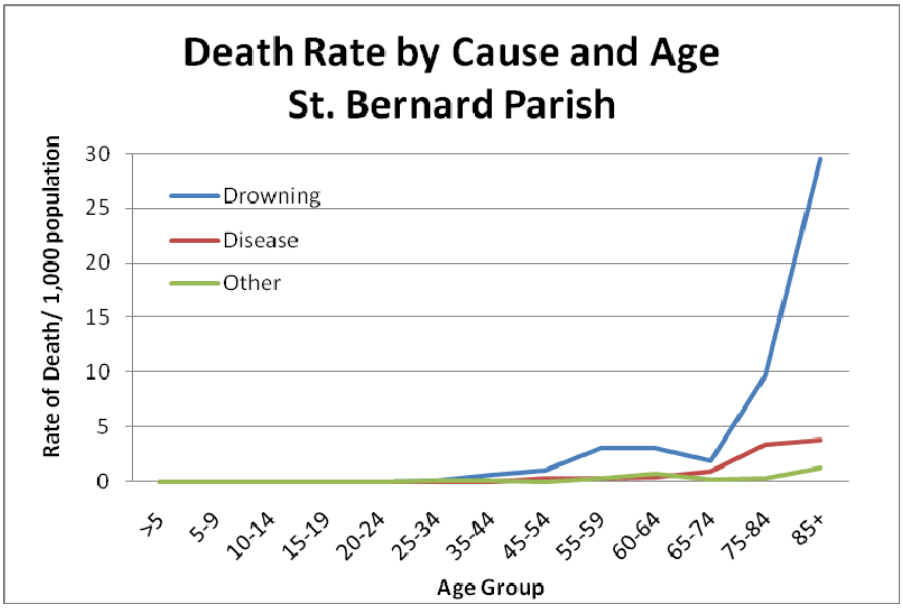


Figure 3: Age specific death rate by cause of death among St. Bernard residents



Mortality rates of drowning, disease and other deaths increased with age. Drowning mortality rates were higher in St. Bernard Parish than in Orleans Parish (29.5 vs. 6.2 deaths/ 1,000 population); however, disease mortality rates were lower in Orleans Parish than in St. Bernard Parish (11.0 vs. 3.8 deaths/ 1,000 population).

Location of Death: Location of death was categorized for 68% of the deaths that. The distribution is presented in Table 4.

Table 4: Number of deaths by Location of death

Cause of Death	Location of Death					
	Hospital	Public Place	Residence	Nursing home	Hospice	Unknown
Deaths from Disease	100	52	113	97	----	180
Hospice/ Terminally Ill	----	----	----	----	9	----
Drowning	0	34	260	35	0	57
Trauma	0	8	10	----	----	15
Suicide	0	1	7	----	----	2
Unknown	41	5	14	----	----	115
Total	141 (12%)	100 (9%)	404 (35%)	132 (11%)	9 (1%)	369 (32%)

Discussion

It is likely that the true number of immediate deaths caused by Hurricane Katrina is somewhere between the 971 deaths that Brunkard et al. (2008) reported and the 1170 deaths described here. The exact number will never be known. Many of these immediate deaths could have been prevented.

While this study addresses only the "immediate" death, it did not attempt to describe the delayed mortality of people that were displaced. Some received no medical care until they were resettled; due to lack of documentation of their past conditions, some did not receive optimal medical care; some suffered mental conditions that would definitely have a strong impact on their future health. This added morbidity and mortality was not within the scope of this study although it may be as important as the immediate consequences of Katrina.

Drowning

Drowning mortality rates were higher in St. Bernard Parish than in Orleans Parish probably because of the differences in storm surges, rapidity of flooding and ease of evacuation to higher grounds or buildings. The storm surge from Hurricane Katrina was 15-19 feet in St. Bernard vs. 10-14 feet in New Orleans (Knabb, 2005). Age was the major factor for drowning risk.

Most drowning deaths occurred at a residential location (67%), indicating that most people were trapped by rising floodwaters while in their home. Evacuees that left their residence and relocated to evacuation shelters such as the Convention Center or Superdome, or even another public location not identified as a an evacuation shelter such as a church, or battered women's shelter, or the I-10 overpass - were less likely to be drowning victims.

It is possible that there is some degree of misclassification and underestimation of deaths occurring at a residence (n=260) vs. public (n=34) drowning deaths. For example, someone that drowns and was found in their front yard was classified as drowning at a residence. However, even if the person died at their home, but their body was washed away and found in a public location, the death would have been categorized as occurring at a public location. Of the 57 drowning deaths that occurred in an unknown location, it is likely that many of the bodies were found in a public location. Had a drowning victim been found at a residence, the location of death would have been more likely to have been recorded than if the victim's body was one of the many collected and taken to a DEMORT center.

Disease

Previous studies have found that chronic diseases such as ischemic cardiovascular disease, renal disease and diabetes mellitus are typically exacerbated following disasters caused by natural hazards (Miller and Arquilla, 2008); obstetric/gynecological conditions and chronic lower respiratory diseases were other chronic diseases posing a burden on the healthcare system immediately after Hurricane Katrina (Sharma et al., 2008). In this study, 542 (47%) of hurricane victims were identified that died from acute and chronic illnesses in hospitals, private residences, and nursing homes. It is likely that many of these deaths due to chronic diseases would have been prevented had emergency and hospital services been undisrupted following the storm.

Hurricane Katrina exacerbated many cases of cardiovascular disease (CVD) in Louisiana residents. This study observed, but did not quantify that the majority of Katrina deaths caused by diseases were due to ischemic CVD and myocardial infarctions. Moreover, Jhung et al. (2007) reported that 39% of all medications dispensed to Katrina evacuees in San Antonio were for cardiovascular conditions. Another study found that the number of cardiac operations performed at a Veterans Affairs Medical Center in Houston, TX more than doubled after the storm, and the hospital was able to maintain good surgical outcomes (Bakaeen et al., 2008). Coroner reports in this study indicated that the majority of adults have some degree of CVD. Hurricane Katrina likely caused acute myocardial infarctions in many people that had no previous indication that they had coronary artery blockage. As suggested by Ferdinand (2006), health impact assessments of every evacuee including blood pressure and glucose measurements is an easy way (given adequate supplies and personnel) to help identify individuals that are in need of immediate medical attention.

Some deaths from chronic diseases were due to renal failure in hemodialysis patients. A study by Anderson et al. (2009) on Hurricane Katrina survivors (n=386) reports that 44% of the study participants missed at least one hemodialysis session and 16.8% reported missing three or more sessions - disproportionally affecting patients that were young, black, or lived alone. Studies have extensively documented the association between missed hemodialysis and mortality (Saran et al., 2003; Leggat et al., 1998; Kimmel et al., 1998; and Kimmel et al., 2000). Hospitalized renal patients that were not evacuated, were not able to receive their dialysis after the city lost water (Brevard et al., 2008). Therefore, this study provides further evidence for the need of chronic hemodialysis patients and providers to have an evacuation plan so that sessions will not be missed, to decrease the likelihood of mortality.

In this study, disease mortality rates among elderly (older than 85 years) were higher in Orleans than in St. Bernard (11 / 1,000 versus 4 / 1,000). One of the reasons may be the higher concentration of nursing home and other long term care facilities in New Orleans. These findings are similar to a study conducted on the sudden burden of chronic diseases on New Orleans emergency treatment facilities after Katrina, which found that 41% of visits for illness due to chronic diseases were for individuals aged 80 years or older (Sharma et al., 2008).

Eighteen percent (97) of the Katrina victims that died of disease were nursing home patients. There are both risks associated with evacuating and not evacuating nursing home residents. Of the 132 nursing home patients that died during Katrina, 15 died during the evacuation process and 35 drowned because they were not evacuated. Laditka et al. (2008) examined the evacuation of 458 nursing home residents from 14 nursing homes for Hurricane Katrina and found that each evacuee was driven an average of 267.5 miles to sheltering nursing homes that were not always prepared to meet the physical and mental health needs of the sheer numbers of evacuees that needed care. These 15 deaths lead nursing home administrators to conclude that nursing home residents left to shelter in place suffer fewer complications than residents that are evacuated (Dosa et al., 2007). However, not evacuating nursing homes can also cause patient deaths due to loss of resources requiring water and electricity, physical damage (Laditka et al., 2008), and due to drowning (our study; Dosa, 2007). Dosa et al. (2008) proposes a graduated approach to make decisions to evacuate individual nursing home residents based on the individual's risk, the facility's risk and the event risk. For example, had the Dosa et al. (2008) aggregate risk paradigm been used during Hurricane Katrina, the 35 drowning deaths of nursing home residents would have been avoided because the facility was at risk of storm surge and would have required evacuation.

Katrina victims that suffered from acute and chronic illnesses died at private residences (21%), in hospitals (18%), in nursing homes (18%), and in public locations (10%). A survey conducted by the Kaiser Foundation (2005) on Katrina survivors evaluated the biggest reasons why 680 New Orleans

residents did not evacuate. Tragically, 5% reported not evacuating because they were physically unable, and another 7% said that they had to care for someone that was physically unable to evacuate. It is probable that many of the Katrina victims that died of disease did not evacuate their residences for these same reasons. Many others died because hospitals were not evacuated, because prior disasters had not demonstrated that it was necessary. Brevard et al. (2008) reports that the major problems faced by Charity Hospital patients too unstable to be evacuated were due to loss of running water and loss of fuel to supply backup generators. Loss of water prevented hand washing, toilet flushing, showers, dialysis, and fire-fighting capability. The lack of fuel posed a significant problem for intensive care patients requiring ventilation.

Trauma

The 33 Katrina deaths due to trauma are consistent with the literature, but are less than many people expected. This study identifies that the deaths of eight persons were caused by gunshot wounds and the mechanisms of 11 fatal traumas are unknown. A trauma surgeon that worked at West Jefferson Hospital for the month following Hurricane Katrina reports working with five to six nonfatal and three fatal gunshot victims (Thompson, 2009). Since this hospital was one of the few functional trauma centers that remained operational in the New Orleans area after the storm, this hospital is likely to have seen many of trauma cases. As suggested by Thompson (2009) it is possible that the number of trauma deaths is underestimated due to misclassification or underreporting. For example, if a victim died from trauma and the body was then submerged by floodwaters, the death may have been misclassified as being caused by drowning.

Despite the distribution of carbon monoxide (CO) poisoning prevention sheets by the CDC and the mayor's office prior to Hurricane Katrina (CDC, 2005), three Louisiana residents died from CO poisoning after Hurricane Katrina and before Rita and 16 additional cases were nonfatal (CDC, 2005). All cases were identified by the CDC (2005) as occurring from the misuse of gasoline-powered electric generators. These deaths are further evidence on which to base public health education campaigns which stress the importance of CO detectors and proper use and placement of portable generators.

It is tragic that 33 relatively young individuals died due to trauma complications in the aftermath of Hurricane Katrina; however, this study is evidence that trauma resources are needed much less frequently than are resources to stabilize patients suffering from acute and chronic illness following a storm. Klein et al. (2007) further illustrates that the majority of the 24,000 New Orleans residents evacuated from the MSY airport following Hurricane Katrina did not fit traditional triage algorithms. Trauma patients following Katrina were scarce as compared to the number of patients suffering from chronic medical conditions.

Conclusions

Louisiana is the second highest ranking state in combined tornado, flood, and hurricane damage with an average annual cost of $966.9 million (University of Colorado at Boulder, 2001). The way a hurricane kills a huge number of people is through its secondary effects, especially flooding. Therefore, it is extremely important for the Gulf Coast to have a plan for hurricane, flooding and related environmental disasters. In preparing for future hurricanes that may hit before the New Orleans levees are safe, this study illustrates the importance of prioritizing the evacuation of elders and those with chronic diseases.

The Hurricane Gustav (2008) evacuation has demonstrated that the city of New Orleans has improved the evacuation procedure since Hurricane Katrina to increase the number of residents - both nursing home and the general population - that evacuate for a storm. Even when there is adequate staff and evacuation plans, stress brought on by the evacuation process will exacerbate acute and chronic conditions that are cable of causing death (Cefalu, 2009).

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