

Major Earthquakes & Cascading Events: Potential Health and Medical Implications

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This [ASPR TRACIE](#) resource provides an overview of the potential significant health and medical response and recovery needs facing areas affected by a major earthquake with or without additional cascading events.

The list of considerations is not exhaustive, but does reflect a thorough scan of publications and resources available that describe past incident effects and response. Earthquakes do not pose a significant risk for every community and those communities that could be affected by earthquakes have different risk levels, different hazards or cascading events, and different levels of existing community preparedness and mitigation. Those faced with planning for—and leading the response to and recovery from—an earthquake may use this document as a reference. Planners and responders should integrate jurisdiction-specific risk assessments and issues specific to their communities in their planning efforts.

Please note that the focus of this document is on human health and the healthcare system response to earthquakes, however, the health of people, animals, and the environment are all interconnected, so general considerations for animals and the environment are included, where applicable to human health or to the overall mission of Emergency Support Function 8.

For additional resources specific to earthquakes and related health effects, please access the [ASPR TRACIE Natural Disasters Topic Collection](#). The [ASPR TRACIE Hazard Vulnerability/Risk Assessment Topic Collection](#) and the [Evaluation of Hazard Vulnerability Assessment Tools](#) can assist with performing a jurisdiction-specific risk assessment.

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Earthquakes in the United States

The United States Geological Survey (USGS) produces an annual probability map of the seismic hazard forecast in the U.S. The 2018 model is shown in Figure 1. The USGS also produces hazard maps and tracks [all current and historical earthquake activity](#).

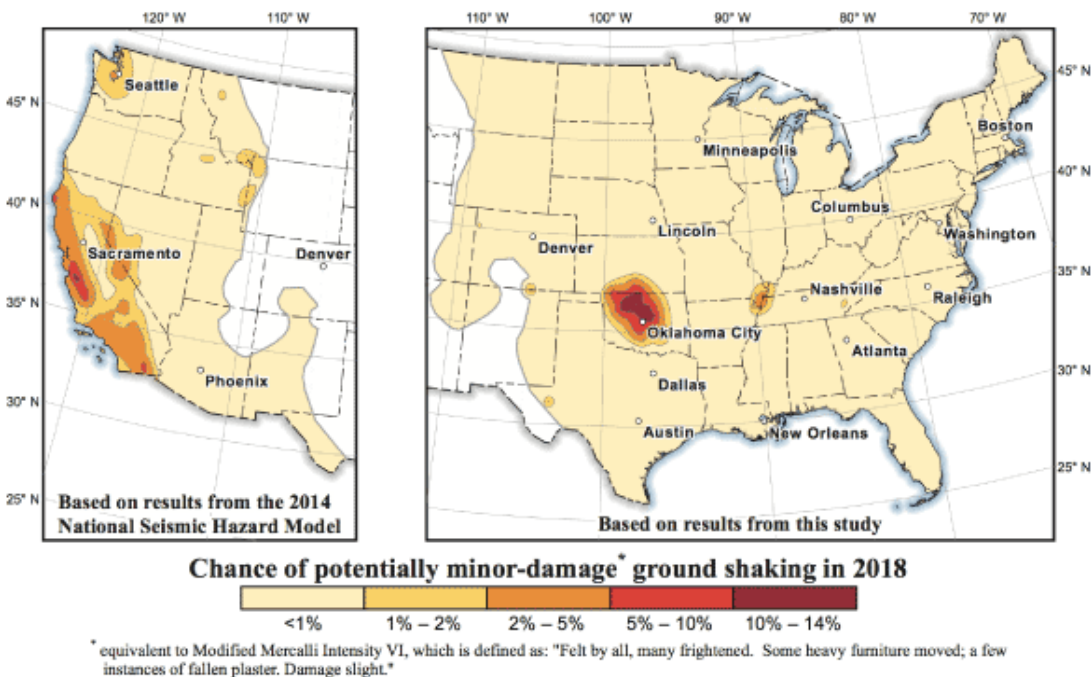


Figure 1. *Chance of Potentially Minor Damage Ground Shaking in 2018.*

The Federal Emergency Management Agency (FEMA) provides information on earthquake [hazard, exposure, and vulnerability](#). Earthquakes occurring in the U.S. will have different effects on the population due to a number of factors, including, but not limited to the type of fault and geography of the area, the building and critical infrastructure vulnerability, and the overall preparedness of the population. For information on the different regions affected by earthquakes in the U.S., visit the FEMA-supported regional earthquake consortia:

- [Central United States Earthquake Consortium \(home to New Madrid Seismic Zone\)](#)
- [Western States Seismic Policy Council](#)
- [Cascadia Region Earthquake Workgroup](#)
- [Northeast States Emergency Consortium](#)

Because of the variance of earthquake types across the U.S., it is important for planners to understand community-specific hazards, vulnerability, and risk. Some earthquakes occur with a main event, followed by diminishing aftershocks. But some seismic zones, specifically the New Madrid Seismic Zone, may experience sequenced events (three or more main shocks in different locations occurring over a period of time), each event accompanied by its own set of aftershocks. There are currently no computer models able to simulate the sequenced impact of such an event. The effects of such an incident and its impact on response and follow-on

recovery efforts remain largely unknown. Additionally, some research estimates that geographical characteristics of the Central and Eastern U.S. contribute to a much larger area of impact, potentially up to 20 times larger than earthquakes of equivalent strength that strike the western U.S.¹ Additionally, many areas of the country not typically susceptible to earthquakes have recently experienced ground shaking in a phenomenon called [induced earthquakes](#). Being aware of jurisdictional hazards is key to emergency planning and management.

Potential Effects of Earthquakes

Earthquakes can significantly damage and disrupt a community's interdependent infrastructure, including: residential and commercial buildings; utilities (e.g., water and sewage); dams; levees; communications technology; healthcare facilities; chemical plants; industrial storage tanks; nuclear power plants and other hazardous materials storage locations; and bridges, tunnels, airports, roads, sea ports, and/or rail lines. Damage may lead to secondary radiological or other hazardous materials incidents; transportation and supply chain disruption (including those used to transport food and medicines); and significant financial losses. Pre-event living and employment conditions may be dramatically altered while healthcare facilities and providers may not be accessible for an extended period of time. Figure 2 illustrates the potential critical infrastructure disruptions and subsequent population effects due to an earthquake.

¹ For additional information, access this [US Geological Survey site](#).

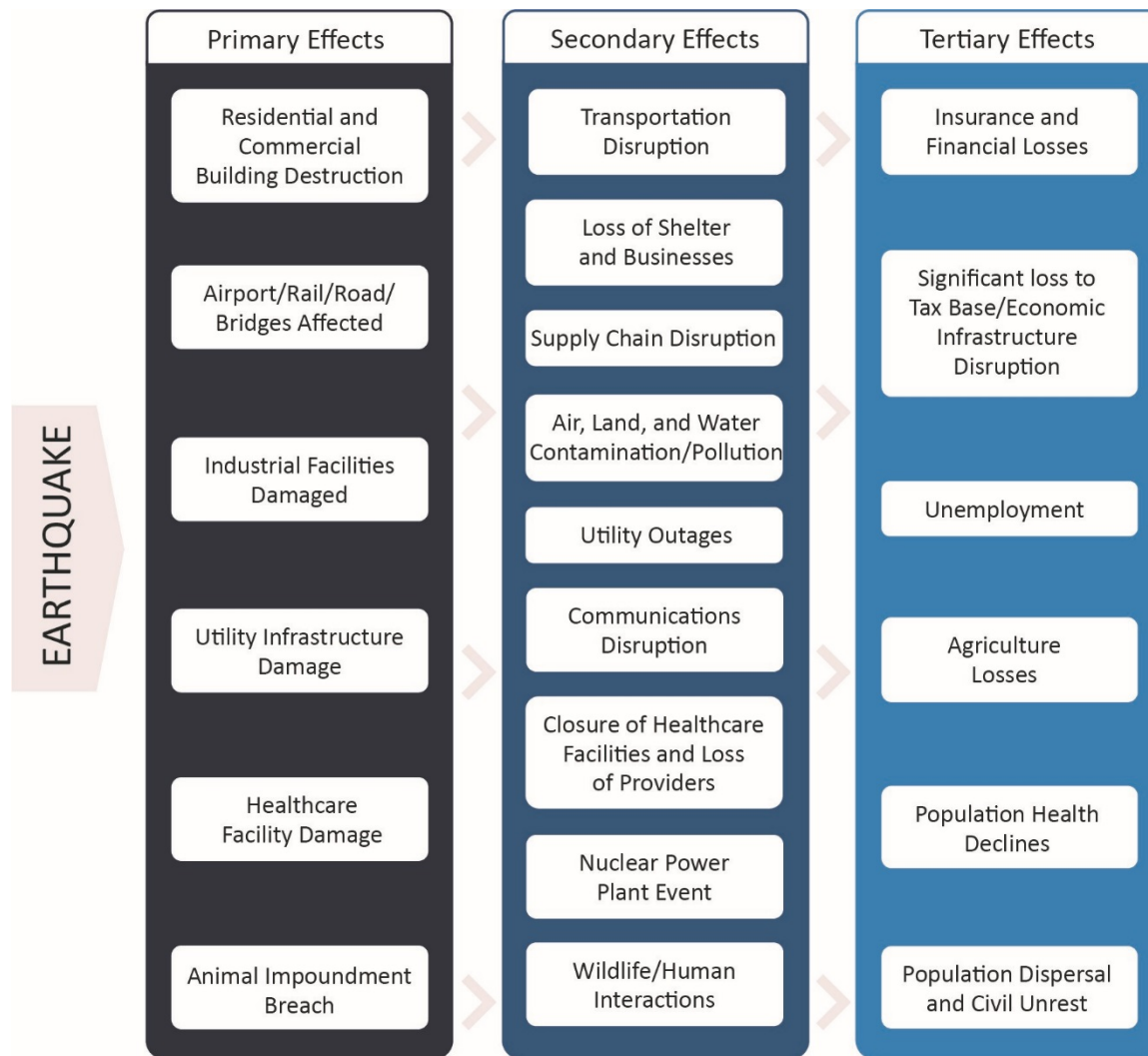


Figure 2. Earthquakes and Critical Infrastructure Disruption. Figure based on data found in Kadri, Chatelet, and Birregah (2014) and Khazai, Daniell, and Wenzel (2011).

Potential Cascading Events Resulting From Earthquakes

Earthquakes can either cause or be caused by other significant disasters, known as “cascading events.”² Earthquakes can trigger tsunamis that can impact not only the earthquake-affected area, but other countries and regions that share the same bodies of water. Leaks from nuclear power stations or releases from hazardous material storage facilities (e.g., hazardous materials, byproducts, radiation) can negatively impact population health, even miles from the initial earthquake zone, depending on meteorological conditions. Additionally, bridge and dam collapses can lead to additional flooding events and infrastructure damage; and landslides/soil

² FEMA defines cascading events as an event that may occur as a direct or indirect result of an initial event.

liquefaction can eradicate access to roads and supplies and/or contribute to power and communication outages.

Examples of some larger-scale earthquakes with cascading events include (but aren't limited to):

- In 1975, Kilauea Volcano in Hawaii experienced a 7.7 magnitude (Richter scale) earthquake that triggered a tsunami and a small lava flow eruption on the caldera floor.³ Two people died and 19 were injured as a result of the tsunami, the largest wave of which reached 26 feet (NOAA).
- The 1998 Papua New Guinea earthquake of a magnitude 7.0 generated a large submarine landslide which in turn quickly generated an approximately 15 meters tsunami (USGS).
- In 2004, the Indian Ocean earthquake (magnitude 9.1) triggered a tsunami wave that hit 14 different countries and killed at least 230,000 people. That earthquake was one of the third largest ever recorded, and caused the “mean north pole” to shift approximately 2.5 cm east (NASA Jet Propulsion Laboratory; U.S. Geological Survey).
- In 2011, following a magnitude 9.1 earthquake and subsequent tsunami in Japan, a nearby nuclear power plant experienced generator failure and three separate meltdowns in their reactors, hydrogen-air explosions, and release of radioactive material into the environment (U.S. Geological Survey; Encyclopedia Britannica).

Cascading events are particularly problematic because:

- The initial event(s) may damage infrastructure or resources (human and other) that are critical to the response to the secondary event.
- Additional injuries can result.
- The damage and distraction of the primary event(s) may delay the timely recognition of cascading events, potentially delaying response.

Figure 3 demonstrates the numerous cascading events and potential secondary disasters that can occur from a single earthquake, including subsequent health effects.

³ The USGS defines caldera as “A large basin-shaped volcanic depression with a diameter many times larger than included volcanic vents; may range from 2 to 50 km (1 to 30 mi) across. Commonly formed when magma is withdrawn or erupted from a shallow underground magma reservoir.”

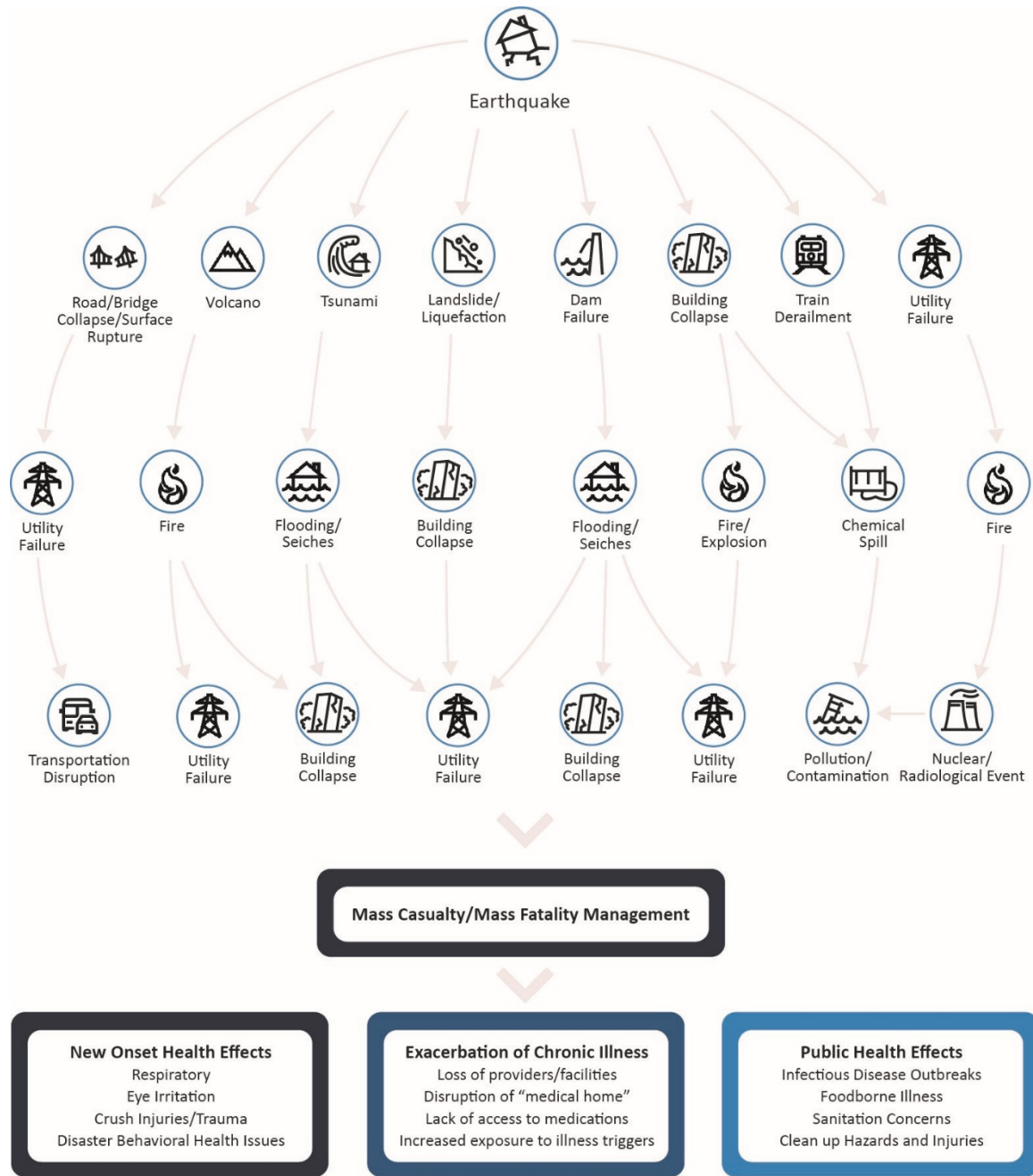


Figure 3. Consequences of Earthquakes and Cascading Events.

Appendix A includes additional information on the effects that tsunamis, volcanic eruptions, and radiologic and other hazardous material releases may have on population and individual health.

Considerations for Healthcare Emergency Planners

The potential for negative post-earthquake health effects is great, regardless of cascading events. Earthquakes should be planned for as no-notice incidents. A comprehensive jurisdictional risk assessment can ensure that appropriate plans are developed and exercised and can help identify the mitigating actions that may prevent or lessen the impact of primary and cascading events.

The following sections describe considerations for healthcare emergency planners and responders under four headings: Overarching (i.e., those that apply throughout the duration of the disaster planning, response, and recovery cycle), and Immediate, Short-term, and Long-term/Recovery. When drafting plans, it is critical to verify that resources, programs, and deployable assets will be available based on input from local stakeholders.

Overarching Considerations

Access and Functional Needs Population Support in Disasters

Before, during, and after a disaster, at-risk individuals with access and functional needs (e.g., children, pregnant women, older adults, people with disabilities, individuals with limited English proficiency) may require additional support from the emergency management system. Loss of primary healthcare facilities, dialysis centers, health clinics, urgent care centers, and home health providers following an earthquake puts the access and functional needs population at higher risk; being located in a rural or tribal community can increase this risk. In the event of an earthquake, at-risk individuals: may experience an exacerbation of chronic health conditions; may not be able to understand or follow emergency instructions due to communication barriers; may not have the resources or ability to evacuate or effectively shelter in place; and may not be able to take protective action measures to mitigate the effects of the earthquake. Members of this population are often targeted by human traffickers in the chaotic aftermath of a disaster.

Ensuring response and recovery operations address the needs of the community can support protection and improve overall community resilience. Pre-event planning and communication, as well as thorough assessment of these at-risk populations and the systems they rely on, can prevent many of these issues and reduce the potential for harm. Working with local home and community-based agencies and checking U.S. Census Bureau and other data sources, such as the U.S. Department of Health and Human Services (HHS) [emPOWER Program](#), can assist with identifying [at-risk individuals with access and functional needs](#). Ensuring that plans and messaging account for linguistic and cultural diversity within a community will also contribute to effective response and recovery following a disaster.

In addition, healthcare providers can play a role in combatting increases in human trafficking, scams, and other exploitation, as well as increases in domestic violence and sexual assault, which may follow disasters, in conjunction with health officials and law enforcement, by providing information to patients and reporting suspicious situations.

The [HHS emPOWER Program](#) provides federal data, mapping, and artificial intelligence tools, as well as training and resources, to help communities nationwide protect the health of at-risk Medicare beneficiaries, including 4.2 million individuals who live independently and rely on electricity-dependent durable medical and assistive equipment and devices, and or essential health care services. The [HHS emPOWER Map](#) provides monthly de-identified totals of Medicare claims submitted for one or more of the fourteen types of life-maintaining or saving electricity-dependent durable medical and assistive equipment (DME) and certain implanted electricity-dependent cardiac devices, at the national, state, territory, county, and ZIP Code levels. Public health authorities receive a monthly updated emPOWER Emergency Planning De-identified Dataset that includes totals by type of equipment, outpatient dialysis, oxygen tank services, home health care, and in-home hospice services at that state, territory, county, and zip code level. In the event of an emergency, a public health authority can request an emPOWER “Response Outreach Individual Dataset” which provides information (e.g., names, addresses) that can support life-saving outreach and assistance. It is important to note that in order to submit a request for the identifiable emPOWER data the public health authority must set up and maintain permissions pre-event.

For More Information:

[ASPR TRACIE Topic Collections](#)

[Access and Functional Needs](#)

[Dialysis Centers](#)

[Homecare](#)

[Long-Term Care Facilities](#)

[Pediatric](#)

[Rural Disaster Health](#)

[Utility Failures](#)

[ASPR TRACIE Pediatric Issues in Disasters Webinar](#)

[ASPR TRACIE Considerations for Oxygen Therapy in Disasters](#)

[ASPR TRACIE Durable Medical Equipment in Disasters](#)

[ASPR At-Risk Individuals](#)

[HHS emPOWER](#)

[HHS emPOWER Fact Sheet](#)

[Cultural and Linguistic Competency for Disaster Preparedness Planning and Crisis Response](#)

[The Role of Healthcare Providers in Combatting Human Trafficking during Disasters](#)

Select Programs/Assets to Consider:

[HHS Response and Recovery Resources Compendium](#)
[Disaster Recovery Assistance](#)

Disaster Behavioral Health Needs

Earthquakes can contribute to significant negative mental and behavioral health effects that can directly impact healthcare systems and healthcare providers. The demand for disaster behavioral health services spikes immediately following an incident—particularly with the loss of homes, experiencing financial upheaval, and potentially being in a shelter. Behavioral health challenges can also have a direct effect on survivor and responder physical health and wellness. Behavioral health resources for affected communities and the responders that serve them should be made available immediately following an earthquake and any aftershocks and during the long-term recovery period. In addition, healthcare providers should be trained in the principles of Psychological First Aid. Long-term behavioral health support will be needed for re-triggering events such as aftershocks.

For More Information:

[ASPR TRACIE Topic Collections](#)

[Mental/Behavioral Health \(non-responders\)](#)

[Responder Safety and Health](#)

[ASPR TRACIE Disaster Behavioral Health: Resources at Your Fingertips](#)

[ASPR TRACIE Tips for Retaining and Caring for Staff](#)

[Tips for Disaster Responders: Preventing and Managing Stress](#)

[The Exchange, Issue 4: Disaster Behavioral Health and Resilience](#)

Select Programs/Assets to Consider:

[HHS Response and Recovery Resources Compendium](#)

[Mental Health and Substance Abuse](#)

[HHS Substance Abuse and Mental Health Services Administration \(SAMHSA\) Disaster Distress Hotline](#)

[SAMHSA Earthquakes](#)

[National Child Traumatic Stress Network: Psychological First Aid](#)

Emergency Information and Risk Communication

As the earthquake evolves from initial impact to response and recovery, the focus of risk communication, messaging, and cultural competency must also evolve. Communication includes providing the public with information through verbal, written, or symbolic means. Plan for many traditional communication channels to not be operable for a period of time. Clear, concise, unified messages provided by trusted leaders before, during, and after an incident can help residents be better informed to take protective action measures and make important health-related decisions to help ensure their safety. Messages should be accessible in multiple

languages and through multiple media. Joint Information Systems (JIS) can help public health, emergency management, healthcare, and Emergency Medical Services (EMS) to ensure appropriate and timely messaging regarding warnings, sheltering/evacuation actions, water quality and other specific hazards, and other proactive and reactive information that can keep the population safer and encourage responsible use of response resources (e.g., when to go to the emergency room versus treating at home). Note: not all incidents will unfold in a “normally” progressing way (e.g., impact, response, recovery). Emergency information and risk communication planning strategies should take into account that in some parts of the U.S. (e.g., Central US), an earthquake may lead to cascading events that will impact traditional response and recovery timelines and efforts.

For More Information:

[ASPR TRACIE Emergency Public Information and Warning/Risk Communications Topic Collection](#)

Select Programs/Assets to Consider:

[HHS Response and Recovery Resources Compendium](#)
[External Communications/Public Affairs](#)

Family Reunification and Patient Tracking

During and after earthquakes, friends and loved ones will be separated from each other; reuniting them should be a priority for healthcare facilities, health officials, and emergency managers. Establishing a coordinated approach for accessing search and rescue data, the use of social media, establishing community hotlines and assistance centers, shelter rosters, and healthcare facility information is key to reuniting those affected by the disaster. Healthcare facility plans should also take into account staff/personnel tracking to ensure employee health and safety as well as adequate staffing levels.

For More Information:

[ASPR TRACIE Topic Collections](#)

[Family Reunification and Support](#)
[Patient Movement and Tracking](#)

[ASPR TRACIE HIPAA and Disasters: What Emergency Professionals Need to Know](#)

[The Exchange Issue 6: Evacuating Healthcare Facilities](#)

[Tips for Healthcare Facilities: Assisting Families and Loved Ones after a Mass Casualty Incident](#)

Select Programs/Assets to Consider:

[HHS Response and Recovery Resources Compendium](#)
[Patient Movement](#)

Health Information Management

During an earthquake, patients may be separated from their “medical home” and medical records. Information technology (IT) systems may be damaged in the event and access to the systems may be limited by physical barriers, access issues, power or network disruptions, or other impacts. Patients being evacuated or moved from one healthcare facility to another need complete medical records transferred with them, but that is not always possible if the facility has experienced significant damage and paper records are damaged or missing, electronic records are not accessible, and/or if an emergency evacuation was necessary. Redundant IT systems in different parts of the country and back-up paper records (including pre-printed face sheets with the critical information) can help mitigate this issue. Patients should also be encouraged to include important medical records/ prescription lists in their emergency kits in the event they are evacuated from their home.

Healthcare facilities must also be aware of the rules regarding what types of patient information may be shared with caregivers and family members, and what they are required to share with authorities. Authorities should develop protocols for how patient information will be shared during a large-scale emergency before an earthquake strikes. The HHS Office of Civil Rights has published a number of [emergency preparedness and response tools](#) and factsheets regarding Health Insurance Portability and Accountability Act (HIPAA) data and information disclosure in the event of a public health emergency or disaster.

For More Information:

ASPR TRACIE Topic Collections

[Continuity of Operations \(COOP\)/ Failure Plan](#)

[Communications Systems](#)

[Electronic Health Records](#)

[Information Sharing \(e.g., partners and employees\)](#)

[ASPR TRACIE HIPAA and Disasters: What Emergency Professionals Need to Know](#)

Select Programs/Assets to Consider:

[HHS Response and Recovery Resources Compendium](#)

[Public Health and Medical Information](#)

Multi-location Mass Casualties and Incident Management

Earthquakes can cause widespread damage that can lead to a surge in calls for emergency assistance. These calls could range from reports of structural damage to individual injuries—to calls from multiple mass casualty incident sites. Having a jurisdictional or regional area command for coordinated triage, treatment, and transport of patients from multiple mass casualty scenes will help distribute patient surge across the entire affected area. It will be important to quickly identify hospitals that can accept patients, those that are too damaged to open, and those that are not damaged but cannot accept patients due to power loss, water

shortage, staffing/supply challenges, or isolation due to bridge or roadway outages. It will also be critical to coordinate with partners such as public works to have debris cleared and roads that lead to open facilities repaired as quickly as possible to support patient transport. Determining the radius of the earthquake's impact can help determine which hospitals outside the immediate impact area can accept patients. Emergency managers should:

- Be prepared to conduct numerous, simultaneous operations and keep them distinct from a communications and mutual aid standpoint. For instance, several neighborhoods or city blocks may contain multiple damaged homes or buildings, with multiple injured per building. First responders, incident commanders, and emergency managers will need to determine the most effective way to manage the resources at these various incident locations to maximize resource availability and span of control and minimize confusion or duplication of effort. Directing services towards specific neighborhood boundaries or small geographic areas of command (instead of focusing on individual structures) may be most appropriate.
- Be mindful of the effects of aftershocks on continuing operations and the stability of permanent and temporary facilities. Damage assessment should be performed after each aftershock.
- Understand that due to the widespread nature of the disaster, local mutual aid resources are likely to be exhausted quickly. Statewide or multi-state regional mutual aid agreements are necessary to ensure timely arrival of replacement resources.
- Be prepared for the potential need to decontaminate patients before or upon arrival at hospitals.

For More Information:

ASPR TRACIE Topic Collections:

[Coalition Response Operations](#)

[Hospital Patient Decontamination](#)

[Incident Management](#)

[On-Scene Mass Casualty Triage and Trauma Care](#)

[Patient Movement and Tracking](#)

[Pre-Hospital](#)

[Pre-Hospital Patient Decontamination](#)

[The Exchange Issue 7: Providing Healthcare During No-Notice Incidents](#)

Select Programs/Assets to Consider:

[HHS Response and Recovery Resources Compendium](#)

[Public Health and Medical Information](#)

[Emergency Management Assistance Compact](#)

Regulatory and Legal Concerns

Healthcare facilities in areas affected by earthquakes will likely be forced to operate outside of their normal operating conditions. A surge of patients may require the healthcare facility to implement mass casualty protocols, crisis standards of care, and activate their emergency plans. Effects from the earthquake could cause the facility to become inoperable, which may lead to forced evacuation, closure, or alteration of regular operations. Some of these impacts, such as evacuation, closure, or activating the facility emergency operation plan will have regulatory repercussions at the local, state, and even federal levels. Healthcare facilities may also have to integrate staff and assets that may raise questions of credentialing, licensure, and reimbursement that should be addressed both pre- and post-event.

Emergency managers, public health officials, and other emergency officials should review their local, state, and federal statutes with regards to declarations of emergency and the effect of such declarations on response operations. Legal reviews are ideally completed prior to an emergency and assumptions and necessary action steps are documented in plans. All stakeholders should participate in these reviews to determine what regulatory relief should be requested at different levels of government. Draft declarations developed prior to an emergency can make it easier for staff to implement a comprehensive earthquake response.

Specialty hospitals and facilities without emergency departments that typically do not accept walk-in patients and choose not to administer aid during the disaster should provide adequate messaging (and additional security as needed) the incident stabilizes.

Also of consideration should be planning for the potential relocation of healthcare professionals after the disaster. This may include continued pay and benefits for personnel, temporary change in work location, and/or temporarily sending staff to other facilities.

For More Information:

[ASPR TRACIE Healthcare-Related Disaster Legal/Regulatory/Federal Policy Topic Collection](#)

[ASPR TRACIE EMTALA and Disasters Fact Sheet](#)

[ASPR TRACIE Crisis Standards of Care Topic Collection](#)

Select Programs/Assets to Consider:

[HHS Response and Recovery Resources Compendium](#)

[General Info](#)

[Centers for Medicare and Medicaid Services Survey and Certification Group](#)

[1135 Waivers](#)

[State Healthcare Facility and Provider Licensure Requirements](#)

[Local Building and Code Inspection Rules](#)

Responder Safety and Health

Earthquakes and their aftershocks result in numerous hazardous situations that can affect responder safety and health. It is critical to ensure that adequately trained Safety Officers are appointed and consulted regularly throughout the response and recovery and that they are aware of earthquake-related safety and health threats. Personal protective equipment (PPE) and safety equipment (e.g., flashlights, hardhats) should be made available when needed. All providers should be mindful of hazardous conditions in the field and to/from their duty stations, such as those resulting from building or roadway, bridge, tunnel collapse; downed power lines; ruptured gas and water lines; and poor air quality. Some staff may be directly impacted by the event (their homes destroyed or loved ones lost) and that loss of staff must be planned for and addressed before an incident. Encouraging staff and volunteer personal preparedness can ensure they are available to work during and after the incident. Considerations for ensuring staff safety may include providing shelter in a healthcare facility or annex for staff and their families (and spontaneous volunteers, as is practical).

In the days and months that follow an earthquake, considerations should be taken for potential environmental hazards caused by the event (e.g., fungal spores from *C. immitis* that cause Valley fever when the soils are disturbed in the southwestern US⁴). Clean-up, construction, and healthcare personnel that may be impacted should be provided information on the possibility of these hazards (e.g., airborne spores) and have appropriate PPE available.

The following sections in this document provide additional considerations: [Staff Fatigue and Replenishment](#); [Assessment of Healthcare Facilities for Safe Operation](#); and [Disaster Behavioral Health Needs](#).

Staff Fatigue and Replenishment

In the first few days of a response, staff are focused on response operations and often cannot or will not rest or remove themselves from operations. This includes clinical providers, administrative staff, and staff who maintain facility operations, who are all critical to the response phase and expected to care not only for their own loved ones, but also community members and the facility. Cognitive abilities decline rapidly with fatigue, stress, and inadequate nutrition and hydration –self-care is of the utmost importance and must be stressed. Incident management should prioritize staffing plans that include adequate time for: rest and replenishment, staff to check in with family and friends to be reassured of their safety, and staff to take care of personal needs. It is important that staffing plans are communicated to all employees and during all shifts.

⁴ For additional information, see “[Emerging Infectious Diseases Coccidioidomycosis Following the Northridge Earthquake -- California, 1994](#)”.

For More Information:

[ASPR TRACIE Responder Safety and Health Topic Collection](#)
[ASPR TRACIE Tips for Retaining and Caring for Staff after a Disaster](#)
[Occupational Safety and Health Administration Earthquake Preparedness and Response](#)
[Tips for Disaster Responders: Preventing and Managing Stress](#)

Select Programs/Assets to Consider:

[HHS Response and Recovery Resources Compendium](#)
[Worker Health and Safety](#)

Animal Health Considerations

Plans should be established to manage post-earthquake issues involving animals (pet, wildlife, agriculture). Disrupted earth may lead to an increase in: zoonotic diseases and animal bites (e.g., leptospirosis concerns post-earthquake, vectored diseases such as malaria, tularemia or plague in some parts of the U.S., and possible increases in situations where rabies exposure might occur). Loose domestic and non-domestic animals (e.g., pets, zoo animals, animals farmed for agricultural purposes)—particularly if there was a loss of power and animal confinements are inoperable—may lead to an increase in novel diseases and the release of certain pathogens from decaying carcasses.

Most service animals and many pets have Radio-Frequency Identification or Passive Integrated Transponder tags or chips implanted. Veterinarians and animal control agents use databases to track these chips and reunite owners. Local plans should allow for a central location to establish a coordinated approach to enable identification/ reunification. Facilities for holding pets with or near owners could reduce stress and encourage individuals to evacuate their homes knowing their pets are cared for. Shelters should also be established for displaced and abandoned animals.

If there are large scale impacts to animal holding facilities with mortality, there will be a need for carcass remediation. This should be a part of planning considerations in areas with confined animal facilities or those that house exotic animals.

For More Information:

[ASPR TRACIE Disaster Veterinary Issues](#)

Select Programs/Assets to Consider:

[American Veterinary Medical Association- Disaster Preparedness Policies and Resources](#)
[USDA Animal and Plant Health Inspection Service- Animal Health Emergency Management](#)
[USDA Animal Welfare Information Center- Disaster Planning](#)
[U.S. Congress- Pets Evacuation and Transportation Standards Act](#)

Immediate earthquake-related considerations can include:

- Water system breaks that may flood any part of the building, particularly basement areas and underground levels
- Water rendered unsafe to drink from damage to community treatment systems
- Water pressure loss or inadequate volume to conduct healthcare facility operations
- Exposure to pathogens from sanitary sewer system breaks
- Exposed and energized electrical wiring
- Airborne hazards (e.g., asbestos, silica, fungal spores)
- Hazardous materials leaks (e.g., ammonia, battery acid, leaking fuel, oxygen)
- Natural gas leaks creating flammable and toxic environment
- Structural instability
- Power losses affecting critical medical equipment
- Insufficient oxygen or other medical gasses
- Slip, trip, or fall hazards (e.g., due to holes or protruding rebar)
- Fire/fire damage
- Proximity to heavy machinery such as cranes
- Sharp objects such as glass and debris
- Disabled security systems (e.g., facility access, fire alarm, medications and supplies, blood products, laboratory chemicals and pathogens, radiologic material) due to power loss
- Secondary collapse from aftershock, vibration, and/or explosions.

Immediate Considerations

Assessment of Healthcare Facilities

Following an earthquake, healthcare facility staff must first clear hallway debris and patient rooms (e.g., damaged ceiling tiles, light fixtures, equipment) to ensure quick evacuation is possible if necessary. Healthcare facilities should activate their response plan and account for patients, staff, and visitors. Next, trained facility staff (e.g., structural engineers, IT professionals), using pre-established protocols, should evaluate, to the best of their ability, the structural integrity of their building and operational status of their infrastructure/utility systems with the goal of ensuring the safety of patients and staff. This will inform decisions related to immediate or delayed response actions, modification or cessation of operations, and/ or facility evacuation. Emergency operation plans should include clear protocols for assessing facility status, rapid debris removal, pre-identified thresholds or triggers for activation of continuity of operations plans (COOP) and reporting that status to the appropriate partners in support of area-wide triage and transport planning. Some plans may also specify when jurisdictions (with the resources) can stand up temporary structures (e.g., tents, alternate care centers).

For More Information:

ASPR TRACIE Topic Collections:

- Alternate Care Sites (including shelter and medical care)
- Continuity of Operations (COOP)/ Failure Plan
- Emergency Operations Plans/Emergency Management Program
- Healthcare Facility Evacuation/Sheltering
- Healthcare-Related Disaster Legal/Regulatory/Federal Policy
- Recovery Planning

Occupational Safety and Health Administration Earthquakes Guide

Post-Disaster Hospital Assessment Tools

The Exchange Issue 6: Evacuating Healthcare Facilities

Select Programs/Assets to Consider:

FEMA National Earthquake Technical Assistance Program

- FEMA P-115 Rapid Visual Screening of Buildings for Potential Seismic Hazards

HHS Response and Recovery Resources Compendium

- Blood Products and Services
- Safety and Security of Drugs and Biologics

Communications Outages

Communications systems outages may occur in the aftermath of a major earthquake. Every healthcare facility, as well as EMS providers, healthcare coalitions, emergency management agencies, and health department/ESF 8 partners, should have a comprehensive communications plan that describes strategies, equipment, and detailed use protocols to ensure the viability of redundant communications after a disaster. In addition, hard copies of staffing lists and contact information for both staff and key response partners should be maintained and available at the time of an incident. Multiple technologies should be employed to relay vital messaging including paging, texting, television, radio, and social media. Facilities should also look at options for how to communicate without electricity or working cellular, VOIP, or land line phones. Responsible staff should be made aware of the location of contact lists and protocols.

For More Information:

ASPR TRACIE Topic Collections:

- Continuity of Operations (COOP)/ Failure Plan
- Communications Systems

Select Programs/Assets to Consider:

- Government Emergency Telecommunications Service (GETS)
- Telecommunications Service Priority (TSP)

[Wireless Priority Service \(WPS\)](#)
[Local HAM Radio Operators \(Amateur License Search\)](#)
[Hospital Emergency Administrative Radio \(HEAR\)](#)

Fatality Management

Earthquakes have the potential to cause mass fatalities and the related destruction can present challenges to death scene investigation, patient identification, decedent transport and storage, and family notification. Fatality management resources may also be limited due to the widespread nature of earthquakes, the number of decedents, and the need to focus on immediate life-saving and life-sustaining operations. Plans should include provisions for these considerations and for the allocation of scarce resources to priority functions. Adaptations to traditional decedent management plans may be required in a post-earthquake resource-constrained setting.

For More Information:

ASPR TRACIE Topic Collections:

[Family Reunification and Support](#)

[Fatality Management](#)

[Mental/Behavioral Health \(non-responders\)](#)

[Tips for Healthcare Facilities: Assisting Families and Loved Ones after a Mass Casualty Incident](#)

[Death Scene Investigation After Natural Disaster or Other Weather-Related Events](#)

Select Programs/Assets to Consider:

[HHS Response and Recovery Resources Compendium](#)

[Victim Identification/Mortuary Services](#)

[Mental Health and Substance Abuse](#)

Healthcare Facility Evacuations

As previously mentioned, a healthcare facility may need to evacuate if its building is structurally unstable or key infrastructure / utility systems are damaged or unable to be used following an earthquake. Structural engineers or trained facility staff will need to determine whether a building is structurally stable. The result of a rapid needs assessment of healthcare and residential care facilities and supplementation with external generators, fuel supplies to run them, and water sources (potable and non-potable) are critical to preventing evacuation.

Anticipating the need to evacuate early to avoid emergency evacuation is ideal. The longer a facility has to execute the evacuation, the more orderly the process can be, as getting patients to the door involves many considerations. Facilities should have: evacuation plans that include partial (vertical and horizontal) and full evacuation procedures (to include pre-identified exterior assembly points to safely stage patients); accessible blueprints or life safety drawings

in case normal evacuation routes are inaccessible; adequate and accessible evacuation equipment/resources; procedures for evacuating specialty wards (e.g., NICU, ICU); and clear protocols on working with receiving facilities and maintaining records upon movement. It is important for facilities to include site security in plans to protect pharmaceuticals, records, financial assets, and data.

Ensure staff are available to inspect the building for damage to confirm it is safe for continued use. Pay particular attention to power, water supply, potential gas leaks (due to shifting ground/pipe or conduit damage), and structural integrity. Prepare staff and patients for aftershocks.

Evacuation equipment should be accessible and include for example, flashlights, stair lights, backup batteries, patient movement devices, blank patient record forms, and patient and staff tracking logs. Staff should be well versed in using the evacuation equipment and implementing the response plan. Plans should include considerations for how to access electronic medical records (EMR) information, and what parts of the EMR should be copied and sent with patients when evacuating, if possible.

Facilities should also be aware of potential competing obligations on the part of transportation vendors needed to support evacuation operations and strain on ambulances and medical transport companies. Hospitals should plan for the transportation resources available that can help support should traditional transportation vendors not be available such as buses for ambulatory patients or ambulances from neighboring jurisdictions. Healthcare coalitions, and health systems can be excellent resources in making systematic decisions and supporting evacuation operations. Planning for use or access to rotary wing transport will also be important if roads are impassable. It is important to determine if aeromedical providers are still able to participate.

Coordination with a regional or multi-area coordination center with local, state, and federal representation can help to ensure patients are distributed in the most efficient way possible and/or to receive additional resources to facilities. Facilities should be conducting regular drills and exercises specific to facility evacuation. Even when a facility can handle the evacuation on their own, contact should still be made with local/regional emergency management and healthcare coalition representatives to provide notification of evacuation plans and to ensure they do not redirect needed resources (e.g., ambulances).

Facilities must be assessed for safe operation before re-occupancy. Work with local emergency management and facility personnel to determine the impact on staff and patient access to the facility (e.g., roadway integrity).

For More Information:

ASPR TRACIE Topic Collections:

[Healthcare Facility Evacuation/Sheltering
Patient Movement and Tracking](#)

Select Programs/Assets to Consider:

HHS Response and Recovery Resources Compendium
Patient Movement

Medical Services Replacement or Augmentation

Healthcare facilities could become isolated or forced to close after earthquakes due to structural damage, loss of utilities, blocked or destroyed roadways/bridges/tunnels, or other physical issues and be “off-line” for an indefinite amount of time. At the same time, individual or office practitioners may not be able to open their offices/clinics due to the same challenges. Even if facilities, offices, and/or clinics are not damaged or cut off from the community by debris, practitioners may be personally affected by the disaster and unable to report to work. There will be a need to coordinate alternate/replacement healthcare services and supplies for those facilities and services that are temporarily unavailable, and those that have been permanently damaged within an affected community.

Healthcare facilities that are able to remain operational may require additional staff, not only to treat those affected by the disaster, but also to manage a surge of patients seeking assistance/routine care with exacerbated chronic conditions in new locations due to a lack of ability to seek care from their pre-disaster providers. Memoranda of Understanding and operational protocols to share staffing and other resources with other facilities should be drafted and maintained pre-disaster, taking into account liability, logistical, and financial concerns.

After a large incident, many volunteers (e.g., Medical Reserve Corps and American Red Cross) will want to help (including some from the international community). It is important to develop a comprehensive volunteer and deployed state and federal staff management plan prior to a disaster, including protocols for: requesting, accepting, and processing volunteers; incorporating them into the larger response operation; credentialing and privileging (including waivers if working in certain facilities); legal/regulatory concerns and issues; and communications.

For More Information:

ASPR TRACIE Topic Collections:

- [Alternate Care Sites \(including shelter medical care\)](#)
- [Ambulatory Care and Federally Qualified Health Centers \(FQHC\)](#)
- [Crisis Standards of Care](#)
- [Healthcare-Related Disaster Legal/ Regulatory/ Federal Policy](#)
- [Hospital Surge and Immediate Bed Availability](#)
- [Mental/Behavioral Health \(non-responders\)](#)

Pre-Hospital
Virtual Medical Care
Volunteer Management

Select Programs/Assets to Consider:

HHS Response and Recovery Resources Compendium

Hospital Care

Medical Care Personnel

Medical Equipment and Supplies

Outpatient Services

Disaster Medical Assistance Teams

Emergency Management Assistance Compact

Emergency System for Advance Registration of Volunteer Health Professionals (includes contact information for state health departments)

Medical Reserve Corps (allows users to search for local and state units)

Mental Health and Substance Abuse

State Medical Response Teams (inter- or intrastate)

Surge of Earthquake-Related Health Emergencies

Hospitals and other healthcare providers should be prepared to handle an increase in patients with a wide range of chief complaints, from respiratory illness to traumatic injuries. Post-earthquake patient surge typically includes the following:

1. Patients becoming ill or injured during the earthquake and able to arrive to definitive care immediately.
2. Patients trapped or unable to access care and whose transport may be delayed—sometimes by several days.
3. Patients who become ill or injured post-earthquake, either during clean up or aftershocks, or because of changes to their baseline health status, including potential, limited infectious disease outbreaks due to loss of sanitation and congregate living conditions.
4. Patients seen in the days and weeks following the earthquake experiencing exacerbations in underlying disease due to disruptions in their care or their environment.
5. Patients experiencing negative mental health effects; those who may not be injured but will surge to a hospital for lights, comfort, and / or information; those needing prescription refills as they cannot get to their medications, physician, or pharmacy; and patients with chronic illnesses who are no longer able to manage their conditions from home.

Staffing plans should take these anticipated patient surges into account, and facilities should be prepared to identify and implement staff augmentation and surge capacity strategies.

Alternate care sites and virtual medical care may need to be established. Public messaging may be used to direct patients to the appropriate care setting, depending upon their injuries/ illnesses. State, local, and federal agencies should be prepared to receive requests for staff and medical service delivery augmentation to support this surge of patients.

EMS providers should be prepared to perform on-scene triage and provide trauma care in the field. Planning with the state should be done to discuss the use of crisis standards of care. Also note that there will be unique injuries associated with earthquakes such as crush injuries, head injuries, complex fractures, and amputations. Surgical expertise is needed for orthopedic, vascular, and neurosurgical injuries. Specialty supplies may be needed as well (e.g., external fixators).

During a catastrophic event, healthcare facilities that are able to restore power may become a community's place of refuge. Healthcare facilities should have a plan for a lockdown while still treating those in need. Note that even with the lockdown, hundreds of people may remain on the hospital's grounds searching for loved ones and looking for power sources (e.g., to charge cell phones).

For More Information:

ASPR TRACIE Topic Collections:

- [Alternate Care Sites \(including shelter medical care\)](#)
- [Ambulatory Care and Federally Qualified Health Centers \(FQHC\)](#)
- [Crisis Standards of Care](#)
- [Homecare and Hospice](#)
- [Hospital Surge and Immediate Bed Availability](#)
- [Incident Management](#)
- [Mental/Behavioral Health \(non-responders\)](#)
- [On-Scene Mass Casualty Triage and Trauma Care](#)
- [Pre-Hospital](#)
- [Virtual Medical Care](#)

CDC Natural Disasters and Severe Weather

- [Emergency Wound Management for Healthcare Professionals](#)
- [Prevent Illness and Injury after a Disaster](#)

Select Programs/Assets to Consider:

HHS Response and Recovery Resources Compendium

- [Hospital Care](#)
- [Mass Care](#)
- [Medical Care Personnel](#)
- [Medical Equipment and Supplies](#)
- [Outpatient Services](#)

Disaster Medical Assistance Teams

Emergency Management Assistance Compact

[Emergency System for Advance Registration of Volunteer Health Professionals](#) (includes contact information for state health departments)

[Medical Reserve Corps](#) (allows users to search for local and state units)

[State Medical Response Teams](#) (inter- or intrastate)

Transportation

EMS and other first responders may have difficulty accessing patients and/or their fleet may have suffered earthquake-related damage. Roads and helipads may not be accessible, so physical access to facilities for both first responders and self-referred patients may be an issue. Residents may not be able to use traditional modes of transportation to access their healthcare providers or emergency services—their vehicles may have been damaged or are inaccessible; buses or accessible transportation services may not be running; taxis and car services may not be operational; and para-transit, wheelchair-accessible vans, and other medical transportation providers may be otherwise committed to response operations.

Many services that provide support to healthcare facilities will have access issues including courier services that handle lab specimens and vendors/services that deliver supplies, equipment, linen, food, fuel, and other necessary resources. These services and vendors may also have difficulty crossing security barriers into affected neighborhoods if they lack proper paperwork or identification. Homecare providers may face similar challenges, which could contribute to the expected surge of patients whose care is disrupted following a disaster. Being connected with the emergency management system can also help alleviate blockade issues.

For More Information:

ASPR TRACIE Topic Collections:

[Federal Patient Movement: Overview Fact Sheet](#)

[Homecare and Hospice](#)

[Patient Movement and Tracking](#)

[Pre-hospital](#)

Select Programs/Assets to Consider:

[FEMA Ambulance Strike Team](#)

[FEMA National Ambulance Contract](#)

[HHS Response and Recovery Resources Compendium](#)

[Outpatient Services](#)

[Patient Movement](#)

Short-Term Considerations

Assessment of Healthcare Facilities for Safe Operation Upon Re-occupancy

If a healthcare facility was forced to close due to structural or other damage sustained during an earthquake, re-inspection of the facility, in addition to surveys to ensure that infrastructure and utility systems are operational, may be required prior to reopening. Additional inspectors may be needed, and clarification of the related federal, state, and local laws and regulations might need to be circulated to all affected healthcare facilities. Coordination of patient repatriation can be complicated. Healthcare coalition partners can be valuable assets in these operations.

For More Information:

ASPR TRACIE Topic Collections:

[Healthcare Facility Evacuation/Sheltering](#)

[Healthcare-Related Disaster Legal/Regulatory/Federal Policy](#)

Select Programs/Assets to Consider:

[HHS Response and Recovery Resources Compendium](#)

[Blood Products and Services](#)

[Safety and Security of Drugs and Biologics](#)

Exacerbation of Chronic Medical Conditions

Any chronic medical condition can be exacerbated in a disaster due to the stress of the event, loss of physical support systems, lack of access to medications, and/or loss of access to equipment or systems needed to support daily medical care. Patients need access to healthcare facilities and services, chronic or maintenance medications or therapies, and operational medical equipment to return to their pre-disaster health conditions. Healthcare facilities and private providers may see a surge of patients no longer able to manage their conditions from home.

It is important to note that individuals who previously lived independently in the community with supports and services should remain in the least-restrictive, most integrated, community-based setting.

Individuals with disabilities and/or chronic health conditions may become separated from their home and community-based services after an earthquake. Individuals who function independently with assistance (e.g., from mobility devices or assistive technology, vision and communication aids, and service animals) may become separated from caregivers and need assistance with personal care. These individuals may also experience higher levels of distress and need behavioral health support and/or support for personal safety. When treating people who, until this disaster, did not need support in a clinical setting (i.e., did not come from another healthcare facility), the focus should be on discharge planning to return them to their prior independent living state while recognizing they may need short-term supportive care to

ensure health, safety, and wellbeing. Note that the loss of critical infrastructure (e.g., prolonged power/water/sewage outages) may require the evacuation of these individuals to another community for extended periods of time and will require long-term supportive care.

Using the [HHS emPOWER Map](#), federal-to-community partners can identify the number of Medicare beneficiaries, down to the ZIP Code level, who rely on life-maintaining or saving durable medical and assistive equipment (DME) or devices. This information can help community partners anticipate, plan for, and respond to the needs of this population prior to, during, and after an incident, emergency, or disaster.

The [Emergency Prescription Assistance Program \(EPAP\)](#) can help affected areas support resident access to prescription medications. In addition, national pharmacy chains have mobile pharmacy units available to deploy to local communities. [Rx Open](#), managed by [Healthcare Ready](#), helps patients and providers find nearby open pharmacies in areas impacted by disaster. Emergency planners may also want to integrate private pharmacies into response and recovery efforts, particularly larger pharmacy chains that may deploy teams into affected areas to establish temporary pharmacies.

Additional information on EPAP and historical use from past activations can be found on ASPR TRACIE:

- [EPAP Overview Fact Sheet](#)
- [EPAP Louisiana Floods](#)
- [EPAP Hurricane Ike](#)
- [EPAP Hurricane Gustav](#)
- [EPAP Hurricane Maria \(Puerto Rico only\)](#)
- [EPAP Superstorm Sandy](#)

For More Information:

ASPR TRACIE Topic Collections:

[Dialysis Centers](#)

[Homecare and Hospice](#)

[Pharmacy](#)

[ASPR TRACIE Drug Shortages and Disasters](#)

[ASPR TRACIE Exchange Issue 6: *How the Private Sector Helps Dialysis Patients and Clinics Prepare for and Respond to Disasters*](#)

[ASPR TRACIE Post-Disaster Lessons Learned: Dialysis Patient Management](#)

[CDC Preparing Your Medicine Cabinet for an Emergency: A Checklist](#)

[Durable Medical Equipment in Disasters](#)

[FDA Safe Drug Use After a Natural Disaster](#)

Select Programs/Assets to Consider:

[HHS Response and Recovery Resources Compendium](#)

[Hospital Care](#)

[Mental Health and Substance Abuse Care](#)

[Outpatient Services](#)

[Public Health Surveillance](#)

Extended Loss of Power and Water

If communities face extended loss of power and/or water, residents with chronic medical conditions may experience exacerbated symptoms, people can become sick from spoiled food, and medications that need to be refrigerated can lose potency. Local healthcare systems may experience those and a host of additional secondary and tertiary effects. Healthcare facilities must have **reliable** power and water in order to continue operations. However, it is important to note that planning should be done to determine what is necessary to ensure proper installation and support of external generators (e.g., transfer switches) and that adequate amounts of fuel and potable and non-potable water can be supplied.

For More Information:

ASPR TRACIE Topic Collection:

[Continuity of Operations \(COOP\)/ Failure Plan](#)

[Mental/ Behavioral Health \(non responders\)](#)

[Utility Failures](#)

[Considerations for Oxygen Therapy in Disasters](#)

[Durable Medical Equipment in Disasters](#)

[Emergency Water Supply Planning Guide for Hospitals and Health Care Facilities](#)

[HHS emPOWER](#)

[Planning for Power Outages: A Guide for Hospitals and Healthcare Facilities](#)

[US Army Corps of Engineers Emergency Power Facility Assessment Tool](#)

Select Programs/Assets to Consider:

[HHS Response and Recovery Resources Compendium](#)

[Potable Water/Wastewater/Environmental Health](#)

[Emergency Toilet Project \(Portland, OR region\)](#)

Food Safety After Power Outages and Earthquake Damage

Prolonged power outages, lack of running potable water, and “pop up” or “just-in-time” food service establishments all pose potential hazards related to food preparation and consumption. Public messaging on food safety, water safety (e.g., acceptable sources of ice), and disposal is critical for staff, patients, and general community. Additional staff will likely be necessary to provide inspections for re-opening closed food service establishments and to examine new

facilities such as shelters. Healthcare providers should also be prepared for a surge in foodborne illness.

For More Information:

[ASPR Food and Water Safety](#)

[Food and Water Safety During Power Outages and Floods](#)

[Keep Your Food Safe During Emergencies: Power Outages, Floods, and Fires](#)

[Refrigerated Food and Power Outages](#)

Select Programs/Assets to Consider:

[HHS Response and Recovery Resources Compendium](#)

[Food Safety and Security](#)

Environmental Health Impacts

The environmental issues following an earthquake can lead to [health impacts](#) such as respiratory disease, skin problems, and ear, eye, and throat problems. These conditions may become chronic, for both residents and responders. Water can be contaminated by leaking sewage, and materials from impacted chemical or other hazardous materials storage facilities, industrial complexes, and/or plants.

Post-earthquake outdoor air and water pollution pose additional potential concerns.

Environmental health assessments, inspections of hazardous materials sites, and monitoring of air and water quality will likely be required to assess the environmental impacts. Responders must be made aware of additional hazards that might be present in the community.

For More Information:

[ASPR TRACIE Responder Safety and Health Topic Collection](#)

[Joint Commission Emergency Management Healthcare Environment Checklist](#)

Select Programs/Assets to Consider:

[HHS Response and Recovery Resources Compendium](#)

[Public Health Surveillance](#)

[APIC Preventing Infections in a Natural Disaster](#)

Shelter and Congregate Living Health Concerns

Widespread major structural damage can create the need for large and sustained shelter operations. While the goal for emergency management is to return people to their homes or to provide transitional housing as quickly as possible, that process can take time. While shelters are operational, the priority for public health and medical response and recovery personnel is to ensure they are safe, and that shelter residents have access to basic hygiene and healthcare services, clean water, and safe food.

Depending on how long people will reside in shelters, potential health hazards must be monitored (e.g., those pertaining to food safety [[as described previously](#)] and personal hygiene). Ensuring environmental health surveillance is in place to monitor for infectious disease outbreaks, specifically respiratory and gastrointestinal diseases, is critical. Certain groups of persons are particularly vulnerable in shelter environments, including children; pregnant and postpartum women and infants; other people with access and functional needs; older adults who are frail; and people with pre-existing behavioral health issues.

Following an earthquake, non-traditional sheltering may be required, such as open-air shelters. These operations will require additional resources and support, and advance planning is recommended.

For More Information:

ASPR TRACIE Topic Collections:

- [Access and Functional Needs](#)
- [Alternate Care Sites \(including shelter medical care\)](#)
- [Disaster Veterinary Issues – Shelter Animal Care](#)
- [Family Reunification and Support](#)
- [Mental/Behavioral Health \(non-responders\)](#)

[ASPR TRACIE Fact Sheet: HIPAA and Disasters: What Emergency Professionals Need to Know](#)
[Information for Disaster Evacuation Centers](#)

Select Programs/Assets to Consider:

HHS Response and Recovery Resources Compendium

- [Food Safety and Security](#)
- [Mass Care and Emergency Assistance](#)
- [Mental Health and Substance Abuse Care](#)
- [Public Health Surveillance](#)

The following patient types are particularly vulnerable during and after earthquakes and may be candidates for evacuation/relocation due to prolonged loss of critical infrastructure:

- Individuals who are frail or have mobility limitations who may also have difficulty seeking safe shelter
- Patients with respiratory illness
- Dialysis patients
- Patients dependent on medical devices that require electricity, for example:
 - Oxygen concentrators
 - Ventilators
 - Home dialysis
 - Infusion therapies
 - Ventricular assist devices
 - Connected health devices (telehealth/telemedicine)
 - Glucose monitors (daily charge)
- Patients dependent on medical devices that require batteries and are unable to purchase them (e.g., durable medical supplies)
- Patients whose conditions must be continually managed by prescription medications (e.g., people with diabetes, who may lack refrigeration for their insulin)
- Patients with mental health illnesses and/or alcohol or other drug dependency

Long-Term Considerations and Recovery

Long-term considerations should focus on the bridge between the immediate response operation and continuity of critical services. The reconstitution of priority services over time in synchrony with available resources and ongoing community needs is important to stabilizing health services and being responsive to any enhanced needs or changes in services due to disaster-related deficits. Having data that can substantiate action is important to developing appropriate service delivery.

Change to the Baseline Level of Health

If access to healthcare is persistently impeded due to the impact of an earthquake, the overall health (both physical and mental) of a community can decline. If the healthier members of the community choose to relocate, leaving behind those with pre-existing conditions and a lack of resources, the baseline health of the community can be affected but with disproportionate effects on residents with chronic conditions and those with access and functional needs. During recovery, efforts to assure continuity of services for these populations is critical to health maintenance.

For More Information:

ASPR TRACIE Topic Collections:

[Access and Functional Needs](#)

[Ambulatory Care and Federally Qualified Health Centers](#)

[Continuity of Operations \(COOP\)/Failure Plan](#)

[Recovery Planning](#)

Select Programs/Assets to Consider:

HHS Response and Recovery Resources Compendium Disaster
Recovery Assistance

Loss of Facilities or Change in Available Services

Many of the healthcare facility closures or disruptions during and immediately following the earthquake are temporary, and normal operations can resume relatively quickly. But there will be facilities that will not be able to quickly or easily re-open—not just hospitals and nursing homes—but also clinics, labs, outpatient offices, health clinics (including community health centers), and individual physician practices. Those with significant flooding or structural damage may need major repairs or rebuilding to be operational again.

Emergency planners and the medical community (including corporate health administrations supporting their enterprise facilities) must consider how to support these individual facilities in recovery and also plan to address the impact their loss will have on the overall delivery of healthcare to the community. System and facility re-design and land use planning offers opportunities to enhance future service provision and protect critical infrastructure against imminent threats. Early identification of compromised services and likely affected populations is critical to successfully reducing the impact of the disaster. Healthcare coalitions may play a key role in the short-term coordination of healthcare service restoration and the long-term planning of new or revised healthcare infrastructure and should be included as a key recovery planning issue.

For More Information:

ASPR TRACIE Topic Collections:

- [Alternate Care Sites \(including shelter medical care\)](#)
- [Ambulatory Care and Federally Qualified Health Centers \(FQHC\)](#)
- [Continuity of Operations \(COOP\)/Failure Plan](#)
- [Crisis Standards of Care](#)
- [Hospital Surge and Immediate Bed Availability](#)
- [Mental/Behavioral Health \(non-responders\)](#)
- [Pre-Hospital](#)
- [Recovery Planning](#)
- [Virtual Medical Care](#)

[Design Guide for Improving Hospital Safety in Earthquakes, Floods, and High Winds: Providing Protection to People and Buildings](#)

Select Programs/Assets to Consider:

HHS Response and Recovery Resources Compendium
Disaster Recovery Assistance
Hospital Care

Mass Care
Medical Care Personnel
Medical Equipment and Supplies
Outpatient Services

Disaster Medical Assistance Teams

Emergency Management Assistance Compact

Emergency System for Advance Registration of Volunteer Health Professionals (contact your State Health Department or more information)

Medical Reserve Corps (search for local and state units)

State Medical Response Teams (Inter- or Intrastate)

Loss of Health Insurance Coverage

In past major disasters, businesses were unable to reopen after the disaster, leading to job loss. Many workers who lose their jobs can also lose their healthcare coverage and may not be able to afford private or subsidized healthcare. This decrease in healthcare coverage could lead to increased financial burdens on individuals and families, an increase in uncompensated care, and possibly increased applications for government health subsidies and programs such as enrollment in Medicaid programs. Mental health issues and chronic disease in affected individuals could go untreated, further contributing to any [change to the baseline level of health](#). Portability of health insurance can be a significant issue for individuals and populations who have moved, had changes in their health status, have no or a decreased means of financial resources, or if in-network providers are not available within proximity. Managed care may include automatic approval of out of coverage care since patients may not be able to access their usual source of care.

Select Programs/Assets to Consider:

[HHS Response and Recovery Resources Compendium Disaster Recovery Assistance](#)

[US Department of Labor, FAQs on COBRA Continuation Health Coverage](#)

Loss of Providers

In addition to the loss of healthcare facilities, the impacted area may experience a loss of individual healthcare providers. Those providers may have relocated due to their own personal loss during the disaster or because there was no available work in the short-term recovery phase, due to facility damage or lower patient volumes. Providers who have relocated, found a new job, and resettled may be reluctant to return to the disaster impacted area once their previous facility is operational again.

There were 4,500 doctors serving three of the parishes surrounding New Orleans prior to Hurricane Katrina's impact. One year later only 1,200 had returned to practice (Rudowitz, et. al. 2006).

Select Programs/Assets to Consider:

HHS Response and Recovery Resources Compendium

Disaster Recovery Assistance

Hospital Care

Mass Care

Medical Care Personnel

Medical Equipment and Supplies

Outpatient Services

Cited Resources

Relevant ASPR TRACIE Topic Collections (Listed Alphabetically)

Access and Functional Needs
Alternate Care Sites (including shelter medical care)
Ambulatory Care and Federally Qualified Health Centers (FQHC)Dialysis Centers
Burns
Coalition Response Operations
Continuity of Operations (COOP)/ Failure Plan
Communications Systems
Crisis Standards of Care
Disaster Ethics
Disaster Veterinary Issues
Electronic Health Records
Emergency Public Information and Warning/Risk Communications
Family Reunification and Support
Fatality Management
Healthcare Facility Evacuation/Sheltering
Healthcare-Related Disaster Legal/Regulatory/Federal Policy
Homecare and Hospice
Hospital Surge and Immediate Bed Availability
Incident Management
Information Sharing (e.g., partners and employees)
Long-Term Care Facilities
Mental/Behavioral Health (non-responders)
On-Scene Mass Casualty Triage and Trauma Care
Patient Movement and Tracking
Pediatric
Pharmacy
Pre-hospital
Recovery Planning
Responder Safety and Health
Utility Failures
Virtual Medical Care
Volunteer Management

Additional ASPR TRACIE Resources (Listed Chronologically)

ASPR TRACIE. (2016). [Drug Shortages and Disasters](#).

Community members with acute or chronic conditions may face challenges accessing their medicine before, during, and after disasters due to insurance or access issues. These barriers can exacerbate their medical conditions, which can also increase the vulnerability of a population and the number of preventable medical care and emergency department (ED) visits. This fact sheet includes resources that can help healthcare providers prepare for and respond to shortages and other pharmaceutical-related challenges that may arise during and after a disaster.

ASPR TRACIE. (2016). [EPAP Overview Fact Sheet](#).

This fact sheet provides an overview of the Emergency Prescription Assistance Program (EPAP), which is funded by the Stafford Act and designed to help disaster survivors access prescription medicines. The program utilizes normal business operations (e.g., electronic prescription claims processing, utilization of the normal pharmaceutical supply chain for distribution and dispensing) to pay for prescription medications for eligible persons. Fact sheets summarizing EPAP data collected after the [Louisiana Floods](#), [Hurricane Ike](#), [Hurricane Gustav](#), and [Superstorm Sandy](#) are also available.

ASPR TRACIE. (2016). [HIPAA and Disasters: What Emergency Professionals Need to Know](#).

Disasters and emergencies can strike at any time with little or no warning. In the midst of an emergency response can be rapidly inundated with patients, worried family and friends looking for their loved ones, and media organizations requesting patient information. Knowing what information can be released, to whom, and under what circumstances, is critical for healthcare facilities in disaster response. This guide is designed to answer frequently asked questions regarding the release of information about patients following an incident.

ASPR TRACIE. (2016). [Tips for Retaining and Caring for Staff after a Disaster](#).

This tip sheet includes general promising practices—categorized by immediate and short-term needs—for facility executives to consider when trying to retain and care for staff after a disaster.

ASPR TRACIE. (2017). [Disaster Behavioral Health: Resources at Your Fingertips](#).

Disaster behavioral health (DBH) includes the provision of mental health, substance abuse, and stress management services to disaster survivors and responders. This document provides information on and links to select DBH programs and resources.

ASPR TRACIE. (2017). [The Exchange, Issue 4.](#)

This issue of the newsletter focuses on disaster behavioral health and resilience.

ASPR TRACIE. (2018). [Durable Medical Equipment in Disasters.](#)

This ASPR TRACIE fact sheet provides information on general durable medical equipment (DME) categories and focuses on electricity-dependent DME that may be affected by disasters and emergencies, including power failures. It also includes information to assist healthcare system preparedness stakeholders plan for medically vulnerable populations who rely on DME.

ASPR TRACIE. (2018). [EMTALA and Disasters Fact Sheet.](#)

This fact sheet addresses several frequently asked questions regarding the Emergency Medical Treatment and Labor Act (EMTALA) and disasters, and provides links to resources for more information.

ASPR TRACIE. (2018). [The Exchange, Issue 6.](#)

In this issue, authors from the private sector and federal, regional, and local levels share lessons learned from their recent evacuation experiences.

ASPR TRACIE. (2018). [Pediatric Issues in Disasters Webinar.](#)

The purpose of this webinar is to help participants learn how to identify and incorporate pediatric special considerations into preparedness, mitigation, response, recovery, and resilience-building plans and actions.

ASPR TRACIE. (2018). [Going with no Flow: Coping with Hospital Water Supply Issues.](#)

ASPR TRACIE interviewed Craig DeAtley (PA-C, Director, Institute for Public Health Emergency Readiness, MedStar Washington Hospital Center) to discuss the facility's response to a 2018 water outage.

ASPR TRACIE. (2018). [Tips for Healthcare Facilities: Assisting Families and Loved Ones after a Mass Casualty Incident.](#)

This ASPR TRACIE tip sheet highlights best practices and issues related to planning for, activating, and operating hospital or healthcare facility Family Information Centers (FIC)/ Family Support Centers (FSC), in collaboration with Family Reception Centers (FRC) and Family Assistance Centers (FAC).

Other Cited Sources

Arnold, C., Holmes, W., Quinn, R., et al. (2007). [Design Guide for Improving Hospital Safety in Earthquakes, Floods, and High Winds: Providing Protection to People and Buildings](#). Federal Emergency Management Agency.

This design guide can inform and help design professionals, hospital administrators, and facility managers employ sound mitigation measures that will decrease the vulnerability of hospitals to disruptions from natural hazard events (e.g., earthquakes, high wind events, and floods).

California Institute of Technology, NASA Jet Propulsion Laboratory. (2005). [NASA Details Earthquake Effects on the Earth](#).

This webpage includes information collected by NASA on how the December 26, 2004 Great Sumatra-Andaman earthquake and tsunami affected the earth.

Centers for Disease Control and Prevention. (2014). [Emergency Wound Management for Healthcare Professionals](#).

This webpage includes information on evaluation, treatment, and management of wounds after disasters. Special considerations for wounds contaminated by water are also discussed.

Centers for Disease Control and Prevention. (2017). [Information for Disaster Evacuation Centers](#).

This webpage contains links to evacuation center-related resources such as: infection control, medical management and patient advisement, guidelines for play areas, and animals in public evacuation centers.

Centers for Disease Control and Prevention. (2017). [Prevent Illness and Injury after a Disaster](#).

This webpage provides links to resources containing specific guidance on ways to prevent illness and injury following disasters.

Centers for Medicare and Medicaid Services. (2017). [1135 Waivers](#).

This webpage contains information on requesting an 1135 waiver which allows for the temporary waiving or modification of certain Medicare, Medicaid, and Children's Health Insurance Program requirements. Links to legal information, steps for requesting a waiver, and other helpful resources are included.

Encyclopedia Britannica. (n.d.). [Fukushima Accident](#). (Accessed 10/11/18.)

This resource is a general reference providing information on the Fukushima nuclear plant accident that occurred as a result of the 2011 earthquake and tsunami in Japan.

FEMA. (n.d.). [National Earthquake Technical Assistance Program](#). (Accessed 10/11/18).

This webpage provides resources for state, local, and tribal governments to support planning for earthquake mitigation strategies.

Kadri, F., Chatelet, E., and Birregah, B. (2014). [The Impact of Disasters on Critical Infrastructures: A Domino Effect-based Study](#). *Journal of Homeland Security and Emergency Management*. 11(2): 217–241.

The authors propose a methodology for conducting risk assessments on critical infrastructure through the analysis of cascade effects. They describe “cascade effect analysis” and illustrate how it can be used by emergency planners.

Khazai, B., Daniell, J., and Wenzel, F. (2011). [The March 2011 Japan Earthquake. Analysis of Losses, Impacts, and Implications for the Understanding of Risks Posed by Extreme Events](#). *Technikfolgenabschätzung – Theorie und Praxis*. 20(3): 22-33.

The authors review, compare, and contrast the cascading effects of several disasters that recently struck Japan.

National Emergency Management Association. (2017). [Emergency Management Assistance Compact](#).

This webpage provides information on the Emergency Management Assistance Compact (EMAC), a congressionally-mandated interstate mutual aid agreement that has been adopted by all 50 states and the District of Columbia. Under EMAC, state assets (supplies, equipment, and/or volunteers) may be deployed to a requesting state. Reimbursement, liability, compensation, and licensure issues are also addressed. The website has links to training and education resources, as well as a document library, and information on deployable resources. The “Learn about EMAC” menu provides helpful documents for those not familiar with the agreement and process.

National Oceanic and Atmospheric Administration (NOAA). (2017) [Hawaii Beach After 1975 Tsunami](#).

This resource includes images of, and information about, the effects of the 1975 earthquake and cascading tsunami event in Hawaii.

Redman, S., Fromknecht, C., Hodge, S., et al. (2017). [Death Scene Investigation After Natural Disaster or Other Weather-Related Events](#). Centers for Disease Control and Prevention.

The authors conducted a literature review and discovered variance in the tools used in disaster death scene data collection. They formed a work group comprised of medical

examiners and coroners, forensic pathologists, death scene investigators, forensic anthropologists, and epidemiologists that developed and pilot tested this toolkit. The toolkit includes templates and checklists by hazard.

Rudowitz, R., Rowland, D., and Scharzter, A. (2006). [Health Care in New Orleans Before and After Hurricane Katrina](#). *Health Affairs*. 25(5): w393-406.

The authors discuss changes to the healthcare system in New Orleans following Hurricane Katrina, including loss of facilities, providers, and healthcare coverage.

Substance Abuse and Mental Health Services Administration. (2014). [Tips for Disaster Responders: Preventing and Managing Stress](#).

This four-page fact sheet provides tips to help disaster response workers prevent and manage stress. It includes strategies to help responders prepare for their assignment, use stress-reducing precautions during the assignment, and manage stress in the recovery phase of the assignment. It also includes lists of signs of stress, and helpful resources.

U.S. Department of Agriculture. (2013). [Keep Your Food Safe During Emergencies: Power Outages, Floods, and Fires](#).

This guide includes information to assist with keeping food safe during and after power outages, floods, and fires.

U.S. Department of Health and Human Services. (2020). [HHS emPOWER Program Factsheet](#).

This factsheet includes information on the HHS emPOWER Program.

U.S. Department of Health and Human Services. (2018). [Refrigerated Food and Power Outages](#).

This resource includes a chart detailing specific foods and whether or not they should be discarded following a power outage.

U.S. Department of Health and Human Services, Office of the Assistant Secretary for Preparedness and Response. (2017). [Cultural and Linguistic Competency for Disaster Preparedness Planning and Crisis Response](#).

This webpage provides links to resources and tools that enhance and address cultural and linguistic competency to help mitigate the impact of disasters and emergency events.

U.S. Department of Health and Human Services, Office of the Assistant Secretary for Preparedness and Response. (2017). [Disaster Medical Assistance Teams](#).

Disaster Medical Assistance Teams (DMATs) are federal assets comprised of medical professionals and para-professionals that can augment the public health and healthcare system of an affected community following a disaster. When DMATs deploy, they bring enough medical supplies and equipment to sustain themselves for three days and they are typically activated for two weeks at a time.

U.S. Department of Health and Human Services, Office of the Assistant Secretary for Preparedness and Response. (n.d.). [Emergency System for Advance Registration of Volunteer Health Professionals](#). (Accessed 10/11/2018.)

This resource provides information about the Emergency System for Advance Registration of Volunteer Health Professionals (ESAR-VHP), a federal program created to support states and territories in establishing standardized volunteer registration programs for disasters and public health and medical emergencies. The program, administered on the state level, verifies health professionals' identification and credentials so that they can respond more quickly when disaster strikes.

U.S. Department of Health and Human Services, Office of the Assistant Secretary for Preparedness and Response. (n.d.). [FEMA National Ambulance Contract](#). (Accessed 10/1/2018.)

This document explains the purpose of the contract, how it would be requested, when it would be activated, and the roles of emergency medical services in this type of response. Photos of ground and air assets during Hurricane Dean (2007) are included.

U.S. Department of Health and Human Services, Office of the Assistant Secretary for Preparedness and Response. (2015). [HHS Response and Recovery Resources Compendium](#).

This resource is a comprehensive web-based repository of U.S. Department of Health and Human Services resources and capabilities available to federal, state, local, territorial, and tribal stakeholders before, during, and after public health and medical incidents. It is divided into 24 sections, including situational awareness, patient movement, decontamination, all hazards consultation, worker health and safety, mortuary services, and recovery. Each section lists programs, teams, and other resources available to public health departments and emergency management agencies to utilize during disasters affecting public health.

U.S. Department of Health and Human Services. (n.d.) [Medical Reserve Corps](#). (Accessed 10/11/2018.)

The Medical Reserve Corps (MRC) is a national network of approximately 190,000 volunteers in 900 community-based units, organized locally to improve the health and

safety of their communities. Public health and healthcare professionals, as well as non-health professional volunteers, are included.

U.S. Department of Health and Human Services, Office of the Assistant Secretary for Preparedness and Response. (2013). [Planning for Power Outages: A Guide for Hospitals and Healthcare Facilities](#).

This document highlights issues for healthcare facilities to consider regarding power outages. It also provides a checklist of key planning considerations, and recommendations for fostering a relationship with a facility's utility company.

U.S. Department of Health and Human Services, Office of the Assistant Secretary for Preparedness and Response. (2017). [The Role of Healthcare Providers in Combatting Human Trafficking during Disasters](#).

This webpage provides information for providers on how to recognize and assist victims of human trafficking, both in, and out, of the disaster context.

U.S. Department of Health and Human Services, Office of the Assistant Secretary for Preparedness and Response. (2017). [Food and Water Safety](#).

This webpage provides resources for ensuring that food and water are safe before and after disasters that include flooding and/or power outages.

U.S. Department of Homeland Security. (2018). [Government Emergency Telecommunications Service \(GETS\)](#).

The Government Emergency Telecommunications Service is a federal communications system meant to be used in an emergency or crisis situation when the landline network is congested and the likelihood of completing a call using traditional methods is reduced.

U.S. Department of Homeland Security. (2018). [Telecommunications Service Priority \(TSP\)](#).

This federal program authorizes national security and emergency preparedness organizations to receive priority treatment for telecommunications services. Qualified applicants may request a code from the Department of Homeland Security that mandates telecommunications service providers to prioritize requests for new service, or to repair existing service if lost, after a disaster.

U.S. Department of Homeland Security. (2018). [Wireless Priority Service \(WPS\)](#).

This webpage provides information on the Wireless Priority Service (WPS), a priority telecommunications service that improves the connection capabilities for authorized public safety and national security and emergency preparedness (NS/EP) cell phone users during emergencies.

U.S. Department of Labor, Occupational Safety and Health Administration. (n.d.). [Earthquakes Guide](#). (Accessed 10/11/2018.)

This webpage provides a brief description of earthquakes, and information related to ensuring the health and safety of responders following a collapsed structure event. The role of the Safety Officer, specific to earthquake response, is also described.

U.S. Department of Labor, Occupational Safety and Health Administration. (n.d.). [Earthquake Preparedness and Response](#). (Accessed 10/11/2018.)

This webpage provides information on worker health and safety considerations related to preparedness, response, and recovery operations for earthquakes, including recommendations for planning, training, and exercising. Links to additional resources are also provided.

U.S. Food and Drug Administration. (2018). [Food and Water Safety During Power Outages and Floods](#).

This resource provides guidance on the proper food safety precautions to take before, during, and after a power outage.

U.S. Geological Survey. (n.d.) [20 Largest Earthquakes in the World](#). (Accessed 10/11/2018.)

This resource provides a listing of the 20 largest earthquakes that occurred since 1900.

Wong, H.T. and Li, S. (2016). [Healthcare Services Demand in Post-disaster Settings: The 2014 Earthquake in Ludian County, Yunnan Province, China](#). International Journal of Disaster Risk Science. 7(4):445-449.

The authors conducted a cross-sectional, records-based study of 2,484 records obtained from a temporary hospital to investigate patterns of healthcare service demand for a rural displaced population following the 2014 Ludian County earthquake. They found that healthcare service demand from younger age groups was higher than that of the older adult group, and observed three major health problems: respiratory disease, skin problems, and ear, eye, and throat (EET) problems.

Additional Resources

American Association of Blood Banks. (2008). [Disaster Operations Handbook- Hospital Supplement: Coordinating the Nation's Blood Supply During Disasters and Biological Events](#).

This document addresses the hospital's role in ensuring that *blood* for transfusion will be available during disasters and biological events. It is a supplement to the Disaster Operations Handbook, whose purpose is to help *blood* centers, hospital *blood* banks,

and transfusion services in the United States prepare for and respond to domestic disasters and acts of terrorism that affect the *blood supply*.

Ardagh, M.W., Richardson, S.K., Robinson, V., et al. (2012). [The Initial Health-System Response to the Earthquake in Christchurch, New Zealand, in February, 2011](#). (Article free with registration.) *Lancet*. 379(9831):2109-15.

The authors describe their experiences and lessons learned working in the emergency department of the only regional acute care hospital following the 2011 New Zealand earthquake. They note that emergency department response plans should account for patients arriving in atypical ways; loss of power; the need for paper registration and tracking systems; volunteer management; and teamwork with clear leadership, among other things.

Burnweit, C. and Stylianos, S. (2011). [Disaster Response in a Pediatric Field Hospital: Lessons Learned in Haiti](#). (Abstract only.) *Journal of Pediatric Surgery*. 46(6):1131-9.

The authors describe their experiences in a pediatric field hospital in Haiti following the 2010 earthquake. They discuss requirements for equipment, manpower, medical records, and systems addressing volunteer stress, as well as ethical issues. They also note that 93% of casualties initially were surgical admissions with 40% undergoing operations in the first week after the event, mostly for fractures and wound care.

California Emergency Medical Services Authority (2014). [Earthquake Incident Planning Guide](#). (Accessed 10/11/2018).

This incident management guide provides key considerations for hospitals to utilize during planning and response to an earthquake.

Cascadia Region Earthquake Workgroup. (2018). [Preparing Hospitals for Earthquakes: Structural and Nonstructural Issues. Fact Sheet No. 9](#).

This factsheet provides planning considerations for hospitals to follow to enhance their building safety features prior to or after an earthquake. The authors include key resources and tips from previous earthquake events to help planners improve their facilities resilience to a seismic incident.

Cascadia Region Earthquake Workgroup. (2018). [Emergency Power for Hospitals. Fact Sheet No. 10](#).

This fact sheet provides emergency power considerations for hospitals to utilized to identify and improve their power resilience prior to, during, and after an earthquake.

Cascadia Region Earthquake Workgroup. (2018). [Emergency Water for Hospitals. Fact Sheet No. 11.](#)

This fact sheet provides emergency power considerations for hospitals to utilize to identify and improve their emergency water resilience prior to, during, and after an earthquake.

Centers for Medicare and Medicaid Service. (2009). [Emergency Medical Treatment and Labor Act \(EMTALA\) Requirements and Options for Hospitals During a Disaster.](#)

This example of a memorandum and associated fact sheet (from 2009) describes EMTALA requirements and flexibility for an appropriate Medical Screening Examination and options for hospitals experiencing an exceptional patient surge. Alternate screening sites on a hospital's campus, referral to a hospital-controlled off-campus site, and referral to a community screening site are addressed in terms of an EMTALA obligation.

Federal Emergency Management Agency. (2013). [Catalog of FEMA Earthquake Resources.](#)

This compilation of earthquake resources includes training materials; and resources for individuals and homeowners, teachers and children, private sector and small businesses; community planning and public policy; and building professionals and engineers.

Federal Emergency Management Agency. (2007). [Design Guide for Improving Hospital Safety in Earthquakes, Floods, and High Winds: Providing Protection to People and Buildings.](#)

This design guide was developed to review mitigation activities and building design solutions that can improve the resilience of hospitals during extreme natural hazard events such as earthquakes, flooding, and high wind events. The guide can be used to gain a greater understanding of natural hazard risk reduction strategies and principles, and design considerations to improve the safety of hospital during natural disaster events.

Federal Emergency Management Agency (2013). [Earthquake Mitigation for Hospitals.](#)

This course was developed to educate healthcare personnel to identify opportunities to conduct seismic mitigation activities within their facilities. The course reviews healthcare specific hazards during earthquakes and provides promising practices that can be used to analyze and reduce risk of damage caused by earthquakes.

Federal Emergency Management Agency. (2003). [Incremental Seismic Rehabilitation of Hospital Buildings: Providing Protection to People and Buildings.](#)

This manual provides healthcare organizations with information to assess the seismic vulnerability of their buildings and to help implement a program of incremental rehabilitation.

Federal Emergency Management Agency (2012). [Reducing the Risks of Nonstructural Earthquake Damage—A Practical Guide](#).

This guide can be used to assess and assist in planning for nonstructural damages caused by earthquakes. Non-structural damage risks, mitigation strategies, and opportunities to limit losses are provided for planning and response activities.

Furukawa, H., Kudo, D., et al. (2014). [Hypothermia in Victims of the Great East Japan Earthquake: A Survey in Miyagi Prefecture](#). (Abstract Only.) *Disaster Medicine and Public Health Preparedness*. 8(5): 379-389.

This study was conducted through a survey of hypothermia victims following the Great East Japan Earthquake. Researchers identified patients suffering from hypothermia and determined the primary cause was due to cold water exposure from the tsunami event. In conclusion all patients with hypothermia were treated successfully despite the large disruption to the healthcare and social infrastructure due to damaged caused by the earthquake and following tsunami.

Heppenstall, C P., Wilkinson, T. J., et al. (2016). [Impacts of the Emergency Mass Evacuation of the Elderly from Residential Care Facilities after the 2011 Christchurch Earthquake](#). (Abstract Only.) *Disaster Medicine and Public Health Preparedness*. 10(4): 419-423

This study described and reviewed the experiences of elderly evacuees from their residential facilities after the 2011 Christchurch, New Zealand earthquake. Through qualitative research methods researchers found that elderly population surveyed demonstrated resilient attitudes during the evacuation which assisted in the emergency evacuation process. In addition, communication challenges and adverse responses such as increased anxiety among the evacuation population were identified as areas for improvement. In conclusion the researched provided recommendations to provide ongoing education for elderly and caregivers about emergency evacuations and promote resilience through encouraging family involvement, and location community collaboration.

Jacques, C. C., McIntosh, J., (2014) [Resilience of the Canterbury Hospital System to the 2011 Christchurch Earthquake](#). (Abstract Only.) *Earthquake Spectra*. 30(1): 533-554.

This study analyzed the resilience of the Canterbury Hospital System during the 2011 Christchurch earthquake. Researchers developed a resilience method that was utilized as a standardized survey tool to assess critical hospital services based on staff, structure, and stuff. Results from the survey identified damaged utility networks and nonstructural damage had the most significant impacts on the hospital operations. The developed tool can also be used to assess performance of hospitals, and for seismic preparedness planning and strategy development.

Kang, P., Zhang, L., Liang, W., et al. (2012). [Medical Evacuation Management and Clinical Characteristics of 3,255 Inpatients after the 2010 Yushu Earthquake in China.](#) (Abstract only.) *Journal of Trauma and Acute Care Surgery*. 72(6): 1626-1633.

The authors conducted a medical analysis of injuries and diseases after an earthquake that struck a remote, high-altitude region. They listed related challenges and suggestions for future healthcare provider training topics.

Kirsch, T., Mitrani-Reiser, J., Bissell, R., et al. (2010). [Impact on Hospital Functions Following the 2010 Chilean Earthquake.](#) (Abstract only.) *Disaster Medicine and Public Health Preparedness*. 4(2); 122-128.

The authors describe loss of functions and structural damage experienced by hospitals in Chile following a major earthquake. Loss of communications capability was cited by hospital administrators surveyed as being most problematic.

Kawano, T., Hasagawa, K., et al. (2014). [Infectious Disease Frequency among Evacuees at Shelters After the Great Eastern Japan Earthquake and Tsunami: A Retrospective Study.](#) (Abstract only.) *Disaster Medicine and Public Health Preparedness*. 8(1): 58-64.

This study reviewed infectious disease transmission of evacuees from the Eastern Japan earthquake and tsunami. The researchers investigated the cumulative incidences of acute respiratory infection, acute gastroenteritis, acute jaundice syndrome, scabies, measles, pertussis, and tetanus. Findings identified outbreaks of acute respiratory infection, and acute gastroenteritis were found in evacuation shelters after the earthquake and tsunami.

Macintyre, A. G., Barbera, J. A., and Petinaux, B. P. (2011). [Survival Interval in Earthquake Entrapments: Research Findings Reinforced During the 2010 Haiti Earthquake Response.](#) *Disaster Medicine and Public Health Preparedness*. (Abstract Only.) 5(1): 13-22.

This article reviews historical entrapment findings from the 2010 Haiti Earthquake. The article provides recommends some decision-making processes that can be considered for assessing critical factors rather than timeframes for search and rescue during the aftermath of earthquakes.

National Institute for Occupational Safety and Health. (2018). [Emergency Responder Health Monitoring and Surveillance \(ERHMS\).](#)

This software product facilitates a rapid assessment and intervention related to health monitoring and surveillance of emergency responders before, during, and after deployments by helping to automate data collection, analysis, and reporting. The software helps decrease the time required to identify causes, determine risk factors, and inform implementation of appropriate interventions for those who manage the health and safety of responders.

National Institute of Environmental Health Sciences (n.d.). [NIEHS Worker Training Program Earthquake Training Resources](#). (Accessed 10/11/2018)

The NIEHS Worker Training Program (WTP) has been actively involved in earthquake response and cleanup activities, including those related to the 2010 Haiti earthquake and the 2011 Japan earthquake and tsunami. This website provides health and safety information and resources for workers who may be involved in earthquake response and cleanup operations.

National Institute of Environmental Health Sciences. (2015). [Rapid Acquisition of Pre-and Post-Incident Disaster Data Study \(RAPIDD Study\)](#).

The RAPIDD study is a pre-positioned protocol intended to minimize the time needed to begin collecting health data and biological samples from disaster response workers who may be exposed to environmental contaminants. RAPIDD includes all the documents and procedures needed to create a registry of workers.

National Institutes of Science and Technology. (2015). [Dependencies and Cascading Effects, Introduction](#). Disaster Resilience Framework.

This resource provides an “overview of aspects of the physical interconnectedness of buildings and infrastructure systems to consider” when developing community recovery plans.

Pescaroli, G., and Alexander, D. (2015). [A Definition of Cascading Disasters and Cascading Effects: Going Beyond the “Toppling Dominos” Metaphor](#). Planet at Risk. 3(1).

The authors define “cascading disasters,” and recommend that “interdependencies, vulnerability, amplification, secondary disasters and critical infrastructure” be considered in mitigation strategies to limit destruction from them.

Suzuki, Y., Fukuda, I., et al. (2014). [The Operating Room During a Severe Earthquake: Lessons From the 2011 Great East Japan Earthquake](#). (Abstract Only.) Disaster Medicine and Public Health Preparedness. 8(2): 123-129. .

This paper reviews lessons learned from healthcare providers working within operation rooms during the 2011 Great East Japan earthquake. Findings demonstrated tremors, electrical blackouts, and nonstructural damage to out-of-hospital telecommunications provided challenges for continuing operations in the immediate aftermath of the earthquake.

Tanisho, Y., Smith, A., Sodeoka, T., and Murakami, H. (2015). [Post-Disaster Mental Health in Japan: Lessons and Challenges](#). Health and Global Policy Institute.

This report describes lessons learned from the Fukushima nuclear disaster in 2012. It includes recommendations for ensuring that psychosocial and mental health interventions consider the unique circumstances and cultural issues of a given disaster.

Wang, Y. (2014). [Hospital and Water System Earthquake Risk Evaluation](#). Oregon Department of Geology and Mineral Industries (DOGAMI) Report to Oregon Health Authority.

This pilot project was conducted to evaluate the earthquake associated risks and vulnerabilities of hospitals and water systems in Cascadia subduction zone within Oregon. Vulnerability assessments of both hospital and water systems were conducted and the data provided from the assessments was further analyzed by using the Federal Emergency Management Agency's Hazmus MH loss estimation software. Critical infrastructure dependencies for hospitals such as water, transportation, fuel, electricity, and communications were assessed along with risk reduction recommendations.

Wang, Y. (2018). [Oregon Hospitals Preparing for Cascadia](#). Oregon Department of Geology and Mineral Industries (DOGAMI) Open File Report O-18-03.

The report provides findings from the Oregon Coastal Hospitals Cascadia planning project which was conducted to improve hospital readiness for earthquakes incidents. Researchers provided 4 key recommendations from project including: clarifying and improving systems requirements; conducting on-site technical assistance at hospitals; establishing a coastal hospital resilience network and sharing earthquake and fuel planning information to statewide partners.

Yonekura, T., Ueno, S., and Iwanaka, T. (2013). [Care of Children in a Natural Disaster: Lessons Learned from the Great East Japan Earthquake and Tsunami](#). (Abstract only.) *Pediatric Surgery International*. 29(10): 1047-1051.

The authors incorporate lessons learned from the Fukushima disaster into response recommendations for pediatric surgeons and physicians.

Post-Disaster Hospital Assessment Tools

Agency for Toxic Substances and Disease Registry. (n.d.). [Exposure History Form](#). (Accessed 10/11/2018.)

This form is from the Agency for Toxic Substances and Disease Registry (ATSDR). Past and current exposures are recorded on Part 1 of an Exposure History Form, which is designed for easy completion by the patient and a quick scan for pertinent details by the clinician. The questions investigate changes in routines and work site characteristics; details about known toxicant exposure; known exposure to metals, dust, fibers, fumes, chemicals, physical agents, and biologic hazards; other persons affected; protective equipment use; and temporal patterns and activities. Part 2 of the Exposure History Form is a comprehensive inventory of hazardous exposures in the patient's

present and past occupations. Part 3 of the form examines environmental history to exposure(s).

American College of Emergency Physicians. (n.d.). [Hospital Disaster Preparedness Self-Assessment Tool](#). (Accessed 10/11/2018.)

Though not an assessment for post-disasters specifically, this tool may provide some helpful information on categories that should be considered in a post-disaster assessment (particularly sections 3-7). This assessment was developed to assist hospitals in revising and updating existing disaster plans or in the development of new plans.

American Medical Association. (2014). [Caregiver Self-Assessment Questionnaire](#).

This questionnaire can help caregivers look at their own behavior and health risks. With their healthcare provider's help, this questionnaire can also help caregivers make decisions that may benefit both the caregiver and the older person. The questionnaire can help healthcare providers to identify and provide preventive services to an at-risk population that may be hidden. It may also improve communication and enhance the healthcare provider-caregiver health partnership.

California Emergency Medical Services Authority. (n.d.). [Hospital Incident Command System 251- Facility Systems Status Report](#). (Accessed 10/11/2018.)

This HICS form is to be used to determine the status (functional, partially functional, non-functional) of a healthcare facility after an emergency event.

Centers for Disease Control and Prevention. (2014). [Checklist for Infection Control Concerns when Reopening Healthcare Facilities Closed Due to Extensive Water and Wind Damage](#).

This checklist provides guidance for completing building and life safety inspections prior to restoration work, and guidance for infection control review of facilities to be done before the hospital can reopen. Attachment A includes a site specific checklist for selected areas of the facility (e.g., laboratory, pharmacy, etc.).

Harvard School of Public Health, Emergency Preparedness and Response Exercise Program. (2014). [Essential Functions and Considerations for Hospital Recovery Version 2](#). Federal Emergency Management Agency.

This document helps hospitals prepare to manage recovery from all types of events. Recovery planning benchmarks are included starting on page 34 to help hospitals independently assess their recovery capabilities. The benchmarks are drawn from a variety of sources including the ASPR Healthcare Preparedness and Response Capabilities, Joint Commission Hospital Accreditation Standards, the NDRF, and lessons

learned from both recovery-focused exercises and real-world disasters. The document also includes questions to consider during recovery planning starting on page 38.

Joint Commission. (2018). [Emergency Management Healthcare Environment Checklist](#).

This checklist can help facilities with identifying fully functioning systems and processes to ensure full patient care delivery after an incident.

Pan American Health Organization, World Health Organization. (2017.) [Hospital Administrator, Post Disaster Functional Checklist](#).

This checklist is meant to be used by a CEO or Hospital Administrator within 24 hours after the impact of a natural or man-made disaster. Its objective is to determine the immediate level of safety and functionality of the hospital. The facility is assessed in three segments: structural, non-structural, and functional capacity.

Greater New York Hospital Association. (2017). [Recovery Checklist for Hospitals After A Disaster](#).

Hospital staff can utilize this facility recovery checklist to check for potential issues in the facility after a disaster.

South Carolina Department of Health and Environmental Control. (2016). [Post-Disaster Hospital Reopening Procedures](#).

This document provides a step-by-step guide for hospitals to follow prior to reopening. It includes five primary steps with action items under each.

U.S. Department of Defense. (2015). [Department of Defense Pre-Deployment Health Assessment](#).

The purpose of the Department of Defense (DoD) Pre-Deployment Health Assessment (DD Form 2795, October 2015) is to document deployment-related health evaluations and evaluations of specific deployment-related conditions. It also contains standard health assessment tools that can be used for evaluating patients with deployment-related concerns.

U.S. Department of Homeland Security. (2012). [Post Deployment Health Screening Questionnaire](#).

This U.S. Department of Homeland Security (DHS) questionnaire can be found on pp. 127-132 of "Emergency Responder Health Monitoring and Surveillance: National Response Team Technical Assistance Document (TAD), January 26, 2012." It addresses deployment related exposures, tasks, health history, health symptoms, and protective equipment for military members or civilian government employees.

Zane, R., Biddinger, P., Gerteis, J., and Hassol, A. (2010). [Hospital Assessment and Recovery Guide](#). AHRQ Publication No. 10-0081.

This guide is designed to help organize the initial assessment of a hospital after an evacuation/closure due to an emergency event. The guide is divided into 11 sections, each with its own team and assessment assignment: Administration, Facilities, Security and Fire Safety, Information Technology and Communications, Biomedical Engineering, Medical, Ancillary Services, Materials Management, Building and Grounds Maintenance/ Environmental Services, and Support Services.

Appendix A: Cascading Events—Potential Effects of Volcanoes, Hazardous Materials and Radiologic Material Releases, and Tsunamis

Volcanoes

There are approximately 169 volcanoes in the United States that scientists consider active. Most of these are located in Alaska and others are located throughout the west and in Hawaii. Kilauea in Hawaii is one of the most active volcanoes on earth and was [erupting at the time this document was published](#) (and has been erupting continuously since 1983, per the [U.S. Geological Survey, 2011](#)). Significant earthquakes causing volcanoes to erupt or volcanic eruptions themselves causing seismic activity above a 5.0 magnitude are very, very rare.

If possible, evacuation is the best mitigation action a community can take against a volcanic eruption. Areas near an erupting volcano can experience clouds of ash; falling blocks of rock; pyroclastic flows or ash hurricanes; lava flows; and floods of debris; similar to landslides. Most deaths occur from volcanic landslides called lahars, and pyroclastic flows. Some may be killed by ash falls that are heavy enough to collapse roofs ([U.S. Geological Survey, 2011](#)). Ongoing volcanic activity can threaten roadways, and ash in the air can severely limit air operations (both rotor-wing and fixed wing, rescue and commercial) for prolonged periods.

Healthcare providers should be prepared to address crush and other traumatic injuries, respiratory symptoms, eye injuries, skin irritation, and burns. Areas in the path of a pyroclastic flow or lahar, or covered in significant ash, may take years to recover and the population may need to be resettled. Long term surveillance of the health impacts of the air and soil contamination may be warranted.

For More Information:

[The Health Hazards of Volcanic Ash: A Guide for the Public](#)

[The Health Hazards of Volcanoes and Geothermal Areas](#)

[Volcano Hazards Program FAQs](#)

Hazardous Materials and Radiologic Releases

Earthquakes that occur in areas with chemical, nuclear, or other industrial plants and complexes can damage or disrupt operation to those facilities, which could affect the public's health. Rapid assessment of impacted areas/facilities to detect damage and potential leaks and hazards is critical. Hazardous materials releases may drive additional evacuations beyond those necessitated by earthquake damage.

A jurisdiction-specific risk assessment should inform response actions, and will assist planners with focusing resources to ensure that public health and healthcare responders are prepared to respond to the most likely chemical or radiologic exposures that may occur in their community. In general, respiratory symptoms, skin and eye irritation, and burns may be expected following exposure to chemical and/or radiologic releases. Healthcare-based and community-based plans for decontamination, and countermeasure distribution and

administration, should be developed and exercised. Long-term health outcomes monitoring may also be warranted.

For More Information:

ASPR TRACIE Topic Collections

[Chemical Hazards](#)

[Hospital Victim Decontamination](#)

[Pre-hospital Victim Decontamination](#)

[Radiological and Nuclear](#)

ASPR TRACIE [Radiological and Nuclear Health and Medical Considerations](#)

Tsunamis

Tsunamis are a series of enormous waves caused by an underwater seismic disturbance such as a landslide, earthquake, or volcanic eruption – anything that causes a rapid displacement of water. The amount of water affected and forces applied determine the destructive potential. Tsunamis are not easily seen until they reach shallower water. Tsunami warning systems are in place along coast lines with the potential for seismic events, but if an earthquake or landslide occurs close to the shore a tsunami wave could reach land before a warning is able to be issued.

As the tsunami wave progresses and then recedes, enormous force and pressure can cause building collapse and structural damage, as well as water damage, destruction of infrastructure, such as roads, bridges, power lines, water distribution systems and other general destruction. The primary, immediate causes of injury and death from tsunamis are drowning and trauma.

For More Information:

[CDC: Health Effects of Tsunamis](#)

[Ready.gov: Tsunamis](#)