Impact of Extreme Heat on Health Care Facilities

CR4HC

3. Assessment and Remediation of Vulnerabilities in Infrastructure and Operations

While the drivers behind climate change are global in scale and decades in the making, patients and staff often experience climate change effects in the form of a canceled clinical appointment, a power outage, or a flooded street. Many of the actions that healthcare organizations can take to avoid disruption in clinical care involve building resilience and redundancy in their facility design and operations. These practices include building and maintaining efficient buildings that can continue to operate during power and water outages. They also include designing resilient supply chains and storage conditions for food and medical supplies that require constant refrigeration. And, perhaps most crucially, they involve plans to protect, house, and possibly provide transportation for staff and their families during extreme weather events. As a result, the facility can serve its dual role in the emergency response system: providing clinical care and acting as a resilience hub for community members seeking refuge from the heat.

The following sub-elements describe specific ways a healthcare organization can enhance the resilience of its infrastructure and operations to extreme heat events.

3.1 Staff Support: Healthcare organizations depend on clinicians, administrators, and facilities and operations staff to deliver care. Staff and their families are often impacted by the same climate change-related hazards as the facilities in which they work. Integrating protections and accommodations for staff into the heat emergency plan can help alleviate logistical difficulties associated with commuting to and from the facility, as well as mental preoccupation of staff members about the safety of loved ones who remain at home.

3.2 Clinical Considerations: Extreme heat events can cause a surge in health care demand. Healthcare organizations can increase resilience by planning ahead for potential patient surges, establishing a protocol for real-time communications with other local health systems during crises, and integrating extreme heat into their syndromic surveillance systems.

3.3 Building and Campus – Design & Construction: Even though building codes require structural redundancies that harden buildings against potential environmental hazards such as extreme heat, prolonged exposure to very high ambient temperatures can lead to deterioration over time. Resilient healthcare facilities are designed to minimize the risk of heat-related failures to the building structure, building materials, and building systems. Many of the same design features also reduce facility greenhouse gas emissions.

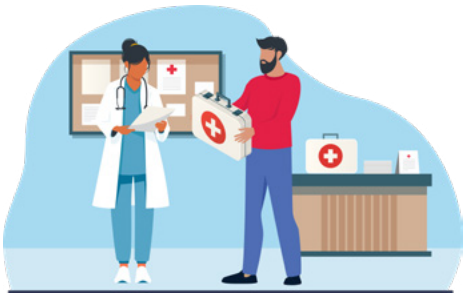
3.4 Building and Campus – Facility Operations: Healthcare facilities are vulnerable to power outages that can disrupt building systems critical to patient care and occupant safety. Healthcare organizations can enhance climate resilience by updating protocols to reflect the results of the organization's prospective risk assessment. For example, preventive facilities maintenance and plans for cycling down systems during power outages may need to be updated in response to a warming climate.

3.5 Supply Chain: Many items in a healthcare organization's supply chain – both clinical and non-clinical – require refrigeration. Healthcare organizations can enhance resilience by developing and implementing a plan for managing their refrigerated supply chain and on-site storage during heat-related regional power outages.

Impact of Extreme Heat on Health Care Facilities

CR4HC

3.1 Staff Support



Healthcare organizations depend on clinicians, administrators, and facilities and operations staff to deliver care. Staff and their families are often impacted by the same climate change-related hazards as the facilities in which they work. Integrating protections and accommodations for staff into the heat emergency plan can help alleviate logistical difficulties associated with commuting to and from the facility, as well as mental preoccupation of staff members about the safety of loved ones who remain at home.

Climate Resilience Actions

Tools and resources relevant to these actions can be found at:
HEAT: Element 3.1: Staff Support

Planning

ACTION: Set staff expectations for their role during climate-related extreme weather events.

SUMMARY: One successful strategy to ensure staff are prepared for their role during disasters is to clearly state in their contracts that extreme weather events – particularly events that lead to power disruptions or outages – are disasters that may require staff to remain at work for multiple days. Co-create policies and programs with staff establishing a flexible and staff-supportive approach to staffing, accommodations, and transportation during disasters (WHO, 2020).

People and Operations

ACTION: Provide alternative transportation and housing for healthcare staff during climate change-related events.

SUMMARY: Consider establishing agreements with nearby transportation providers and temporary housing facilities (such as hotels) to support employees and their immediate families in the event that transportation pathways and/or utilities are disrupted during an extreme climate change-related disaster. Such agreements may also allow for staff to stay at healthcare facilities before the extreme weather event begins to mitigate potential transportation interruptions (WHO, 2020).

ACTION: Provide staff support post-disaster.

SUMMARY: Creating a post-disaster employee assistance program for staff and their families in the aftermath of a climate change-related event – including mental health services – can help them build the long-term physical, mental, and social resilience that will be needed to respond to the next disaster (WHO, 2020).

Impact of Extreme Heat on Health Care Facilities

CR4HC

3.2 Clinical Considerations

Extreme heat events can cause a surge in health care demand – for both heat-related illness and all cause morbidity and mortality. Records from the U.S. Centers for Disease Control and Prevention indicate that within an average year, 9,235 people are hospitalized and 67,512 emergency department visits occur in the U.S. due to heat-related illness (Rosenthal, 2022). Studies have found increases of 3%–14% in medical care utilization above baseline across a range of medical complaints during extreme heat events (Hess et al., 2023). Healthcare organizations can increase resilience by planning ahead for potential patient surges, establishing a protocol for real-time communications with other local health systems during crises, and integrating extreme heat into their syndromic surveillance systems.

Climate Resilience Actions

Tools and resources relevant to these actions can be found at:
HEAT: Element 3.2: Clinical Considerations

Planning

ACTION: Integrate epidemiological and meteorological data into extreme heat event preparedness.

SUMMARY: Consider combining local epidemiological and meteorological data with downscaled climate models for your region to estimate the increase in patient volume (and corollary staff and medical supplies) that might be expected for different levels and durations of extreme heat events (Patel et al., 2022).

ACTION: Enhance syndromic surveillance during extreme heat events.

SUMMARY: Consider enhancing the healthcare system's syndromic surveillance during extreme heat events by submitting heat-related illness data to the Electronic Surveillance System for the Early Notification of Community-Based Epidemics (ESSENCE) (Burkom et al., 2021). Heat exposure can cause not only heat exhaustion and heat stroke but can also exacerbate chronic conditions (including cardiovascular, respiratory, renal disease, and mental health conditions) and cause pregnancy complications. It can be helpful to collaborate with local public health partners to interpret and act on real time heat-related illness and all-cause morbidity and mortality data during and immediately following extreme heat events.

ACTION: Integrate a heat stroke management protocol into the healthcare organization's heat emergency plans.

SUMMARY: Consider including a heat stroke management protocol in the healthcare organization's heat emergency plan to streamline appropriate clinical responses during extreme heat events (Hess et al., 2023; Rublee et al., 2021).

People and Operations

ACTION: Enhance heat preparedness by adding heat-related illness screening to the healthcare organization's electronic medical records system

SUMMARY: Consider including in the healthcare organization's heat resilience and preparedness plan

Climate Resilience Actions continued on next page

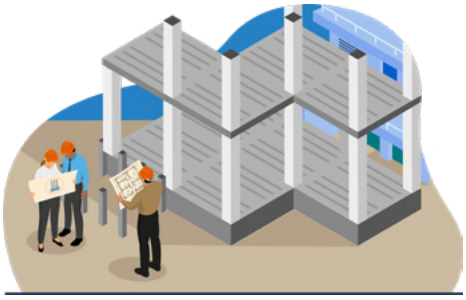
Climate Resilience Actions, continued

a protocol for activating heat-related illness screening questions in the electronic medical records system when local authorities declare a heat hazard event. Sensitive patient groups who might be flagged for additional screening during heat events include: psychiatric patients, individuals experiencing housing insecurity or homelessness, outdoor workers, pregnant individuals, children, adults over 65 years of age, people with substance use disorder, and chronic disease patients (particularly patients with chronic respiratory, cardiovascular, and/or kidney disease) (Hess et al., 2023).

Impact of Extreme Heat on Health Care Facilities

CR4HC

3.3 Building and Campus: Design & Construction



Even though building codes require structural redundancies that harden buildings against potential environmental hazards such as extreme heat, prolonged exposure to very high ambient temperatures can lead to deterioration over time. This is particularly true for asphalt-capped roads and bridges, as experienced in the Pacific Northwest during the 2021 heat dome. In British Columbia, Canada, thermal expansion resulted in deep ruts in roads and structural damage to bridges. The extreme temperatures created atmospheric conditions that prevented helicopters from hovering, causing hospital heliports to close in Vancouver and surrounding areas (Beugin et al., 2023).

Resilient healthcare facilities are designed to minimize the risk of heat-related failures to the building structure, building materials, and building systems. Many design features that reduce patient and staff exposure to heat and lengthen the amount of time a facility can continue to function during a power outage also reduce its contribution to greenhouse gas emissions – the primary cause of climate change.

Climate Resilience Actions

Tools and resources relevant to these actions can be found at:
HEAT: Element 3.3: Building and Campus – Design and Construction

Planning

ACTION: Use regional climate models to future-proof the efficiency and redundancy of building systems in the face of projected increases in the frequency and severity of climate change-related hazards.

SUMMARY: Building codes and engineering best practice guides use historical weather trends to set guidelines for the overall capacity of building systems, the maximum temperature at which they will function, and expectations for "average" temperature and rainfall. Climate models indicate that using historical trends to set the outer limits of building system functionality will likely fall short of operational needs within a few decades. It is therefore advisable for healthcare facilities (many of which are designed to function for 50 or more years) to maximize energy efficiency and identify opportunities for diversifying their energy supply (such as by installing renewable power microgrids for backup power) in order to extend the functional life of the building as long as possible in a rapidly changing climate (Casanueva et al., 2019).

People and Operations

ACTION: Work with consultants who are familiar with climate resilient design and construction techniques.

SUMMARY: Working with architects, engineers, owner's representatives, and general contractors who are knowledgeable about the different design strategies, building technologies, and materials required to build and operate a climate resilient healthcare facility is often key to integrating climate resilience planning into a new building, renovation project, or facility upgrade (Darko et al., 2017).

Climate Resilience Actions continued on next page

Climate Resilience Actions, continued

Physical Infrastructure

Landscaping and Roof

ACTION: Provide and maintain safe, shaded pathways between the property line or patient drop-off point and the facility entrance for multiple modes of transportation.

SUMMARY: Providing shaded pathways linking the facility's main entrance with transit stops, parking, and other access points can increase the safety and effectiveness of multi-modal evacuation plans when they are deployed during a climate change-related event (Basu et al., 2022).

ACTION: Use vegetation, light-colored surfaces, and insulation to reduce heat exposure inside and outside the facility.

SUMMARY: Maximizing vegetation and shade on and around the building and installing light colored roofing materials and pavement for all sidewalks, roads, and parking lots lowers the air temperature around the building (its microclimate), thereby reducing the amount of air conditioning required to maintain a safe temperature inside a healthcare facility (Akbari, et al, 2001; O'Hara et al., 2022).

ACTION: Maximize green space on the ground level and facility roofs to reduce exposure to heat and flooding.

SUMMARY: Installing native, drought-resistant landscaping and nature-based solutions like low impact development on both the ground level and facility roofs can reduce utility costs (both energy and water) and reduce exposure to extreme heat. Low impact development and green roofs further reduce flood risk by filtering stormwater and slowing its movement across the property (Chu et al. Figure 12.7, 2023).

Energy Efficiency and Renewable Energy

ACTION: Establish a net zero requirement for all new buildings and major renovations in the healthcare system.

SUMMARY: Net zero facilities are designed with enough energy efficiency measures (e.g., enhanced building and wall insulation, efficient building and mechanical equipment, and efficient lighting systems) to reduce their energy demand to a level where they can generate sufficient electricity using on-site renewable power (e.g., solar, wind, geothermal). These facilities can continue to provide clinical care during climate change-related events that disrupt regional power grids. For more information about net-zero buildings, see: A Common Definition for Zero Energy Buildings | Department of Energy.

ACTION: Use building design strategies like insulation and shading devices to maintain safe temperatures inside the healthcare facility during extreme heat and cold events.

SUMMARY: Design strategies that improve the efficiency of the building envelope can reduce the risks of extreme indoor temperatures, decrease heating and cooling demand, and extend the length of time the facility can function on back-up power systems. For example, buildings in warm climates in the Northern Hemisphere should install white or garden roofs and minimize unprotected windows on the south and west side of the building to reduce the amount of solar radiation entering the building. Overhangs on the south and vertical screens (including plants) on the east and west side of the building can reduce exposure to both heat and glare. Installing high performance windows (e.g., with two or three sheets of glass and solar film) and highly insulated wall and roof construction (e.g., R-30 or higher in many climates) also reduce the transfer of heat or cold into the building. Installing windows that open in low acuity areas of the facility can help maintain safe temperatures during power outages (Sun et al., 2020).

ACTION: Install energy efficient building equipment to extend the length of time the facility can function on back-up power systems.

SUMMARY: Installing energy efficient building equipment (such as air conditioning, heating, ventilation, and lighting systems) can reduce demand for air conditioning and heating and extend the length of time the facility can function on back-up power systems (Carvallo, et al., 2022).

ACTION: Incorporate renewable power generation infrastructure in the design of new facilities and major renovations.

Climate Resilience Actions continued on next page

Climate Resilience Actions, continued

SUMMARY: Many healthcare facilities are designed to operate for 50 or more years. It is therefore particularly important to build today's facilities to accommodate future retrofits such as solar arrays, all-electric building systems, battery storage, geothermal heat pumps, and parking garages dominated by electric vehicles. All of these strategies serve dual purposes. They both reduce greenhouse gas emissions and increase the facility's resilience to climate change-related events (Lazo et al., 2023).

ACTION: Increase resilience to power outages by installing cogeneration facilities on site or in the medical district.

SUMMARY: Investing in an on-site or district-wide cogeneration plant connected to secure power sources, such as geothermal, and storage capacity can reduce a healthcare facility's reliance on external power sources needed to maintain continuity of care (Isa et al., 2018).

ACTION: Design solar arrays to provide multiple benefits to the healthcare campus, such as solar canopies that also shade pedestrian pathways and parked cars.

SUMMARY: Photovoltaic solar panels are thin, modular, and relatively easy to install on many surfaces. They are therefore well-adapted to offer multiple uses – particularly shading. Installing them as shading devices on the roof, as pedestrian or car canopies, and on building facades that face the most intense direct sunlight (the south and west facades in the northern hemisphere) will maximize both their daily electricity production and their cooling effect on the building envelope (Golden et al., 2007).

Thermal Comfort and Indoor Air Quality

ACTION: Install operable windows with screens in non-clinical spaces to increase the healthcare facility's resilience during power outages.

SUMMARY: Installing operable windows with screens can extend the period of time a healthcare facility can function during a power outage by reducing reliance on the air conditioning system for cooling and ventilation (Sun et al., 2020).

ACTION: Install high efficiency air filtration systems to reduce the concentration of pollutants in indoor air.

SUMMARY: Installing highly efficient air filtration systems (e.g., MERV 13) and increasing the volume of outdoor air introduced to the building can reduce the concentration of a range of airborne contaminants, including airborne pathogens; particulate matter; cleaning and disinfection chemicals; and toxins emitted from furniture, architectural finishes, and composite wood products like plywood (Mousavi et al., 2020).

Impact of Extreme Heat on Health Care Facilities

CR4HC

3.4 Building and Campus: Facility Operations

Healthcare facilities are vulnerable to power outages because they rely on electricity, plumbing systems, and energy sources like natural gas to operate building systems that are critical to patient care and occupant safety, such as: lighting, air conditioning, medical and sterilization equipment, security systems, fire alarms, and electronic medical records. Buildings without operable windows can be especially at risk of overheating during power outages. Inpatients also require access to food service, clean water, laundry, and custodial services.

Operational resilience starts with design conversations about the building shape and structure, the location and type of windows, the building's overall insulation, its roof type and color, and the extent to which landscaping will be used to protect the building from exposure to climate change-related hazards like extreme heat and flooding (Element 3.3). Healthcare organizations can enhance the climate resilience of their facilities by updating preventive maintenance protocols and plans for cycling down systems during power outages to reflect the results of the organization's prospective risk assessment (Element 1).

Climate Resilience Actions

Tools and resources relevant to these actions can be found at:
HEAT: Element 3.4: Building and Campus – Facility Operations

Planning

ACTION: Integrate pre-event resilience measures into healthcare facility operations preventive maintenance and emergency management plans.

SUMMARY: Pre-event resilience measures in healthcare facilities include maintaining building systems to maximize energy efficiency and enhanced ventilation, diversifying the energy supply (such as installing renewable power and battery storage for backup power), increasing insulation and solar reflection for the facility walls and roof, installing shading devices to minimize heat exposure inside the building, and performing routine maintenance to seal cracks and fix plumbing leaks (Casanueva et al., 2019).

ACTION: Integrate extreme heat drills into the healthcare organization's rotating roster of emergency preparedness activities.

SUMMARY: Most building and IT equipment in healthcare facilities are designed to function within a relatively narrow range of moderate temperatures. When outdoor temperatures rise to levels that threaten human health, they can also damage equipment and lead to temporary or even permanent failure. Performing heat drills – both as stand-alone scenarios and in conjunction with scenarios of cascading or simultaneous climate change-related events – can help emergency managers, facility operations, and maintenance teams identify and protect systems that are vulnerable to failing during an extreme heat event (Hess et al., 2023).

ACTION: Categorize electricity loads by their contribution to critical operations.

SUMMARY: Healthcare facilities can increase resilience to power outages by creating a load-shedding protocol that powers down building systems based on their level

Climate Resilience Actions continued on next page

Climate Resilience Actions, continued

of importance to clinical care. Consider cross-referencing the protocol with stages of evacuation preparation, so that patient transfers to partner facilities take place before conditions in the facility (such as extreme temperatures, exposure to flood waters, etc.) reach dangerous levels (FEMA ASPR, 2019).

People and Operations

ACTION: Implement a preventive maintenance program to ensure that energy efficient building systems function as designed.

SUMMARY: All building systems require regular maintenance. Preventive maintenance, an approach to regularly inspecting and tuning equipment, is particularly important for facilities that are designed to continue operations during utility outages. These programs ensure that the energy and water demand remain at levels that can be met by on-site sources, such as renewable power and recycled process water (Kolokotsa et al., 2012).

ACTION: Conduct regular stress tests of the healthcare facility's ability to continue providing clinical care during extreme heat events.

SUMMARY: Consider performing regular stress tests of the healthcare facility's ability to continue providing clinical care during extreme weather events. Incorporate scenarios such as brownouts, blackouts, low water pressure, surge of patients experiencing heat-related illness, surge of all-cause complaints, and surge of community members seeking to use the facility as a cooling center and safe place to charge electrical devices (including medical equipment). These tests can help identify critical systems whose failure would result in cascading effects across the facility and impact delivery of critical care (Ebi et al., 2018).

Physical Infrastructure

ACTION: Operate net zero healthcare facilities to increase resilience to temperature extremes and power outages.

SUMMARY: Net zero facilities are able to continue operating during brownouts and blackouts, because they are both highly efficient and produce renewable energy on-site. As a result, they are more resilient than conventional buildings to climate change-related hazards that cause utility disruptions (Lakatos et al., 2023).

ACTION: Generate renewable energy on the healthcare campus.

SUMMARY: Producing electricity on-site using renewable energy sources such as solar and geothermal coupled with storage capacity (e.g., batteries) can reduce reliance on external sources for electricity needed to maintain continuity of care (Lazo et al., 2023).

ACTION: Separate potable and process water systems from each other and source an emergency water supply to maintain water pressure during water outages.

SUMMARY: Water pressure can drop in a community during extreme weather events (e.g., extreme heat, extreme cold, drought) or as a result of infrastructure failures caused by hazards like hurricanes and tornadoes. Healthcare facilities located in high-risk areas can increase resilience by identifying water sources that can be used to maintain water pressure during low pressure events. Facilities with the ability to separate process water systems from potable water systems are particularly resilient to water outages (HERC, 2015).

Impact of Extreme Heat on Health Care Facilities

CR4HC

3.5 Supply Chain

Many items in a healthcare organization's supply chain – both clinical and non-clinical – require refrigeration. Healthcare organizations can enhance resilience by developing and implementing a plan for managing their refrigerated supply chain and on-site storage during heat-related regional power outages.

Climate Resilience Actions

Tools and resources relevant to these actions can be found at:
HEAT: Element 3.5: Supply Chain

Planning

ACTION: Integrate regional climate change projections into the healthcare organization's supply chain emergency planning process.

SUMMARY: Identifying potential vulnerabilities within a healthcare organization's supply chain related to the full range of regional projected climate change-related hazards can inform contingency planning and emergency preparedness planning, including establishing redundancy among providers for critical supplies (Lakatos et al., 2023; Sherman et al., 2023).

ACTION: Integrate storage of medical supplies for heat-related illness into the facility heat preparedness plan.

SUMMARY: Consider how the healthcare organization's prospective risk assessment of extreme heat events (Element 1) might lead to supply chain disruptions and/or changing needs. Storing sufficient medical supplies for treating patients with heat-related illness can help the facility withstand a temporary pause in deliveries (Hess et al., 2023).

Physical Infrastructure

ACTION: Boost the resilience of refrigerated storage areas.

SUMMARY: Consider increasing wall insulation and access to auxiliary power in refrigerated storage areas to extend the shelf life of temperature-sensitive products like pharmaceuticals and food supplies during brownouts and blackouts (Lazo et al., 2023).