ORIGINAL RESEARCH

Emergency Health Surveillance After Severe Flooding in Louisiana, 1995

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Abstract
Introduction: In disaster situations, timely surveillance systems that provide illness, injury, and mortality information to public health officials and hospitals are essential for planning and evaluating interventions.
Objectives: To describe flood surveillance methodology, the impact of the event on hospitals, and the number of daily patient visits due to selected illnesses and injuries before, during, and after severe flooding in southeastern Louisiana in May 1995.
Methods: Survey of disaster-area hospitals regarding flood impact. Emergency department surveillance of injuries and illnesses for the week before, the two days during, and the week after the flood.
Results: There occurred an increase in the number of persons who drowned or were injured that presented to the moderately affected hospitals during the storm, but there was no increase in visits for gastroenteritis to any group of hospitals. Services were disrupted in more than half of hospitals. The severely affected hospitals had the least variation in the average number of daily visits. None of the drownings were reported by those hospitals that reported severe service disruption.
Conclusions: Data should be collected from all hospitals in or near disaster areas, even if they were not directly affected by the disaster. Public education about the danger of drowning during flash flooding must be improved. The Louisiana experience emphasizes the need for a disaster-preparedness plan for rapid surveillance of illnesses and injuries.

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Introduction

Floods are responsible for an estimated 40% of natural disasters worldwide and cause the greatest amount of damage. In the United States, flash flooding is the leading cause of weather-related mortality.[1] Floods also cause acute morbidity due to illnesses or injuries.[2] Flooding may lead to disruptions in water systems, limited availability of health services, and crowded shelters with the potential for infectious disease outbreaks.[3] The incidence of injuries also may increase during the clean-up phase of a disaster.[1,4,5]

In disaster situations, timely surveillance systems that provide illness, injury, and mortality information to public health officials are essential for planning and evaluating the effects of interventions.[6,7] The use of such systems in such circumstances has been well-documented. Studies have documented if changes in mortality, water- and vector-borne disease, endemic illnesses, and clean-up injuries have occurred after floods and other disasters.[3,4,8-14] Few studies,

Disruption	Number hospitals	(%) hospitals
1. Curtailed services	2	(6.4)
2. Used backup power	7	(22.6)
3. Sewage problems	6	(19.4)
4. Alternative water used	4	(12.9)
5. Food shortages	2	(6.4)
6. Medical supply shortages	2	(6.4)
7. Routes blocked	21	(67.7)
8. Structural damage	4	(12.9)
9. Flood damage	8	(25.8)

Table 1—Hospital disruptions (n = 31 hospitals with impact information)

	n	Pre-impact 1–7 May	Impact 8–9 May	Post-impact 10–16 May	ANOVA p-value
All hospitals	29	1,528 ±97	1,469 ±27	1,610 ±126	0.1939
Hospitals without information	3	129 ±20	112 ±4	124 ±35	0.4752
Unaffected hospitals	9	595 ±31	610 ±4	649 ±76	0.3735
Moderately affected hospitals	14	689 ±51	634 ±45	729 ±40	0.0630
Severely affected hospitals	3	116 ±17	113 ±10	127 ±17	0.5811

Table 2—Mean ±SD number of daily hospital visits, before, during, and after the flood

however, describe the methodology for setting up surveillance systems or link surveillance to the level of hospital disruption during the disaster.

On 8–12 May 1995, Louisiana, Mississippi, and Texas were scheduled for an emergency preparedness exercise involving the simulation of a hurricane hitting southern Louisiana. As part of this exercise, the Louisiana Office of Public Health (LOPH) was conducting a hurricane drill in hospitals throughout the state. As these exercises began, an actual event did occur. On 8–9 May 1995, the metropolitan New Orleans area received more than 20 inches (50.8 cm) of rain that caused widespread flash flooding, six fatalities, and up to [U.S.]$3 billion in property damage [23] The LOPH received inquiries from the press and the public about possible outbreaks of gastrointestinal illness in the flooded areas. To answer these inquiries and to assess other possible health effects of the flood, on 15 May 1995, the LOPH began passive emergency department (ED) surveillance of all injuries and illnesses in the 12 parishes (counties) declared federal disaster areas. Using the ED surveillance data, the number of hospital visits before, during, and after the flood were determined, and the number of visits in hospitals affected by the flood were compared with those in hospitals not affected by the flood. This information may provide guidance for directing emergency medical services and hospital emergency planning in future disaster events. Additionally, methodological issues involved in setting-up a hospital-based surveillance system are discussed.

Methods

The LOPH began ED surveillance by contacting ED nurses, infection control nurses, and safety personnel for each of the 37 hospitals within the 12 parishes declared federal disaster areas. Aggregate daily patient visits were categorized by specific illnesses or injuries for the month of May. The LOPH requested that Emergency Departments: 1) Report the daily aggregate numbers of patient visits for categories of injuries and illnesses, as well as aggregate patient outcomes regardless of whether the injury or illness was flood-related; and 2) Complete a questionnaire regarding the impact of the storm on hospital operations[15] during 8–11 May.

Because of potential response rate differences, the hospitals were categorized by type of administration and severity of impact from the storm. Thirteen hospitals (35%) were under corporate ownership; 14 (38%) were operated by a hospital district or authority; four (11%) were operated by the state or the Veteran's Administration (VA); and the remaining six (16%) were nonprofit and nongovernmental.[24] On the basis of information from the hospital impact survey, the hospitals were categorized further as "Unaffected" if they answered "no" to each of the questions listed in Table 1 "Moderately affected" if they answered "yes" to between one and four of the questions or "Severely affected" by the flood if they answered positively to at least five of the questions or had medical supply shortages.

Data were entered with Epi Info Version 6;[16] and analyzed using SAS for Windows Release 6.12[17] and Lotus 1-2-3, 97 Edition.[18] Differences in the meanof daily patient visits before, during, and after the flood were tested for statistical significance using the Kruskal-Wallis one-way analysis of variance (ANOVA). The proportions of patient visits due to illnesses were compared to visits due to injuries using chi-square tests for all of the hospitals and for each group of affected hospitals. If a chi-square test indicated statistical significance, a second chi-square test was performed to assess if the proportion of visits due to specific illnesses or injuries differed by impact period for that group of hospitals.

The analysis was focused on the number of daily patient visits due to selected illnesses and injuries for the first 16

	Pre-impact 1–7 May	Impact 8–9 May	Post-impact 10–16 May	p-value*
All hospitals				
Illnesses	6,863	1,966	7,584	0.248
Injuries	3,790	1,061	3,996	
Total	10,653	3,027	11,580	
Hospitals with no information on affect				
Illnesses	504	127	369	0.005
Injuries	394	97	391	
Total	898	224	760	
Unaffected hospitals				
Illnesses	2,602	824	3,050	0.001
Injuries	1,537	373	1,479	
Total	4,139	1,197	4,529	
Moderately affected hospitals				
Illnesses	3,209	861	3,526	0.007
Injuries	1,588	519	1,855	
Total	4,797	1,380	5,381	
Severely affected hospitals				
Illnesses	548	154	639	0.330
Injuries	271	72	271	
Total	819	226	910	

*p-values calculated using chi-square

Table 3—Numbers of hospital visits due to illnesses and injuries before, during, and after the flood

days of May in order to take advantage of the higher response rate for those days. This works out to be the week before the flood as the pre-impact period, the two days of the flood, and the week after the flood as the post-impact period.

Results

Of the 37 hospitals with emergency departments in the declared disaster areas, 24 (65%) provided at least 30 days of surveillance data and hospital impact information. An additional four hospitals provided some surveillance data along with impact information, four others provided only surveillance data, three provided only hospital impact data, and two did not provide any information to the LOPH. The results presented in the remainder of this paper are based on data from the 31 (84%) hospitals that provided hospital impact data, and the 29 (78%) that also provided at least 15 days of ED data for the first 16 days of May. Twenty-six of the hospitals (70%) provided both sets of data.

Hospitals administered by hospital districts or authorities were more likely to supply information than were other hospitals. Twelve (86%) of these hospitals provided surveillance and impact data for the first 16 days of May compared with eight (62%) of the corporate-controlled hospitals, three (75%) of the state or VA hospitals, and three (50%) of the "other" hospitals.

Although the data presented cover the period from 1–16 May, much of the data were not received by the LOPH until June. By 20 June 1995, the 31 hospitals used in the current analysis had supplied hospital impact information and at least 15 days of surveillance data for the period 1–26 May. The LOPH staff members made >150 telephone calls to the 37 hospitals in the disaster areas in order to obtain information. Some hospitals were called more than five times before information was received. To lessen the burden of reporting, the LOPH gave hospitals the option of faxing a copy of their ED logbook (without identifiers such as name or social security number) to the LOPH; health department staffers then classified the hospital visits.

Impacts on Area Hospitals

Table 1 summarizes the types of disruptions that affected the area hospitals. Among those hospitals providing impact information, more than half had access/egress routes blocked because of the storm. More than a quarter sustained flood damage. Approximately one-fifth used backup power or had sewage problems. Although not shown in the table because the questions were not included in the categorization of severity of impact, more than one-fifth of the hospitals were short of physicians, almost a third were short of nurses, and three (10%) turned patients away.

Using the disruption information from the 31 hospitals that completed the questionnaire and the definitions described above, five hospitals (16%) were categorized as "severely affected", 17 (55%) as "moderately affected", and nine (29%) as "unaffected". Only one hospital answered affirmatively to at least seven of the nine questions and one answered affirmatively to four questions, including the question of whether it had medical supply shortages.

Response rates for surveillance data varied by the degree of hospital service disruption. All nine (100%) of the unaffected hospitals, 14 (82%) of the moderately affected hospitals, and three (60%) of the severely affected hospitals reported surveillance data for the first 16 days of May.

Disease and Injury Surveillance

Emergency Department surveillance data showed a slight decrease in the average of the numbers of patient visits during the storm, and a slight increase in the average of the number of visits after the storm. There was a mean number of 1,528 visits per day for all causes in the seven days before the storm, 1,469 visits per day for all causes during the two

	Pre-impact 1–7 May	Impact 8–9 May	Post-impact 10–16 May	p-value*
Injuries				0.057
Falls	42	14	56	
Lacerations	71	22	67	
Musculoskeletal	142	30	135	
Motor vehicle crashes	41	8	37	
Other injuries[a]	98	23	96	
Illnesses				
Cardiac events	38	10	25	
Chronic diseases	33	13	11	
Gastroenteritis	25	8	15	
Respiratory problems	60	15	43	
Other illnesses[b]	348	81	275	

*p value calculated using chi-square
[a] For example, injuries caused by ingestion of foreign objects, burns, assaults, animal bites, drownings, and insect stings
[b] For example, migraine headaches, otitis media, heat exhaustion, mental health, rashes, and obstetrics

Table 4—Number of visits due to specific illnesses and injuries before, during, and after the flood in hospitals without impact information

	Pre-impact 1–7 May	Impact 8–9 May	Post-impact 10–16 May	p-value*
				0.001
Injuries				
Assaults	32	5	21	
Falls	56	12	46	
Insect stings	44	9	50	
Lacerations	254	70	310	
Musculoskeletal	693	176	660	
Motor vehicle crashes	149	53	139	
Other injuries[a]	309	48	253	
Illnesses				
Cardiac events	137	52	174	
Chronic diseases	88	7	35	
Gastroenteritis	145	41	155	
Mental health	80	28	86	
Obstetrics	44	19	56	
Rashes	83	34	123	
Respiratory problems	322	103	346	
Other illnesses[b]	1703	540	2075	

*p value calculated using chi-square
[a] For example, injuries caused by ingestion of foreign objects, burns, animal bites, and drownings
[b] For example, migraine headaches, otitis media heat exhaustion

Table 5—Number of visits due to specific illnesses & injuries before, during, and after the flood in unaffected hospitals

days of the storm, and 1,610 visits per day for all causes in the seven days after the storm (p <0.20, Table 2). A similar pattern was seen in unaffected, moderately affected, and severely affected hospitals, and in hospitals without impact information. In all categories, the p-value for the differences between the mean number of visits was >0.05.

Chi-square tests were used to determine if the proportion of visits due to illness and injury had changed over the three time periods (Table 3). In all cases, the greatest proportion of visits was due to illnesses. However, the proportion of visits due to injuries was significantly higher after the flood than it was before the flood in hospitals that did not provide impact information (44%, 43%, and 51%). An increase in the proportion of visits due to injuries also occurred during the storm in moderately affected hospitals (33%, 38%, and 34%). However, among unaffected hospitals, a decrease in the number of visits due to injuries occurred during and after the storm (37%, 31%, and 33%). Data describing of the visits due to specific illnesses and injuries in hospitals without impact information, and in unaffected and moderately affected hospitalsa are provided in Tables 4–6. These groups of hospitals had a significantly different proportion of visitis due to injuries compared to illnesses over the 3 month time periods. If the number of

	Pre-impact 1–7 May	Impact 8–9 May	Post-impact 10–16 May	p-value*
				0.001
Injuries				
Assaults	51	12	43	
Falls	135	21	134	
Insect stings	47	11	64	
Lacerations	317	112	385	
Musculoskeletal	749	238	791	
Motor vehicle crashes	140	49	142	
Other injuries[a]	149	76	296	
Illnesses				
Cardiac events	231	74	252	
Chronic diseases	144	40	165	
Gastroenteritis	219	67	275	
Mental health	109	34	105	
Obstetrics	73	17	91	
Rashes	173	38	184	
Respiratory problems	366	93	367	
Other illnesses[b]	1894	498	2087	

*p-value calculated using chi-square
[a] For example, injuries caused by ingestion of foreign objects, burns, animal bites, and drownings
[b] For example, migraine headaches, otitis media and heat exhaustion

Table 6—Number of visits due to specific illnesses & injuries before, during, and after the flood in moderately affected hospitals

visits due to a specific complaint was <5 for any time period, this category was included in the other injuries or other illnesses category as appropriate.

Table 4 summarizes the number of visits at hospitals without impact information by illness and injury category. The proportion of visits due to specific complaints did not differ across the three time periods (p =0.057). Among injury categories, musculoskeletal injuries were the largest number of injuries reported. Persons with musculoskeletal injuries accounted for approximately 16% of the total number of ED visits before, 13% during, and 18% after the storm. Information on the causes of these injuries was not collected. Among illness categories, the largest number of visits were for "other illnesses" (for example, migraines, headaches, otitis media, heat exhaustion, mental health, rashes, obstetrics, etc.). These illnesses accounted for 39% of the visits before, 36% during, and 36% after the storm. Unfortunately, more detailed information on these illnesses was not collected.

The proportion of visits due to specific complaints in unaffected hospitals (Table 5) was significantly different by time period (p =0.001). Persons with musculoskeletal injuries were the major contributors to injury category (15–17%), and the proportion of visits due to other injuries dropped from 7% before to 4% during, and to 6% after the storm. Other illnesses contributed to 41% of visits before the storm, 45% during, and 46% after the storm. The proportion of visits due to chronic diseases dropped from >2% before the flood to <1% during and after the flood.

Similar to the unaffected hospitals, the proportion of visits due to specific complaints (Table 6) in moderately affected hospitals was significantly different by time period (p = 0.001). Moreover, the combination of musculoskeletal injuries and other illnesses made up over half of the visits to EDs in moderately affected hospitals. The proportion of persons with musculoskeletal injuries increased from 16% before to 17% during the storm, and decreased to 15% after the storm. The proportion of persons with "other" illnesses decreased during the storm from 39% of visits before the storm, to 36% and increased to 39% of visits after the storm. Although not included separately in the chi-square test due to a 0 cell size before the flood, the proportion of persons who drowned increased from 0% before the storm to almost 1% during the storm. All drownings were reported in unaffected or moderately affected hospitals.

Discussion

The findings of an increase in the number of persons who drowned during the storm and no significant change in the number of visits due to waterborne or infectious diseases are consistent with those of other studies.[4,8,11,12,19] The proportion of visits due to injuries increased during or after the storm in hospitals without impact information, and in the moderately affected hospitals respectively. This also is consistent with at least one other study that has suggested that acute problems due to floods may be related to injuries.[20] Services were disrupted in more than half of the hospitals within the disaster areas. When these hospitals were categorized by the severity of disruptions caused by the storm, the severely affected hospitals had the least variation in the mean number of visits. Of note, none of the drownings were reported by the hospitals that reported severe service disruption. Patients may have chosen to go to hospitals in the less severely affected areas because it was too difficult for them to reach the more severely affected hospitals or because they feared that those hospitals would not be able to meet their needs. In fact, three severely affected hospitals reported turning patients away. If data collection is undertaken in all hospitals within and around the disaster area, the information can be used in planning appropriate emergency medical services and public health announcements. This disaster event also confirms the need for public warnings about the dangers of drowning and motor vehicle accidents during flash floods.

Morbidity surveillance after hurricanes also shows an increase in the number of injuries reported. After Hurricane Andrew in 1992, active morbidity surveillance was conducted in south Florida by monitoring the visits of civilians and military service members to care sites for approximately one month. Injuries were an important source of morbidity, whereas enteric and respiratory agents did not cause disease outbreaks during the surveillance period.[4] Results of surveillance of seven hospital emergency departments[22] and a pediatric emergency department[20] after hurricanes also indicated that the number of injuries increased after hurricanes.

One of the limitations of this study is that only 60% of severely affected hospitals supplied surveillance data. This may be part of the reason that an expected flood-related increase in the number of injuries was not detected in severely affected hospitals. Hospitals may have determined that providing direct clinical services was more important than reporting data to the health department, and hence, allocated their staff resources accordingly. To address this problem in the future, those responsible for surveillance should make special efforts to obtain data from hospitals within severely affected areas. This might mean (if possible) sending health department personnel to these hospitals, instead of relying on hospital personnel to collect the data. Hospitals may need additional resources to do surveillance, especially if they are directly or indirectly affected by a disaster.

Considerable effort was expended to collect the data in this study. However, even with this effort, not all of the hospitals participated, and some of those that did participate often did not submit their data in a timely manner. The overlap of this flooding with the emergency preparedness exercise referred to earlier also may have contributed to confusion about the need to provide reports.

To design effective interventions to prevent injuries, health officials need information on the cause of the injuries. The EDs of most of the hospitals studied did not record such information routinely. Even when the information was available, it still was difficult to classify injuries according to the schema used in this study, because the categories used were not mutually exclusive. For example, a visit by a person who had been in a motor vehicle crash could have been reported as a visit for any of three categories of injury: motor vehicle accident, laceration, and musculoskeletal injury. This uncertain classification also made it difficult to run routine data cleaning steps on the data reported by the hospitals, since the sum of the number of visits in each of the individual categories could exceed the total number of visits reported by the ED. Ambiguity in the meaning of the categories also makes interpretation of these data difficult. For example, "chest pain" may have been classified by one hospital as a "cardiac event," but by another hospital as an "other illness."

This experience emphasizes the need for a disaster preparedness plan specifically for rapid surveillance of illnesses and injuries. If the health department had had an established surveillance system for disasters that included trained hospital personnel, some of these difficulties might have been avoided. The use of electronically transmitted data would greatly facilitate the timeliness of such data collection. In addition, the health department should use individuals in the hospitals that already are reporting other illness or injury data to the state. These "reporters" more likely understand the need for collecting such data, assume responsibility for reporting such data, know how to gather data from various sources in the hospital, and have an established relationship with health department epidemiologists. Having designated "reporters" also would facilitate the standardization of data collection, and thereby, enhance the quality of the data collected.

Conclusions

Despite the limitations of this study, the data collected were used to reassure the public about the health impact of the flooding, and to inform acute relief service providers about the need for services. Within the health department, this experience has been valuable in setting goals and priorities for future disaster surveillance planning.

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