

## Health Issues Related to Hurricanes

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### Health Problems During Hurricanes

#### Introduction

The health care response to a disaster should be guided by the known and expected needs of the affected population. It should be prepared for needs caused by the direct effect of the hurricane and for the indirect outcomes of the initial impact. This can be achieved by knowing if and how the health of a population changes after a hurricane. Response plans should use the best available evidence to understand the immediate, short-term, and long-term health outcomes after a disaster, and how ordinary health care needs are affected. These approaches take a preventative public health perspective and are important for reducing a disaster's health impact.

The aim of this review is to elucidate the human health problems following hurricanes, floods and storm disasters. It will highlight the health problems and needs over time.

#### Damages that could result from a hurricane

Hurricanes affect health in various ways. Contact with flood waters and high-speed winds during a hurricane, contact with debris, and evacuation and clean-up activities can cause injury. Floods and storms can destroy residential buildings, leading to displacement, overcrowding, increased exposure to animals and insects, and worsened living conditions. They also can damage infrastructure (such as sewage systems or electrical supply), the agricultural process, and health care facilities. This can indirectly lead to the transmission of infectious diseases, increased physiological stress, exacerbation of existing conditions, malnutrition, and lack of access to preventative and curative health care. Improperly using carbon-based fuels during electrical power outages can result in poisonings. However, in order to guide health care activities afterwards, it is essential to know to what extent the burden of disease varies during different phases after hurricanes.

Health problems were defined as states related to the physical condition that were harmful or unwelcome and could lead to ill health, morbidity, or mortality. Hurricane or storm refers to an organized, rotating storm system that originates over water and reaches sustained wind speeds of at least 34 knots. The generic terms for storms are hurricanes, typhoons, or cyclones.

Health problems were sorted into five groups: (1) injuries and poisonings; (2) infectious and parasitic diseases; (3) noncommunicable diseases (NCDs) and chronic illnesses; (4) contact with health services; and (5) other. Groupings were based on the International Classification of Diseases and Related Health Problems 10th Revision (ICD-10).

The final analysis included 113 studies. The disasters occurred between 1985 and 2014, and the most frequently studied disaster was Hurricane Katrina (2005; Gulf Coast, USA) with 25 articles.

#### Poisoning and Injuries

Poisonings and injuries, especially wounds, were reported as a major source of morbidity after hurricanes. Injuries regularly increased in the period immediately following hurricanes: a study of all emergency care facilities (ECFs) on the island of Hawaii (USA) found an increase in the proportion of injury-related visits within two weeks after a hurricane compared to the five previous years (213 injuries/100,000 people/week increase to 1,461 injuries/100,000 people/week) and an increase in the relative risk (RR) of being injured and a study of 113 ECFs found a significant increase of 22.3% in the number of injury-related visits when compared to the same week in the previous year.

Multiple studies reported increases in carbon monoxide (CO) and gasoline poisonings after storms; CO intoxications presenting at an ECF significantly increased from zero (0.0%) to 1.1% of all ECF visits ( $P = .015$ ) in the three days after landfall. Within two to four weeks after other hurricanes, electronic surveillance identified a



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significant increase in CO poisoning, gasoline exposure was 18 to 283 times higher than the previous four years, and calls to poison control centers for CO and gasoline exposure increased from baseline values. A pediatric ECF recorded 13 cases of hydrocarbon and/or bleach poisoning within two weeks after a storm, compared to zero cases in the pre-storm control week and 26 cases for the previous year.

Within one week after hurricanes, the proportion of visits for lacerations and corneal abrasions significantly increased at treatment facilities. Within two weeks, the proportion of visits for open wounds increased. The risk of contusions and open wounds also rose at ECFs in the two weeks following a hurricane compared to the two weeks prior. Within three weeks after hurricanes, significant increases at treatment facilities in visits for infected wounds, lacerations, and puncture wounds were all reported. No studies reported significant changes in wounds more than one month after landfall.

There were less data showing changes in orthopedic and other injuries. One study found a small but significant decrease ( $P < .001$ ) in the percentage of orthopedic trauma visits during the two weeks after a storm, while a second ECF-based study reported an increase in the risk of sprains and fractures compared to two weeks before the storm. Other reported changes included a significant decrease in visits for soft tissue wounds at a pediatric ECF and an increase in the risk of burns and head injuries in the first week after a hurricane, along with an unexpected number of cases of hypothermia within six weeks after a hurricane. While animal bites and insect stings are causes of injuries, not outcomes, it should be noted that five studies reported significant increases at treatment facilities in injuries from bites and stings during the first four weeks after storms.

### Infectious and Parasitic Diseases

Gastrointestinal illness, leptospirosis, and skin or soft tissue infections generally increased after hurricanes, both at the population and health facility levels. Some studies reported changes in respiratory infections, fevers, and other infectious diseases, but the given information remained inconclusive.

Within seven days, significant increases were seen in diarrhea or gastroenteritis in flooded households and

in visits to treatment facilities. An analysis of national surveillance system data found an increased risk for shigellosis and other infectious diarrhea, peaking at five days post-cyclone. Within five weeks of landfall, the proportion of visits to treatment facilities for diarrhea remained significantly higher than pre-storm levels at an ECF, the RR for visiting an ECF for diarrhea was elevated compared to a same week in the previous year, and a community survey found a slightly higher risk of diarrhea in two of four storm-affected areas compared to the previous two years. In the long-term, atypical and significant increases were seen in the incidence of acute diarrhea and dysentery in the eight months after a storm, and the average number of cases utilizing health services for intestinal infections doubled in the year after storm landfall (6.5 cases/month to 13.1 cases/month;  $P < .01$ ). Outbreaks of cholera and norovirus were both identified within two weeks, acute watery diarrhea within six weeks, and cholera again within three months. The outbreaks all declined within one to four weeks after they began.

Leptospirosis outbreaks were identified within two weeks, six weeks, and two months after storms. A study of patients who presented at treatment facilities with a dengue-negative fever in the first month after a hurricane found a RR of 4.4 for having leptospirosis. Significant increases in impetigo, conjunctivitis, and cellulitis at treatment facilities were reported in the first two weeks after storms, and the number of lower extremity cellulitis cases receiving treatment at ECFs increased during the first week after landfall compared to the control period. Eighteen cases of wound-associated *Vibrio* illness, linked to a hurricane, also were identified two weeks after landfall.

While one study found a significantly higher incidence rate of acute respiratory illness over the course of a cyclone (pre-storm: 4,041.91 cases/100,000 people; storm period: 7,279.7/100,000; post-storm: 4,661.59/100,000) and a second study saw a single, unexpected case of legionellosis in a severely affected area.

Information on other infectious diseases was limited. Visits to treatment facilities for unspecified febrile illness increased in the first week after a storm. A study of West Nile neuroinvasive disease found an increased incidence in hurricane-affected areas in the three weeks post-storm compared to the three previous years. Malaria was diagnosed in only 2.5% and dengue in 1.7% of patients

presenting with fever at a treatment facility more than three months post-storm.

A surveillance system study of multiple diseases gave seven alerts for suspected measles, one alert for acute hemorrhagic fever syndrome, two alerts for suspected meningitis, and two alerts for suspected poliomyelitis.

### Noncommunicable Diseases & Chronic Illnesses

Data in this review suggested an increase in cardiovascular disease and diabetes outcomes in the short- and long-term after storms, and nutritional outcomes manifested in the long-term after some storms.

The proportion of cardiovascular complaints significantly increased at treatment facilities, especially in people 45 years and older, in the two weeks to one month after a hurricane. The incidence of stroke increased by seven percent and myocardial infarction increased by 22% in areas highly impacted by a hurricane during the first year afterwards, and the percentage of admissions to hospitals for acute myocardial infarctions increased significantly within two years.

Evaluations for diabetic foot increased significantly at an ECF within four weeks after a cyclone. A study of diabetic patients between six and 16 months after a hurricane found worsened levels of glycated hemoglobin (7.7% to 8.1%;  $P < .01$ ) compared to measurements taken in the six months before the storm, with a significant linear trend over time. The available information on changes in respiratory illness was contradictory. Some treatment facilities saw significant increases in visits for asthma two weeks and one month post-hurricane. In the one to three months after a hurricane, children with chronic conditions were more likely to have worsened asthma (16.3% versus 1.9%;  $P < .01$ ) than children without chronic conditions. However, no significant relationship was seen between exposure to mold and respiratory allergic response in patients at an allergy clinic in the year after a hurricane.

The remaining studies on NCDs and chronic illnesses saw significantly less height gained in the three months following a hurricane in nutritionally at-risk children under five years old and a significant increase in the stunting/underweight one year after. A spike in renal-related hospital admissions was seen in the month after a hurricane compared to pre-hurricane rates, and a study of babies born with neural tube defects after a hurricane

suggested a link between significantly decreased consumption of folate by mothers and destruction of food crops by a hurricane. Information on NCDs after floods was limited, but worsened hypertension and diabetes and long-term malnutrition outcomes were both seen.

### Contact with Health Services

Although articles frequently described an increase in contact with health services after storms, especially within the first week and for health maintenance reasons like prescription refills. Of the reported results, an increase in ECF visits for oxygen, medication refills, dialysis, vaccination, or hemodialysis was seen in the first week after a hurricane, and also in “miscellaneous” visits for vaccinations and routine care to a primary health care facility in the week after a hurricane.

### Other Health Problems

Nutritionally at-risk children under five years of age experienced nasal discharge or cough more often in the first one to three months after a hurricane than in the four months preceding the storm, and a linear increase ( $P < .05$ ) was observed for lower and upper respiratory tract symptoms among people exposed to water-damaged homes. Finally, a significant increase in visits for dermatitis at an ECF was seen within one week. By the second week after storms, significant increases were seen in visits to ECFs for dermatologic conditions and gastrointestinal complaints while significant decreases were seen for genitourinary complaints and abdominal pain.

### Mortality

Thirty-two studies reported information on mortality, and fifteen studied it exclusively. Deaths were most often presented as a summary of the cases and causes. Table 1 lists all given causes of death.

A study of areas highly impacted by a hurricane found that the 30-day mortality rate for both myocardial infarctions and other cardiovascular events increased when compared to the five years before the storm; no significant changes in stroke-related mortality were seen. Over the course of a hurricane season, overall mortality was significantly elevated for two months after the first storm landfall when compared to non-hurricane years; heart, cancer, and accident-related deaths all significantly increased.



## Discussion

The results of the review show that health does change differently after hurricanes. The increases in both acute injuries and some infectious diseases, and the increase in treatment facility visits for NCDs and chronic illnesses seen after hurricanes, is likely to significantly raise the need for both emergency and routine health care services. Although outbreaks of gastrointestinal infections and leptospirosis occurred after hurricanes, no articles reported sustained epidemics of any infectious diseases. This may help in dispelling the myth that epidemics are an inevitable consequence of disasters. The risk of infectious disease transmission is primarily related to a storm's indirect outcomes, as was seen in this review, where the reported outbreaks were all caused by contaminated water, overcrowded shelter, displacement, and poor sanitation. Public health interventions can be targeted to these outcomes in order to prevent outbreaks.

The increase in treatment for poisonings and wounds seen after hurricanes is likely the result of strong winds and wind damage during storms. Some wounds were directly sustained during the impact phase of storm (e.g., being struck by flying debris); the remaining wounds and the poisonings were indirectly caused in the weeks afterwards (e.g., stepping on debris while cleaning up, and CO poisoning from incorrect use of a gasoline- powered generators). The variation in timing and cause means injuries and poisonings will require different medical needs and this should be accounted for during storm responses. Hurricanes are indirectly responsible for the exacerbation, acute onset, and worsened management of chronic illnesses and NCDs. Disasters affect both individuals and health service delivery, which in turn affects the management and continuity of care for chronic diseases and NCDs.

## Conclusion

The review summarizes the current published knowledge on health effects of hurricanes. It has shown an increase in some injuries, poisonings, infectious diseases, and chronic diseases or NCDs. However, there is a clear need for more information on the long-term changes in health.

Table 1. All Causes of Death Reports in the included article.

Group and Subgroup	Reported Cause
<i>Injuries and Poisonings</i>	
Drownings	Flood Waters
Poisonings	Carbon monoxide, ingestion of drugs or substance
Burns and Electrocutions	Fires, chemicals, smoke inhalation, power source, lightning strike
Trauma	Motor vehicle accidents, falls, boating accidents, fallen trees, flying debris, power tools
Crush Injuries and Asphyxia	Structural collapse, fallen trees
Violence	Gunshot Wound, Homicide, Suicide
Other	Hypothermia, cerebrovascular accident, landslide
<i>Infectious and Parasitic Diseases</i>	
Gastrointestinal Infections	Diarrhea
Leptospirosis	Leptospirosis
Bacterial	Sepsis
<i>NCDs and Chronic Illnesses</i>	
Cardiovascular Event	Myocardial infarction, hypertension
Respiratory Event	Chronic obstructive pulmonary disorder, pulmonary conditions, respiratory failure
Brain Syndromes	Seizures, central nervous system events
Gastrointestinal/ Genitourinary Disease	Pancreatitis, Renal Failure
Other	Cirrhosis, cancer, myopathy
<i>Other</i>	
Obstetric	Obstetric hemorrhage, Obstetric problems
Natural Causes	Old age
Neurologic	Intracranial hemorrhage
Other	Shock

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