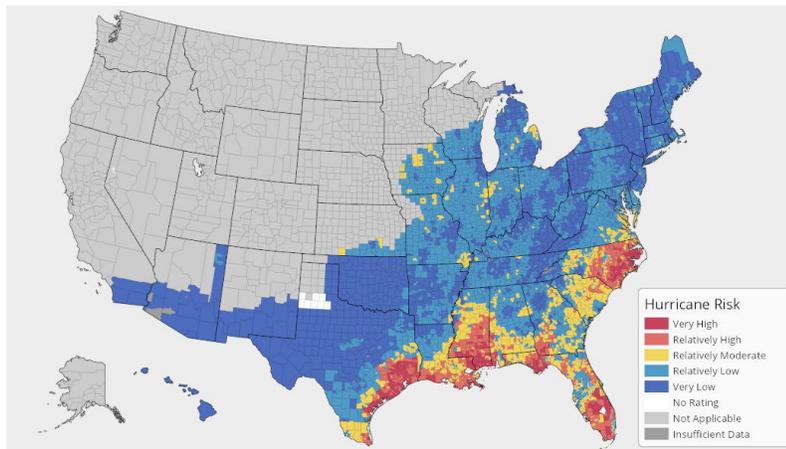




Hurricanes, Floods and Health Providers

Hurricanes, Floods and Climate Change

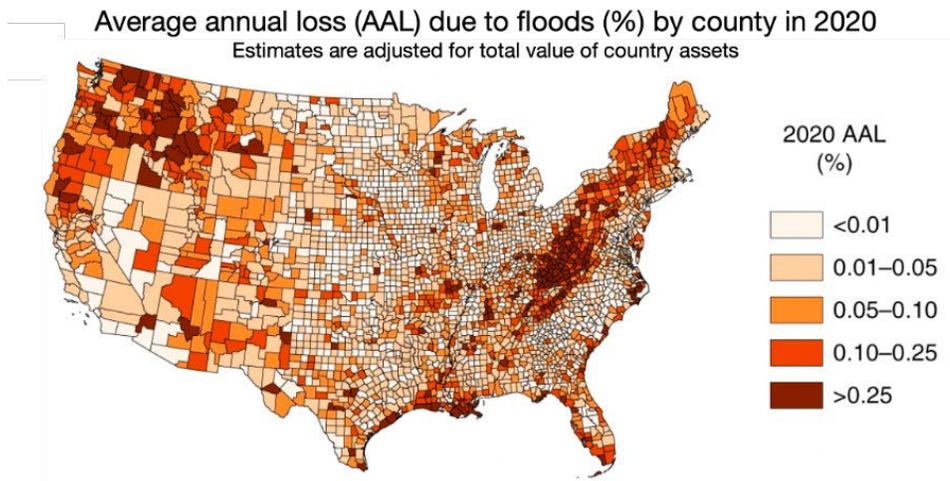
Hurricanes – intense low-pressure tropical storms producing destructive wind speeds and heavy rain – have far-reaching effects on health, especially for individuals with chronic medical conditions. The likelihood of hurricanes making landfall in the United States is illustrated in the map below.



Map of hurricane risk in the United States. Courtesy of FEMA

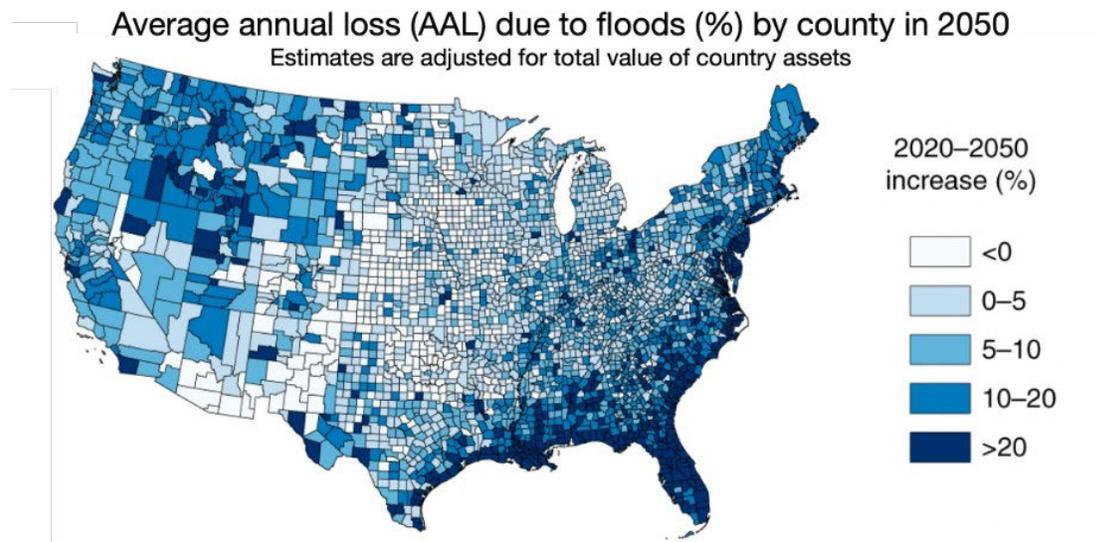
Climate change warms the oceans, and hurricane strength comes from ocean heat. Climate models project more intense hurricanes and associated coastal flooding and wind damage in this century.¹ Trends show that hurricane peak intensity has been occurring closer to shore and their tracks have been moving north, putting more northern coastal areas, which may have less investment in preparedness, at greater risk from hurricane strikes.^{2,3}

Damage from floods due to heavy rainfall and overflow of rivers have a different geographic range than hurricanes, shown below.



Wing, O.E.J., Lehman, W., Bates, P.D. *et al.* Inequitable patterns of US flood risk in the Anthropocene. *Nat. Clim. Chang.* 12, 156–162 (2022).
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The map above shows where damages from flooding have been greatest, with darker red and brown counties suffering more losses (damages are adjusted for total assets in the county). It reveals that the Pacific Northwest, Appalachia and the Gulf Coast are flood prone.



Wing, O.E.J., Lehman, W., Bates, P.D. *et al.* Inequitable patterns of US flood risk in the Anthropocene. *Nat. Clim. Chang.* 12, 156–162 (2022).

This map shows that in the coming decades, damages from floods will grow most along the Gulf and Atlantic coasts.

Health Impacts of Hurricanes and Floods

Hurricanes affect health through strong winds, heavy rains, and storm surge, all of which can cause injuries. They also can result in floods that can disrupt essential services, including power, water, and healthcare access.

Hurricanes and floods can increase morbidity and mortality for individuals with a variety of medical conditions, as well as affect perinatal outcomes.

- **Respiratory disease** related mortality has been found to increase 8.3% one month after hurricanes.⁴
- **Cardiovascular disease** hospitalizations were double in older patients up to 1 year after Hurricane Sandy. Myocardial infarctions and strokes were 22%⁵ and 7% higher, respectively, in areas more severely affected by the storm.⁶
- **Type II diabetes** related emergency room visits increased 84% during the week of Hurricane Sandy.⁷ Increased diabetic morbidity after hurricanes may result from lack of access to medications and healthy foods.⁸
- **Chronic kidney disease** patients on dialysis have elevated mortality after hurricanes and may be more likely to need emergency department care, be hospitalized, and receive dialysis during hospitalization.^{9,10} Risks to renal patients may result from lack of access to dialysis, concurrent heat wave exposure and associated health risks, infectious diseases, or direct trauma from the storm.⁹
- **Eye injuries** and infections may be more likely after hurricanes.¹¹
- **Pregnant** people exposed to hurricanes were more likely to experience **preterm birth**.¹² Stress associated with many forms of disaster has been linked to preterm birth, and this may be mediated through corticotropin releasing hormone and the HPA axis.¹³

Floods can also contribute to infectious disease outbreaks, mold infestations in buildings, and mobilize harmful substances into the environment.

Populations at greater risk for harm after hurricanes and flooding

Population	Risk
Black and Hispanic	<p>More likely to live:</p> <ul style="list-style-type: none"> • near industrial facilities that release toxic substances during and after hurricanes¹⁴ • in areas with high flood risk¹⁵
Chronic Diseases	<p>May be more likely to have disease flares due to:</p> <ul style="list-style-type: none"> • supply chain disruptions and medication shortages • difficulty accessing treatment or care • power outages affecting electric medical devices¹⁶
Disabilities	<p>Face barriers to:</p> <ul style="list-style-type: none"> • receiving emergency communications • evacuation due to inaccessible transportation options or lack of necessary mobility assistance • access to evacuation shelters¹⁷ <p>May be more likely to live in public housing or in higher flood risk areas.¹⁸</p>
Low-income	<p>More likely to live:</p> <ul style="list-style-type: none"> • closer to industrial facilities and toxic waste sites that may release pollution after a storm.¹⁹ • in areas with high flood risk^{14,15}
Older Adults	<p>More likely to have:</p> <ul style="list-style-type: none"> • medical comorbidities • limited capacity to evacuate or be resilient to a hurricane or flood, especially if they lose their homes^{20,21}
Rescue Workers and First Responders	<p>More likely to:</p> <ul style="list-style-type: none"> • sustain unintentional injuries during and after hurricanes¹⁶

Immediate health risks from hurricanes and flooding

Immediate impacts of hurricanes are often due to high windspeeds and flooding. Unintentional injuries are also common during and immediately following hurricanes, as well as during rebuilding efforts.

Common unintentional injuries due to hurricanes include:

- Drowning
- Electrocution
- Cuts, lacerations, and puncture wounds
- Falls
- Traumatic head injuries from falling debris
- Trauma from motor vehicle accidents²²

Deaths from injuries after hurricanes have been found to peak about 1 month after a storm occurs.⁴

Infectious diseases associated with flooding

Flooding has been found to increase risks of infections, including vector, rodent and waterborne diseases, as well as illnesses associated with exposure to fungi. Infectious disease risk after hurricanes appears to peak 2 months after the event, but infections can be seen in the days after a storm occurs.⁴

Timing of post-flood infectious diseases in the United States

Early (<10 d after event)

- Cellulitis, including from *Vibrios*
- Pneumonias (may be aspiration related and polymicrobial)
- Viral respiratory infections
- Gastroenteritis (SSYCE, *Vibrios*, viruses)

Late (>10 d after event)

- Mosquito-borne illnesses
- Skin infection from atypical organisms (fungi, mycobacteria, mold)
- Hepatitis A or E

Adapted from Paterson et al. Clin Inf Dis. doi:10.1093/cid/ciy227 and Ivers and Ryan. Curr Op Inf Dis. doi: 10.1097/01.qco.0000244044.85393.9e.

Floods have been commonly associated with outbreaks of waterborne diseases, including from bacterial and viral pathogens.²³ Individuals who obtain water from private wells may be at particularly high risk, but even public water systems can be contaminated during extreme storms.²⁴

Standing water may create breeding grounds for disease-carrying mosquitos²⁵ and fungal growth. Flooded homes are much more likely to have higher levels of molds, such as *Aspergillus*, *Penicillium*, and *Cladosporium*.²⁶ Patients with allergic disorders may be more likely to develop symptoms from mold exposures.²⁷ Fungal infections are less common, but immunocompromised individuals have developed respiratory fungal infections after flood induced mold exposures.²⁷

Population displacement that occurs after hurricanes and floods can result in overcrowded homes and shelters, sometimes with inadequate sanitation. These conditions can result in the spread of many different infections, especially those transmitted by respiratory or fecal-oral routes.²⁷

Toxic exposures

Hurricanes have caused massive releases of toxic industrial, wastewater, and agricultural substances into the environment. What toxins may be most prevalent in a community after a flood may reflect what is stored in local toxic substance impoundments. The EPA tracks sites in your community that may contain hazardous substances which can be mobilized by flooding [here](#).

Hurricanes Katrina and Harvey damaged fossil fuel processing and storage facilities, which released hydrocarbons (known to cause respiratory irritation and arrhythmias), volatile organic compounds (which can be carcinogenic), and heavy metals, such as lead, into air, water, and soil. Hurricane Florence breached a coal ash pit in North Carolina. Coal ash is a byproduct of coal combustion and coal ash pits are present across the country. Coal fly ash contains volatile organic compounds as well as heavy metals, including mercury, arsenic and/or chromium.

The figure below shows the location of coal ash contamination sites as of February 2014. Red denotes a coal ash contamination site. Green denotes a coal ash spill. Black denotes both a contaminated site and spill.



Sources: Esri, USGS | Esri, HERE, Garmin, FAO, NOAA, USGS, EPA-

Infrastructure failures can cause additional unique and harmful exposures. Gasoline shortages after Hurricane Sandy led to increased gastrointestinal and pulmonary symptoms due to gasoline-siphoning related exposures.²⁸ Acute intoxication from gasoline fumes can cause confusion, giddiness, nausea, headache, blurred vision, dizziness, and weakness. Severe exposure can result in respiratory depression, seizures, loss of consciousness, and coma.

Carbon monoxide poisonings often increase after disasters, most often from indoor or inadequately ventilated electrical generator use combined with absent or non-functional carbon monoxide monitors.²⁹ Patients may also attempt to cook or heat their homes by burning fuels, such as wood or propane, indoors, or to run their vehicle for air conditioning in an enclosed garage, which can also lead to carbon monoxide poisoning.

Hurricanes, floods, and mental health

Increases in PTSD, depression, and anxiety symptoms have been documented after hurricanes.¹⁶ Prevalence of diagnoses after floods and hurricanes vary with the intensity of the storm or flood. A meta-analysis of tropical cyclone survivors globally found ~18% had PTSD with more severe storms.³⁰ Need for psychiatric care can extend for prolonged periods after hurricanes make landfall. Reports of psychiatric concerns have been elevated for years following Hurricanes Sandy and Katrina.³¹⁻³³

Children, females, and older individuals may be most at risk of mental health symptoms after hurricanes.³⁴ Individuals in certain occupations, such as farm workers and first responders (e.g., emergency medical personnel, police officers, and fire fighters), may also be more at risk. Mental health symptoms after exposure to a hurricane have also been found to be associated with lack of necessities, including medications and access to medical care as discussed above, personal physical exposure to hurricane forces (e.g., wind, rain, storm surge), evacuation, loss of a loved one or pet, repeat exposure to hurricanes, existing mental health disorders or recent personal adversity.³⁵⁻³⁷

Disruption of health-systems infrastructure and displacement

Hurricanes and floods often impede healthcare delivery as they can damage healthcare facilities, cut off essential utilities, disrupt supply chains, and inundate roads. Patients who are displaced by storms may be unable to refill medications, and lack of access to medications after hurricanes and floods has been associated with increased morbidity.^{22,38}

Patients with chronic conditions, including diabetes and cancer, may delay necessary healthcare services because of healthcare facility closure, difficulty with transportation, or competing demands on time²⁰ and may have worse outcomes as a result.³⁹

Hurricane and Flood Action Plans for Patients

We recommend that you familiarize yourself with the “Hurricane & Flood Action Plan for Patients” provided in the toolkit and review it with any patient at risk of experiencing a hurricane and/or flood. The action plan can be provided during care visits with adolescents and adults and can be the basis for a discussion around safety planning and care management in the event of a hurricane or flood. Action plans should be completed before hurricane season in your locale.

Anticipatory Guidance for Providers to Give to Patients

Anticipatory guidance for hurricanes and floods may contribute to improved health outcomes. The strategies and resources below may be helpful for you to provide to patients who are at risk from hurricanes or floods and reflect the “Hurricane & Flood Action Plan for Patients” available in the toolkit.

Forecasts

Baseline and future flooding risk for many properties in the United States can be found at riskfactor.com. Hurricane forecasts are available from several outlets including the [National Hurricane Center](http://NationalHurricaneCenter.gov).

A “hurricane watch” indicates that hurricane conditions (winds of greater than 74 mph) are possible. A “hurricane warning” indicates that hurricane conditions are expected. Hurricane warnings are given 36 hours prior to the expected hurricane impact to give residents time to prepare or evacuate.

Flood forecasts are less certain than hurricane forecasts as flood risk depends on many factors aside from absolute rainfall, including geography, volume of recent rainfall, the built environment, and proximity to rivers (and their levels). The National Weather Service does provide [flash flood forecast maps](http://flashfloodforecastmaps.com) that show where flooding may be most likely given expected precipitation.

Reduce risks from hurricanes and floods

We encourage you to provide patients with both patient handouts available in this toolkit (“Tip Sheet for Patients: Staying Safe During Hurricanes and Floods” and “Hurricane & Flood Action Plan for Patients”).

In addition, [hurricane](http://hurricane.cdc.gov) and [flood](http://flood.cdc.gov) preparedness guidance is available from CDC and FEMA in multiple languages. CDC also has an infographic for [hurricane](http://hurricane.cdc.gov) and [flood](http://flood.cdc.gov) preparedness and for [keeping safe after hurricanes](http://keeping-safe-after-hurricanes.com).

Evacuation

Evacuation may be the best choice when hurricanes or flooding are expected near a patient’s home. Patients can be encouraged to pay attention to local media outlets for evacuation orders (i.e., through newscasts, social media, or automated alerts on a smart phone).

Responsiveness to evacuation alerts has been found to vary by age, gender, and other factors. Men and full-time residents may be more likely to want to stay and protect their property, whereas homes with children, elderly individuals, pregnant women, individuals with health concerns, or part-time residents are more likely to evacuate early.³⁸

Providers can ask whether a patient would be willing to evacuate when asked to do so. For those individuals who are unwilling to evacuate, especially for individuals with chronic medical conditions or who rely on electronic devices such as ventilators, reviewing the risks from hurricanes and floods may be helpful to enabling evacuation to safety when necessary.

If a high-risk patient will not have the needed assistance to evacuate, a provider can ask permission to share the patient's contact information with local emergency managers.

Extensive, multilingual [guidance on evacuation planning](#) is available from FEMA.

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