CR4HC

Climate Resilience for Health Care Toolkit

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Acknowledgments

Robin Guenther (1954–2023)

Robin Guenther, FAIA, LEED AP, was a pioneering architect and global leader in sustainable healthcare architecture. She was a lead author of the Sustainable and Climate-Resilient Healthcare Facilities Toolkit – the predecessor to CR4HC, to which she contributed foundational content. Robin's legacy lives on in the sustainable and resilient healthcare buildings she helped design; the impact of her advocacy for human- and planetary-health-promoting healthcare facilities, and; the countless colleagues, clients, and others she inspired, mentored, and taught.

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Contributors:

Adele Houghton FAIA, DrPH, LEED AP; Aparna Bole, MD; John Balbus, MD, MPH
Nisha Shah, DO; Ashley Sanders-Jackson, PhD; Tess Wiskel, MPH
Ana Abel, MPH; Hollynd Boyden, MPH; Edyta Debowska, MPH; Lauren Jensen, MPH; Katie Lichter, MD, MPH; Caroline Olson, MPH

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Administration for Strategic Preparedness and Response's (ASPR) Technical Resources, Assistance Center, and Information Exchange (TRACIE) Program; Jenna Agins, MBA, MS, NYU Langone Health; Ana Arevalo, UC San Diego Health; Jerrod Bley, CEM; Jen Boothroyd, MPA, Northern Light Health; David Burson, Mass General Brigham; Jeffrey Butler, MPA, IPEM, CHSP, CHEP, CEDP, CHPA, Medxcel; Richard Cohen, PE, MBA, NYU Langone Health; Scott Cormier, NRP, CHEP, Medxcel; Tim Doak, PE, PLS, MBA, Northern Light Health; Caleb Dresser, MD, MPH, Harvard T.H. Chan School of Public Health; Alan Foster, MBA/MHA, CHEC II, UNC Health Rex; Jocelyn Gan, MS, NYU Langone Health; Arnab Ghosh, MD, MSc, MA, Weill Cornell Medicine; Rame Hemstreet, CEM, PgMP, PE; Ann Ihaza, ASPR Critical Infrastructure Protection (CIP); Kelley Kelso, Kaiser Permanente; Matthew Le, UC San Diego Health; Marry Ellen Leciejewski, CommonSpirit Health; Taina Lopez, National Association of Community Health Centers (NACHC); Paul Maniscalco, Ph.D, MPA, MS, EMT/P, LP, CHEP, GCITP, Medxcel; Nate Matthews-Trigg, MPH, CEM, Americares; Kelly McKinney, MPA, NYU Langone Health; John Messervy, Mass General Brigham; Leanna Molnar, MS, NYU Langone Health; Donald E Moore, Pueblo Community Health Center; Nicole Poletto, UC San Diego Health; Kim Ray, CommonSpirit Health; Christina Sanborn, AIA, LEED AP, MAZZETTI; Shelly Schlenker, CommonSpirit Health; Grace Thomas, Verdis Group; Sarah Tsay, DrPH, MPH, UC San Diego Health; Walt Vernon, PE, LEED AP, EDAC, FASHE, JD, LLM, MAZZETTI; Seema Wadhwa, ALM, LEED AP, Kaiser Permanente; Charles Weir, PhD, MPH, PE, ASPR (CIP); Rachel Wenger, CommonSpirit Health; Sunny Wescott, DHS Cybersecurity and Infrastructure Security Agency.

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Access the full CR4HC Toolkit: https://toolkit.climate.gov/topics/health-care

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Introduction to Climate Resilience for Health Care

Why and How to Use this Toolkit

The Climate Resilience for Health Care (CR4HC) Toolkit provides climate resilience planning guidance for healthcare organizations.

CR4HC is designed to inform emergency preparedness and resilience planning after completing a hazard vulnerability assessment with tools like the ASPR Risk Identification and Site Criticality (RISC) Toolkit.

This introduction includes background information about the impacts of climate change on healthcare delivery as well as the mission-based and financial rationale for climate resilience planning in health care. This section also explains the toolkit's organizing framework and principles of resilience.

What you'll find in the Climate Resilience for Health Care Toolkit

Who Should Use the CR4HC Toolkit

This toolkit is intended primarily for healthcare emergency management professionals. It also contains recommendations and resources useful to others involved in emergency preparedness, environmental sustainability, and resilience planning in health care. See "The Climate Resilience Team" figure below for more detail.

Enhancing resilience across the emergency management cycle requires input from every department in a healthcare organization as well as coordination with external partners. For instance, coordination between Emergency Management, Facilities, and Design/Construction/Real Estate, with support from Executive Leadership, is essential to improving a healthcare organization's infrastructure resilience to current and future climate hazards. Coordination between Emergency Management, Clinical Operations, Community Engagement, and External Partners helps ensure that the needs of populations most at risk from climate-related health threats are anticipated and addressed. The figure and table on the following pages share specific examples of actions that can enhance a healthcare organization's resilience at each phase of the emergency management cycle.

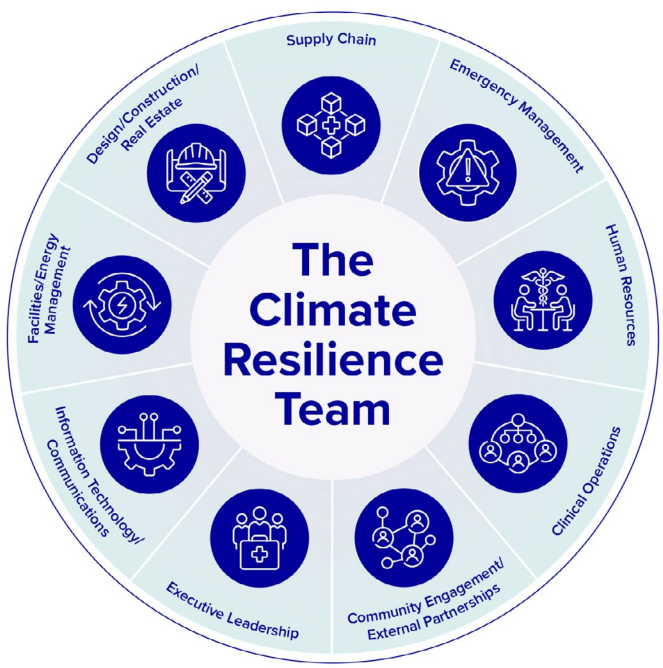

Figure 1: The Climate Resilience Team

Table 1: Emergency Management Cycle Phases and Resilience-Promoting Activities

Emergency Management Cycle Phase	Examples of Resilience-Promoting Activities
MITIGATION **Prevent or reduce the cause, impact, and consequences of disasters**	• Use local climate modeling data from the CDC National Environmental Tracking Network data portal to assess the prospective risk of events, such as flooding and heat waves, in your area. • Use data from social determinants of health screening (SDOH), and resources from community partners, to identify and address factors (like housing and utility insecurity) that increase community members' risk of climate-related health harms.
PREPAREDNESS **Planning, training, and educational activities for events that cannot be mitigated**	• Develop an all-hazards risk plan and individual plans for the highest risk current and future climate-related hazards in your area. Include support for outpatient facilities, crisis communication in collaboration with trusted community organizations, an energy demand management strategy, and clinician education. • Collaborate with community partners to develop a plan for community-based distribution of essential resources during disasters (such as food and emergency power).
RESPONSE **Provide immediate and coordinated assistance to address the most urgent needs in the aftermath of a disaster**	• Fold climate resilience messaging into communication and outreach efforts alongside trusted community partners, to ensure that protective information reaches populations at highest risk. • Establish a system for stockpiling and distributing essential medical supplies and services to designated community locations when disasters disrupt access to healthcare facilities.
RECOVERY **Restoration efforts involve long-term repair and replacement of damaged infrastructure, support for affected individuals and businesses, and measures to reduce future disaster impact**	• Develop a process for evaluating disaster response within a context of climate resilience that includes external healthcare and community partners, and informs continuous improvement of infrastructure, operations, and community outreach. • Identify opportunities to develop new partnerships (e.g., between healthcare organizations, with public health entities, and with other community partners) to improve response to future disasters.

Why is Climate Resilience Important for Health Care?

Health systems face a growing imperative to anticipate and mitigate the impacts on health and health care from increasingly frequent and severe natural disasters (FEMA, 2023 b.) and extreme weather events (NASA, n.d.). Similar to other critical facilities – such as fire and police stations – healthcare facilities need to continue operations in the face of power outages, disruptions to transportation systems, and extreme weather. Climate-resilient healthcare organizations anticipate and respond to the impacts of climate change to protect the lives of people living in the United States.

Investment in Resilience Pays Dividends

Climate change-related events can cause expensive damage to facility infrastructure, disrupt supply chains, and increase the need to pay staff overtime rates during disasters. Investment in resilience strategies, such as the recommendations included in the CR4HC Toolkit, can reduce the risk of unanticipated expenses in four ways, which are:

1. Preventing damage to facility buildings and **infrastructure**
2. Reducing the risk of disruption to **clinical care**
3. Bolstering **community capacity** to meet essential needs during and after disasters, which reduces the risk of community members using healthcare facilities as ad hoc emergency shelters
4. **Protecting those most at risk** for climate-related health harms

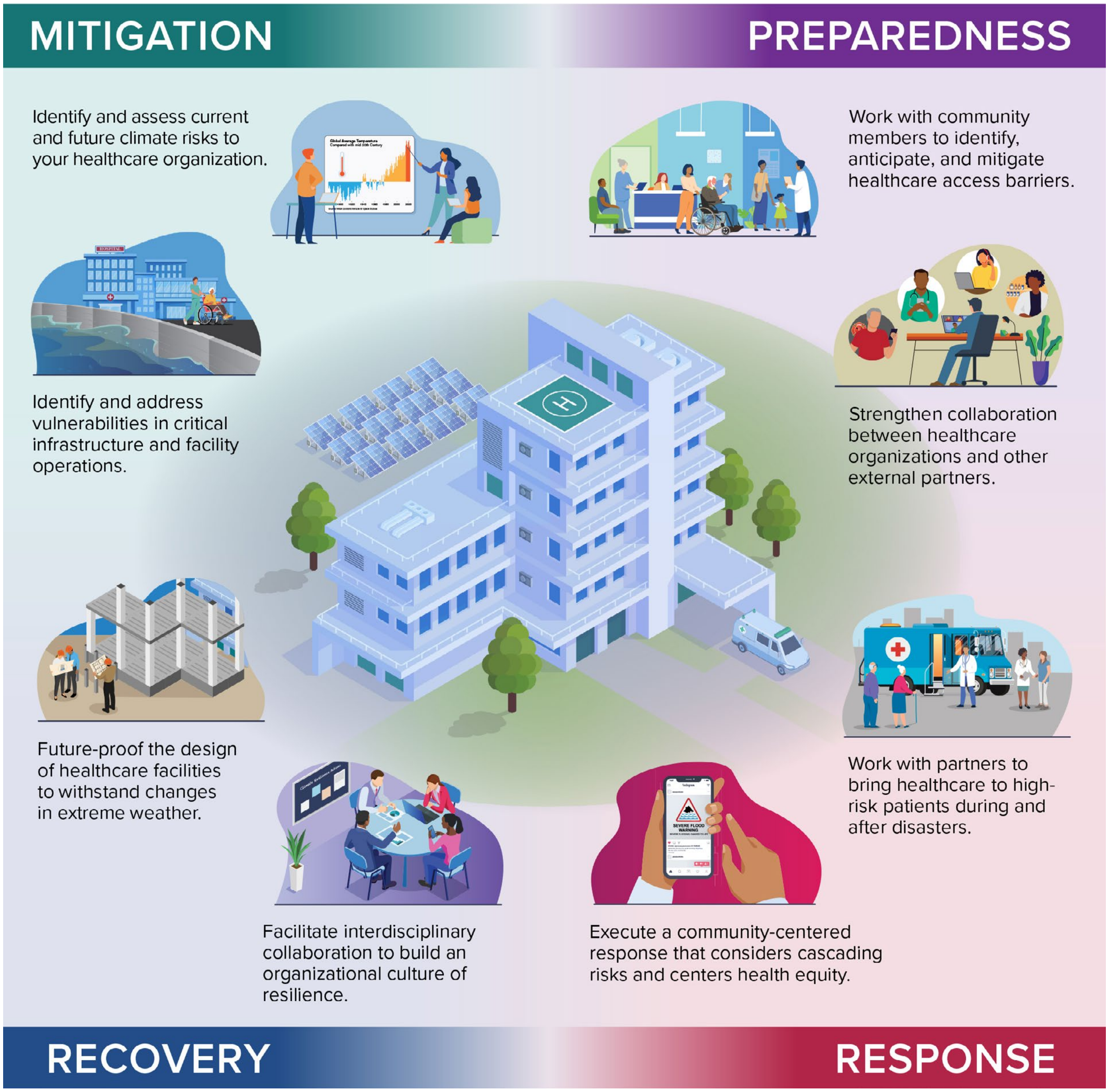

Figure 2: Emergency Management Cycle Phases and Resilience-Promoting Activities

Protecting infrastructure: Climate change-related events can damage healthcare facilities, the transportation infrastructure connecting them to their patients, and irreplaceable research specimens. For example, in 2001, Tropical Storm Allison resulted in at least $2 billion in damages to the Texas Medical Center in Houston, Texas (Hays, 2001). Seven years later, in 2008, Hurricane Ike caused lost income from disrupted clinical care and $110 million in losses to research projects at the University of Texas Medical Branch (UTMB) in Galveston, Texas, leading to layoffs of 20% of UTMB's workforce (Goodwin et al., 2010).

The National Institute of Building Sciences found that every $1 invested in climate resilience activities returns up to $13 in reduced risk of damage to infrastructure (NIBS, 2020). In the case of hospitals, FEMA estimates that the average infrastructure cost to hospitals from storm damage ranges from $600,000–$2 billion per facility, whereas the cost of resilience retrofits for the three types of equipment that are most likely to be damaged (elevator crankcases, windows, and generators) is much less (Thomas, 2011). WHO estimates that nonstructural retrofits that enhance a hospital's resilience cost 1% of the facility's total value and can protect up to 90% of its assets (WHO, 2009). The CR4HC Toolkit's

Taking an all-hazards approach to resilience planning, design, operations, and clinical care can help healthcare organizations continue operations during and after climate-related disasters and extreme weather events, which is critical to both community health and the financial sustainability of the healthcare organization.

Appendix, which shares links to relevant tools and resources, includes funding opportunities that can further increase the return on resilience investments.

Preserving continuity of care: Climate change is already disrupting clinical care, both in the United States and globally. A survey of close to 800 healthcare leaders around the world found that 75% of them have noticed climate change-related events impacting their abilities to deliver quality care (Salas, 2022). A survey of health centers in Florida reported that operational disruptions caused by power outages averaged $41,000 in losses per outage, and some losses tracked as high as $300,000 per day of outage (Van Winkle et al., 2023). Losses were linked to missed appointments, loss of anticipated medication and vaccine reimbursements, and expenses related to staff missing work. In New Orleans, Louisiana, CrescentCare Health Center lost more than $250,000 in refrigerated vaccines and medications during a power outage following Hurricane Ida in 2021 (Van Winkle et al., 2023).

Within a week of 2012's Superstorm Sandy, 26 out of the 61 nursing homes in the path of the storm closed due to power outages (ASPR TRACIE, 2022). Meanwhile, the emergency response to Superstorm Sandy cost hospitals in New York City an estimated $1 billion in staff overtime, emergency equipment repairs, and patient evacuations, as well as an additional $1 billion in physical repairs to their facilities. The New York City hospitals also estimated permanent losses of $70 million per week in the weeks immediately following the event (NYC, 2013). Taking an all-hazards approach to resilience planning, design, operations, and clinical care can help healthcare organizations continue operations during and after climate-related disasters and extreme weather events, which is critical to both community health and the financial sustainability of the healthcare organization.

Bolstering community capacity: Healthcare organizations play a critical role in the resilience of their communities. In addition to providing essential medical care, they can serve as a trusted hub for crisis services. For example, they can play a role in distributing food, providing access to emergency power, and sustaining access to essential medications.

Healthcare organizations can minimize the nonreimbursable expenses they incur during a crisis by supporting community interventions that enhance community resilience. For example, Oregon used part of a $1.1 billion Medicaid package to provide air conditioners, air purifiers, and battery storage to Medicaid recipients at a high risk of exposure to extreme heat and air pollution from wildfires (Young, 2024).

Investments in health-promoting community infrastructure and public health interventions, such as nutrition, housing, transportation, education, sanitation, parks and recreation, and public safety, are associated with significantly better population health outcomes for chronic conditions that increase vulnerability to climate change-related health harms. These chronic conditions include obesity, diabetes, asthma, cardiovascular disease, and mental health conditions (Bradley et al., 2016).

Healthcare organizations, individually and collectively, can bolster local resilience through their roles as "anchor institutions" in their communities. Anchor institutions are large, often not-for-profit organizations that are geographically rooted in place and whose operations can have social and economic impacts (Koh et al., 2020). Purchasing local goods and services, using equitable workforce policies, and investing in housing and transportation are examples of anchor institutions' abilities to positively impact community health and resilience (Koh et al., 2020). As anchor institutions, climate-resilient healthcare organizations can leverage their

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Protecting those most at risk for climate-related health harms: Exposure, sensitivity, and adaptive capacity to climate-related hazards are modulated by social determinants of health (SDOH), such as housing, access to transportation, and food and energy security. Healthcare organizations are increasingly integrating programs that address patients' SDOH in their care delivery, recognizing that these interventions improve health outcomes and may mitigate risks of climate-related health harms. For example, home weatherization and utility assistance can reduce the risk of exposure to extreme temperatures. In addition, SDOH screening programs can help inform healthcare organizations' plans to prioritize focused protection for at-risk populations in their emergency management and climate resilience planning. The specific needs of patients with medical vulnerabilities to climate-related health hazards should also be considered in resilience planning. For example, patients who rely on electricity-dependent durable medical equipment are at particular risk in the event of power disruptions during and after disasters.

Partnerships with community organizations, frontline community members, and service organizations can help healthcare organizations identify and effectively prioritize at-risk populations for the collaborative delivery of information, resources, and essential services. They also help healthcare organizations understand and support essential community services, including SDOH referral resources for patients who identify unmet health-related social needs. Finally, connections with trusted community organizations can help with communication and the distribution of resources before, during, and after disasters.

Decreasing greenhouse gas emissions and increasing efficiency: The U.S. healthcare sector generates about 8.5% of total U.S. greenhouse gas emissions (Eckelman & Sherman, 2018), causing air pollution and climate change that harm health and contribute to health disparities. Interventions that contribute to decarbonizing the healthcare sector by reducing greenhouse emissions can also help increase resilience. For example:

Increasing energy efficiency of healthcare buildings reduces operating costs and helps shore up resources that can be redirected toward patient care, capital investments, and financial reserves.

Renewable energy investments and battery storage can help reduce utility costs and prevent power outages when the central grid is damaged.

Lower carbon purchasing practices, such as purchasing from local vendors, can contribute to supply chain resilience and the healthcare organization's mission to act as an anchor institution.

Elements of Climate Resilience for Health Care (CR4HC)

Planning for climate resilience in health care aligns with the all-hazards approach to emergency preparedness. Effective planning takes a proactive approach to addressing simultaneous and cascading threats to patient health, facility infrastructure, and staff safety.

Climate resilience in the healthcare setting integrates the following six elements into healthcare organizations' emergency preparedness framework:

Element 1: Prospective risk assessment

- Traditionally, risk assessment relies on retrospective data. Consideration of forward-facing climate data as well as cascading risks supports preparation for current and future vulnerabilities.
- For example, the CDC hosts the National Environmental Public Health Tracking Network (EPHT) that provides county and sub-county level indicators on climate change-related exposures, like extreme temperature, flood, drought, precipitation, and wildfire smoke. EPHT has multiple historical and projected indicators for each of these hazards.

Element 2: Health equity and community engagement

- Identifying the populations most at risk from climate-related hazards could incorporate information from:
  i. Clinical assessment of patients' social and environmental determinants of health
  ii. Identification of patients with specific medical vulnerabilities to climate-related hazards
  iii. Community outreach and partnership with community organizations
- Addressing the needs of at-risk populations can include:
  i. Outreach to at-risk patients to prepare for a climate-related disaster or extreme weather event, to provide resources to mitigate health risks before, during, and after the event
  ii. Community investments and partnership with community organizations to address health-related social and environmental needs
  iii. Community engagement and input in the development of the healthcare organization's climate resilience plan and participation by the healthcare organization in community climate resilience efforts

Element 3: Assessment and remediation of vulnerabilities in infrastructure and operations

- Infrastructure and operational climate vulnerabilities can include building(s), land use, energy systems, water sanitation, transportation, supply chains, and the healthcare workforce.
- Assessment of return on climate resilience investments can take into consideration increasing costs from climate-related hazards, can help prioritize future investments, and can inform climate resilience efforts across the health sector.

Element 4: Collaboration between healthcare organizations

- Healthcare delivery in one setting can be affected by stressors in other healthcare settings. For example, demand for acute care is affected by disruptions to other local and regional healthcare services, including health centers, pharmacies, long-term care facilities, rehabilitation centers, infusion centers, dialysis centers, community mental and behavioral health centers, and home health services. A collaborative approach to climate resilience planning that acknowledges the interrelationships and interdependencies between diverse healthcare facility types can enhance the resilience of the entire system.

Element 5: Interdisciplinary planning, oversight, and evaluation

- In addition to disaster preparedness protocols, healthcare climate resilience requires attention to areas such as infrastructure investments, supply chain reliability, and community partnerships.
- Development and implementation of healthcare climate resilience plans should involve diverse disciplines, such as emergency planners, healthcare providers, Emergency Medical Services, facility and energy managers, administrators and executives, pharmacy, purchasing, food and nutrition services, information technology, and waste management.
- Evaluation and process improvement can include input from diverse stakeholders, lessons learned and best practices from peer institutions, and the refinement of measures of success during and after disasters.

Element 6: Communications and all-hazards approach

- Many climate-related events occur simultaneously or in quick succession. For example, heat waves and droughts often coincide and create conditions that increase wildfire risk. Drought-ending heavy precipitation events often cause flooding. Developing an all-hazards approach to external-facing communications can help healthcare organizations tailor real-time messaging to support patients and staff before, during, and after disasters.

Strategies to enhance resilience to climate-related hazards: The next section of CR4HC, the Toolkit's core content, describes evidence-based actions that can increase healthcare organizations' resilience to all / multiple hazards as well as to the following seven individual climate-related hazards that align with the ASPR RISC Toolkit's organization: extreme heat, flooding, hurricanes, thunderstorms and tornadoes, wildfire, drought, and extreme winter weather. These actions are further categorized into the six elements of climate resilience described above. Tools and resources supporting the implementation of these recommended actions are included in the Appendix of this Toolkit.

Climate Resilience Strategies for Health Care

This section of the CR4HC Toolkit describes specific, evidence-based actions designed to help healthcare organizations build resilience to all climate change-related hazards (the All / Multiple Hazards section) as well as to the following seven individual hazards: Extreme Heat, Flooding, Hurricanes, Thunderstorms and Tornadoes, Wildfire, Drought, and Extreme Winter Weather.

For recommended actions in this toolkit whose implementation is well established, accompanying references and related tools provide step-by-step guidance on how to execute the actions. Some recommended actions are included because they are conceptually important, but they lack well-established implementation guidance. These conceptual recommendations can be considered to inform resilience planning, and they also represent opportunities for future evaluation and peer-to-peer learning.

To facilitate coordination across hazards, each set of actions is organized into the six elements of climate resilience in health care: (1) prospective risk assessment; (2) health equity and community engagement; (3) assessment and remediation of vulnerabilities in infrastructure and operations; (4) collaboration between healthcare organizations; (5) interdisciplinary planning, oversight, and evaluation; (6) communications and all-hazards approach. Elements two and three are divided into sub-elements. Within each of these elements and sub-element pages, resilience actions are further organized into three types: Planning, People and Operations, and Physical Infrastructure.

Each hazard and element page in this section of the Toolkit is meant to be comprehensive, shareable, and independently useful to the many people fulfilling the roles that come together to create and implement a holistic approach to climate resilience for a healthcare organization. At the same time, many climate resilience strategies create co-benefits for multiple hazards and/or multiple aspects of the healthcare organization. As a result, several actions in this section may repeat or share common language across multiple hazard pages.

Similarly, many of the tools and resources available to help healthcare organizations implement climate resilience strategies are applicable to more than one climate change-related hazard. Therefore, the tools and resources in the Appendix are organized by climate resilience element because most of them can be used to support actions across all of the hazards included in this Toolkit.

Impact of Climate-Related Hazards on Healthcare Organizations

Direct impacts to healthcare delivery from climate-related disasters and extreme weather events can include power disruptions from increased demand on energy systems as well as infrastructure damage that causes interruptions in critical utilities. Indirect impacts can include patient surges from hazard-specific and all-cause morbidity as well as disruptions to supply chains and local transportation infrastructure (that result in barriers to access the facility for both staff and patients).

When extreme weather events and climate-related disasters occur, healthcare organizations often confront multiple crises at once or in quick succession. For example, in the aftermath of Hurricane Beryl in 2024, millions of Texas residents experienced power outages – some for 10 days – while, at the same time, the region experienced an extreme heat wave. Immediately following Beryl's landfall, hospitals were unable to safely discharge patients because of widespread power outages. The number of patients with heat-related illnesses tripled compared to the previous week, and carbon monoxide poisoning cases spiked from improper use of emergency generators. In the weeks following the event, the local public health department reported an outbreak of West Nile Virus that they suspected was linked to the flooding and heat following the storm (DeGuzman, 2024 a.; DeGuzman, 2024 b.; Gill & MacDonald, 2024; Johnson, 2024; Martinez & Foxhall, 2024). Twenty-nine hospitals in the region surrounding Houston, Texas, faced patient surges for weeks after the event.

An all-hazards approach to resilience planning fosters multidisciplinary collaboration and leads to resilience strategies that can work synergistically and confer multiple benefits. Following Superstorm Sandy in 2012, surveys of affected hospitals in New York and New Jersey identified recommended best practices that can confer resilience to multiple stressors and disruptions, such as:

- Implementing redundant communication systems
- Sharing disaster plans and developing a clear, specific chain of representation for planning and operations with the inclusion of Emergency Medical Services, hospitals, emergency management, public utilities, and ancillary health services
- Planning for staff's potential need to shelter in place, making provisions for loved ones affected by damaged community infrastructure, and caring for their mental health (American College of Emergency Physicians, 2015)

Applying an all-hazards preparedness lens to campus design and construction can be more efficient and more effective than focusing on one hazard at a time. For example, increasing water and energy efficiency can reduce operating costs, which increases financial resilience as well as resilience to utility disruptions. Solar installations can also reduce operating costs, serve as a backup power source, provide shade for staff and visitors, and permit a healthcare facility to serve as a community resilience hub during periods of grid disruption. In New Orleans, CrescentCare Community Health Center's solar microgrid with a backup battery system will reduce utility expenses, help ensure the continuous provision of essential health services during and after disasters, and allow CrescentCare to serve as a Lighthouse of the Community Lighthouse Project, created by the nonprofit, Together Louisiana. A Lighthouse is a place of refuge for community residents to access essential resources, such as cooling and charging stations, food, and water (Dempsey, 2023).

Elements of a Climate-Resilient Healthcare Organization: All / Multiple Hazards

Climate resilience complements core emergency management activities. It expands vulnerability assessments to consider the implications of the changing climate – not only on a healthcare organization's physical infrastructure but also on its staff, clinical care, relationship with the community, and evolving role as a key member of the multidisciplinary emergency response network that operates during disasters to keep the community safe.

This section of the Toolkit underscores the foundational importance of an all-hazards approach to improving climate resilience and complements the Toolkit's hazard-specific sections. It includes crosscutting resilience actions that healthcare organizations can implement to build resilience to all climate change-related hazards in their region. Tools and resources that can inform the implementation of these resilience actions can be found in the Appendix.

1. Prospective Risk Assessment

Climate change is leading to changes in the incidence and severity of extreme weather events and disasters, such as heat waves, wildfires, and storms. Because historical patterns may not accurately reflect future risk, using forward-facing climate projections can help to mitigate the impacts of future climate-related events on community health and healthcare delivery.

2. Health Equity and Community Engagement

Climate change impacts vary within and among communities and regions and across the United States. As a result of racial inequality and other societal and political factors, certain groups experience more environmental exposures than others. Therefore, healthcare organizations' action plans should focus on health equity and community engagement to help providers build resilience among their most medically-fragile populations and reduce the risk of all-cause patient surges during and after climate change-related disasters.

3. Assessment and Remediation of Vulnerabilities in Infrastructure and Operations

Healthcare organizations are on the front lines when a climate-related disaster or extreme weather event takes place. Regardless of the specific climate hazard, healthcare organizations are called to staff their facilities and deliver quality medical care – for both disaster-related complaints and all-cause clinical visits.

4. Collaboration Between Healthcare Organizations

Disruption in care delivery in an outpatient facility may result in a patient surge in an acute care setting, and evacuation and transfers between facilities during and after disasters may be required. Therefore, sharing information and resources across the full range of regional healthcare providers is important for increasing resilience both at the facility level and across the regional healthcare delivery ecosystem. Collaboration between healthcare facilities to increase climate resilience can include communication and information sharing, resource coordination, plans for potential evacuation and transfers, medical staff deployment, data sharing, joint public health outreach efforts, and joint disaster preparedness drills.

5. Interdisciplinary Planning, Oversight, and Evaluation

Planning for climate resilience requires an interdisciplinary team and coordination across a range of critical functions, including administration, emergency management, clinical leadership, information technology, construction and real estate, facility operations (e.g., power, water, waste disposal, food service, custodial services, etc.), communications, transportation, and purchasing. Aligning facility operations, procurement, and capital expenditures to balance climate change mitigation goals (i.e., reducing greenhouse gas emissions) and resilience goals can help the organization chart a climate-positive and cost-neutral path toward resilience.

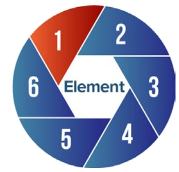
6. Communications and All-Hazards Approach

Climate-related disasters and extreme weather events often occur simultaneously or in quick succession, which increases the risk of multisystem failures at the community scale (such as disruptions to water and power utilities) that can cause compounding threats to healthcare infrastructure and operations and surges in healthcare demand. The effects of simultaneous or sequential climate-related hazards can be particularly prolonged and cascading for populations at disproportionate risk of health harms.

Resilience Strategies:
All / Multiple Hazards

CR4HC

Element 1. Prospective Risk Assessment



Climate change is leading to changes in the incidence and severity of extreme weather events and disasters, such as heat waves, wildfires, and storms. The annual average number of (Consumer Price Index-adjusted) billion-dollar extreme weather events and disasters in the United States increased from 8.5 in the period of 1980–2023 to 20.4 in the period of 2019–2023. The geographic distribution of events is also changing. For example, historically-temperate regions, such as the Pacific Northwest, are increasingly experiencing extreme summer heat (Heeter et al., 2023). Because historical patterns may not accurately reflect future risk, using forward-facing climate projections can help mitigate the impacts of future climate-related events on community health and healthcare delivery; for example, a health impact assessment of regional climate action plan strategies in Western Massachusetts combined historical baseline data with projected changes in extreme heat exposure to evaluate the potential health impacts of two interventions: (1) providing cooling centers and other protective outreach to at-risk populations, and (2) improving energy efficiency in municipal buildings (Massachusetts Department of Public Health, 2016).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
[Element 1: Prospective Risk Assessment]

Planning

ACTION: Consider both historical trends and climate projections to identify regional climate change-related hazards.

SUMMARY: As a result of the climate changing, historical trend lines are not necessarily an accurate predictor of the future. Incorporating both historical trends and climate projections when developing emergency management strategies around climate change-related hazards can thus help organizations future-proof the planning, response, and recovery process.

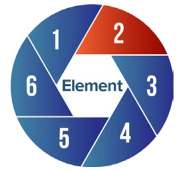
ACTION: Consider both historical trends and climate projections to inform an emergency preparedness plan.

SUMMARY: Integrating regional climate projections into a healthcare organization's emergency preparedness plan can help enrich understanding of how its facilities' current risk profiles are likely to change in the coming decades as a result of climate change.

ACTION: Add a prospective risk assessment and impact forecasting to the local hazard mitigation plan.

SUMMARY: It can be helpful to work with public health and local emergency management partners to add a prospective risk assessment and impact forecasting to the local hazard mitigation plan (Hess et al., 2017).

Element 2. Health Equity and Community Engagement



Climate change impacts vary within and among communities and regions and across the United States. As a result of racial inequality and other societal and political factors, certain groups experience more harmful environmental exposures than others. Blending empirical data with community members' lived experience and sense of place is crucial to ensuring that climate action is designed to reduce historic inequities in both exposure and health outcomes (Marino et al., 2023). Therefore, healthcare organizations' action plans should focus on health equity and community engagement to support at-risk populations and reduce the risk of all-cause patient surges during and after climate change-related disasters. Healthcare organizations should also include patient and community voices as an integral part of their climate change resilience planning process so that they can tap into shared perceptions of local assets, vulnerabilities, and healthcare needs; feelings of empathy and a shared sense of care for at-risk community members; and the local knowledge, sense of place, and belief systems that are foundational to fostering a culture of resilience in the community (Imperiale & Vanclay, 2021).

The following sub-elements describe specific ways in which a healthcare organization can integrate health equity and community engagement into its hazard planning.

2.1. Community Input: Frameworks, like social determinants of health (U.S. HHS, n.d.) and vulnerability assessments, can help healthcare organizations map the location of patients and community members who are at higher risk of harm from one or more climate-related hazards. It can be helpful to include community input in the vulnerability mapping exercise. Furthermore, community-based organizations are often in the best position to connect patients with local resources, such as emergency power, food distribution, housing and utility assistance.

2.2. Community Infrastructure: Climate-related disasters and extreme weather events can damage buildings, transportation routes, and utility infrastructure. Healthcare organizations can enhance community resilience by supporting programs that increase redundancy in local utilities, increase adaptive capacity in home environments, and provide emergency distribution of essential goods and services.

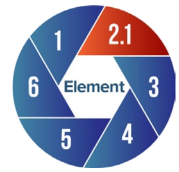
2.3. Community Services: Healthcare organizations can collaborate with community partners to (1) mitigate risk factors (such as housing or utility insecurity) for climate-related health harms, (2) coordinate emergency outreach efforts to at-risk populations, and (3) provide essential community-based services (such as emergency power and food distribution) during and after disasters.

2.4. Coordination with Local Office of Emergency Management: It has become increasingly important for healthcare organizations to develop, implement, and revise their emergency preparedness plans in coordination with peer organizations, the local health department, the local office of emergency management, and the local utility to ensure that the entire emergency response network activates as a single, cohesive team when a climate change-related event occurs. The coordination process can also reveal gaps and redundancies across organizations before the event takes place, helping to prevent unintended negative outcomes. Coordination also fosters personal relationships across disciplines, which can benefit the speed and effectiveness of the emergency response.

Resilience Strategies:
All / Multiple Hazards

CR4HC

Element 2.1 Community Input



Frameworks, like social determinants of health (U.S. HHS, n.d.) and vulnerability assessments, can help healthcare organizations map the location of patients and community members who are at higher risk of harm from one or more climate-related hazards. It can be helpful to include community input in the vulnerability mapping exercise. Furthermore, community-based organizations are often in the best position to connect patients with local resources, such as emergency power, food distribution, housing and utility assistance.

For example, in the aftermath of Superstorm Sandy (2012), healthcare institutions partnered with the New York City Department of Health and Mental Hygiene, community-based organizations, and others to integrate empirical data with judgments informed by lived experience to develop a consensus weighting of the probability, severity, and manageability of nine hazards. The ranking survey collected 1,834 responses, including 160 responses from hospitals, 185 from nursing homes, and 72 from other types of healthcare facilities. Participating organizations have used the resulting rankings to prioritize emergency management activities and enhance regional preparedness across multiple hazards. Results from this participatory decision-making process highlighted that different stakeholder groups had different hazard management priorities. The final list synthesized high ranking strategies into a single set of priorities that represent the overall region (Ray et al., 2024).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 2.1: Community Input

Planning

ACTION: Map patient populations who are sensitive to high-priority climate change-related hazards.

SUMMARY: Collaborating with community partners to map patient populations who are at high risk of negative health outcomes after short-term and/or long-term exposure to climate change-related hazards can increase organizational and community resilience by helping to ensure that protocols supporting healthcare access during and after climate change-related emergencies are tailored to those populations' needs (Patel et al., 2022).

ACTION: Use the JEDI framework to structure community input.

SUMMARY: Consider following the Justice, Equity, Diversity, and Inclusion (JEDI) framework to integrate community input into the development and operation of the healthcare organization's climate resilience plan (American Public Health Association & CDC, 2021).

People and Operations

ACTION: Integrate community input into conversations about the implications of regional climate projections on a healthcare organization's emergency planning process, future clinical needs, and opportunities to support community resilience.

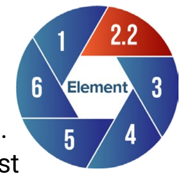
SUMMARY: Creating opportunities for community members to share their needs in the face of new and more frequent and/or extreme environmental hazards can help healthcare providers target investment in areas that will bring the greatest co-benefits to the communities they serve (American Meteorological Society, 2014).

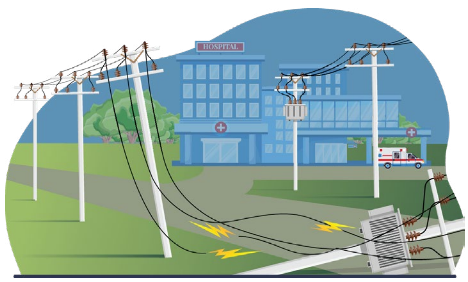
Climate Resilience Actions, continued

ACTION: Regularly engage with community organizations in climate resilience education, communication, and integration sessions.

SUMMARY: Creating and maintaining regular opportunities for community organizations to facilitate a two-way conversation between the healthcare organization and community members around climate resilience can increase the effectiveness of the organization's emergency preparedness plan when it is implemented (Day et al., n.d.).

Element 2.2 Community Infrastructure





Climate-related disasters and extreme weather events can damage buildings, transportation routes, and utility infrastructure. For example, the 2021 summer heat wave in the Pacific Northwest caused roads to buckle and public transportation infrastructure, such as streetcar cables, to be compromised (Thompson et al., 2022). Following Hurricane Ian in 2022, approximately 25% of Florida's residential customers lost power and over 90% of homes on Florida's southwest coast remained without power a week after the storm (Entress & Stevens, 2023). Healthcare organizations can enhance community resilience by supporting programs that increase redundancy in local utilities, increase adaptive capacity in home environments, and provide emergency distribution of essential goods and services.

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
[Element 2.2: Community Infrastructure]

People and Operations

ACTION: Integrate regional climate projections into multiagency disaster protocols related to utilities, communications, and transportation.

SUMMARY: Collaborating with public agencies responsible for utilities, communications, and transportation is essential to ensure that healthcare services remain accessible and functional during crises (American College of Healthcare Executives, 2020; Marinucci et al., 2014).

ACTION: Support and direct patients to local programs that increase adaptive capacity in the home environment.

SUMMARY: Support and direct patients to local programs that increase the adaptive capacity of low-income residents and other high-risk groups (such as adults over 65 years of age). Examples are weatherization programs, air conditioning rebates and donations, community solar subscriptions, and utility assistance programs (e.g., Low Income Home Energy Assistance Program) (Patel, 2022).

Physical Infrastructure

ACTION: Catalyze the development of resilient infrastructure at the neighborhood and community level.

SUMMARY: As anchor institutions, healthcare campuses and public health institutions can catalyze neighborhood and community-scale efforts to increase resilience against anticipated climate change-related environmental hazards (Pastor & Morello-Frosch, 2014; Hacke & Deane, 2017).

ACTION: Enhance community resilience by remediating contaminated sites for healthcare installations.

SUMMARY: Strategically locating healthcare facilities on sites in need of environmental remediation (such as brownfields) can accelerate the clean-up process, thereby reducing the risk of community exposure to toxin-laden dust and flood waters during extreme weather events (Ballogg, 2015; ATSDR, 2021).

ACTION: Support protective measures that mitigate hazard exposure at the community level.

SUMMARY: Support protective measures that mitigate extreme hazard exposure at the community level, such as increasing trees and greenspace, expanding and improving cooling centers, and using building materials

Climate Resilience Actions, continued

that increase insulation and are more reflective of solar radiation (Casanueva, 2019).

ACTION: Work with local and regional partners to lower barriers to travel for patients and staff during climate change-related emergencies.

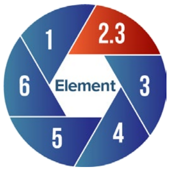
SUMMARY: Transportation infrastructure failures can prevent staff from reporting to work and patients from traveling to healthcare facilities to receive needed care during natural and human-caused disasters. Healthcare organizations can support regional climate change resilience by working with local and regional partners to lower barriers to travel (WHO, 2020). For example, limited public transit service and priority access to gas stations could be offered for essential workers (U.S. HHS, 2014).

OASH | Office of Climate Change and Health Equity

Resilience Strategies: All / Multiple Hazards

CR4HC

Element 2.3 Community Services



Healthcare organizations can collaborate with community partners to (1) mitigate risk factors (such as housing or utility insecurity) for climate-related health harms, (2) coordinate emergency outreach efforts to at-risk populations, and (3) provide essential community-based services (such as emergency power and food distribution) during and after disasters.

For example, Oregon Medicaid provides air conditioners, space heaters, air purifiers, mini-fridges for medication, and battery packs for electricity-dependent durable medical equipment, such as ventilators to low-income residents who have been diagnosed with health conditions that would worsen during an extreme heat event, air pollution event (such as wildfire), or power outage. The goal of the program is to protect 200,000 of the most at-risk residents in the state as a response to the 2021 heat dome that resulted in 102 deaths (primarily adults 65+ and low-income individuals); 60% of patients who visited the emergency department (ED) during the heat dome with a heat-related complaint reported a household income of less than $50,000 per year. The program is similar to an effort spearheaded by integrated health system, Kaiser Permanente, during the 2021 Pacific Northwest heat wave. Kaiser Permanente estimated that it saved $42,000 in avoided ED visits and $400,000 in avoided hospital admissions by distributing air conditioners to 81 patients in Oregon and Washington State (Young, 2024).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
[Element 2.3: Community Infrastructure](#)

Planning

ACTION: **Consider preemptive planning for patients who use electricity-dependent DME.**

SUMMARY: Proactively help patients who rely on electricity-dependent durable medical equipment (DME) to ensure that they have a backup power source or another contingency plan in the event of power shutoffs during extreme weather events (Pacific ADA Center, 2017).

People and Operations

ACTION: **Coordinate with community partners to create a multi-sector protocol for the delivery of mental health services during and after climate change-related emergencies.**

SUMMARY: The mental health impact of climate change-related emergencies can be severe. Healthcare organizations can help increase community resilience by supporting crisis response planning among community partners in the public and private sectors who provide mental health care for survivors of natural disasters (WHO, 2020).

ACTION: **Fill gaps in local services to increase resilience, such as acting as a place of refuge during extreme weather events.**

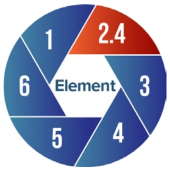
SUMMARY: Healthcare facilities equipped to continue operations during power outages can enhance local resilience by offering their facilities as refuges for community members during extreme weather events (Johns & Rosenthal, 2024; Toner et al., 2017). It is important to formalize this role with the Office of Emergency Management ahead of the event so that the facility receives extra fuel, supplies, and staff to manage non-medical emergency services (U.S. HHS, 2014).

Climate Resilience Actions, continued

ACTION: Integrate community resilience needs into healthcare organization emergency management plans.

SUMMARY: Include provisions in the healthcare organization's emergency plan to accommodate community members who may seek to use the facility as a refuge and patients who require access to electrical power to charge their medical devices and/or refrigeration for their medications. Consider creating a registry of patients needing this kind of assistance and setting up a two-way communications protocol (such as a Reverse 911 or wireless emergency alert system [National Academies of Sciences, 2018]) to contact them in the event of a power disruption or outage (Patel et al., 2022).

Element 2.4 Coordination with Local Office of Emergency Management



Population health emergencies linked to climate change are increasingly experienced as a rapid succession of related disasters or compound events (Ebi et al., 2021). In response, it has become increasingly important for healthcare organizations to develop, implement, and revise their emergency preparedness plans in coordination with peer organizations, the local health department, the local office of emergency management, and the local utility to ensure that the entire emergency response network activates as a single, cohesive team when a climate change-related event occurs. The coordination process can also reveal gaps and redundancies across organizations before the event takes place, helping to prevent unintended negative outcomes. Coordination also fosters personal relationships across disciplines, which can benefit the speed and effectiveness of the emergency response.

For example, an analysis of the effectiveness of interagency coordination during the 2014 Ebola virus outbreak in the Dallas-Fort Worth, Texas, metroplex found that effective coordination across healthcare organizations, the local public health department, and the local office of emergency management required three parallel components: (1) formal mechanisms, such as the official community emergency management plan, (2) informal mechanisms, such as back-channel conversations based on previous relationships, and (3) a strong information and communications network that consistently broadcast high-quality information to partners and the general public (Soujaa et al., 2021).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 2.4: Coordination with Local Office of Emergency

Planning

ACTION: Add local and regional climate change vulnerability assessments to the healthcare organization's emergency preparedness plan.

SUMMARY: Consider adding local and regional climate change vulnerability assessments to the healthcare organization's emergency preparedness plan to integrate projections of how the region's exposure to climate change-related hazards may change in coming decades compared with historical trends (Marinucci et al., 2014).

ACTION: Formalize cooperation agreements with utility providers (both power and water) to ensure that the healthcare organization's facilities are integrated into local emergency management and climate resilience planning efforts.

SUMMARY: Critical facilities, hospitals, and other healthcare building types should be fully integrated into local utilities' emergency management and climate resilience planning efforts. It is particularly important to include facility power and water needs in emergency preparedness and climate resilience planning efforts to ensure that they can continue to provide care during and after climate change-related disasters (McCabe et al., 2023; Van der Heijden, 2022).

Climate Resilience Actions, continued

ACTION: Integrate legal preparedness into the healthcare organization's emergency management and climate action plans.

SUMMARY: Uncertainty about who has the legal authority to authorize difficult decisions during disasters can slow a healthcare organization's ability to pivot from normal operations to respond to a disaster. Healthcare organizations can enhance the resilience of their emergency management and climate action plans by including parameters that clarify the conditions in which a facility may share information outside of the healthcare organization, administrators may order facility evacuations, and clinical staff from outside organizations are authorized to practice in the healthcare facility. These plans may also include a decision framework for deciding how to allocate scarce resources during utility outages (Toner et al., 2017; VanDevanter et al., 2014).

ACTION: Collaborate with local partners to coordinate climate-related disaster messaging.

SUMMARY: It can be helpful to collaborate with local public health department partners to coordinate climate-related hazard messaging with clinicians and patients, such as through prompts in the healthcare organization's electronic health record, e-newsletter, and patient texting system. This approach can increase community awareness of both the short- and long-term health risks associated with exposure to climate-related disasters (WHO, 2020)

People and Operations

ACTION: Build relationships with the local public health department, other health systems, and the wider community to facilitate coordination around climate resilience and emergency response.

SUMMARY: Setting up an institutional framework that fosters personal relationships across key agencies, organizations, and community groups is often the first step in establishing effective communication and a shared goal around priority hazards – both related to investing in climate resilience before disaster strikes and during the emergency itself (Chi et al., 2015; Gooding et al., 2022; Nuzzo et al., 2019).

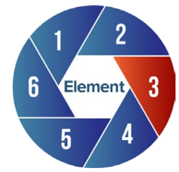
ACTION: Coordinate climate hazard-related syndromic surveillance with the local office of emergency management and the local weather station.

SUMMARY: It can be helpful to add climate hazard-related illness to your organization's syndromic surveillance reports during and immediately following designated emergencies. Aligning the organization's protocol for collecting relevant diagnostic data with the local office of emergency management and weather station's protocol for declaring a climate-related emergency will help ensure that your organizational climate resilience action plan deploys in coordination with local alerts (Hess et al., 2023).

ACTION: Leverage healthcare facilities as intervention sites for local hazard action plans.

SUMMARY: Healthcare organizations often offer their locations as community intervention sites for the local hazard action plan. For example, allowing the Office of Emergency Management to use strategically located hospitals, medical office buildings, and clinics as distribution sites for water bottles, food, etc., can increase community access to health-promoting supplies. Officially designating publicly available spaces in healthcare facilities – such as the cafeteria – as resilience hubs or temporary shelters during climate-related events can help support patients and family members as well as raise awareness in the community that climate-related events are public health emergencies (Hess et al., 2023; IOM, 2012).

Element 3. Assessment and Remediation of Vulnerabilities in Infrastructure and Operations



Healthcare organizations are on the front lines when a climate-related disaster or extreme weather event takes place. Regardless of the specific climate hazard, healthcare organizations are called to staff their facilities and deliver quality medical care – for both disaster-related complaints and all-cause clinical visits. As a result, many of the actions that healthcare organizations can take to enhance their climate change resilience improve the efficiency, flexibility, and redundancy of their facility infrastructure and operations (Ebi et al., 2021).

Taking an all-hazards approach to climate-resilient facilities often involves selecting the set of design and operations strategies that bring the greatest co-benefits to both climate change mitigation (i.e., reducing greenhouse gas emissions through efficiencies and generating on-site renewable power) and resilience. Many strategies serve both purposes. For example, a healthcare facility that is at risk of extreme heat, flooding, and hurricanes can enhance resilience to all three hazards by minimizing its use of electricity from the central grid (through efficiencies and renewable energy), reducing flood and heat exposure (by maximizing vegetation at the ground and roof level), and placing critical building and medical equipment in locations that are protected from heat, water, and wind. Many of these strategies would also reduce the facility's greenhouse gas emissions. Recognizing the strong synergies linking climate change mitigation and resilience building design strategies, several federal programs encourage capital investments that both reduce a healthcare facility's carbon footprint and also increase its resilience to power outages. For example, CMS has issued a categorical waiver allowing healthcare facilities to supply emergency power from a clean-energy-powered microgrid rather than a fossil fuel-powered generator (CMS, 2023).

Similarly, research shows that staffing, clinical, and supply chain protocols aimed at increasing the healthcare organization's resilience to climate change benefit from taking an all-hazards approach because the fundamental approach remains constant even when the details change from one hazard to the next. For example, the major outline of protocols that govern which staff will work during a disaster, staff accommodations at the facility, staff's family members and pet accommodations, and plans for emergency communications and transport remain the same regardless of whether the disaster is a hurricane, flood, winter weather event, or inland storm (Nuzzo et al., 2019).

The following sub-elements describe specific ways in which a healthcare organization can enhance its facility infrastructure and operations' climate resilience.

3.1. Staff Support: Healthcare organizations depend on dedicated 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 staff protections and accommodations into healthcare emergency planning can mitigate logistical challenges (such as disruption of transportation routes) that can make it difficult for staff to get to work. These measures can also reduce mental strain caused by worrying about loved ones at home, allowing staff to focus on providing essential patient care.

3.2. Clinical Considerations: Climate change health impacts can be grouped into short-term and long-term effects. Short-term effects include acute impacts of extreme weather events and disasters, whereas long-term effects can result from air pollution, changing patterns of infectious diseases, altered food systems, and harms to mental and behavioral health. Climate resilience planning in health care includes both (1) anticipating potential patient surges during and after acute events, and (2) implementing preventative clinical and community health interventions that can mitigate risk factors for climate change-related health harms prior to the event.

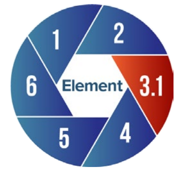
3.3. Building and Campus – Design & Construction: While building codes require structural redundancies that harden buildings against potential environmental hazards, future-proofing healthcare facilities in the setting of evolving and cascading climate-related hazards requires incorporation of forward-facing risk assessment in campus design, construction, and renovation. Climate-resilient healthcare facilities maximize energy efficiency, use diverse energy sources and on-site energy storage, protect critical operating systems, and incorporate landscaping and indoor environmental quality measures that mitigate risk from climate-related events, such as extreme temperature and precipitation.

3.4. Building and Campus – Facility Operations: Facility operations are essential to building a healthcare organization's resilience to any and all climate change-related hazards. Many clinical procedures depend on ready and consistent access to electricity, water, temperature control, and oxygen – as do many infection control protocols. Building equipment, like air conditioning and heating systems, and medical equipment, like X-rays and sterilizers, use large quantities of energy and water to function.

Given healthcare facilities' dependence on active systems to provide clinical care, operational resilience is at the center of all climate change resilience conversations.

3.5. Supply Chain: Climate-related disasters and extreme weather events can affect the production of critical supplies and can damage transportation infrastructure, resulting in disruptions to commercial shipping routes. Furthermore, equipment failure can jeopardize the safety of many items in a healthcare organization's supply chain – both clinical and non-clinical – that require refrigeration. Healthcare organizations can enhance their resilience by assessing supply chain vulnerabilities, for contingencies that can be implemented in the event of regional transportation or production disruptions.

Element 3.1 Staff Support



Healthcare organizations depend on dedicated 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 staff protections and accommodations into healthcare emergency planning can mitigate logistical challenges (such as disruption of transportation routes) that can make it difficult for staff to get to work. These measures can also reduce mental strain caused by worrying about loved ones at home, allowing staff to focus on providing essential patient care.

A survey after Hurricane Katrina in 2005 found that 80% of public hospitals set up sleeping areas for staff during disasters, 73% include childcare and food provisions for staff's children, 37% include provisions for elderly relatives under staff's care, and 23% include pet care. The same survey reflected strong interest (over 90%) in reducing the pressure on regular medical staff during disasters by credentialing "volunteer health professionals" as a supplemental workforce during disaster events; 85% of respondents plan to credential outside physicians, 78% plan to credential nurses, and 68% plan to credential pharmacists to work in their facilities during emergencies (National Association of Public Hospitals and Health Systems, 2007).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
[Element 3.1: Staff Support](#)

Planning

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

SUMMARY: Clearly define expectations with healthcare facility staff related to working during extreme weather events – particularly under circumstances that lead to power disruptions or outages, and those that may require staff to remain at work for extended periods. Share with staff a list of personal items they should bring with them to an anticipated multi-day response effort, such as food, water, personal medication, hand sanitizer, extra clothes, and sleeping gear. Co-create policies and programs with staff establishing a flexible and supportive approach to staffing, accommodations, and transportation during and after disasters. For example, it may be necessary to shorten staff shifts during emergency operations to give staff the ability to rest mentally and physically. Include daycare, shelter, and other accommodations for staff family members, as needed (Danna et al., 2010; Toner et al., 2017; WHO, 2020).

ACTION: Train staff in all types of healthcare facilities (including community-based outpatient clinics) in disaster management.

SUMMARY: Training clinical healthcare staff in emergency preparedness can increase their ability to work with in-house emergency preparedness teams and external partners to effectively respond to climate change-related disasters. Relevant training topics may include education about how to prepare the facility to continue operations during a disaster; clinical skills specific to high-risk climate change-related events; training in relevant medical equipment, building equipment, and telecommunications equipment that may be needed during a utility outage; standard operating procedures for different disasters; clear roles and responsibilities; and training in how to work as a group during disaster scenarios (Hilton et al., 2015).

Climate Resilience Actions

ACTION: Train clinical staff in alternative procedures for delivering care during disasters.

SUMMARY: Healthcare organizations can support staff in preparing for disaster response by offering training in alternative procedures for intake and triage if inpatients are transferred from other facilities without their medical records, as well as training in alternative procedures for delivering care in situations with limited access to electricity and water, such as manually counting intravenous pump drips, manually suctioning intubated patients, and manually taking blood pressure readings (U.S. HHS, 2014).

People and Operations

ACTION: Integrate regular emergency preparedness employee training into the healthcare organization's continuing education program.

SUMMARY: Implementing a regular emergency preparedness employee training program can increase awareness of climate change-related risks to the healthcare organization, as well as protocols and procedures designed to enhance resilience in the face of increasingly frequent and severe climate change-related events (Hilton, 2015; WHO, 2020). Include training on how key staff roles will be assigned during emergencies, and consider developing checklists for each department that break down key tasks according to when they should occur – pre-event, during response, and post-event (U.S. HHS, 2014).

ACTION: Provide alternative transportation and housing for healthcare staff during extreme weather events and disasters.

SUMMARY: Consider establishing agreements with nearby transportation providers and temporary housing facilities (such as hotels) to support employees and their immediate families (including pets) in the event that transportation pathways and/or utilities are disrupted during an extreme climate change-related disaster. This may also involve preparing for staff to stay at healthcare facilities before the extreme weather event begins to mitigate potential transportation interruptions (Morris et al., 2016; WHO, 2020).

ACTION: During transportation disruptions, coordinate across the healthcare system to redistribute staff to facilities they can access – even if they are not at their "home" facility.

SUMMARY: It may be necessary immediately following climate change-related events that damage infrastructure – such as hurricanes, severe inland storms, and floods – to temporarily redistribute the healthcare system's staff to facilities they can access (Morris et al., 2016). Establish a tracking system so that staff can report to supervisors who are physically located in different facilities (Wyte-Lake et al., 2018). Cross-training staff so that they can fulfill multiple roles can benefit the overall healthcare system by ensuring essential clinical services are offered by a mixture of permanent and temporary staff (Hilton et al., 2015).

ACTION: Ensure that staff who are supporting a disaster effort have access to clothing, a place to sleep, routine medications, and wellness services.

SUMMARY: Given the often-rapid evolution of many climate change-related disasters and their impacts on community infrastructure, staff may be required to stay at their place of work for more than 24 hours without access to basic necessities, such as a change of clothes and daily medications. Healthcare organizations can increase the resilience of their clinical services by ensuring that staff have access to clothing, a place to sleep, routine medications, and wellness services while they support patients in the midst of a disaster (Evans, 2017; Hilton et al., 2015; Morris et al., 2016; Toner et al., 2017).

ACTION: Establish a culture that acknowledges the personal challenges staff are facing during a disaster.

SUMMARY: Acknowledging the personal challenges faced by staff during a climate change-related disaster can increase a healthcare facility's resilience by increasing the willingness of staff who are able to report to work. It also creates space for staff to request tangible assistance (such as a hotel room or childcare) that would make it possible for them to support the disaster response (Morris et al., 2016; Toner et al., 2017).

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 (Dana et al.,

Climate Resilience Actions, continued

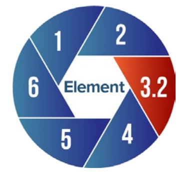
2010; WHO, 2020). Immediate support for staff who have experienced a major loss (such as their home) can also increase their ability and willingness to return to work after the event (Morris et al., 2016).

Physical Infrastructure

ACTION: Establish alternative communications channels for contacting staff during utility outages.

SUMMARY: Staffing during and immediately following climate change-related disasters that cause utility outages can be complicated by disruptions to telecommunications infrastructure. Establishing alternative communications channels (such as multiple cell phone providers, satellite phones, walkie-talkies, and installing a generator-powered cell tower on the roof of the facility) can increase a healthcare organization's resilience to these events by making it possible to share important information with staff – such as facility closures and requests that staff report to the facility closest to their home (U.S. HHS, 2014; Morris et al., 2016; Wyte-Lake et al., 2018).

Element 3.2 Clinical Considerations



Climate change health impacts can be grouped into short-term and long-term effects. Short-term effects include acute impacts of extreme weather events and disasters, whereas long-term effects include air pollution, changing patterns of infectious diseases, altered food systems, and mental and behavioral health. Climate resilience planning in health care includes both anticipating potential patient surges during and after acute events and implementing preventative clinical and community health interventions that can mitigate risk factors for climate change-related health harms prior to the event.

Examples of clinical improvements that can help healthcare organizations prepare for compound and cascading climate change-related events include programming the electronic health records system to flag heat-sensitive medications during heat events and power outages, stocking up on respiratory medications in preparation for poor air quality events, and making mental health services available to both patients and staff during and after disasters (Sorensen et al., 2020). Social work and social determinants of health programs are well-positioned to connect at-risk patients to related behavioral interventions, such as community air conditioning distribution programs, home environmental health programs, and education about ways to reduce their risk of exposure to environmental hazards and infectious disease pathogens (Sorensen et al., 2020). Participating in the development of a crisis standard of care can further guide clinical decisions during patient surges, shortages in supplies, and/or disrupted access to utilities during and following disasters.

From 2012–2014, the State of Maryland used a deliberative democracy approach (e.g., engaging with healthcare providers and the general public) to develop a consensus crisis standard of care for the state that reflected local values. The framework was revised and expanded during the COVID-19 pandemic to reduce the cognitive burden on triage clinicians in determining where to allocate scarce resources in the face of an extended patient surge (Biddison et al., 2019; Ehrmann et al., 2021).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:

Element 3.2: Clinical Considerations

Planning

ACTION: Integrate epidemiological and meteorological data into climate-related hazard 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 climate-related hazard events.

SUMMARY: Consider enhancing the healthcare system's syndromic surveillance during climate-related hazard events by submitting hazard-related illness data to the Electronic Surveillance System for the Early Notification of Community-Based Epidemics (Burkom et al., 2021). Work with local public health partners to interpret and act on real-time hazard-related illness and all-cause morbidity and mortality data during and immediately following extreme weather events.

Climate Resilience Actions, continued

ACTION: Develop a continuity of care plan listing essential clinical services that will be provided at different tiers of utility disruption.

SUMMARY: Many healthcare facilities are designed to function at full or partial capacity under a variety of environmental stressors. Organizations can increase resilience to climate change-related events by creating and training staff to implement a continuity of care plan outlining essential clinical services that will be provided at different tiers of utility disruption (Toner et al., 2017).

People and Operations

ACTION: Adjust normal procedures and standards of care ahead of forecasted climate change-related events to extend the amount of time existing patients can go without routine treatment.

SUMMARY: Consider establishing protocols triggering an adjustment to the healthcare organization's clinical procedures (e.g., in pharmacy, drug treatment, dialysis, etc.) ahead of forecasted climate change-related events to extend the amount of time existing patients can go without routine treatment. When possible, expedite inpatient discharge to free up bed space ahead of expected patient surges during and immediately following the event (Scott, 2017; Toner et al., 2017).

ACTION: Develop a plan for patient surges and train staff in its implementation, including scenarios for accommodating cascading and simultaneous climate change-related disasters.

SUMMARY: Many climate change-related events occur simultaneously or in quick succession. For example, hurricanes often occur during heat waves. Wildfires, drought, flooding, and landslides often trigger or exacerbate each other. It is, therefore, increasingly important to develop a plan for patient surges and train staff in its implementation. Include procedures for bringing in temporary staff, adapting clinician services to fast-changing conditions, and altering the schedule for routine operating procedures to free up space and staff to provide emergency care (Toner et al., 2017).

ACTION: Co-locate critically ill and fragile patients on the same floor of the facility as the emergency command center to maximize staff communication and patient safety.

SUMMARY: Identify the safest floors of the healthcare facility when exposed to different types of climate change-related events. Consider co-locating the most critically ill and fragile patients on those floors alongside the emergency command center to expedite communication between leadership and staff to maximize patient safety (U.S. HHS, 2014).

ACTION: If it is necessary to evacuate patients during a disaster, consider sending nurses, nursing assistants, and leadership staff with them to ensure continuity of care.

SUMMARY: Hospitals that evacuated patients alongside care staff and their leadership team during Superstorm Sandy (2012) reported lower rates of anxiety about the evacuation among patients and their families (U.S. HHS, 2014).

Physical Infrastructure

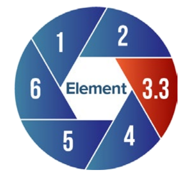
ACTION: Deploy mobile health units to take medical care to high-risk patients in the community during transportation disruptions.

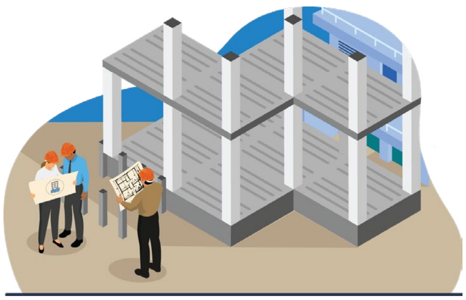
SUMMARY: Consider including in the healthcare organization's list of emergency response assets mobile units that are used to deliver routine care to community members. Use the organization's map of high-risk patients – such as patients who need dialysis or those with a substance use disorder, diabetes, or heart disease – to prioritize the provision of medical care during transportation disruptions caused by a climate change-related event (Toner et al., 2017).

Resilience Strategies: All / Multiple Hazards

CR4HC

Element 3.3 Building and Campus: Design & Construction





While building codes require structural redundancies that harden buildings against potential environmental hazards, future-proofing healthcare facilities in the setting of evolving and cascading climate-related hazards requires incorporation of forward-facing risk assessment in campus design, construction, and renovation. Climate-resilient healthcare facilities maximize energy efficiency, use diverse energy sources and on-site energy storage, protect critical operating systems, and incorporate landscaping and indoor environmental quality measures that mitigate risk from climate-related events, such as extreme temperature and precipitation.

A survey of public hospitals after Hurricane Katrina in 2005 found that 73% plan to convert non-clinical areas of the hospital into patient areas during disaster-related patient surges; 66% have also put in place plans to expand their footprint into the community during disasters by delivering care at alternative care sites, such as at schools and religious institutions. Over 60% of respondents have established a staffing plan and supply cache for alternative care sites – often in coordination with local partners (National Association of Public Hospitals and Health Systems, 2007).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 3.3: Building and Campus: Design & 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 installing renewable power microgrids for backup power) in order to extend the functional life of the building as long as possible within the context of 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 & Chan, 2017).

Physical Infrastructure

Structure and Landscaping

ACTION: **Design new buildings and reinforce existing structures to withstand future climate change-related exposures as described in the healthcare organization's prospective risk assessment (Element 1).**

SUMMARY: Many building codes rely on historical data

Climate Resilience Actions, continued

to set structural requirements for withstanding climate change-related hazards like wind, flooding, fire, heat, and landslides. Healthcare organizations can reduce the risk of a major disaster causing sufficient physical damage that shuts down operations by designing and renovating facilities to withstand future climate change-related exposures as described in their prospective risk assessment (Element 1) (U.S. HHS, 2014).

ACTION: Design facilities to promote both environmental sustainability and resilience.

SUMMARY: Many green and healthy design strategies bring multiple co-benefits to healthcare facilities, such as reducing utility costs, reducing their contribution to climate-warming fossil fuel emissions, enhancing their resilience to climate change-related events, demonstrating the organization's commitment to environmental stewardship, and promoting the health and well-being of patients and staff (WHO, 2020).

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 multimodal evacuation plans when they are deployed during a climate change-related event (Basu et al., 2022).

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 to climate change-related events that disrupt regional power grids.

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 to improve the efficiency of the building envelope can reduce the risks of extreme temperature, decrease heating and cooling demand, and extend the length of time the facility can function on backup 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 reduces 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 backup 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 during which the facility can function on backup power systems (Carvallo et al., 2022)

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

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 disasters and extreme weather 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 to on-site power storage capacity can reduce a healthcare facility's reliance on external power sources needed to maintain continuity of care (Isa et al., 2018).

Climate Resilience Actions, continued

Water Efficiency and Flood Resilience

ACTION: **Maximize water efficiency to reduce demand during low water pressure and boil water notice events.**

SUMMARY: Water is critical to the functioning of healthcare facilities – both clinical and building systems. To maximize the availability of potable water for clinical uses, consider minimizing once-through use in process equipment – such as the heating, ventilation, and air conditioning (HVAC) system, sterilizers, and medical equipment. Further, consider installing low-flow toilets, urinals, handwash stations, and showers – except where volume is needed for occupational uses (such as water filling stations and decontamination showers) (Van der Heijden, 2022; WHO, 2015).

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, and drought) or as a result of infrastructure failures caused by hazards like hurricanes and tornadoes. Healthcare facilities should be designed to operate using on-site water supplies for at least 72 hours. Facilities located in high-risk areas can increase resilience by identifying supplementary water sources (such as connections to allow temporary water supply from trucks or other sources, permanent storage tanks/cisterns, and wells) 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 (Healthcare Environmental Resource Center, 2015; Van der Heijden, 2022; WHO, 2015).

ACTION: **Protect the permanent and emergency water supply from extreme weather and contamination from flood waters.**

SUMMARY: Weatherize water supply pipes, cisterns, and tanks to prevent breakages in extreme cold weather. Place emergency water storage (such as tanks and cisterns) outside of areas at risk of flooding or landslides. Install float valves and overflow outlets that drain away from the facility to avoid flooding interior spaces after a cistern or tank fills up. Install one or more supplementary water pumps (depending on need) and connect them to the emergency power supply to keep water pressure at safe levels when the power goes out (Van der Heijden, 2022; WHO, 2015).

ACTION: **Install backflow prevention valves to prevent sanitary sewage from backing up into the hospital during flood events.**

SUMMARY: Healthcare facilities located in communities with combined sanitary and storm sewers may experience sewage backup during extreme flood events. Facilities can enhance resilience by installing backflow prevention valves and capping drains on lower floors during flooding events (Van der Heijden, 2022; WHO, 2015).

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) coupled with 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).

Resilient Critical Operating Systems

ACTION: **Install redundant communication systems for use during power and communications outages.**

SUMMARY: Extreme weather events can disrupt electricity supply, cell towers, radio transformers, and other community communications networks. Healthcare organizations can reduce the risk of disruption in communications to other facilities in their network, regional healthcare organizations, and local emergency management agencies by installing and maintaining redundant communication systems, such as analog phones, fax machines, handheld two-way radios, ham radios, and solar-powered devices (Hedges et al., 2018).

Element 3.4 Building and Campus: Facility Operations

Facility operations are essential to building a healthcare organization's resilience to any and all climate change-related hazards. Many clinical procedures depend on ready and consistent access to electricity, water, temperature control, and oxygen – as do many infection control protocols. Building equipment, like air conditioning and heating systems, and medical equipment, like X-rays and sterilizers, use large quantities of energy and water to function. The healthcare sector is the second most energy-intensive commercial building type in the United States (EIA, 2022).

Given healthcare facilities' dependence on active systems to provide clinical care, operational resilience is at the center of all climate change resilience conversations. Many resilience strategies can be deployed across multiple climate change-related hazards. For example, facility operations strategies that increase resilience to power outages are protective in the face of climate-change related hazards that result in power outages, such as extreme heat, hurricanes, flooding events, landslides, inland storms, and wildfires. A post-disaster assessment of a nursing home in Florida where 12 residents succumbed to heat-related illness after a power outage caused by Hurricane Irma in 2017 found that a combination of nonmechanical facility operations strategies (such as opening windows and doors to enhance natural ventilation) and mechanical interventions (such as installing and maintaining on-site power generators and thermal storage) would have reduced the risk of loss of life during the combined hurricane and extreme heat event (Fritz, 2017; Sun et al., 2020).

An all-hazards approach to climate-resilient facility operations begins by considering how the building design (Element 3.3) can be enhanced to reduce energy and water demand. Building design enhancement involves strategies such as increasing wall and roof insulation, installing white or garden roofs, and shading the building (particularly windows) from the outside by either using shade structures or vegetation. The organization's prospective risk assessment (Element 1) can then be used as a guide for prioritizing operational strategies with the greatest number of co-benefits in the face of projected climate change-related hazards.

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
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 enhance 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: 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 of importance to clinical care. Consider cross-referencing the protocol with stages of evacuation preparation so that

Climate Resilience Actions, continued

patient transfers to partner facilities take place before conditions (such as extreme temperatures, exposure to flood waters, etc.) reach dangerous levels (FEMA & ASPR, 2019).

ACTION: Perform a baseline analysis of water usage and categorize usage types into tiers of critical need.

SUMMARY: Water is a critical component of clinical care, including sanitizing medical equipment. Performing a baseline analysis of the healthcare facility's water usage and categorizing usage types into tiers of critical need can help facility managers direct potable water supply to the most important clinical needs during low water pressure and boil water notices while also reducing overall facility water usage (WHO, 2015; Van der Heijden, 2022).

ACTION: For climate change-related hazards that could result in widespread damage to utilities and community infrastructure, include security considerations in the healthcare facility's emergency preparedness plan.

SUMMARY: Extreme weather events that cause widespread damage to utilities and community infrastructure can result in a temporary need for increased security at a healthcare facility, particularly if it experiences a patient surge and/or acts as a place of respite for community members (Danna et al., 2010).

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 demands 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 tests of emergency generators, water supplies, and transportation plans to ensure that they are ready to deploy in the event of an emergency.

SUMMARY: It can be difficult to source fuel, water trucks, and emergency transportation contractors in the immediate run-up to a climate change-related event. Healthcare organizations can check the status of their resilience to the first 72 hours of anticipated climate change-related events by performing regular tests and maintenance on emergency generators and on-site sources of emergency water. It can also be helpful to perform regular drills with outside contractors who will be responsible for supplying more fuel, trucked-in water, emergency transportation for staff and patients, and other activities included in the facility's emergency operations plan (U.S. HHS, 2014).

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

SUMMARY: Consider performing regular stress tests of the healthcare facility's ability to continue providing clinical care during extreme weather events. Incorporate scenarios that involve power outages, low water pressure, a surge of patients experiencing hazard-related illness, a surge of all-cause complaints, and a surge of community members seeking to use the facility as a resilience hub and safe place to charge electrical devices (including medical equipment). Stress tests can help identify critical systems (such as vacuum suction systems and electricity-dependent medication delivery 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: Conduct regular walk-throughs of the healthcare facility to confirm compliance with fire safety and evacuation signage requirements.

SUMMARY: Facility evacuation can be impeded if exits are obstructed, signage is missing or confusing, or life safety equipment, like sprinklers and fire extinguishers, is missing or broken. Conducting regular walk-throughs of the healthcare facility to confirm that these essential emergency preparedness components are in place and in working order could be seen as a first level of resilience to any climate change-related hazard that might damage the building structure or result in an eventual evacuation (U.S. HHS, 2014).

Climate Resilience Actions, continued

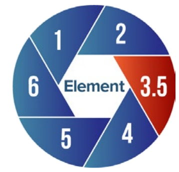
ACTION: Generate renewable energy on the healthcare campus.

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: Prior to an anticipated disaster, walk through the facility to identify locations that might require repair during and immediately following the event and stage the necessary materials and equipment (including pumps) nearby.

SUMMARY: Certain locations in and around the healthcare facility – such as the roof, windows, and lower floors – are more vulnerable to damage from wind, flooding, heat, fire, and external soil and water pressure. Healthcare organizations can reduce the risk of disruption to clinical operations by identifying likely repair needs prior to the event and staging the relevant construction materials and equipment within easy reach to minimize the impact of minor leaks, broken windows, and other building damage on regular facility operations (ASPR TRACIE, 2023 b.).

Element 3.5 Supply Chain



Climate-related disasters and extreme weather events can affect the production of critical supplies and can damage transportation infrastructure, resulting in disruptions to commercial shipping routes. Furthermore, equipment failure can jeopardize the safety of many items in a healthcare organization's supply chain – both clinical and non-clinical – that require refrigeration. Healthcare organizations can enhance their resilience by assessing supply chain vulnerabilities for contingencies that can be implemented in the event of regional transportation or production disruptions. In addition, they should develop and implement a plan for managing their refrigerated supply chain and on-site storage during power outages (Rublee et al., 2021).

For example, during the COVID-19 pandemic, the public healthcare system in New York City, NYC Health + Hospitals, met the need for three times the normal demand for ventilators by both sourcing the equipment itself and building out temporary infrastructure to accommodate a dramatic increase in piped oxygen. The organization installed sprinklers in its facilities to thaw oxygen tank valves, which can freeze when supplying large quantities of oxygen. Hospital staff monitored the tanks 24/7, and the system coordinated with fire and emergency management authorities due to the combustion risk. Disposable components of ventilator equipment, which reached critically low levels, were redistributed throughout the network on an as-needed basis. Bedside staff also communicated frequently with supply chain leadership to ensure placement of orders for personal protective equipment and common hospital supplies, like intravenous (IV) tubing, blood sample supplies, infusion pumps, and wound dressings, before supplies reached stock levels that would trigger a new order under normal conditions (Uppal et al., 2020).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
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 medical supply storage into resilience planning.

SUMMARY: Consider how your organization's prospective risk assessment of climate-related hazards (Element 1) might lead to supply chain disruptions and/or changing needs. Maintain an adequate supply of medical supplies to treat patients with hazard-related illnesses, particularly for products that are most vulnerable to weather-related disruptions in transportation routes (Hedges et al., 2018). Consider separating emergency supplies into two categories: high-volume medical supplies (such as IV bags, sharps, and oxygen) and equipment/supplies that would only be needed during a disaster. Establish a timeline for activating the supply chain plan ahead of the anticipated climate change-related event. Include in the

Climate Resilience Actions, continued

timeline when a comprehensive check of both types of inventory should take place and when normal deliveries should be suspended (for example, 120 hours and 12 hours ahead of an anticipated hurricane, respectively) (Maslanka & Hurwitz, 2022).

People and Operations

ACTION: Add net-zero requirements to purchasing contracts.

SUMMARY: A healthcare organization's supply chain may represent more than half of its total carbon footprint. At the same time, the purchasing office has limited control over reducing the carbon intensity of the products it buys. Signaling demand for low-carbon products by adding net-zero requirements to purchasing contracts can be effective for encouraging suppliers to reformulate products – particularly when healthcare organizations coordinate contracting language with other leaders in the field.

ACTION: Require suppliers of essential goods and services to provide a continuity of operations plan for climate change-related disasters.

SUMMARY: Healthcare organizations are dependent on a large network of vendors to supply goods and services that are essential to facility operations and continuity of care. Requiring suppliers of essential goods and services to provide a continuity of operations plan is an important first step in building the healthcare organization's resilience to disasters that disrupt transportation infrastructure (Toner et al., 2017).

ACTION: Stockpile potable water.

SUMMARY: Maintaining a stockpile of potable water, either inside the healthcare organization's storage facilities or through a contract with external vendors, can bridge the gap for both medical procedures and community services (i.e., sharing bottled water with community members) during water shortages.

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).

ACTION: Store essential medical supplies, food, and fuel lasting 5–7 days on or near the healthcare campus to facilitate rapid deployment ahead of extreme weather events that could disrupt supply chains and/or utility and transportation infrastructure.

SUMMARY: One of the hallmarks of climate change is the increased length of utility outages and damage to transportation infrastructure, leading to supply chain disruptions of a week or more. Healthcare organizations can increase their resilience to this changing landscape by stockpiling 5–7 days' worth of medical supplies, food, and fuel on or close to healthcare facility campuses (Danna et al., 2010).

Element 4. Collaborations Between Healthcare Organizations

Disruption in care delivery in an outpatient facility may result in a patient surge in an acute care setting, and evacuation and transfers between facilities during and after disasters may be required. Therefore, sharing information and resources across the full range of regional healthcare providers is important for increasing resilience both at the facility level and across the regional healthcare delivery ecosystem. Collaboration between healthcare facilities to increase climate resilience can include communication and information sharing, resource coordination, plans for potential evacuation and transfers, medical staff deployment, data sharing, joint public health outreach efforts, and joint disaster preparedness drills.

For example, because of the VA's experience in providing trauma-informed behavioral health care to its veterans, the VA is often well-positioned to serve as a key partner in local communities' disaster behavioral health response. Partnerships between the VA and local communities are facilitated by establishing and maintaining emergency management and clinical relationships, as illustrated by the VA Pacific Island Healthcare System's (VAPIHC) provision of disaster behavioral health care in the Mariana Islands following Typhoon Yutu in 2018. VAPIHC, based in Honolulu, Hawai'i, had previously established telemental health in a non-VA healthcare clinic on the island of Tinian. After Typhoon Yutu devastated the island, causing many essential healthcare staff to lose their homes, the clinic was able to serve as a temporary housing site for its employees, and VAPIHC was able to provide telemental health services to healthcare staff (Wyte-Lake et al., 2021).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 4: Collaboration Between Healthcare Organizations

Planning

ACTION: Create plans to increase the resilience of critical outpatient care during climate change-related emergencies.

SUMMARY: Create contingency plans in coordination with regional healthcare partners to ensure that individuals with chronic physical and/or mental health conditions – who are at high risk due to potential interruptions in medication administration or outpatient care – have access to alternative arrangements if their usual care becomes unavailable or inaccessible due to a climate change-related event (Toner et al., 2017; WHO, 2020).

ACTION: Enhance healthcare organization preparedness for climate-related hazards through mutual aid MOU.

SUMMARY: A mutual aid memorandum of understanding (MOU) with other healthcare providers in the region that includes the results of a prospective risk assessment (Element 1) can help prepare for circumstances that require patient transfers or referrals – such as utility outages, patient surges, etc. Pay particular attention to current gaps in preparedness for climate-related events that are projected to increase in frequency and/or severity in the region. It is important to address legal and reimbursement challenges that can limit a facility's ability to quickly and efficiently transfer patients and/or supplies to other facilities in the region. Consider working with CMS and other healthcare organizations in the region to fill in those gaps over time using an all-hazards approach (U.S. HHS, 2014; Patel et al., 2022).

Climate Resilience Actions, continued

ACTION: Exchange epidemiological data and health assessments related to climate hazards with other healthcare organizations and the local health department.

SUMMARY: Exchanging epidemiological data and health assessments related to climate hazards with other healthcare organizations and the local health department can support regional climate resilience planning efforts. Use these conversations to jointly develop protocols for identifying emerging climate-related health threats in the region, collecting and disseminating data, and coordinating emergency response across the range of facility types in the regional health system – including acute care hospitals, community clinics, and long-term care facilities (Patel, 2022).

ACTION: Integrate an analysis of cross-institutional collaboration in regional after-action reviews of climate change-related events.

SUMMARY: As part of an all-hazards emergency management plan, include an after-action analysis of interdisciplinary coordination within the organization, as well as with other regional healthcare organizations and the local office of emergency management to assess how well the emergency response system functioned as a whole. Consider including prospective climate metrics (Element 1) as one indicator of the system's resilience to future events (Davies et al., 2019; Parker, 2020).

ACTION: Perform joint disaster preparedness exercises and drills with other local healthcare organizations, the local health department, and the local office of emergency management.

SUMMARY: Joint disaster preparedness exercises and drills can help healthcare organizations test their readiness for climate-related disasters and extreme weather events (including simultaneous and cascading events), identify areas for improvement in their emergency response plans, and build working relationships with other first responders. Including representation from multiple institutions and professions in the exercise can also help identify emerging at-risk populations who are projected in climate models to require more protection and/or resources as certain climate-related events occur more frequently and/or with greater severity (WHO, 2020; ASPR, 2024).

ACTION: Work with other regional healthcare organizations to develop integrated patient evacuation plans.

SUMMARY: Healthcare organizations can increase their own and regional resilience by working together to develop integrated emergency evacuation plans. Consider including contingency plans to address damage to a facility's structure, exposure to contaminated air and/or water damage, power and water outages, destruction of electronic medical records, infrastructure failures, and a limited number of ambulances. Contingency plans may involve transferring patients to alternate facilities or establishing temporary medical sites in safer areas (Patel, 2022).

People and Operations

ACTION: Share resources and coordinate personnel during climate-related events.

SUMMARY: Collaboration between response organizations may involve sharing critical resources and coordinating the deployment of personnel to support impacted communities in areas of greatest need (Patel, 2022). Consider integrating the results of the organization's prospective risk assessment (Element 1) into planning conversations to funnel resources to new and emerging at-risk populations related to the changing climate.

ACTION: Collaborate with regional healthcare organizations on public health education and outreach programs.

SUMMARY: Healthcare institutions can collaboratively develop and disseminate public health education and outreach programs so that the community receives a consistent and coordinated message about climate-related hazards, protective behaviors, and access to resources such as healthcare services (California Department of Public Health, 2022).

ACTION: Consider proactively credentialing neighboring healthcare facility staff to help execute the healthcare organization's emergency preparedness protocol.

SUMMARY: Proactively credentialing staff at neighboring healthcare facilities to prepare for emergencies can contribute to backup care if one facility is unable to provide care due to hazard-related and extreme weather utility interruptions (WHO, 2020).

ACTION: Establish effective communication channels to share real-time information across healthcare organizations during climate-related events.

SUMMARY: Consider working with other healthcare organizations and entities in the region to establish effective real-time communication channels with one another and the public during climate-related events. Examples of critical information that can be shared this

Climate Resilience Actions, continued

way include information about the progression of the hazard, who should evacuate, where evacuees should go, which healthcare facilities are open to receive new patients and/or community members seeking refuge, real-time information about the number of beds available in the region and consistent definitions for each bed type, and levels of critical medical supplies needed and available for each facility in the cooperation network (CDC, 2003; California Department of Public Health, 2022; U.S. HHS, 2014).

ACTION: Share knowledge and lessons learned with other regional healthcare organizations.

SUMMARY: Sharing knowledge and lessons learned across healthcare organizations can help the entire region coordinate their climate resilience plans, investments in resilient facilities and operations, and protocols for information and resource sharing during events (ASPR, 2024).

Physical Infrastructure

ACTION: Build out alternative communications channels to help regional healthcare organizations share real-time information with each other during disasters.

SUMMARY: Interorganizational cooperative agreements for sharing resources and transferring patients during climate change-related disasters depend on real-time communication among facilities in the network. Building out alternative communications channels connecting healthcare organizations with each other (such as multiple cell phone providers, satellite phones, walkie-talkies, and generator-powered cell towers on the roof of key facilities) can increase the effectiveness of the entire network's emergency response (U.S. HHS, 2014).

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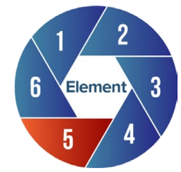
Resilience Strategies:

All / Multiple Hazards

CR4HC

Element 5. Interdisciplinary Planning, Oversight, and Evaluation



Planning for climate resilience requires an interdisciplinary team and coordination across a range of critical functions, including administration, emergency management, clinical leadership, information technology, construction and real estate, facility operations (e.g., power, water, waste disposal, food service, custodial services, etc.), communications, transportation, and purchasing. Aligning facility operations, procurement, and capital expenditures to balance climate change mitigation goals (i.e., reducing greenhouse gas emissions) and resilience goals can help the organization chart a climate-positive and cost-neutral path toward resilience.

For example, the Massachusetts General Brigham healthcare system in New England conducted climate change vulnerability analyses of over 30 buildings, including hospitals, outpatient facilities, administrative buildings, research labs, and rehabilitation centers. The analysis team included clinical leaders, architects, engineers, climate change consultants, facilities managers, research leads, and emergency preparedness leaders from across the system. The team emphasized the importance of engaging local leaders from a variety of disciplines in each facility in the process. The range of viewpoints resulted in a robust and holistic vulnerability assessment that mapped the relationships between vulnerabilities related to physical infrastructure, patient needs, and clinical services. The assessment identified vulnerabilities and recommended solutions related to heat waves, flooding, and high winds. The system immediately addressed several high priority vulnerabilities – such as connecting air conditioning systems to emergency power sources – and is including long-term vulnerabilities in future renovation and new construction plans. Sustained engagement with local member facility leaders increased these facilities' buy-in to the recommended actions coming out of the process (Baugh et al., 2021).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 5: Interdisciplinary Planning, Oversight, and Evaluation

Planning

ACTION: Incorporate interdisciplinary approaches into hazard planning.

SUMMARY: Consider incorporating interdisciplinary approaches into the healthcare organization's hazard planning process since natural disasters and hazard events can impact a range of dependencies – such as infrastructure, clinical care, energy systems, and waste management (Rogers et al., 2020).

ACTION: Incorporate long-term goals and climate projections into healthcare extreme weather planning and response plans.

SUMMARY: It can be helpful to integrate long-term, interdisciplinary strategic goals into the healthcare organization's extreme weather emergency preparedness and response plans – including community input as outlined in the Justice, Equity, Diversity, and Inclusion (JEDI) framework (American Public Health Association & CDC, 2021).

Climate Resilience Actions, continued

ACTION: **Implement surveillance and interdisciplinary after-action reviews in organizational hazard action plans.**

SUMMARY: Incorporate building surveillance and interdisciplinary after-action reviews into the healthcare organization's hazard action plan. These measures will help identify and evaluate the elements of the plan that worked during a recent event; assess whether changing climatic conditions might have influenced aspects of the event (such as its severity); and change the parts of the plan that did not meet expectations. The after-action review should be tailored to the specific disaster type experienced (Hess et al., 2023; Parker, 2020).

ACTION: **Maintain a hard copy of the most current emergency management plan and contact information for key emergency management personnel.**

SUMMARY: Power, internet, and cell phone outages can slow emergency response efforts, particularly early on in the disaster. Healthcare organizations can streamline deployment of emergency response plans by maintaining a hard copy of the most current emergency management plan and protocols for each individual hazard, as well as emergency roles, addresses, and phone numbers for all staff with key roles in an emergency response (Becker's Healthcare, 2018).

People and Operations

ACTION: **Develop a system-wide plan for coordinating care across all facility types under different disaster scenarios.**

SUMMARY: Establishing a protocol for coordinating care and opportunities to shelter in place during extreme weather events across all facility types in a healthcare system (from acute care to neighborhood clinic) can help direct at-risk populations to appropriate services (ASPR, 2024).

ACTION: **Integrate viewpoints from all segments of the healthcare organization, as well as from outside partners, into climate resilience and emergency planning.**

SUMMARY: The impacts of climate change touch every department in a healthcare organization as well as every partner in government and the community. Therefore, climate vulnerability assessments, resilience plans, and emergency planning efforts are most valuable and impactful when they combine insights from a wide range of disciplines drawn from both inside and outside the organization (ASPR, 2024; Parker, 2020).

ACTION: **Use the hazard vulnerability assessment process as an opportunity to build a culture of resilience within the healthcare organization.**

SUMMARY: Conducting a multidisciplinary hazard vulnerability assessment that integrates stakeholder feedback can help build a culture of resilience both within the healthcare organization and between the organization and community partners so that protocols and procedures safeguarding the continuity of clinical care are in place ahead of hazardous events (ASPR TRACIE, n.d.b.; Parker, 2020).

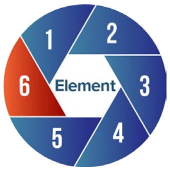
ACTION: **Develop a digital operations center for the healthcare system to monitor potential emergencies that could impact critical services and to coordinate resilience strategies and emergency response.**

SUMMARY: Digital platforms that facilitate communication across campuses within a healthcare organization and externally with other healthcare organizations and emergency management partners can help build a learning organization culture by supporting evidence-based decision-making during emergencies as well as after-event evaluations (Al Knawy et al., 2022; Reifels et al., 2022).

Resilience Strategies:
All / Multiple Hazards

CR4HC

Element 6. Communications and All-Hazards Approach



Climate-related disasters and extreme weather events often occur simultaneously or in quick succession, which increases the risk of multisystem failures at the community scale (such as disruptions to water and power utilities) that can cause compounding threats to healthcare infrastructure and operations and surges in healthcare demand. The effects of simultaneous or sequential climate-related hazards can cause prolonged and cascading health harms for populations at disproportionate risk. In fact, climate change is projected to exacerbate existing racial disparities across a range of health outcomes (Berberian et al., 2022).

Proactive planning and coordination of disaster-related education and messaging for clinicians, staff, patients, community partners, and the public increase healthcare organizations' and communities' resilience to multiple hazards. This is an essential feature of an all-hazards approach to climate resilience planning. For example, in a series of focus groups with San Diego residents representing populations at risk for heat-related illness, participants consistently identified diversification of communication channels as an important strategy to increase the reach and effectiveness of heat risk education and warning messaging (VanderMolen et al., 2022). In particular, participants recommended leveraging existing networks that have high levels of social capital, cultural competence, and extensive local reach (such as community centers, schools, and faith-based organizations). Establishing and maintaining relationships with these trusted messengers can help healthcare organizations effectively disseminate and target disaster-related risk communication across multiple hazards.

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 6: Communications and All-Hazards Approach

Planning

ACTION: Collaborate with local partners to coordinate climate-related disaster messaging.

SUMMARY: It can be helpful to collaborate with local public health department partners to coordinate climate-related hazard messaging with clinicians and patients, such as through prompts in the healthcare organization's electronic health record, e-newsletter, and patient texting system. This approach can increase community awareness of both the short- and long-term health risks associated with exposure to climate-related disasters (WHO, 2020).

ACTION: Use simultaneous disasters as an opportunity for education about the co-benefits of taking an all-hazards approach to resilience.

SUMMARY: Simultaneous and cascading disasters can be opportunities to educate the community, staff, and emergency management partners about the value associated with using a co-benefit approach to risk assessment, emergency planning, emergency response, and rebuilding efforts (National Academies of Sciences, 2022).

People and Operations

ACTION: Broadcast climate-related hazard alerts using culturally appropriate language and communication pathways.

SUMMARY: Broadcasting alerts about climate-related hazard vulnerability and protective behaviors to patients, staff, and community partners using culturally appropriate language and communication pathways can help amplify the local public health department and office of emergency management's communication efforts (Hasan et al., 2021; O'Neill et al., 2009).

Climate Resilience Actions, continued

ACTION: Establish two-way communication systems with patient populations who are sensitive to high priority climate change-related hazards.

SUMMARY: Implementing two-way communication systems, like Reverse 911 and wireless emergency alerts (National Academies of Sciences, 2018), can aid in connecting sensitive populations with protective measures before an event occurs and direct them to community services during the event. With the assistance of community groups and local health departments, designated community leaders can deliver culturally sensitive messages. These messages would inform residents about safeguarding themselves and their neighbors against climate change-driven hazards and provide guidance on actions to take if they experience illness during such events (Steinberg & Sprigg, 2016).

Climate Resilience for Health Care: Drought

CR4HC

Impact of Drought on Healthcare Organizations

Drought-related effects on water and air quality, along with economic strain, can trigger or exacerbate respiratory and cardiovascular diseases and lead to increased cases of waterborne and vector-borne diseases and mental health concerns. These effects can lead to patient surges in healthcare settings, especially in agriculturally reliant rural areas (U.S. HHS, 2021). Moreover, thermal plants may suffer from reduced power generation during droughts due to high water temperatures that reduce cooling capacity. Reduction in water quantity and quality, especially across an entire community or region, can increase water utility rates (U.S. HHS, 2021). Hospitals are major consumers of potable water and energy (U.S. HHS, 2014) and face operational risk from reduced power generation and increased water utility rates. A significant portion of commercial water supply is used by hospitals for heating and cooling systems, restrooms, and medical equipment (Fink, 2022 a.). Furthermore, loss of soil moisture and groundwater levels during droughts can lead to subsidence, damaging roads and foundations (Ohenhen et al., 2024), while insufficient river levels disrupt water-bound transportation. These multifaceted challenges can collectively impact health care by affecting its infrastructure, facility operations, medical supply chains, and patient care. Further, drought often occurs in conjunction with other climate change-related hazards, such as heat waves, wildfires, flooding, and disease-carrying vectors, which can increase the complexity of the required response.

Important Considerations

Health Effects of Drought: Impaired access to drinking water leading to dehydration; impaired sanitation and hygiene leading to skin infections; decreased air quality; increased waterborne, vector-borne, respiratory, and cardiovascular diseases; food shortages and malnutrition; mental health effects

Populations at Risk: People with chronic conditions, immune-compromised populations, outdoor workers, older adults, young children, pregnant women, populations reliant on well water, populations living near contaminated soil

Risks to Facility Operations: Supply chain disruption, patient surge, insufficient potable water, disruption of supporting infrastructure

Infrastructure Risk: Disruption of industrial processes, utilities, and transportation, subsidence damage to building foundations

Elements of a Climate-Resilient Healthcare Organization: Drought

Integrating the following climate resilience elements into the healthcare system's emergency management plan can enhance its ability to respond to increasingly frequent and severe drought events.

The following six elements characterize a drought-resilient healthcare organization. Review each element section to explore more detail.

1. Prospective Risk Assessment

Emergency preparedness plans that include drought risk assessments should incorporate forward-facing climate projections to adequately address the possibility of more frequent, severe, and prolonged droughts. The impacts of a drought may be compounded by extreme heat, wildfire, and heavy rainfall (e.g., flooding from heavy rainfall can be more likely in a drought-affected landscape), affecting healthcare facilities' – and their patients' and communities' – access to safe and clean water. In addition, droughts may not prompt the urgency required for a timely response because they often develop more gradually than other disasters and extreme weather events, although so-called "flash droughts," droughts that develop over the course of a few weeks, are becoming more common in the era of climate change. And, urban areas may not realize that droughts affect the entire region – not just agricultural communities. Proactive and early response can help mitigate the impacts of drought on healthcare organizations and the communities they serve.

2. Health Equity and Community Engagement

Droughts can negatively impact populations for prolonged and variable lengths of time, requiring proactive and collaborative approaches to mitigate inequitable health harms. Community partners can help healthcare organizations identify populations at risk from drought-related health harms, design and implement targeted strategies to mitigate community-level and individual risk factors, and effectively prioritize protective interventions.

3. Assessment and Remediation of Vulnerabilities in Infrastructure and Operations

The effects of drought have been described as creeping up on communities because it takes time for a shortage or absence of water to be felt. When a drought's effects finally become evident, they are often most extreme for infrastructure. Climate change is already causing more frequent, severe, and long-lasting droughts in many regions of the world. As those changes increase over time, healthcare organizations located in drought-prone regions will need to plan for (1) alternative water sources to supplement local water supply when water pressure drops, (2) alternative electricity sources in regions dependent on hydropower, and (3) more flexible utility infrastructure in regions at risk of subsidence. These facilities are also at risk of direct structural damage as well as the indirect effects of impaired roads, bridges, water lines, and other community infrastructure serving the facility.

4. Collaboration Between Healthcare Organizations

During drought events, surges in clinical and nonclinical demands as well as evolving water supply challenges can stress healthcare facilities. Given the importance of minimizing the time that sensitive patients are exposed to the repercussions of drought, collaborations among healthcare organizations can help direct patients to the closest facility with the capacity to meet patients' needs.

5. Interdisciplinary Planning, Oversight, and Evaluation

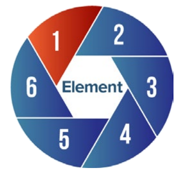
Droughts can affect various critical dependencies within healthcare organizations, such as administration, information technology, electricity, natural gas, water, wastewater and waste disposal, communications, transportation, and critical products. An interdisciplinary approach to planning, oversight, and evaluation is essential for comprehensive drought preparedness. For example, engaging staff and community members early in developing the drought resilience plan can raise awareness about the interconnected impacts of droughts on clinical care, facility operations, and community infrastructure.

6. Communications and All-Hazards Approach

Droughts often occur together or in succession with extreme heat and/or wildfires and can often end with a heavy rainfall that results in flooding. Multi-hazard events increase the risk of multiple system failures at the community scale (such as disruptions to the water and power utilities), and they can result in both direct and indirect harm to population health. Repeated patient surges and cascading infrastructure failures, both in the community and within healthcare facilities, can temporarily disrupt the entire healthcare system in a region. Fortunately, many policy, infrastructure, and communications interventions can increase organizational resilience to more than one climate-related hazard.

Resilience Strategies: Drought

Element 1. Prospective Risk Assessment



Emergency preparedness plans that include drought risk assessments should incorporate forward-facing climate projections to adequately address the possibility of more frequent, severe, and prolonged droughts. The impacts of a drought may be compounded by extreme heat, wildfire, and heavy rainfall (flooding from heavy rainfall can be more likely in a drought-affected landscape), affecting healthcare facilities' – and their patients' and communities' – access to safe and clean water. In addition, droughts may not prompt the urgency required for a timely response because they often develop more gradually than other disasters and extreme weather events, although so-called "flash droughts," droughts that develop over the course of a few weeks, are becoming more common in the era of climate change (Yuan et al., 2023). And, urban areas may not be prepared for the fact that droughts affect the entire region – not just agricultural communities. Proactive and early response can help mitigate the impacts of drought on healthcare organizations and the communities they serve.

For example, the Pacific Northwest Drought Early Warning System (NIDIS, n.d.), established by the National Integrated Drought Information System in 2015, is comprised of a collaborative network of federal, Tribal, state, and local partners that share information and coordinate actions to improve early warning capacity and resilience to drought. In the spring of 2024, Washington state issued a nearly statewide Drought Emergency Declaration (Mellor et al., 2024) prior to anticipated drought conditions taking hold in the summer. This allowed proactive preparation to mitigate impacts on water supply and related effects on critical systems and infrastructure.

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 1: Prospective Risk Assessment

Planning

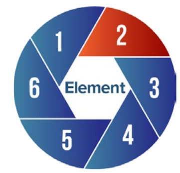
ACTION: Add projected drought measures to the healthcare organization's drought risk assessment.

SUMMARY: Consider adding one or more of the projected drought measures in the CDC's National Environmental Public Health Tracking Network data portal to an organization's drought risk assessment.

ACTION: Add a prospective risk assessment and impact forecasting related to slow and rapid onset drought to the local hazard mitigation plan.

SUMMARY: It can be helpful to work together with public health and local emergency management partners to include projections of future drought impacts (particularly flash droughts) in the local hazard mitigation plan because drought can exacerbate other related hazards, such as heat, wildfire, and flooding (Hess et al., 2017).

Element 2. Health Equity and Community Engagement



Droughts can negatively impact populations for prolonged and variable lengths of time, requiring proactive and collaborative approaches to mitigate inequitable health harms. Community partners can help healthcare organizations identify populations at risk from drought-related health harms, design and implement targeted strategies to mitigate community-level and individual risk factors, and effectively prioritize protective interventions. For example, in 2011, San Antonio, Texas, implemented a multifaceted drought management approach involving citizens, local government, and industry, saving 120,000 acre-feet of water and $84 million in water infrastructure costs in one summer (Center for Climate and Energy Solutions, 2018) Healthcare organizations are encouraged to consult community partners and synchronize their drought emergency planning protocols with the local office of emergency management to enhance cross-organizational coordination during response operations. This can help ensure minimal disruption to critical water-dependent supplies and systems during drought events.

The following sub-elements describe specific ways in which a healthcare organization can integrate health equity and community engagement into their drought resilience planning.

2.1 **Community Input:** Frameworks like social determinants of health and vulnerability assessments can help identify subgroups in a healthcare organization's patient population and community who may be at higher risk of negative health outcomes during and after a drought (U.S. HHS, n.d.). Community partnerships are critical to validate these assessments, target and tailor drought-related public messaging, and collaboratively implement an effective response. Key partners include providers of essential goods and services, like food pantries and cooling centers; trusted community institutions, like public libraries and faith-based organizations; community organizations serving at-risk populations, such as agricultural workers; and others.

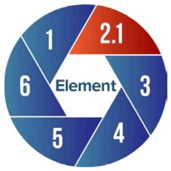
2.2 **Community Infrastructure:** Drought has widespread implications on community infrastructure, including both short- and long-term consequences. Decreased precipitation and reduced water flow for rivers can concentrate pollutants, lower water levels, and cause stagnation, all of which negatively affect water availability and quality for individuals, recreation, agriculture, and industry. Implementing water management strategies and infrastructure upgrades can mitigate the impact of drought on water quality and availability, ensuring that critical services remain operational. Healthcare organizations and communities at-large can invest in resilient water management systems and infrastructure upgrades to handle reduced water availability and maintain essential services during droughts. This includes effectively treating recycled water to prevent contamination and ensuring critical areas have adequate water resources.

2.3 **Community Services:** Collaborating with community partners to provide information and supports that mitigate the effects of drought can increase a healthcare organization's resilience by reducing potential patient surge in acute care settings and by improving the well-being and resilience of the broader community.

2.4 **Coordination with Local Office of Emergency Management:** Synchronizing a healthcare organization's drought emergency plan with regional peers, the local office of emergency management, and local utilities can result in a more efficient and effective coordinated response before (for projected droughts), during, and after droughts.

Resilience Strategies:
Drought

Element 2.1 Community Input



Frameworks like social determinants of health and vulnerability assessments can help identify subgroups in a healthcare organization's patient population and community who may be at higher risk of negative health outcomes during and after a drought (U.S. HHS, n.d.). Community partnerships are critical to validate these assessments, target and tailor drought-related public messaging, and collaboratively implement an effective response. Key partners include providers of essential goods and services, like food pantries and cooling centers; trusted community institutions, like public libraries and faith-based organizations; community organizations serving at-risk populations, such as agricultural workers; and others that are detailed in a checklist of key recommended partners in Drought and Health: A Messaging Framework for Public Health Professionals & Healthcare Providers, a report published by NOAA's National Integrated Drought Information System and the University of Nebraska Medical Center (Lookadoo, 2024).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 2.1: Community Input

Planning

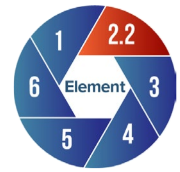
ACTION: Map patient populations who may be sensitive to drought (and frequently concurrent hazards, like heat and wildfire).

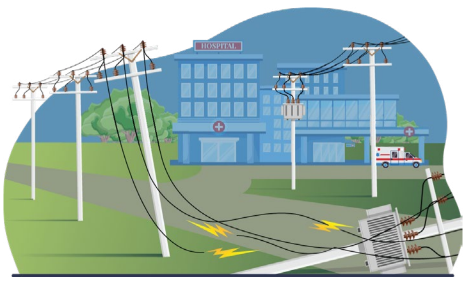
SUMMARY: Collaborating with community partners to map patient populations who are at high risk of negative health outcomes after short-term and/or long-term exposure to the environmental effects of drought (such as poor air quality and reduced access to potable water) can increase organizational and community resilience by helping ensure that protocols supporting healthcare access during drought and concurrent climate change-related emergencies are tailored to those populations' needs (Patel et al., 2022).

ACTION: Use the JEDI framework to structure community input.

SUMMARY: Consider following the Justice, Equity, Diversity, and Inclusion (JEDI) framework to integrate community input into the development and operation of the healthcare organization's climate resilience plan (American Public Health Association & CDC, 2021).

Element 2.2 Community Infrastructure





Drought has widespread implications on community infrastructure, including both short- and long-term consequences. Decreased precipitation and reduced water flow for rivers can concentrate pollutants, lower water levels, and cause stagnation, all of which negatively affect water availability and quality for individuals, recreation, agriculture, and industry. For example, farmers may need to use recycled water to irrigate and process crops during droughts. Insufficiently treated water can result in the spread of infectious diseases and surface runoff that contaminates other crops (CDC, 2024 b.). Additionally, drought strains water resources for healthcare facilities, power plants, chemical manufacturers, data centers, and government buildings (CISA, n.d.b.; Center for Climate and Energy Solutions, 2018). Implementing water management strategies and infrastructure upgrades can mitigate the impact of drought on water quality and availability, ensuring that critical services remain operational. Healthcare organizations and communities at-large can invest in resilient water management systems and infrastructure upgrades to handle reduced water availability and maintain essential services during droughts. This includes treating recycled water effectively to prevent contamination and ensuring critical areas have adequate water resources.

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 2.2: Community Infrastructure

People and Operations

ACTION: Support and direct patients to local programs that increase their adaptive capacity in the home environment.

SUMMARY: Connect low-income residents and high-risk groups (like adults over age 65 and people living with chronic illness) to programs that will help them weather a drought (Patel et al., 2022). These programs and resources can include assistance like free water-saving installations, financial aid for water bills, rainwater harvesting rebates, drought preparedness workshops, and well inspections/repairs. Additionally, community water distribution points ensure access to clean water in severe drought areas.

Physical Infrastructure

ACTION: Catalyze the development of resilient infrastructure at the neighborhood and community level.

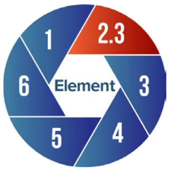
SUMMARY: As anchor institutions, healthcare campuses and public health institutions can catalyze neighborhood and community-scale efforts to increase resilience against anticipated climate change-related environmental hazards (Pastor & Morello-Frosch, 2014; Hacke & Deane, 2017).

ACTION: Support policies and programs that implement drought resilience strategies across local water, wastewater, stormwater, and park systems to lessen the impact of water scarcity at the community level.

SUMMARY: Communities can use policy mechanisms, like regional planning, zoning, and climate policies, to enhance local resilience to drought. Healthcare organizations can help advance these policies by publicly expressing their support for them and by integrating them into their campus design, construction, and facility maintenance program (Center for Climate and Energy Solutions, 2018).

Resilience Strategies: Drought

Element 2.3 Community Services



Collaborating with community partners to provide information and supports that mitigate the effects of drought can increase a healthcare organization's resilience by reducing potential patient surge in acute care settings and by improving the well-being and resilience of the broader community. For example, healthcare organizations can help inform patients and community members about assistance programs, such as the USDA's Disaster Assistance Program that helps farmers, ranchers, communities, and businesses that have been hit hard by natural disaster events, including drought (Farm Service Agency, n.d.), and the Disaster Supplemental Assistance Program (D-SNAP), which can help with food assistance for households that might not normally qualify for SNAP when they have disaster-related expenses, including lost or no access to income.

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
[Element 2.3: Community Services](#)

People and Operations

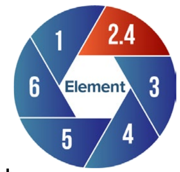
ACTION: Coordinate with community partners to create a multi-sector protocol for the delivery of mental health services during and after drought events.

SUMMARY: Severe drought is associated with poor mental health, psychological distress, emotional/behavioral problems, and increased risk of deaths by suicide, particularly in rural areas. These feelings of distress are often connected with worries about loss of income, concern that the landscape will change, and damage to community connectedness and mutual social support (Petkova et al., 2017). Healthcare providers can partner with community partners, like AgriSafe (https://www.agrisafe.org/), to raise public awareness about mental health services that are available in the community and through regional hotlines.

ACTION: Integrate drought-related community resilience needs into healthcare organization emergency management plans.

SUMMARY: Include provisions in the healthcare organization's hazard emergency plan to support community-based organizations during drought events. Depending on the local climate and location of water resources, a drought might cause loss of income in agricultural communities and disruptions to the potable water supply, electrical grid (for hydropower plants), locally sourced fresh fruits and vegetables, and products that are normally transported by river barges. Healthcare organizations can support community resilience by expanding their facility-level contingency supply chains to accommodate community partners who provide direct services to community members during droughts (Brzozowski, 2017). Expanding access to food, water, and other basic goods can reduce the risk of increases in waterborne disease, skin rashes, malnutrition, and other preventable diseases in the community.

Element 2.4 Coordination with Local Office of Emergency Management



Synchronizing a healthcare organization's drought emergency plan with regional peers, the local office of emergency management, and local utilities can result in a more efficient and effective coordinated response before (to prepare for projected droughts), during, and after droughts. During the 2012–2014 Great Plains drought in McCook, Nebraska, which occurred during a heat wave, collaboration between the city manager, health department, and community partners (including, for example, home health providers and the fire department) facilitated the provision of protective resources to at-risk populations. These resources included rehydration therapy for first responders, electric fans for elderly residents, and emergency cooling centers (Jedd et al., 2018).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 2.4: Coordination with Local Office of Emergency Management

Planning

ACTION: Add local and regional climate change vulnerability assessments to the healthcare organization's emergency preparedness plan.

SUMMARY: Consider adding local and regional climate change vulnerability assessments to the healthcare organization's emergency preparedness plan to integrate projections of how the region's exposure to climate change-related hazards may change in the coming decades compared to historical trends (Marinucci et al., 2014).

ACTION: Collaborate with local partners to coordinate drought health messaging.

SUMMARY: It can be helpful to collaborate with local public health department partners to coordinate drought-related messaging with clinicians and patients, such as through prompts in the healthcare organization's electronic health record, e-newsletter, and patient texting system. Each stage of drought may require a different message for patients and community members. For example, in early stages, the primary message to patients may be to monitor existing respiratory conditions, like asthma, which could be exacerbated by increased exposure to dust. For more severe drought stages, health messaging might include information about monitoring water quality and/or increased wildfire risk (Lookadoo et al., 2024).

ACTION: Formalize cooperation agreements with utility providers (both power and water) to ensure that the healthcare organization's facilities are integrated into local drought emergency management and climate resilience planning efforts.

SUMMARY: Critical facilities, hospitals, and other healthcare building types should be fully integrated into local utilities' emergency management and climate resilience planning efforts. It is particularly important to include facility power and water needs in emergency preparedness and climate resilience planning efforts, to ensure that healthcare organizations can continue to provide care during water shortages and periods of elevated concentrations of waterborne toxins and pathogens (McCabe et al., 2023; Van der Heijden, 2022).

Climate Resilience Actions, continued

People and Operations

ACTION: Coordinate drought-related syndromic surveillance with the local office of emergency management and the local weather station.

SUMMARY: It may be helpful to add health conditions that can be triggered or exacerbated by drought to the healthcare organization's syndromic surveillance reports during and immediately following drought emergencies. Depending on the community, these conditions could include respiratory disease, heart disease, heat-related illness, waterborne disease, vector-borne disease, and mental health conditions. Aligning the organization's protocol for collecting relevant diagnostic data with the local office of emergency management and the local weather station's protocol for declaring a drought emergency will help ensure that the organizational drought resilience action plan deploys in coordination with local alerts (Hess et al., 2023).

ACTION: Leverage healthcare facilities as intervention sites for local drought action plans.

SUMMARY: Healthcare organizations can support multi-jurisdictional efforts to distribute necessary supplies and social services during droughts by identifying their locations as community intervention sites in the local drought action plan. For example, allowing the Office of Emergency Management to use strategically located hospitals, medical office buildings, and clinics as distribution sites for water bottles, food, mechanical air filters, and factsheets explaining how residents can protect themselves from drought-related exposures, etc., can increase community access to health-promoting supplies and information. Officially designating healthcare facilities as locations for drought-related health screenings – such as for respiratory disease, waterborne disease, toxic chemical exposure, and vector-borne disease – can support local public health and emergency management efforts to track and effectively respond to shifting health effects at different phases of a drought event (Hess et al., 2023; IOM, 2012).

Resilience Strategies: Drought

Element 3. Assessment and Remediation of Vulnerabilities in Infrastructure and Operations

The effects of drought have been described as creeping up on communities because it takes time for a shortage or absence of water to be felt. When a drought's effects finally become evident, they are often most extreme for infrastructure. Climate change is already causing more frequent, severe, and long-lasting droughts in many regions of the world. As those changes increase over time, healthcare organizations located in drought-prone regions will need to plan for (1) alternative water sources to supplement local water supply when water pressure drops, (2) alternative electricity sources in regions dependent on hydropower, and (3) more flexible utility infrastructure in regions at risk of subsidence. Fourteen percent (n=42) of hospitals in counties along the U.S. East Coast are located in areas where subsidence is already occurring at a rate of 2–5 millimeters/year (Ohenhen, 2024). These facilities are at risk of direct structural damage as well as the indirect effects of impaired roads, bridges, water lines, and other community infrastructure serving the facility.

The drought resilience actions in this section of the Climate Resilience for Health Care Toolkit are designed to support healthcare organizations with building redundancy and flexibility into their staffing, clinical operations, supply chain, and facility design and operations.

3.1 Staff Support: Given many healthcare facilities' designation as critical infrastructure, healthcare staff are more likely to experience the effects of drought at home and in their communities before they experience its effects at work. In agricultural areas, clinicians may experience the economic impacts of crop loss either directly as farmers and ranchers or indirectly through family members and neighbors. In urban areas, staff may experience drought restrictions on watering their gardens, low water pressure in their homes, bans on recreational water sports, and/or disruption to electricity supplies in regions dependent on hydropower for electricity generation. In more extreme cases, their homes, streets, schools, or other community infrastructure might be impacted by subsidence.

Healthcare organizations can support staff by alerting them to drought conditions, sharing community resources at appropriate phases of a drought, and providing direct aid (such as potable water), when needed. Extending mental health care and relevant physical health screenings (such as respiratory and heart health screenings if a drought is causing poor air quality) to both staff and their families is one way a healthcare organization can recognize that staff are more likely to report to work and excel in their jobs if they and their families are safe and protected.

3.2 Clinical Considerations: Healthcare organizations can increase drought resilience by planning ahead for potential patient surges, anticipating the needs of specific at-risk patient populations, establishing a protocol for real-time communications with other local health systems during crises, and integrating drought into their syndromic surveillance systems.

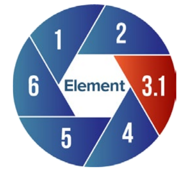
3.3 Building and Campus – Design & Construction: Drought can affect healthcare facilities in a variety of ways, including increased strain on outdoor air filtration systems during dust storms, disruptions to the local water and/or electricity supply when regional water levels drop to dangerously low levels, and structural damage to the building and utility infrastructure caused by subsidence. Many design features that increase resilience to drought also reduce greenhouse gas emissions.

3.4 Building and Campus – Facility Operations: Healthcare buildings rely on electricity, plumbing, and natural gas systems for critical operations. Droughts can strain water supplies and disrupt energy production, impacting a building systems. Implementing strategies to maintain essential services during droughts can mitigate the impact on healthcare facility operations.

3.5 **Supply Chain:** Droughts affect different regions differently, so resilient operations need to be tailored to those differences. Dust can contaminate water supplies, which places additional burden on municipal water treatment plants. Healthcare organizations are encouraged to establish contingency plans for alternative sanitation methods, secure reliable sources of medications and food, and prioritize essential procedures to maintain supply chain integrity during droughts.

Resilience Strategies: Drought

Element 3.1 Staff Support



Given many healthcare facilities' designation as critical infrastructure, healthcare staff are more likely to experience the effects of drought at home and in their communities before they experience its effects at work. In agricultural areas, clinicians may experience the economic impacts of crop loss either directly as farmers and ranchers or indirectly through family members and neighbors. In urban areas, staff may experience drought restrictions on watering their gardens, low water pressure in their homes, bans on recreational water sports, and/or disruption to electricity supplies in regions dependent on hydropower for electricity generation. In more extreme cases, their homes, streets, schools, or other community infrastructure might be impacted by subsidence.

Forty-five percent of respondents to a survey of healthcare staff in a Midwestern community in the United States reported that concern or fear for their family influenced their willingness to report to work during a disaster (Adams & Berry, 2021). Healthcare organizations can support staff by alerting them to drought conditions, sharing community resources at appropriate phases of a drought, and providing direct aid (such as potable water), when needed. Extending mental health care and relevant physical health screenings (such as respiratory and heart health screenings if a drought is causing poor air quality) to both staff and their families is one way a healthcare organization can recognize that staff are more likely to report to work and excel in their jobs if they and their families are safe and protected.

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
[Element 3.1: Staff Support](#)

Planning

ACTION: Communicate to staff the potential short-term and long-term impacts that severe drought could have on staffing.

SUMMARY: The slow-moving nature of drought and its changing characteristics as it moves from one phase of severity to another can make it easy to overlook until it causes or creates an emergency. However, studies in Australia have shown that the long-term economic impact of droughts includes loss of services, such as medical care (Lester et al., 2022). Droughts can also cause or exacerbate patient surges for a variety of conditions, including vector-borne disease, psychological distress, respiratory and cardiovascular diseases from dust storms, waterborne disease from recreational waters, and sickness from exposure to unsafe potable water (Yusa et al., 2015). Healthcare organizations can enhance resilience by including staff in strategic planning efforts that integrate drought surveillance, as well as in decisions to include drought as a component of staffing protocols for patient surges.

People and Operations

ACTION: Provide emergency housing for healthcare staff.

SUMMARY: Consider establishing agreements with temporary housing facilities (such as hotels) to support employees and their immediate families (including pets) in the event that severe drought disrupts utilities. (Morris et al., 2016; WHO, 2020).

ACTION: Provide staff support post-disaster.

SUMMARY: Creating an employee assistance program for staff and their families during and after droughts – including mental health services – can help them build

Climate Resilience Actions, continued

the long-term physical, mental, and social resilience that will be needed to respond to the next disaster (Dana et al., 2010; WHO, 2020). Consider offering permanent, drought-resilient housing options to full-time staff in areas where climate models predict worsening drought conditions over time and where economic models link a drought with populations moving away from the area.

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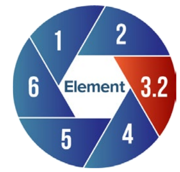
Resilience Strategies: Drought

CR4HC

Element 3.2 Clinical Considerations



Healthcare organizations can increase drought resilience by planning ahead for potential patient surges, anticipating the needs of specific at-risk patient populations, establishing a protocol for real-time communications with other local health systems during crises, and integrating drought into their syndromic surveillance systems.

For example, drought has been found to be associated with increased occupational psychosocial stress among farmers (Berman et al., 2021). Potential mental health harms may be an important consideration when planning tailored and targeted drought-related health messaging, collaborating with partner organizations to provide community-based mental and behavioral health services, and tracking the health effects of drought.

In addition, patients and community members may turn to healthcare providers during droughts with questions about water safety, especially for medically sensitive populations. When low water levels in the lower Mississippi River in 2023 caused saltwater intrusion from the Gulf of Mexico, regular updates about water quality, as well as practical information about safely mixing infant formula, WIC (Women, Infants, and Children) program assistance for ready-to-feed formula, and the prevention of risks to pregnant women, were available from the Louisiana Department of Health to help healthcare providers counsel their patients (Louisiana Department of Health, 2023).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
[Element 3.2: Clinical Considerations](#)

Planning

ACTION: Enhance drought preparedness by adding drought-related illness screening to the healthcare organization's EMR system.

SUMMARY: Consider including in an organization's drought resilience and preparedness plan a protocol for activating drought-related illness screening questions in the electronic medical record (EMR) system when a severe drought is declared (Hess et al., 2023). Drought-related illnesses include dehydration, malnutrition, water contamination issues, and vector-borne diseases. Droughts often occur in phases, so the specific health conditions they create or exacerbate can change from one phase to the next. Sensitive patient groups who might be flagged for additional screening during drought conditions include unhoused individuals, outdoor workers, pregnant women, children, adults over 65 years of age, populations reliant on well water, and patients with a chronic disease (particularly those with chronic respiratory, cardiovascular, and/or kidney disease) (Yusa et al., 2015). Early identification through EMR screening allows healthcare providers to flag sensitive patient groups for further evaluation and intervention, potentially improving patient outcomes during droughts.

ACTION: Enhance syndromic surveillance during drought events.

SUMMARY: Consider enhancing the healthcare system's syndromic surveillance during drought events by submitting drought-related illness data to the Electronic Surveillance System for the Early Notification of Community-Based Epidemics (Burkom et al., 2021), bearing in mind that the health effects of drought can include respiratory symptoms related to air pollution from particulate matter and airborne toxins; outbreaks of waterborne, foodborne, and vector-borne diseases; and mental health symptoms.

Climate Resilience Actions, continued

Work with local public health partners to interpret and act on real-time drought-related illness and all-cause morbidity and mortality data during and immediately following drought events.

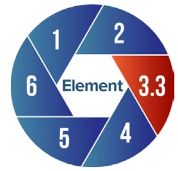
ACTION: Integrate epidemiological and meteorological data into drought preparedness.

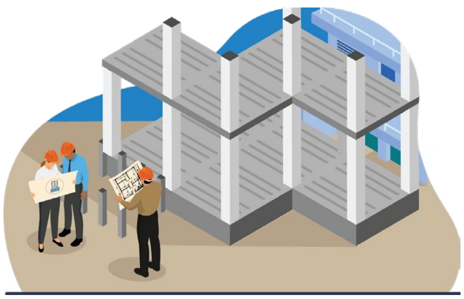
SUMMARY: Consider combining a region's local epidemiological and meteorological data with downscaled climate models to estimate the increase in patient volume (and corollary staff and medical supplies) that might be expected for different levels and durations of drought events (Patel et al., 2022).

Resilience Strategies:
Drought

CR4HC

Element 3.3 Building and Campus: Design & Construction





Drought can affect healthcare facilities in a variety of ways, including increased strain on outdoor air filtration systems during dust storms, disruptions to the local water and/or electricity supply when regional water levels are dangerously low, and structural damage to building and utility infrastructure caused by subsidence. Many design features that increase resilience to drought also reduce community greenhouse gas emissions. For example, healthcare facilities consume about 7% of all water used in commercial and institutional buildings in the United States, primarily through toilets, faucets, air conditioning and heating systems, and medical equipment (EPA, 2012). Installing water-efficient fixtures and equipment both reduces water demand within the facility and reduces demand on the local infrastructure for treating and pumping water, which is often the largest energy consumer in a community (EPA, 2024).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 3.3: Building and Campus: Design & Construction

Planning

ACTION: Use regional climate models to future-proof the efficiency and redundancy of building systems that are vulnerable to direct and indirect effects of drought.

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 a building system's functionality will likely fall short of operational needs within a few decades. Therefore, it is advisable for healthcare facilities (many of which are designed to function for 50 or more years) to maximize energy and water efficiency and to identify opportunities for diversifying their energy and water supplies in order to extend the functional life of the building for as long as possible within the context of a rapidly changing climate (Casanueva et al., 2019). In some cases, it may be more efficient to build out a resilient energy and water supply system at the campus or neighborhood scale rather than focus only on an individual building.

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 & Chan, 2017).

Physical Infrastructure

Structure and Landscaping

ACTION: Install native, drought-resistant landscaping to reduce outdoor water use.

SUMMARY: Installing native, drought-resistant landscaping can reduce utility costs (both energy and water) and increase the length of time a facility can rely on emergency water supplies during a drought (Chu et al., 2023).

Climate Resilience Actions, continued

ACTION: **Use green infrastructure practices to absorb rainwater on-site and reduce the risk of subsidence.**

SUMMARY: Ground subsidence occurs when more water is removed from the ground than is replaced through rainfall. Drought can exacerbate subsidence, particularly in areas with high levels of impervious surface and conditions that allow soil to compact when it dries out. Healthcare organizations in areas at risk of subsidence can enhance resilience by increasing vegetated areas on their campus and using green infrastructure practices, like rain gardens that maximize the amount of rainfall absorbed on-site instead of leaving the site as stormwater (U.S. Climate Resilience Toolkit, n.d.a.).

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 at which they can generate sufficient electricity using on-site renewable power (e.g., solar, wind, geothermal). These facilities can continue to provide clinical care during disasters that disrupt regional power grids.

ACTION: **Install energy efficient building equipment to extend the length of time the facility can function on backup 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 a facility can function on backup power systems (Carvallo et al., 2022).

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

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 (Lazo et al., 2023). In some cases, it may be more efficient to build a campus or neighborhood scale microgrid rather than focus only on an individual building.

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).

Water Efficiency

ACTION: **Maximize water efficiency to reduce demand during low water pressure and boil water notice events.**

SUMMARY: Water is critical to healthcare facilities' clinical and building system functions. To maximize the availability of potable water for clinical use, minimize once-through use in process equipment, such as in the HVAC system, sterilizers, and medical equipment. Further, consider installing low-flow toilets, urinals, handwash stations, and showers, except where volume is needed for occupational uses, such as water filling stations and decontamination showers (Van der Heijden, 2022; WHO, 2015).

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 droughts – potentially for weeks or months at a time. Healthcare facilities in regions that climate models have indicated are at risk of increased exposure to drought can build resilience by developing supplementary water sources, such as connections that allow a temporary water supply from trucks or other sources, permanent storage tanks/cisterns, and wells. These can be used to maintain water pressure during low pressure events. Separating process water systems from potable water systems further enhances resilience by allowing supplementary potable water sources to serve occupant-facing plumbing fixtures, while separate non-potable water sources serve process uses, such as an air conditioning system (Healthcare Environmental Resource Center, 2015; Van der Heijden, 2022; WHO, 2015).

Thermal Comfort and Indoor Air Quality

ACTION: **Install high efficiency air filtration and ventilation systems in drought-prone regions to reduce the concentration of pollutants in indoor air.**

SUMMARY: Installing highly efficient air filtration systems (e.g., MERV 13) can reduce the risk to indoor air quality of particulate air pollution from dust storms. Coupling high efficiency filtration with increased outdoor

Climate Resilience Actions, continued

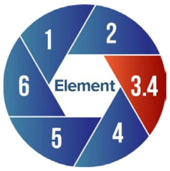
air ventilation can reduce the concentration of a range of airborne contaminants inside the facility, including airborne pathogens; particulate matter; cleaning and disinfection chemicals; and toxins emitted from furniture, architectural finishes, and composite wood products, like plywood (Mousavi et al., 2020).

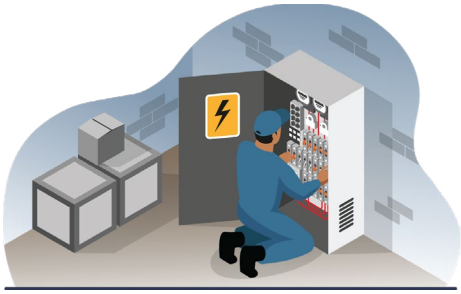
ACTION: Isolate ventilation systems during poor air quality events.

SUMMARY: Certain areas of healthcare facilities need to maintain extremely clean air to avoid harming patients. For example, patients in surgical suites, bone marrow transplant wards, and intensive care units are often at a high risk of infection. Designing and maintaining the ventilation systems in these areas so that they can isolate from the rest of the facility could increase the facility's resilience to poor air quality events, like dust storms and wildfires, by providing more highly filtered air to the highest risk patients (U.S. Climate Resilience Toolkit, n.d.b.).

Resilience Strategies:
Drought

Element 3.4. Building and Campus: Facility Operations





Healthcare buildings rely on electricity, plumbing, and natural gas systems for critical operations. Droughts may lead to water restrictions and increased energy costs that affect sanitation, hygiene, and air conditioning. For example, Sky Lakes Medical Center in Klamath Falls, Oregon, is located in a mountainous, wooded region where drought conditions have increased risk of wildfire and led to decreased snowpack and dry wells (Fink, 2022 a.). Resilient operations in this region include maximizing water efficiency and identifying supplementary water sources – particularly to protect the facility from wildfire risk.

Dust storms in a dry state like Arizona are associated with higher concentrations of particulate matter in outdoor air and increased intensive care unit (ICU) admissions for respiratory conditions (Rublee et al., 2020). Resilient operations strategies in these conditions include installing high efficiency filtration and entry vestibules to minimize the amount of particulate matter entering the facility. Dust can also contaminate water supplies, which places additional burden on municipal water treatment plants. For example, a climate vulnerability analysis conducted by the city of Keene, New Hampshire, found that prolonged droughts followed by flooding are increasingly likely to cause turbidity and other pollution in the reservoir that serves as their main potable water supply (Hall & Averett, 2024). Healthcare organizations can mitigate the impacts of drought on facility operations by developing resilience plans to ensure water supply, maintain comfortable indoor temperatures, and secure energy resources to ensure continuous patient care and safety (FEMA & ASPR, 2019).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 3.4: Building and Campus: Facility Operations

Planning

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

SUMMARY: Pre-drought resilience measures include: (1) maintaining building systems to maximize the efficien use of energy and water and to enhance ventilation; (2) diversifying the energy and water supply; (3) increasing insulation and solar reflection for the facility walls and roof; (4) installing shading devices to minimize heat exposure inside the building; and (5) performing routine maintenance to seal cracks and fix plumbing leaks (Casanueva et al., 2019).

ACTION: Perform a baseline analysis of water usage and categorize usage types into tiers of critical need.

SUMMARY: Water is a critical component of clinical care, including its use to sanitize medical equipment. Performing a baseline analysis of the healthcare facility's water usage and categorizing usage types into tiers of critical need can help facility managers direct the potable water supply to the most important clinical needs during low water pressure and boil water notices while also reducing overall facility water usage (WHO, 2015; Van der Heijden, 2022).

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

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 (such as low water pressure, extreme temperatures, wildfire risk, etc.) reach dangerous levels (FEMA & ASPR, 2019).

People and Operations

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

SUMMARY: Consider performing regular stress tests of the healthcare facility's ability to continue providing clinical care during drought events. Incorporate scenarios that involve power outages, low water pressure, a surge of patients experiencing hazard-related illness, a surge of all-cause complaints, and a surge of community members seeking to use the facility as a resilience hub and place to access potable water. Stress tests can help identify critical systems (such as fire suppression systems, outdoor air filtration systems, and process water systems) whose failure would result in cascading effects across the facility and impact delivery of critical care (Ebi et al., 2018).

ACTION: Implement a preventive maintenance program to ensure that building systems that could be compromised in drought conditions remain at levels that can be met by on-site resources.

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 under drought-related extreme conditions. Preventative maintenance programs ensure that critical systems, such as the HVAC system, air filtration, fire suppression, and separated potable and process water systems, can transition seamlessly over to emergency operations, when necessary (Kolokotsa et al., 2012).

ACTION: Implement a ventilation protocol for poor air quality days caused by drought, wildfire, and other types of air pollution.

SUMMARY: Establishing an air quality protocol tied to tools, like the EPA Air Quality Index, can assist building engineers in tuning the healthcare facility's ventilation systems in response to changing outdoor air conditions. Building systems that should be governed by the air quality protocol include operable windows, positively pressurized entrance vestibules, air filtration systems (e.g., High Efficiency Particulate Air [HEPA] filters and air scrubbers), and clean rooms that protect highly sensitive patients (Stone et al., 2019).

Physical Infrastructure

ACTION: Use drought-resilience landscaping best practices to minimize the healthcare campus's contribution to airborne dust and turbidity in local waterways.

SUMMARY: Maintaining landscaping using drought-resilience best practices can reduce a healthcare facility's exposure to airborne and waterborne dust during droughts and reduce its contribution to local air and water pollution. Best practices include protecting trees and other existing plants to minimize the use of mulch to retain water in the soil; planting drought-tolerant bushes downwind of landscaping so that they can capture particulate matter before it blows off the property; and limiting irrigation and fertilizers in favor of building up healthy soils and encouraging plants to grow deep roots (Abraham et al., 2020; Hennepin County Facility Services Department, 2023).

ACTION: Monitor subsidence on and near the healthcare campus and modify facility infrastructure in affected areas to reduce the risk of disruption to utility and transportation infrastructure.

SUMMARY: Healthcare facilities in areas at risk of subsidence can increase resilience by installing subsidence monitors on their campus and by working with local partners to monitor trends in land movement across the community and region (U.S. Climate Resilience Toolkit, n.d.a.). Update the building, utility infrastructure, and access roads according to engineering recommendations related to the soil type and cause of subsidence.

ACTION: Regularly maintain and upgrade water fixtures and process water equipment to maximize facility water efficiency.

SUMMARY: According to the EPA, healthcare facilities can reduce their water use by up to 20% simply by installing and maintaining high efficiency HVAC equipment, water fixtures, and medical equipment. Integrating continuous commissioning and leak monitoring practices into facility operations is one of the most effective ways for a healthcare facility to increase its resilience to drought conditions (EPA, 2014).

ACTION: Generate renewable energy on the healthcare campus.

SUMMARY: Producing electricity on-site using renewable energy sources, such as solar and geothermal, coupled

Climate Resilience Actions, continued

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: Isolate ventilation systems during poor air quality events.

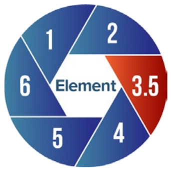
SUMMARY: Certain areas of healthcare facilities need to maintain extremely clean air to avoid harming patients. For example, patients in surgical suites, bone marrow transplant wards, and ICUs are often at a high risk of infection. Designing and maintaining the ventilation systems in these areas so that they can isolate from the rest of the facility could increase the facility's resilience to poor air quality events, like dust storms and wildfires, by providing more highly filtered air to the highest risk patients (U.S. Climate Resilience Toolkit, n.d.b.).

ACTION: Use portable air scrubbers when the building ventilation system is shut down during air pollution events.

SUMMARY: Consider placing portable air scrubbers in nursing units to remove harmful particles and aerosols from indoor air, if the overall building ventilation system has been shut down, or to reduce the amount of harmful air pollution entering the building during a wildfire, dust storm, chemical fire, or other air-related disaster (U.S. Climate Resilience Toolkit, n.d.b.).

Resilience Strategies: Drought

Element 3.5 Supply Chain



Droughts can disrupt a healthcare organization's supply chain in both clinical and non-critical areas. Developing alternative methods and contingency plans can help maintain supply chain integrity during droughts. For example, limited water access can threaten the sterility of medical supplies and equipment, requiring alternative sanitation methods or postponing non-essential procedures. Drought-induced strain on agriculture may limit access to certain medications and food for patients and staff (Fink, 2022 a.; Lookadoo et al., 2024). Healthcare organizations are encouraged to establish contingency plans for alternative sanitation methods, secure reliable sources of medications and food, and prioritize essential procedures to maintain supply chain integrity during droughts.

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 3.5: Supply Chain

Planning

ACTION: Consider drought-related disruptions to the global medical supply chain when planning the list of critical supplies that should be stockpiled as part of the healthcare organization's resilience plan.

SUMMARY: Consider the role of drought in disrupting global medical supply chains that are critical to healthcare operations. Maintain an adequate supply of medical supplies, particularly for products that are most vulnerable to weather-related disruptions in transportation routes (Hedges et al., 2018). Establish a timeline for activating the supply chain plan ahead of anticipated droughts (Maslanka & Hurwitz, 2022).

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

SUMMARY: The medical supply chain is influenced by global trends. For example, a drought in the Panama Canal in late 2023 resulted in a 33% reduction in daily volume of cargo passing through the canal in 2024 (Health Industry Distributors Association, 2024). Identifying potential vulnerabilities related to drought within a healthcare organization's supply chain and sourcing products from local and regional suppliers can increase resilience (Lakatos et al., 2023; Sherman et al., 2023).

People and Operations

ACTION: Require suppliers of essential goods and services to provide a continuity of operations plan for drought.

SUMMARY: Healthcare organizations are dependent on a large network of vendors to supply goods and services that are essential to facility operations and continuity of care. Many vendors rely on global barge and shipping supply routes, which are vulnerable to drought-related disruptions. Vendors with local supply chains – for example, farm to hospital operations – may be vulnerable to regional drought conditions. Requiring suppliers of essential goods and services to provide a continuity of operations plan is an important step in building the healthcare organization's resilience to all climate-related disasters, especially drought (Toner et al., 2017).

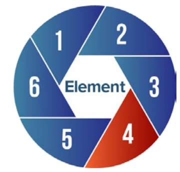
Physical Infrastructure

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).

Resilience Strategies: Drought

Element 4. Collaboration Between Healthcare Organizations



During drought events, surges in clinical and nonclinical demands, as well as evolving water supply challenges, can stress healthcare facilities. Given the importance of minimizing the time that sensitive patients are exposed to the repercussions of drought, collaboration between healthcare organizations can help direct patients to the closest facility with capacity to meet their needs. For example, in 2023, Lee Health's coordination with the Florida Hospital Association and hospitals across the state, which included preparatory exercises and collaborative drills, enabled the safe and efficient evacuations of patients from three of its facilities – including 67 neonatal intensive care patients – in less than 24 hours. While the evacuation was needed because city and county utilities' water line leaks in the aftermath of Hurricane Ian (2022) created insufficient water pressure to maintain fire suppression systems, the lessons learned from this event are applicable to healthcare organizations facing similar water supply challenges during droughts (ASPR TRACIE, 2022).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 4: Collaboration Between Healthcare Organizations

Planning

ACTION: Create plans to increase the resilience of critical outpatient care during drought events.

SUMMARY: Create contingency plans in coordination with regional healthcare partners to ensure that individuals with chronic physical and/or mental health conditions – who are at high risk due to potential interruptions in medication administration or outpatient care – have access to alternative arrangements if their usual care becomes unavailable or inaccessible (U.S. HHS, 2014; Toner et al., 2017; WHO, 2020).

ACTION: Enhance healthcare organization preparedness for droughts through mutual aid MOU.

SUMMARY: A mutual aid memorandum of understanding (MOU) with other healthcare providers in the region that includes the results of a prospective risk assessment (Element 1) can help prepare for circumstances that require patient transfers or referrals, such as utility outages, patient surges, etc. It is important to address legal and reimbursement challenges that can limit a facility's ability to quickly and efficiently transfer patients and/or supplies to other facilities in the region. Consider working with CMS and other healthcare organizations in the region to address these legal and reimbursement challenges over time using an all-hazards approach (U.S. HHS, 2014; Patel et al., 2022).

ACTION: Exchange epidemiological data and health assessments related to droughts with other healthcare organizations and the local health department.

SUMMARY: Exchanging epidemiological data and health assessments related to drought with other healthcare organizations and the local health department can support regional climate resilience planning efforts. Use these conversations to jointly develop protocols for identifying emerging climate-related health threats in the region, collecting and disseminating data, and coordinating emergency response across the range of facility types, in the regional health system – including acute care hospitals, community clinics, and long-term care facilities (Patel, 2022).

ACTION: Integrate an analysis of cross-institutional collaboration in regional after-action reviews of droughts.

SUMMARY: As part of an all-hazards emergency management plan, include an after-action analysis of interdisciplinary coordination within the organization, as well as with other regional healthcare organizations and

Climate Resilience Actions, continued

the local office of emergency management, to assess how well the emergency response system functioned as a whole. Consider including prospective climate metrics (Element 1) as one indicator of the system's resilience to future events (Davies et al., 2019; Parker, 2020).

ACTION: Perform joint disaster preparedness exercises and drills with other local healthcare organizations, the local health department, and the local office of emergency management.

SUMMARY: Joint disaster preparedness exercises and drills can help healthcare organizations test their readiness for simultaneous and cascading events (such as drought, extreme heat, and wildfires), identify areas for improvement in their emergency response plans, and build working relationships with other first responders. Including representation from multiple institutions and professions in the exercise can also help identify emerging at-risk populations who are projected in climate models to require more protection and/or resources as droughts and concomitant hazards occur more frequently and/or with greater severity (ASPR, 2024; WHO, 2020).

ACTION: Work with other regional healthcare organizations to develop integrated patient evacuation plans.

SUMMARY: Healthcare organizations can increase their own and regional resilience by working together to develop integrated emergency evacuation plans. Consider including contingency plans to address exposure to contaminated air and/or water damage, power and water outages, and infrastructure failures. Contingency plans may involve transferring patients to alternative facilities or establishing temporary medical sites in safer areas (U.S. HHS, 2014; Patel, 2022).

People and Operations

ACTION: Collaborate with regional healthcare organizations on public health education and outreach programs.

SUMMARY: Healthcare institutions can collaboratively develop and disseminate public health education and outreach programs so that the community receives consistent and coordinated messages about climate-related hazards, protective behaviors, and access to resources, such as healthcare services (California Department of Public Health, 2022).

ACTION: Consider proactively credentialing neighboring healthcare facility staff to help execute the healthcare organization's emergency preparedness protocol.

SUMMARY: Proactively credentialing staff at neighboring healthcare facilities to prepare for emergencies can contribute to backup care if one facility is unable to provide care due to hazard-related and extreme weather utility interruptions (WHO, 2020).

ACTION: Establish effective communication channels to share real-time information across healthcare organizations during droughts.

SUMMARY: Consider working with other healthcare organizations and entities in the region to establish effective real-time communication channels with one another and with the public during droughts. Organizations can share critical information about drought progression, community assistance programs, real-time information about the number of beds available in the region and consistent definitions for each bed type, and the levels of critical medical supplies needed and available for each facility in the cooperation network (CDC, 2003; California Department of Public Health, 2022; U.S. HHS, 2014).

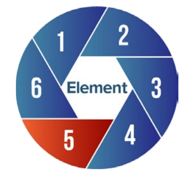
ACTION: Share resources and coordinate personnel during droughts.

SUMMARY: Collaboration between response organizations may involve sharing critical resources and coordinating the deployment of personnel to support impacted communities' areas of greatest need (Patel, 2022). Consider integrating the results of the organization's prospective risk assessment (Element 1) into regional planning conversations, to funnel resources to new and emerging at-risk populations related to the changing climate.

Resilience Strategies: Drought

CR4HC

Element 5. Interdisciplinary Planning, Oversight, and Evaluation



Droughts can affect various critical dependencies within healthcare organizations, such as administration, information technology, electricity, natural gas, water, wastewater and waste disposal, communications, transportation, and critical products. An interdisciplinary approach to planning, oversight, and evaluation is essential for comprehensive drought preparedness.

For example, engaging staff and community members early in developing the drought resilience plan can raise awareness about the interconnected impacts of droughts on clinical care, facility operations, and community infrastructure. This engagement also helps prioritize interventions (WHO, 2020). Healthcare organizations are encouraged to align their facility operations, procurement, and capital expenditures with climate change mitigation and resilience goals. This approach ensures the efficient use of energy and water, reduces property damage, and lowers the risk of patient evacuation during droughts and other climate-related events (WHO, 2020).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 5: Interdisciplinary Planning, Oversight, and Evaluation

Planning

ACTION: Implement surveillance and interdisciplinary after-action reviews into organizational drought action plans.

SUMMARY: Incorporate building surveillance and interdisciplinary after-action reviews into the healthcare organization's drought action plan; these measures will help identify and evaluate the elements of the plan that worked during a recent event. Assess whether changing climatic conditions might have influenced aspects of the event (such as its severity), and change the parts of the plan that did not meet expectations (Hess et al .,2023 ; Parker, 2020).

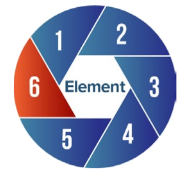
ACTION: Incorporate long-term goals and climate projections into healthcare drought planning and response plans.

SUMMARY: It can be helpful to integrate long-term, interdisciplinary strategic goals into the healthcare organization's drought preparedness and response plans, including community input as outlined in the Justice, Equity, Diversity, and Inclusion (JEDI) framework (American Public Health Association & CDC, 2021).

ACTION: Incorporate interdisciplinary approaches into drought planning.

SUMMARY: Consider incorporating interdisciplinary approaches into the healthcare organization's drought planning process since drought events can impact a range of dependencies, such as infrastructure, clinical care, and energy systems (Rogers et al., 2020).

Element 6. Communications and All-Hazards Approach



Droughts often occur together or in succession with extreme heat and/or wildfires and can often end with a heavy rainfall that results in flooding. Multi-hazard events increase the risk of multiple system failures at the community scale (such as disruptions to the water and power utilities), and they can result in both direct and indirect harm to population health. Repeated patient surges and cascading infrastructure failures, both in the community and within healthcare facilities, can temporarily disrupt the entire healthcare system in a region. Fortunately, many policy, infrastructure, and communications interventions can increase organizational resilience to more than one climate-related hazard. For example, Drought and Health: A Messaging Framework for Public Health Professionals & Healthcare Providers, a report published by NOAA's National Integrated Drought Information System and the University of Nebraska Medical Center, recommends using a communications strategy that both points community members to resources that help them build resilience to discrete health impacts of drought (such as exposure to particulate air pollution, unclean water, extreme heat, wildfire, or disease-carrying vectors) and also reminds community members that healthcare organizations and public agencies are standing by to offer assistance (Lookadoo et al., 2024).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 6: Communications and All-Hazards Approach

Planning

ACTION: Collaborate with local partners to coordinate drought messaging.

SUMMARY: It can be helpful to collaborate with local public health department partners to coordinate drought-related messaging with clinicians and patients, such as through prompts in the healthcare organization's electronic health record, e-newsletter, and patient texting system. This approach can increase community awareness of both the short- and long-term health impacts of drought (WHO, 2020).

ACTION: Develop a drought communications plan that includes different messaging for different stages of a drought event.

SUMMARY: Drought is often experienced differently at different stages. One stage might be characterized by dust storms while another stage might coincide with an extreme heat event and/or a vector-borne disease outbreak. More severe droughts might coincide with heightened wildfire risk, and many droughts end as a result of a heavy rainfall that causes flooding, which could cause erosion that contaminates community water sources. Therefore, drought communications plans should anticipate a wide variety of messaging that can be tailored to the shifting conditions and health needs of the healthcare organization's patient base (Lookadoo et al., 2024).

ACTION: Use simultaneous disasters as an opportunity for education about the co-benefits of taking an all-hazards approach to resilience.

SUMMARY: Simultaneous and cascading disasters can be opportunities to educate the community, staff, and emergency management partners about the value of using a co-benefit approach to risk assessment, emergency planning, emergency response, and rebuilding efforts (National Academies of Sciences, 2022).

Climate Resilience Actions, continued

People and Operations

ACTION: Broadcast drought alerts using culturally appropriate language and communication pathways.

SUMMARY: Broadcasting alerts about drought vulnerability and protective behaviors to patients, staff, and community partners using culturally appropriate language and communication pathways can help amplify communication efforts from the local public health department and office of emergency management (Hasan et al., 2021; O'Neill et al., 2009).

ACTION: Establish two-way communication systems with at-risk patient populations.

SUMMARY: Implementing two-way communication systems, like Reverse 911 and wireless emergency alerts (National Academies of Sciences, 2018), can aid in connecting sensitive populations with protective measures and direct them to community services during a drought event. With the assistance of community groups and local health departments, designated community leaders can deliver culturally sensitive messages. These messages would inform residents about safeguarding themselves and their neighbors and provide guidance on actions to take if someone experiences health harms (Steinberg and Sprigg, Ed., 2016; Toner et al., 2017).

Climate Resilience for Health Care:
Extreme Heat

CR4HC

Impact of Extreme Heat on Healthcare Organizations

Extreme heat impacts healthcare organizations both directly and indirectly. An example of a direct impact is the increased burden on facility air conditioning systems. Examples of indirect impacts include (1) an increased risk of power outages when excessive demand overburdens the local electrical grid, (2) electrical lines drooping, sparking, or no longer transmitting electricity, (3) patient surge from both heat-related and all-cause morbidity, (4) community members using the facility as an ad hoc cooling center, and (5) the risk of supply chain disruption if transportation infrastructure is impacted by the heat.

Important Considerations

Health Effects of Extreme Heat: Heat cramps, heat exhaustion, heatstroke, exacerbation of chronic medical conditions such as cardiovascular disease and diabetes, pregnancy complications, and mental and behavioral health symptoms (such as increased interpersonal violence and impaired attention and cognition)

Populations at Risk: Older adults (especially those who live alone), infants and children, pregnant women, low-income populations, people with housing instability and homelessness, people with substance use disorder, people with chronic conditions (such as cardiovascular, pulmonary, and renal disease), people on medications that increase heat sensitivity, outdoor workers, outdoor athletes

Risks to Facility Operations: Storage of medications and clinical supplies, supply chain disruption, patient surge, prolonged power outage

Infrastructure Risk: Compromised transportation and building infrastructure, rolling blackouts/power loss, inefficient utilities

Elements of a Climate-Resilient Healthcare Organization: Extreme Heat

Climate resilience complements core emergency management activities. Vulnerability assessments that include climate resilience consider the implications of the changing climate on a healthcare organization's physical infrastructure, on its staff, on clinical care, on the organization's relationship with community members, and on its evolving role as a key member of the multidisciplinary emergency response network that operates during disasters to keep the community safe.

This section of the Toolkit details specific actions that healthcare organizations can take to enhance resilience to extreme heat events. This section complements the All / Multiple Hazards section, which contains actions that can build resilience to all climate change-related hazards.

The following six elements characterize a heat-resilient healthcare organization. Review each section to explore in more detail.

1. Prospective Risk Assessment

Extreme heat risk assessments in emergency management plans are traditionally retrospective. Adding forward-facing climate projections to the risk assessment can help healthcare organizations plan for changing exposures and vulnerabilities, such as more frequent, severe, and longer heat waves.

2. Health Equity and Community Engagement

Heat-related illness disproportionately affects at-risk populations. Seeking community input to identify populations most at risk of negative health outcomes during and after extreme heat events helps to ensure that healthcare heat resilience plans prioritize health equity. Healthcare organizations can also work with community planners, transportation authorities, and public utilities to build resilience and redundancy into community infrastructure, so that homes and essential community services, as well as healthcare facilities, are less likely to experience disruptions during heat events. Educating patients and connecting them to funding opportunities that will help to reduce their exposure to extreme heat, such as home weatherization and utility assistance programs, can benefit healthcare organization resilience by reducing the risk of a patient surge during or after an extreme heat event. Finally, healthcare organizations are encouraged to synchronize their heat emergency planning protocols with the local office of emergency management to enhance cross-organizational coordination during response operations.

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 constructing and maintaining efficient buildings that can continue to operate during power and water outages. Healthcare organizations can also develop resilient supply chains and storage conditions for food and medical supplies that require constant refrigeration. Healthcare facilities designed and operated with heat resilience in mind can serve a dual role in the emergency response system: providing clinical care and acting as a resilience hub for community members seeking refuge from the heat.

4. Collaboration Between Healthcare Organizations

The shifting landscape of patient surges, rolling brownouts and blackouts, and surges in nonclinical demands on healthcare institutions during extreme heat events can stress a healthcare facility's ability to provide high quality clinical care. Sharing information and resources across the full range of regional healthcare providers during an extreme heat event can increase resilience both at the facility level and system-wide.

5. Interdisciplinary Planning, Oversight, and Evaluation

Planning for heat resilience requires an interdisciplinary team and coordination across a range of critical functions, including administration, emergency management, information technology, facility operations (e.g., power, water, waste disposal, food service, custodial services, etc.), communications, transportation, and purchasing. It is important to engage staff and community members early in the process of developing the heat resilience plan, both to raise awareness about the interconnected nature of heat exposure on clinical care, facilities operations, and community infrastructure, and to seek input from all key stakeholder groups about which interventions should be prioritized.

Aligning facilities operations, procurement, and capital expenditures to balance climate change mitigation (i.e., reducing greenhouse gas emissions) goals and resilience goals can help the organization chart a climate-positive and cost-neutral path towards heat resilience, because facilities will experience less heat stress while simultaneously using less energy and water, and operate at a lower risk of evacuating patients due to unsafe indoor temperatures when the power goes out.

6. Communications and All-Hazards Approach

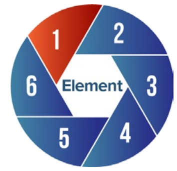
Extreme heat events often occur simultaneously or in quick succession with other climate change-related hazards, such as drought, wildfire, hurricanes, and flooding. Multi-hazard events increase the risk of multiple system failures at the community scale (such as disruptions to the water and power utilities) and can result in both direct and indirect harm to population health. Repeated patient surges and cascading infrastructure failures both in the community and within healthcare facilities can temporarily disrupt the entire healthcare system in a region. Fortunately, many policy, infrastructure, and communications interventions can increase organizational resilience to more than one climate-related hazard. This is particularly true if emergency management and climate resilience planners use an all-hazards approach to designing, implementing, and testing proposed interventions.

Link to the Fifth National Climate Assessment, Chapter 18, for more information.

Resilience Strategies:
Extreme Heat

CR4HC

Element 1. Prospective Risk Assessment



Extreme heat risk assessments in emergency management plans are traditionally retrospective. Adding forward-facing climate projections to the risk assessment can help healthcare organizations plan for changing exposures and vulnerabilities, such as more frequent, severe, and longer heat waves. For example, a study found that New York City's decision in 2008 to lower its threshold for activating the local heat emergency plan was subsequently associated with a daily reduction of 0.8 heat-related illness hospital admissions among patients over 65 years (Benmarhnia et al., 2019).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 1: Prospective Risk Assessment

Planning

ACTION: Add projected temperature and heat measures to the healthcare organization's extreme heat risk assessment.

SUMMARY: Consider adding one or more of the projected temperature and heat measures in the CDC National Environmental Public Health Tracking Network data portal (https://ephtracking.cdc.gov/) to the healthcare organization's extreme heat risk assessment.

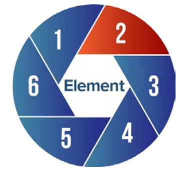
ACTION: Consider both historical trends and climate projections to identify regional climate change-related hazards.

SUMMARY: The changing climate means that historical trend lines are not necessarily an accurate predictor of the future. Considering both historical trends and climate projections when developing emergency management strategies around climate change-related hazards can help organizations future-proof the planning, response, and recovery process. See the tools and resources in the Appendix of this toolkit for data sources for both historical trends and future climate projections.

ACTION: Add a prospective risk assessment and impact forecasting to the local heat warning system and heat action plan.

SUMMARY: It can be helpful to work with public health and local emergency management partners to add a prospective risk assessment and impact forecasting to the local heat warning system and heat action plan. These models can assist in predicting the frequency and severity of heat waves in an upcoming warm season and can be used to periodically reassess the region's expectations of an average heat wave's length and intensity (Domeisen et al., 2023).

Element 2. Health Equity and Community Engagement



Heat-related illness disproportionately affects at-risk populations. Groups most at risk for heat-related illness include, but are not limited to, outdoor workers, unhoused people, and people living in historically redlined urban neighborhoods (due to disparities in heat exposure); pregnant people, people with cardiovascular disease, people with substance use disorder, and very young and older individuals (due to physiologic risk factors); and low-income individuals (due to lower adaptive capacity) (Hoffman et al., 2020). Seeking community input to identify populations most at risk of negative health outcomes during and after extreme heat events helps to ensure that healthcare heat resilience plans prioritize health equity. Healthcare organizations can also work with community planners, transportation authorities, and public utilities to build resilience and redundancy into community infrastructure, so that homes and essential community services, as well as healthcare facilities, are less likely to experience disruptions during heat events. Educating patients and connecting them to funding opportunities that will help to reduce their exposure to extreme heat, such as home weatherization and utility assistance programs, can benefit healthcare organization resilience by reducing the risk of a patient surge during or after an extreme heat event. Finally, healthcare organizations are encouraged to synchronize their heat emergency planning protocols with the local office of emergency management to enhance cross-organizational coordination during response operations.

For example, the City of Boston's Heat Resilience Plan, which includes healthcare organizations as key community assets, centers health equity by prioritizing community input and engagement in its development. The strategies in the plan are directly shaped by community feedback and lived community experiences with heat (City of Boston, 2022).

The following sub-elements describe specific ways in which a healthcare organization can integrate health equity and community engagement into their extreme heat resilience planning.

2.1 Community Input: Frameworks like social determinants of health and vulnerability assessments can help identify populations in a healthcare organization's catchment area who may be at higher risk of negative health outcomes during an extreme heat event (U.S. HHS, n.d.). Seeking community input can be helpful for refining and validating the organization's initial assessment and for clarifying which services – either on campus or in the community – increase the likelihood of protecting the health of community members who are at highest risk of heat-related illness.

2.2 Community Infrastructure: Electrical infrastructure can be compromised during extreme heat events because both power lines and transformers become less efficient when overheated. Power lines can sag, increasing the risk of electrical sparks. Electrical facilities that use water cooling can become less efficient when water temperatures rise. Increased community air conditioning demand during heat waves can further stress the system. The combination of less efficient power delivery and excessive demand increases the burden on community utilities and can lead to rolling blackouts and power outages. Healthcare organizations can enhance resilience by supporting community programs that increase redundancy in local utilities, increase adaptive capacity in the home environment, and mitigate extreme heat exposure at the community level.

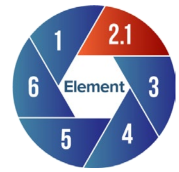
2.3 Community Services: Partnering with community services to provide community-facing supports that reduce the risk of heat-related illness can benefit healthcare organization resilience by reducing the surge in demand for healthcare services during an extreme heat event. During power outages, individuals relying on medical equipment that require electricity or who take medications requiring refrigeration, such as insulin, may turn to healthcare facilities for help.

2.4 Coordination with Local Office of Emergency Management: Synchronizing a healthcare organization's heat emergency plan with peer organization plans, the local office of emergency management, and the local utility can improve the efficiency and coordination of emergency response during and after extreme heat events. Plan synchronization can also reveal gaps and redundancies that could impact the effectiveness of responders during an emergency, and support the development of personal relationships across organizations and agencies – an important factor during emergency response.

Resilience Strategies:
Extreme Heat

CR4HC

Element 2.1 Community Input



Frameworks, like social determinants of health and vulnerability assessments, can help identify populations in a healthcare organization's catchment area who may be at higher risk of negative health outcomes during an extreme heat event (U.S. HHS, n.d.). Seeking community input can be helpful for refining and validating the organization's initial assessment and for clarifying which services – either on campus or in the community – increase the likelihood of protecting the health of community members who are at highest risk of heat-related illness.

A study of emergency department (ED) visits from 2010 to 2017 in Roanoke, Virginia, found that the odds of an ED visit were 6–7% higher during heat waves compared with non-heat wave days. Risk was particularly heightened for young children and people with pre-existing medical conditions (Davis et al., 2020). After the city mapped which neighborhoods were at highest risk of heat-related illness, youth from a local public middle school participated in a summer STEM program that used data and lived experience to develop neighborhood-scale heat resilience plans. Efforts such as this, which involve youth in gathering and analyzing data related to temperature and thermal comfort, can provide insight into effective strategies for healthcare organizations' approach to community-engaged heat resilience planning (Lim et al., 2022).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 2.1: Community Input

Planning

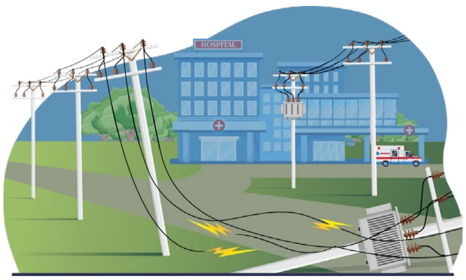
ACTION: Use the JEDI framework to structure community input.

SUMMARY: Consider following the Justice, Equity, Diversity, and Inclusion (JEDI) framework to integrate community input into the development and operation of the healthcare organization's climate resilience plan (American Public Health Association & CDC, 2021).

ACTION: Map patient populations who are sensitive to extreme heat.

SUMMARY: Collaborating with community partners to map patient populations who are sensitive to heat exposure, power outages, and other climate change-related hazards can increase community resilience and reduce patient surges during climate change-related events (Patel et al., 2022).

Element 2.2 Community Infrastructure



Electrical infrastructure can be compromised during extreme heat events because both power lines and transformers become less efficient when overheated. Power lines can sag, increasing the risk of electrical sparks. Electrical facilities that use water cooling can become less efficient when water temperatures rise. Increased community air conditioning demand during heat waves can further stress the system. The combination of less efficient power delivery and excessive demand increases the burden on community utilities and can lead to rolling blackouts and power outages. A modeling estimate of hourly individual heat exposure during historic heat wave events in three cities found that a concurrent multiday power outage would result in more than doubling of the rate of heat-related mortality across all three cities, and between 3% (Atlanta) and 50% (Phoenix) of the total urban population requiring medical attention for heat-related illness. Community cooling infrastructure such as street trees reduced the estimated number of excess emergency department (ED) visits by almost 70% in Atlanta and 8% in Phoenix. Converting all building roofs to cool roof materials (like light colors and vegetation) was estimated to reduce excess ED visits by 80% in Atlanta and 15% in Phoenix (Stone et al., 2023). Healthcare organizations can enhance resilience by supporting community programs that increase redundancy in local utilities, increase adaptive capacity in the home environment, and mitigate extreme heat exposure at the community level.

For example, the Houston Health Department worked with an environmental organization to create a novel community tree planting framework. The department integrated health with climate considerations to prioritize tree planting locations to mitigate the health effects of urban heat islands (Hopkins et al., 2022). Healthcare organizations can contribute to and refine frameworks such as these for community infrastructure investments: they can offer clinical expertise and inform the medical and psychosocial risk factors incorporated into the frameworks' health indicators.

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
[Element 2.2: Community Infrastructure]

People and Operations

ACTION: Support and direct patients to local programs that increase adaptive capacity in the home environment.

SUMMARY: Support and direct patients to local programs that increase the adaptive capacity of low-income residents and other high-risk groups (such as adults over 65 years of age). Examples are weatherization programs, air conditioning rebates and donations, community solar subscriptions, and utility assistance programs (e.g., Low Income Home Energy Assistance Program) (Patel, 2022).

Physical Infrastructure

ACTION: Work with local and regional partners to lower barriers to travel for patients and staff when transportation infrastructure is affected by extreme heat.

SUMMARY: Transportation infrastructure failures can prevent patients from traveling to healthcare facilities to receive necessary care. Healthcare organizations can support regional climate change resilience by working with local and regional partners to lower barriers to travel for patients and staff during climate change-related emergencies (WHO, 2020).

Climate Resilience Actions, continued

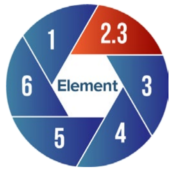
ACTION: Support protective measures that mitigate extreme heat exposure at the community level.

SUMMARY: Support protective measures that mitigate extreme heat exposure at the community level, such as increasing trees and greenspace, expanding and improving cooling centers, and using building materials that increase insulation and are more reflective of solar radiation (Casanueva, 2019).

ACTION: Catalyze the development of resilient infrastructure at the neighborhood and community level.

SUMMARY: Healthcare campuses and public health institutions, as anchor institutions, can catalyze neighborhood and community-scale efforts to increase resilience against extreme heat events (Pastor & Morello-Frosch, 2014; Hacke & Deane, 2017).

Element 2.3 Community Services



Partnering with community services to provide community-facing supports that reduce the risk of heat-related illness can benefit healthcare organization resilience by reducing the surge in demand for healthcare services during an extreme heat event. During power outages, individuals relying on medical equipment that requires electricity or who take medications requiring refrigeration, such as insulin, may turn to healthcare facilities for help.

For example, SWLA Center for Health Services, a Federally Qualified Health Center in Louisiana, launched a heat campaign in 2024. This campaign includes education tailored to patients with chronic health conditions (e.g., those with hypertension or heart disease who take diuretic medicines that may cause them to lose fluids rapidly on hot days). It also includes general patient information about using air conditioning and fans, staying properly hydrated, and promoting awareness of community cooling centers (HRSA, n.d.).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:

Element 2.3: Community Services

Planning

ACTION: Consider preemptive planning for patients who use electricity-dependent DME.

SUMMARY: Proactively plan for patients who rely on electricity-dependent durable medical equipment (DME) by ensuring they have a backup power source or an alternative in the event of power shutoffs during extreme weather events (Pacific ADA Center, 2017).

People and Operations

ACTION: Integrate community needs into healthcare organization heat emergency plans.

SUMMARY: Include provisions in the healthcare organization's heat emergency plan to accommodate community members who may seek to use the facility as a cooling center, and patients who require access to electrical power to charge their medical devices and/or refrigeration for their medications. Consider creating a registry of patients needing this kind of assistance and setting up a two-way communications protocol (such as a Reverse 911 or wireless emergency alert system (National Academies of Sciences, 2018)) to contact them in the event of a power outage (Patel et al., 2022).

ACTION: Coordinate with community partners to create a multi-sector protocol for the delivery of mental health services during and after heat waves.

SUMMARY: The mental health impact of heat waves can be significant. Healthcare organizations can engage in crisis response planning to support community partners in the public and private sectors in providing community support during and after heat waves (WHO, 2020).

ACTION: Collaborate with community partners to refer patients to programs that address risk factors for heat-related illnesses, such as housing or utility insecurity, and ensure safe discharge plans are implemented for at-risk populations during extreme heat events.

SUMMARY: Inadequate housing significantly contributes to heat-related illnesses. People experiencing housing insecurity and older adults living in homes without adequate cooling systems are at particularly high risk. By collaborating with community partners, healthcare

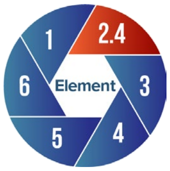
Climate Resilience Actions, continued

providers can refer patients to programs that address these health-related social needs before and during extreme heat events. This includes ensuring discharge plans incorporate home safety interventions, such as providing temporary shelter and enhancing the home environment with cooling solutions and weatherization improvements. These interventions can increase healthcare resilience in two ways: 1) they can reduce the risk of patient surge caused by new or recurrent illness; and 2) they can increase the resilience of individual patients through current and future heat events (Eisenman et al., 2016; Hacke & Deane, 2017; Hu et al., 2022).

ACTION: Fill gaps in local services to increase resilience, such as acting as a place of refuge during heat waves.

SUMMARY: Healthcare facilities equipped to continue operations during power outages can enhance local resilience by offering their facilities as refuges for community members during heat waves (Johns & Rosenthal, 2024; Toner et al., 2017).

Element 2.4 Coordination with Local Office of Emergency Management



Synchronizing a healthcare organization's heat emergency plan with peer organization plans, the local office of emergency management, and the local utility can improve the efficiency and coordination of emergency response during and after extreme heat events. Plan synchronization can also reveal gaps and redundancies that could impact the effectiveness of responders during an emergency and support the development of personal relationships across organizations and agencies – an important factor during emergency response.

For example, Miami Dade County's Climate and Heat Health Task Force includes healthcare professionals in addition to policy makers, scientific experts, and citizen members. The goal of the Task Force is to prioritize short-term actions, create a framework for prioritizing future actions, develop metrics to monitor progress, and recommend staffing and other resources needed to implement heat mitigation strategies (Miami-Dade County, n.d.). Collaborative efforts such as these can help ensure that healthcare organizations' heat resilience plans are coordinated with peer organizations, local governments, and community partners.

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 2.4: Coordination with Local Office of Emergency Management

Planning

ACTION: Periodically evaluate the roles and responsibilities of healthcare organizations and other partners in responding to extreme heat events.

SUMMARY: After-action reviews conducted under the auspices of the local office of emergency management offer an opportunity to revisit and revise (if needed) the roles and responsibilities of healthcare organizations during extreme heat events, particularly in regions where events are occurring more often, for longer durations, and at higher temperatures (Davies et al., 2019; Parker, 2020).

ACTION: Add local and regional climate change vulnerability assessments to the healthcare organization's emergency preparedness plan.

SUMMARY: Consider adding local and regional climate change vulnerability assessments to the healthcare organization's emergency preparedness plan to integrate projections of how the region's exposure to extreme heat events may change in coming decades compared with historical trends (Marinucci et al., 2014).

ACTION: Collaborate with local partners to coordinate heat and health messaging.

SUMMARY: It can be helpful to collaborate with local public health department partners to coordinate heat and health messaging with clinicians and patients, such as through prompts in the healthcare organization's electronic health record, e-newsletter, and patient texting system. This approach can increase community awareness of the risks associated with exposure to extreme heat (WHO, 2020).

Climate Resilience Actions, continued

People and Operations

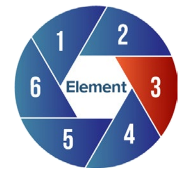
ACTION: Leverage healthcare facilities as intervention sites for local heat action plans.

SUMMARY: Healthcare organizations often offer their locations as community intervention sites for the local heat action plan. For example, allowing the Office of Emergency Management to use strategically located hospitals, medical office buildings, and clinics as distribution sites for water bottles, fans, and air conditioners can increase community access to health-promoting supplies. Officially designating publicly available spaces in healthcare facilities – such as the cafeteria – as cooling centers during extreme heat events can help support heat-sensitive patients and family members as well as raise awareness in the community that extreme heat events are public health emergencies (Hess et al., 2023).

ACTION: Coordinate heat-related syndromic surveillance with the local office of emergency management and the local weather station.

SUMMARY: It can be helpful to add heat-related illness to the healthcare organization's syndromic surveillance reports during and immediately following extreme heat events. Aligning the organization's protocol for collecting heat-related diagnostic data with the local office of emergency management and weather station's protocol for declaring a heat emergency will help to ensure that the organizational heat action plan deploys in coordination with local alerts (Hess et al., 2023).

Element 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 its effects in the form of a canceled clinical appointment, a power outage, or a flooded street. For example, some hospitals in the Pacific Northwest struggled to adequately cool their facilities during the 2021 heat dome, even as their emergency departments saw a surge of patients with heat-related illness. The increased temperatures inside their facilities strained key medical equipment (like imaging and radiation equipment) and directly impacted patient and staff thermal comfort (Hostetter & Klein, 2022). 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 constructing and maintaining efficient buildings that can continue to operate during power and water outages. Healthcare organizations can also develop resilient supply chains and storage conditions for food and medical supplies that require constant refrigeration. Designed and operated with heat resilience in mind, healthcare facilities can serve a 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 in which 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 healthcare demand – for both heat-related illness and all-cause morbidity and mortality. 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:** 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 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.

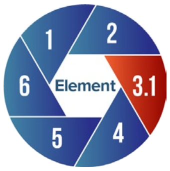
3.4 **Building and Campus – Facility Operations:** Healthcare facilities are vulnerable to power outages because they rely on regional electrical grids, water systems, and energy sources, like natural gas, to operate building systems that are critical to patient care and occupant safety, such as: lighting, 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 continuous access to food service, clean water, laundry, and custodial services.

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.

Resilience Strategies:
Extreme Heat

CR4HC

Element 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. An analysis of Canadian news articles about the 2021 heat dome revealed reports of physical and mental health symptoms in paramedics responding to heat-related illness calls (Tetzlaff et al., 2023).

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.

For example, Stony Brook University Hospitals' climate resilience plan includes provisions for staff accommodations, transportation assistance, access to medications, childcare and elder care, and psychological support (Stony Brook Medicine, 2023).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 3.1: Staff Support

Planning

ACTION: Set staff expectations for their role during extreme heat events.

SUMMARY: Clearly define expectations with healthcare facility staff related to working during extreme heat events – particularly under circumstances that lead to power disruptions or outages, and those that may require staff to remain at work for extended periods. Share with staff a list of personal items they should bring with them to an anticipated multi-day response effort, such as food, water, personal medication, hand sanitizer, extra clothes, and sleeping gear. Co-create policies and programs with staff establishing a flexible and supportive approach to staffing, accommodations, and transportation during and after disasters. For example, it may be necessary to shorten staff shifts during emergency operations to give staff the ability to rest mentally and physically. Include daycare, shelter, and other accommodations for staff family members, as needed (Danna et al., 2010; Toner et al., 2017; WHO, 2020).

People and Operations

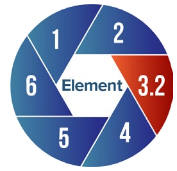
ACTION: Provide alternative transportation and housing for healthcare staff when needed during extreme heat events.

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 heat event (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 extreme weather 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).

Element 3.2 Clinical Considerations



Extreme heat events can cause a surge in healthcare demand – for both heat-related illness and all-cause morbidity and mortality. Records from the CDC indicate that within an average year, 9,235 people are hospitalized and 67,512 emergency department visits occur in the United States 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 in the appendix:
[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: Develop a continuity of care plan listing essential clinical services that will be provided at different tiers of utility disruption.

SUMMARY: Many healthcare facilities are designed to function at full or partial capacity under a variety of environmental stressors. Organizations can increase resilience to extreme heat events by creating and training staff to implement a continuity of care plan outlining essential clinical services that will be provided at different tiers of utility disruption (Toner et al., 2017).

ACTION: Enhance heat preparedness by adding heat-related illness screening to the healthcare organization's EMR system.

SUMMARY: Consider including in the healthcare organization's heat resilience and preparedness plan a protocol for activating heat-related illness screening questions in the electronic medical record (EMR) 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).

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 (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. Work 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: Recognize the unique needs of at-risk populations in the community during extreme heat events.

SUMMARY: During extreme heat events, pay special attention to the unique clinical needs of at-risk groups, including children, the elderly, and individuals with certain medical conditions and medications. For example, alcohol and drugs can impair judgment and reduce the ability to notice temperature changes, increasing the risk of dehydration and heat-related injury. Additionally, individuals with mental health issues may not fully understand or prepare for the dangers of extreme heat, while those who are unhoused or have lower incomes might have inadequate shelter or protective clothing (Hess et al., 2023).

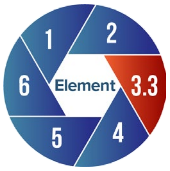
Physical Infrastructure

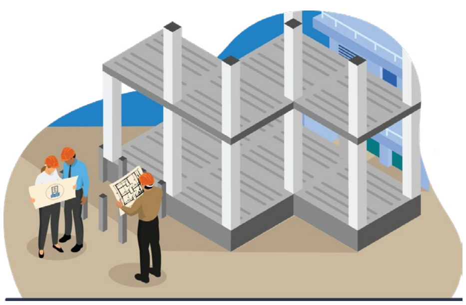
ACTION: Deploy mobile health units to take medical care to high-risk patients in the community during prolonged extreme heat events.

SUMMARY: Consider including in the healthcare organization's list of emergency response assets mobile units that are used to deliver routine care to community members. Use the organization's map of high-risk patients – such as patients who need dialysis or those with a substance use disorder, diabetes, or heart disease – (Element 2.1) to prioritize the provision of medical care during extended extreme heat events (Toner et al., 2017).

Resilience Strategies: Extreme Heat

Element 3.3 Building and Campus: Design & Construction





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.

For example, Valley Children's Hospital, in Madera, California, is installing a solar microgrid, fuel cell, and battery storage system that will help to ensure that the hospital remains operational during regional power outages. Regional power outages are common during heat waves due to increased air conditioning use and due to transmission line sparks starting wildfires, which, in turn, can disrupt power generation and transmission over large areas of the state. Valley Children's renewable energy microgrid system will decrease the hospital's greenhouse gas emissions and increase its resilience to power outages (U.S. HHS OCCHE, 2023).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 3.3: Building and Campus: Design & 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 heat waves.

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

Climate Resilience Actions, continued

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 & Chan, 2017).

Physical Infrastructure

Structure and Landscaping

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 safety for patients and staff (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., 2023).

Energy Efficiency and Renewable Energy

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).

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.

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

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: 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: 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

Climate Resilience Actions, continued

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 reduces 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).

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).

Element 3.4 Building and Campus: Facility Operations

Healthcare facilities are vulnerable to power outages because they rely on regional electrical grids, water 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 continuous 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).

For example, Spaulding Rehabilitation Hospital, in Boston, Massachusetts, installed operable windows as part of its power resilience strategy (read Spaulding's case study in this toolkit). In addition, CommonSpirit's Dignity Health California Hospital Medical Center, in Los Angeles, California, conducted an extreme heat drill that led to the remediation of infrastructure vulnerabilities. Remediation included (1) upgrading backup generators, (2) enhancing energy efficiency strategies, and (3) installing on-site sources of alternative energy to ensure consistent temperature control on patient care floors during power outages.

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
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 enhance 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 information technology 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).

Climate Resilience Actions, continued

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 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 demands 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).

Element 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.

For example, during the heat wave that coincided with a prolonged power outage in New Orleans following Hurricane Ida in 2021, CrescentCare Community Health Center lost over $250,000 in refrigerated medicines and vaccines. Following this event, CrescentCare installed a solar microgrid with a backup battery system that will help to ensure that the health center can remain operational during natural disasters and power outages (Walker, 2023).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
[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 medical supply storage into resilience planning.

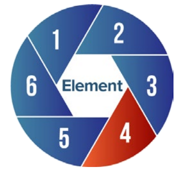
SUMMARY: Consider how your organization's prospective risk assessment of extreme winter weather (Element 1) might lead to supply chain disruptions and/ or changing needs. Maintain an adequate supply of medical supplies, particularly for products that are most vulnerable to weather-related disruptions in transportation routes (Hedges et al., 2018). Consider separating emergency supplies into two categories: high volume medical supplies (such as intravenous bags, sharps, and oxygen) and equipment/supplies that would only be needed during a disaster. Establish a timeline for activating the supply chain plan ahead of the anticipated climate change-related event. Include in the timeline when a comprehensive check of both types of inventory should take place and when normal deliveries should be suspended (Maslanka & Hurwitz, 2022).

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).

Element 4. Collaboration Between Healthcare Organizations



The shifting landscape of patient surges, rolling brownouts and blackouts, and surges in nonclinical demands on healthcare institutions during extreme heat events can stress a healthcare facility's ability to provide high quality clinical care. Sharing information and resources across the full range of regional healthcare providers during an extreme heat event can increase resilience both at the facility level and system-wide.

For example, the Greater New York Hospital Association, a trade association representing 55 hospitals in New York City, acts as a conduit for sharing real-time information between area hospitals and the local office of emergency management during emergency responses. They also host a dashboard called SitStat that is used by around 140 hospitals and over a dozen city and state agencies to share information about the operational capabilities and needs of area facilities during events so that support and resources can be distributed to facilities that are at or exceeding capacity (Patel et al., 2022). Given the importance of minimizing the time that sensitive patients are exposed to excessive heat, these kinds of collaborations can help direct patients to the closest facility with capacity to meet their needs.

Climate Resilience Actions

Tools and resources relevant to these actions can be found at:
[Element 4: Collaboration Between Healthcare Organizations]

Planning

ACTION: Enhance healthcare organization preparedness for extreme heat events through mutual aid MOU.

SUMMARY: A mutual aid memorandum of understanding (MOU) with other healthcare providers in the region that includes the results of a prospective risk assessment (Element 1) can help prepare for circumstances that require patient transfers or referrals – such as utility outages, patient surges, etc. It is important to address legal and reimbursement challenges that can limit a facility's ability to quickly and efficiently transfer patients and/or supplies to other facilities in the region. Consider working with CMS and other healthcare organizations in the region to fill in those gaps over time using an all-hazards approach (U.S. HHS, 2014; Patel et al., 2022).

ACTION: Exchange epidemiological data and health assessments related to extreme heat events with other healthcare organizations and the local health department.

SUMMARY: Exchanging epidemiological data and health assessments related to extreme heat events with other healthcare organizations and the local health department can support regional resilience planning efforts. Use these conversations to jointly develop protocols for identifying emerging climate-related health threats in the region, collecting and disseminating data, and coordinating emergency response across the range of facility types in the regional health system – including acute care hospitals, community clinics, and long-term care facilities (Patel, 2022).

ACTION: Work with other regional healthcare organizations to develop integrated patient evacuation plans.

SUMMARY: Healthcare organizations can increase their resilience as well as regional resilience by working together to develop integrated emergency evacuation plans. Consider contingency plans to address damage to a facility's structure, exposure to contaminated air and/or water damage, power and water outages, destruction of electronic medical records, and infrastructure failures. Contingency plans may involve transferring patients to

Climate Resilience Actions, continued

alternate facilities or establishing temporary medical sites in safer areas (Patel, 2022).

ACTION: Create plans to ensure outpatients receive necessary care during extreme heat events.

SUMMARY: Create contingency plans in coordination with regional healthcare partners to ensure that individuals with chronic medical conditions – who are at high risk due to potential interruptions in medication administration or outpatient care – have access to alternative arrangements if their usual care becomes unavailable or inaccessible (WHO, 2020).

ACTION: Perform joint disaster preparedness exercises and drills with other local healthcare organizations, the local health department, and the local office of emergency management.

SUMMARY: Joint disaster preparedness exercises and drills can help healthcare organizations test their readiness for heat waves (as well as simultaneous and cascading events), identify areas for improvement in their emergency response plans, and build working relationships with other first responders. Including representation from multiple institutions and professions in the exercise can also help identify emerging at-risk populations who are projected in climate models to require more protection and/or resources as heat waves begin to occur more frequently and/or with greater severity (WHO, 2020; ASPR, 2024).

People and Operations

ACTION: Establish effective communication channels to share real-time information across healthcare organizations during heat waves.

SUMMARY: Consider working with other healthcare organizations and entities in the region to establish effective real-time communication channels with one another and the public during extreme heat events. Examples of critical information that can be shared in this way include guidance for at-risk populations to prevent heat-related illness, and information about emergency cooling center locations (CDC, 2003; California Department of Public Health, 2022).

ACTION: Collaborate with regional healthcare organizations on public health education and outreach programs.

SUMMARY: Healthcare institutions can collaboratively develop and disseminate public health education and outreach programs so that the community receives a consistent and coordinated message about heat-related illness, protective behaviors, and access to resources such as healthcare services (California Department of Public Health, 2022).

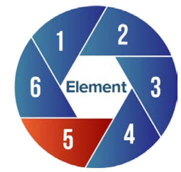
ACTION: Consider proactively credentialing neighboring healthcare facility staff to help execute the healthcare organization's emergency preparedness protocol.

SUMMARY: Proactively credentialing staff at neighboring healthcare facilities to prepare for emergencies can contribute to backup care if one facility is unable to provide care due to extreme heat-related utility interruptions (WHO, 2020).

ACTION: Share resources and coordinate personnel during extreme heat events.

SUMMARY: Collaboration between response organizations may involve sharing critical resources and coordinating the deployment of personnel to support impacted communities in areas of greatest need (Patel, 2022). Consider integrating the results of the organization's prospective risk assessment (Element 1) into planning conversations to funnel resources to new and emerging at-risk populations related to the changing climate.

Element 5. Interdisciplinary Planning, Oversight, and Evaluation



Planning for heat resilience requires an interdisciplinary team and coordination across a range of critical functions, including administration, emergency management, information technology, facility operations (e.g., power, water, waste disposal, food service, custodial services, etc.), communications, transportation, and purchasing. It is important to engage staff and community members early in the process of developing the heat resilience plan, both to raise awareness about the interconnected nature of heat exposure on clinical care, facilities operations, and community infrastructure and to seek input from all key stakeholder groups about which interventions should be prioritized.

Aligning facilities operations, procurement, and capital expenditures to balance climate change mitigation (i.e., reducing greenhouse gas emissions) goals and resilience goals can help the organization chart a climate-positive and cost-neutral path towards heat resilience, because facilities will experience less heat stress while simultaneously using less energy and water, operating at a lower risk of evacuating patients due to unsafe indoor temperatures when the power goes out.

During the 2021 heat dome in Seattle, area hospitals experienced significant and cascading impacts on their emergency departments, staff, and operations. Following this event, the Northwest Healthcare Response Network began treating anticipated heat waves as critical events and reviewing facilities' levels of preparedness sooner. Interdisciplinary evaluation of the 2021 heat dome's impacts resulted in area healthcare organizations' increased readiness to invest in chillers and mitigate infrastructure risk. Lessons learned from the 2021 heat dome resulted in a more proactive, interdisciplinary, and regional approach to heat preparedness that improved regional health systems' preparedness and response to another heat dome that occurred the following year (ASPR TRACIE, n.d.a.).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 5: Interdisciplinary Planning, Oversight, and Evaluation

Planning

ACTION: Incorporate long-term goals and climate projections into healthcare extreme heat planning and response plans.

SUMMARY: Integrating long-term, interdisciplinary strategic goals into the healthcare organization's extreme heat emergency preparedness and response plans, including community input as outlined in the Justice, Equity, Diversity, and Inclusion (JEDI) framework, can be helpful (American Public Health Association & CDC, 2021).

ACTION: Implement surveillance and interdisciplinary after-action reviews into organizational heat action plans.

SUMMARY: Incorporate building surveillance and interdisciplinary after-action reviews into the healthcare organization's heat action plan. These measures will help identify and evaluate the elements of the plan that worked during a recent event; assess whether changing climatic conditions might have influenced aspects of the event (such as its severity); and inform changes to the parts of the plan that did not meet expectations (Davies et al., 2019; Hess et al., 2023; Parker, 2020).

Resilience Strategies:
Extreme Heat

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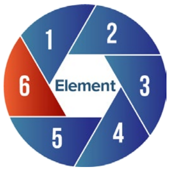
Element 6. Communications and All-Hazards Approach



Extreme heat events often occur simultaneously or in quick succession with other climate change-related hazards, such as drought, wildfire, hurricanes, and flooding. Multi-hazard events increase the risk of multiple system failures at the community scale (such as disruptions to the water and power utilities) and can result in both direct and indirect harm to population health. Repeated patient surges and cascading infrastructure failures both in the community and within healthcare facilities can temporarily disrupt the entire healthcare system in a region. Fortunately, many policy, infrastructure, and communications interventions can increase organizational resilience to more than one climate-related hazard. This is particularly true if emergency management and climate resilience planners use an all-hazards approach to designing, implementing, and testing proposed interventions.

For example, Detroit, Michigan, developed a Heat Health Warning System in 2008. The city has made special efforts to reach populations at risk for heat-related illness using tailored protective messaging and wellness checks. The city leverages multiple networks to connect with these populations, with the goal of protecting residents from multiple hazards. A "Gatekeeper Program" involves utility service providers going out into the field to provide assistance to customers. If these gatekeepers see that an older adult is in danger, they alert the Detroit Area Agency on Aging. In Southwest Detroit, which is a predominantly Hispanic community, non-governmental organizations have developed processes to help homeless people and new immigrants during extreme temperature events. Community Emergency Response Team members, citizens trained to prepare for and respond to emergencies and natural disasters, engage residents in the prevention of heat-related illness (White-Newsome et al., 2014).

Link to the Fifth National Climate Assessment, Chapter 18, for more information.

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 6: Communications and All-Hazards Approach

Planning

ACTION: Use simultaneous disasters as an opportunity for education about the co-benefits of taking an all-hazards approach to resilience.

SUMMARY: Simultaneous and cascading disasters can be opportunities to educate the community, staff, and emergency management partners about the value associated with using a co-benefit approach to risk assessment, emergency planning, emergency response, and rebuilding efforts (National Academies of Sciences, 2022).

ACTION: Collaborate with local partners to coordinate heat and health messaging.

SUMMARY: It can be helpful to collaborate with local public health department partners to coordinate climate-related hazard messaging with clinicians and patients, such as through prompts in the healthcare organization's electronic health record, e-newsletter, and patient texting system. This approach can increase community awareness of the health risks associated with extreme heat exposure (WHO, 2020).

People and Operations

ACTION: Broadcast heat alerts using culturally appropriate language and communication pathways.

SUMMARY: Broadcasting alerts about heat vulnerability and protective behaviors to patients, staff, and community partners using culturally appropriate language and

Climate Resilience Actions, continued

communication pathways can help amplify the local public health department and office of emergency management's communication efforts (Hasan et al., 2021; O'Neill et al., 2009).

ACTION: Establish two-way communication systems with at-risk patient populations.

SUMMARY: Implementing two-way communication systems like reverse 911 and wireless emergency alerts (National Academies of Sciences, 2018) can aid in connecting sensitive populations with protective measures before extreme winter weather occurs and directing them to community services during the event. With the assistance of community groups and local health departments, designated community leaders can deliver culturally-sensitive messages. These messages would inform residents about safeguarding themselves and their neighbors and provide guidance on actions to take if they experience health harms (Steinberg & Sprigg, 2016; Toner et al., 2017).

Climate Resilience for Health Care: Extreme Winter Weather

Impact of Extreme Winter Weather on Healthcare Organizations

Extreme winter weather can include extreme cold temperatures, blizzards, and ice storms. These events can damage healthcare and community infrastructure by freezing pipes, which can burst and cause flooding. Melted snow and the aftermath of flooding in buildings can cause moisture damage and mold. Roofs and power lines can buckle under the weight of snow and ice, and communication systems can be disrupted. High winds can cause flying debris and damage to buildings. Hazardous travel conditions can affect the delivery of supplies and impede staff and patients' access to healthcare facilities.

Exposure to extreme cold can cause health harms, including hypothermia and frostbite. Icy conditions can cause injury from falls and traffic accidents, and can prevent access to necessities such as food, medications, and medical care. Power disruptions can increase the risk of exposure to dangerous temperatures and put at risk those who rely on electricity-dependent durable medical equipment. The improper use of generators and gas stoves for warming homes can pose risks of carbon monoxide poisoning.

These overlapping challenges – a potential surge in demand for care, damage to buildings and roads, and utility and supply chain disruptions – can stress healthcare operations.

Important Considerations

Health Effects of Extreme Winter Weather: Injury (from falls and accidents), hypothermia, frostbite, carbon monoxide poisoning (from generators or stoves used for warming)

Populations at Risk: Older adults (especially those who live alone), infants and children, people with disabilities, low-income populations, people with housing instability and homelessness, outdoor workers

Risks to Facility Operations: Storage of medications and clinical supplies, supply chain disruption, patient surge, prolonged power outage, disrupted communication systems

Infrastructure Risk: Damage to buildings from debris, snow, or ice; flooding from burst pipes

Elements of a Climate-Resilient Healthcare Organization: Extreme Winter Weather

The following six elements characterize a winter weather-resilient healthcare organization. Review each element section to explore it in more detail.

1. Prospective Risk Assessment

Warming polar temperatures due to climate change are weakening and disrupting the polar vortex, a spinning mass of cold air in the atmosphere above the North Pole (Mostafiz et al., 2020). This phenomenon can contribute to extreme cold weather events and winter storms in areas of the continental United States, such as Texas (during Winter Storm Uri in 2021), that are unaccustomed to extreme cold. Climate change can also affect precipitation patterns.

Incorporating a forward-looking approach to extreme cold and winter weather risk assessment allows healthcare organizations to enhance infrastructure and emergency preparedness plans to prepare for these evolving extreme winter weather patterns.

2. Health Equity and Community Engagement

Extreme winter weather can be especially hazardous to the health of people who lack adequate housing, heating, and mobility resources. Healthcare organizations can integrate health equity into their emergency preparedness plans by identifying and supporting vulnerable populations during extreme winter weather (U.S. HHS, 2021). CDC provides resources for integrating health equity into emergency preparedness plans, and emphasizes the importance of focusing on vulnerable populations during extreme weather events (CDC, 2024 c.).

3. Assessment and Remediation of Vulnerabilities in Infrastructure and Operations

Many of the actions that healthcare organizations can take to avoid disruption in clinical care during extreme winter weather involve building resilience and redundancy into their facility design and operations. These practices include (1) building and maintaining highly insulated, energy and water efficient buildings that can continue to operate during utility outages; (2) designing resilient supply chains and storage conditions for food and medical supplies; and (3) making plans to protect, house, and possibly provide transportation for staff and their families when roads are impassable due to snow and ice accumulation.

4. Collaboration Between Healthcare Organizations

The shifting landscape of patient surges and surges in nonclinical demands on healthcare institutions during extreme cold events and winter storms can stress a healthcare facility's ability to provide high-quality clinical care. Sharing information and resources across the full range of regional healthcare providers during an extreme cold event can increase resilience both at the facility level and system-wide.

5. Interdisciplinary Planning, Oversight, and Evaluation

Extreme cold and winter storm resilience requires coordination across various critical dependencies within healthcare organizations, that impact clinical care, facilities operations, and community infrastructure. An interdisciplinary approach involving early engagement with staff and community members can enhance awareness and prioritize interventions for cold resilience planning. Aligning operations with climate goals ensures efficient use of resources and minimizes damage during extreme cold events (WHO, 2020).

6. Communications and All-Hazards Approach

Multi-hazard events increase the risk of multiple system failures at the community scale (such as disruptions to water and power utilities) and can result in both direct and indirect harm to population health. Repeated patient surges and cascading infrastructure failures both in the community and within healthcare facilities can temporarily disrupt the entire healthcare system in a region.

Fortunately, many policy, infrastructure, and communications interventions can increase organizational resilience to more than one climate-related hazard. This is particularly true if emergency management and climate resilience planners use an all-hazards approach to designing, implementing, and testing proposed interventions. By adopting an all-hazards approach, healthcare organizations can improve communication and coordination during extreme cold events, ensuring effective responses to a wide range of emergencies.

Resilience Strategies:
Extreme Winter Weather

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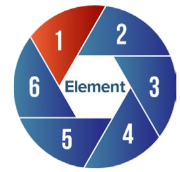
Element 1. Prospective Risk Assessment



Warming polar temperatures due to climate change are weakening and disrupting the polar vortex, a spinning mass of cold air in the atmosphere above the North Pole (Mostafiz et al., 2020). This phenomenon can contribute to extreme cold weather events and winter storms in areas of the continental United States, such as Texas (during Winter Storm Uri in 2021), that are unaccustomed to extreme cold. Climate change can also affect precipitation patterns. For example, the State of Wisconsin's 2021 Threat and Hazard Identification and Risk Assessment projected that the trend of higher winter temperatures attributed to climate change would result in increased amounts of rain, as well as more freezing rain, during winter months (Lindsey, 2021).

Incorporating a forward-looking approach to extreme cold and winter weather risk assessment allows healthcare organizations to enhance infrastructure and emergency preparedness plans to prepare for these evolving extreme winter weather patterns.

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
[Element 1: Prospective Risk Assessment]

Planning

ACTION: **Add a prospective risk assessment and impact forecasting to the local winter storm mitigation plan.**

SUMMARY: It can be helpful to work with public health and local emergency management partners to add a prospective risk assessment (Ponce et al., 2014). and impact forecasting to plans for managing extreme cold and winter storms (Merz et al., 2020).

Element 2. Health Equity and Community Engagement

Extreme winter weather can be especially hazardous to the health of people who lack adequate housing, heating, and mobility resources. During the 2021 winter storm in Texas, low-income and minority communities faced prolonged power outages and greater challenges accessing essential services (Lee et al., 2022). Healthcare organizations can integrate health equity into their emergency preparedness plans by identifying and supporting vulnerable populations during extreme winter weather (U.S. HHS, 2021). CDC provides resources for integrating health equity into emergency preparedness plans, that emphasizes the importance of focusing on vulnerable populations during extreme weather events (CDC, 2024 c.).

The following sub-elements describe specific ways a healthcare organization can integrate health equity and community engagement into their extreme winter weather planning.

2.1 Community Input: Frameworks like social determinants of health and vulnerability assessments can help to identify populations who may be at higher risk of negative health outcomes during and after extreme cold and winter storms (U.S. HHS, n.d.). Seeking community input can be helpful for refining and validating these assessments and for clarifying which services – either on campus or in the community – would be most helpful to reduce the risk of negative population health outcomes.

Healthcare organizations can also play a role in referring patients to resources to mitigate housing and utility-related risks, and partner with community organizations to effectively deliver protective messaging to at-risk populations.

2.2 Community Infrastructure: Extreme cold can strain electrical systems and increase demand for heat, causing rolling blackouts and infrastructure damage, that disproportionately impact low-income communities. Heavy snow can down trees and damage power lines, leading to power outages, particularly in areas unaccustomed to severe winter weather. Accumulated snow and ice can make roads, bridges, and rail lines impassable, and ground airplanes.

Healthcare organizations can support vulnerable populations during extreme cold events by enhancing healthcare infrastructure resilience, referring patients to utility assistance programs to help ensure reliable heating, and providing resources and education on safe heating methods to prevent fires and carbon monoxide exposure (FEMA, 2020).

2.3 Community Services: Partnering with community services can enhance healthcare resilience during extreme cold events by preventing surges in patients seeking care and community members seeking shelter. Power outages can place individuals reliant on medical equipment or refrigerated medications at risk of negative health outcomes (Klinger et al., 2014). Healthcare organizations can support these patients' ability to remain safely in their homes during extreme winter weather events by connecting them with community-based organizations that provide access to backup power equipment, contingency plans, emergency transportation, and other services.

Extreme cold events can also disrupt food distribution. Healthcare organizations can collaborate with community assistance programs to help ensure that at-risk patients have access to food and water during and after winter storms (Tchonkouang et al., 2024).

2.4 Coordination with Local Office of Emergency Management: Coordination with local emergency management is vital for aligning healthcare plans with regional emergency strategies and ensuring a seamless response to disasters, including winter storms and extreme cold events.

Resilience Strategies: Extreme Winter Weather

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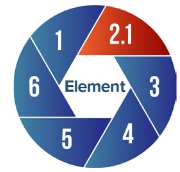
Element 2.1 Community Input



Frameworks like social determinants of health (SDOH) and vulnerability assessments can help to identify populations who may be at higher risk of negative health outcomes during and after extreme cold and winter storms (U.S. HHS, n.d.). Seeking community input can be helpful for refining and validating these assessments and for clarifying which services – either on campus or in the community – would be most helpful to reduce the risk of negative population health outcomes.

For example, following the severe blizzard in Buffalo, New York in 2022, important lessons learned came from feedback from community leaders and residents of neighborhoods where disproportionate health harms were clustered during and following the storm (Kaufman et al., 2023). These community members reported disparities in road plowing services, 911 response times, pre-existing housing and utility insecurity, and access to communication channels used by the city's emergency managers (Kaufman et al., 2023). Healthcare organizations can play a role in referring patients to resources to mitigate housing and utility related risks, and partner with community organizations to effectively deliver protective messaging to at-risk populations.

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 2.1: Community Input

Planning

ACTION: Map patient populations who are sensitive to extreme winter weather.

SUMMARY: Collaborating with community partners to map patient populations who are at high risk of negative health outcomes after short-term and/or long-term exposure to extreme winter weather can increase organizational and community resilience by helping to ensure that protocols supporting healthcare access during winter storms are tailored to those populations' needs (Patel et al., 2022).

ACTION: Connect at-risk communities to heating resources during cold weather.

SUMMARY: Collaborating with community partners to connect at-risk individuals, such as those experiencing homelessness, with available resources, like shelters and financial assistance for heating, can reduce the risk of an extreme winter weather event resulting in a patient surge at local healthcare facilities (Steinberg & Sprigg, 2016).

ACTION: Use the JEDI framework to structure community input.

SUMMARY: Consider following the Justice, Equity, Diversity, and Inclusion (JEDI) framework to integrate community input into the development and operation of the healthcare organization's climate resilience plan (American Public Health Association & CDC, 2021).

Resilience Strategies:
Extreme Winter Weather

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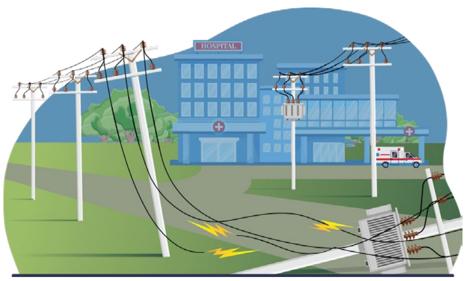
Element 2.2 Community Infrastructure



Extreme cold can strain electrical systems and increase demand for heat, causing rolling blackouts and infrastructure damage, that disproportionately impact low-income communities. Heavy snow can down trees and damage power lines, leading to power outages, particularly in areas unaccustomed to severe winter weather. Accumulated snow and ice can make roads, bridges, and rail lines impassable, and ground airplanes.

Healthcare organizations can support vulnerable populations during extreme cold events by enhancing healthcare infrastructure resilience, referring patients to utility assistance programs to help ensure reliable heating, and providing resources and education on safe heating methods to prevent fires and carbon monoxide exposure (FEMA, 2020).

For example, Community Care Alliance, a Community Action Program Agency and Community Behavioral Health Clinic, opened a warming center called Safe Haven in Woonsocket, Massachusetts, and collaborated with local organizations to place behavioral health staff in community emergency warming centers (Community Care Alliance, n.d.).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
[Element 2.2: Community Infrastructure]

People and Operations

ACTION: Support and direct patients to local programs that increase adaptive capacity in the home environment.

SUMMARY: Connect low-income residents and other high-risk groups (like those over 65 and those with chronic illness) with programs that can help them prepare for and recover from extreme winter weather (Patel et al., 2022). Examples include weatherization programs to improve their home's insulation, heating system rebates and donations, the Low-Income Home Energy Assistance Program, community solar programs, provisions for backup generators or charged batteries for medical equipment, and emergency preparedness workshops.

Physical Infrastructure

ACTION: Catalyze the development of resilient infrastructure at the neighborhood and community level.

SUMMARY: As anchor institutions, healthcare campuses and public health institutions can catalyze neighborhood and community-scale efforts to increase resilience against winter weather events. Examples include weatherizing utility infrastructure, supporting multiple modes of transportation, tree trimming programs around power lines, and neighborhood microgrids (Pastor & Morello-Frosch, 2014; Hacke & Deane, 2017).

ACTION: Ensure communities are prepared for ice and snow accumulation.

SUMMARY: Support community programs designed to ensure snow removal and the electricity and water restoration are equitably implemented community-wide (FEMA, 2020).

ACTION: Support protective programs that mitigate extreme winter weather exposure at the community level.

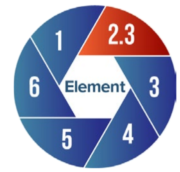
SUMMARY: Support protective measures that mitigate winter storm and cold exposure at the community level, such as expanding and improving warming centers and establishing portable heater distribution programs (Casanueva, 2019).

Climate Resilience Actions, continued

ACTION: Work with local and regional partners to lower barriers to travel for patients and staff during winter storms.

SUMMARY: Transportation infrastructure failures can prevent staff from reporting to work and patients from traveling to healthcare facilities to receive needed care during winter storms. Healthcare organizations can support regional climate change resilience by working with local and regional partners to lower barriers to travel (WHO, 2020). For example, limited public transit service could be offered to patients and essential workers, and medical workers could be granted priority access to gas stations (U.S. HHS, 2014).

Element 2.3 Community Services



Partnering with community services can enhance healthcare resilience during extreme cold events by preventing surges in patients seeking care and community members seeking shelter. Power outages can place individuals reliant on medical equipment or refrigerated medications at risk of negative health outcomes (Klinger et al., 2014). Healthcare organizations can support these patients' ability to remain safely in their homes during extreme winter weather events by connecting them with community-based organizations that provide access to backup power equipment, contingency plans, emergency transportation, and other services.

Extreme cold events can also disrupt food distribution. Healthcare organizations can collaborate with community assistance programs to help ensure that at-risk patients have access to food and water during and after winter storms (Tchonkouang et al., 2024).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 2.3: Community Services

Planning

ACTION: **Consider preemptive planning for patients who use electricity-dependent DME.**

SUMMARY: Proactively help patients who rely on electricity-dependent durable medical equipment (DME) to ensure they have a backup power source or another contingency plan in the event of power shutoffs during an extreme winter weather event (Pacific ADA Center, 2017).

ACTION: **Partner with local EMS providers to convey guidance to patients in the community about ways to increase their resilience to extreme winter weather.**

SUMMARY: Coordinate with Emergency Medical Services (EMS) providers to identify patients who are at highest risk during extreme winter weather events. This may involve gathering neighborhood information about the average age of residents, age of housing, type of heating system, priority for the local weatherization program, heating assistance usage rate, frequency of power outages, proportion of renter-occupied homes, neighborhood average income, and percent of the population with access to a car. Help EMS identify patients who require evacuation or who rely on critical medical equipment that may be compromised during a cold weather-related power outage. Provide resources to support patients who could remain at home rather than travel to healthcare facilities for treatment (O'Meara et al., 2016).

ACTION: **Work with partners to educate community members about cold-related symptoms and protective actions.**

SUMMARY: Work with community-based organizations and faith-based organizations to engage and educate community members about the symptoms of hypothermia, frostbite and frostnip, and simple measures for prevention of cold-related illness to improve community baseline preparedness for winter weather events (Conlon et al., 2011).

People and Operations

ACTION: **Integrate community resilience needs into healthcare organization emergency management plans.**

SUMMARY: Include provisions in the healthcare organization's winter weather emergency plan to accommodate community members who may seek to use

Climate Resilience Actions, continued

the facility as a refuge and patients who require access to electrical power to charge their medical devices and/or refrigeration for their medications. Consider creating a registry of patients needing this kind of assistance and setting up a two-way communications protocol (such as a Reverse 911 or wireless emergency alert system (National Academies of Sciences, 2018) to contact them in the event of a power disruption or outage (Patel et al., 2022).

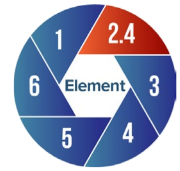
ACTION: Collaborate with community partners to refer patients to programs that address risk factors for cold-related illnesses, such as housing or utility insecurity, and ensure safe discharge plans are implemented for at-risk populations during extreme winter weather events.

SUMMARY: Inadequate housing significantly contributes to cold-related illnesses. People experiencing housing insecurity and older adults living in homes without adequate insulation and heating systems are at particularly high risk. By collaborating with community partners, healthcare providers can refer patients to programs that address these health-related social needs before and during extreme winter weather events. This includes ensuring discharge plans incorporate home safety interventions, such as providing temporary shelter and enhancing the home environment with heating solutions and weatherization improvements. These interventions can increase healthcare resilience in two ways: 1) they can reduce the risk of patient surge caused by new or recurrent illness; and 2) they can increase the resilience of individual patients through current and future extreme winter weather events (Eisenman et al., 2016; Hacke & Deane, 2017; Hu et al., 2022).

ACTION: Fill gaps in local services to increase resilience, such as acting as a place of refuge during extreme winter weather events.

SUMMARY: Healthcare facilities equipped to continue operations during power outages can enhance local resilience by offering their facilities as refuges for community members during extreme winter weather events (Johns & Rosenthal, 2024; Toner et al., 2017). For example, in periods of extreme cold, counties in Pennsylvania declare a Code Blue and offer expanded services to those without adequate shelter, including at healthcare facilities, and work with community teams to reach those experiencing homelessness (Project Home, 2022; Office of Homeless Services, n.d.). It is important to formalize this role with the Office of Emergency Management ahead of the event so that the facility receives extra fuel, supplies, and staff to manage non-medical emergency services (U.S. HHS, 2014).

Element 2.4 Coordination with Local Office of Emergency Management



Coordination with local emergency management is vital for aligning healthcare plans with regional emergency strategies and ensuring a seamless response to disasters, including winter storms and extreme cold events.

For example, following the 2022 blizzard in Buffalo, New York, healthcare organizations and local emergency managers coordinated to prioritize access to healthcare facilities and pharmacies when planning road maintenance, clearance of disabled vehicles, and snow removal. Healthcare organizations, such as the Hospital & Health System Association of Pennsylvania, have identified coordinated efforts such as this as a key element of winter storm preparation (NYS DHSES, 2023; Linse, 2023).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
[Element 2.4: Coordination with Local Office of Emergency Management]

Planning

ACTION: Collaborate with local partners to coordinate extreme winter weather messaging.

SUMMARY: It can be helpful to collaborate with local public health department partners to coordinate winter weather-related messaging with clinicians and patients, such as through prompts in the healthcare organization's electronic health record, e-newsletter, and patient texting system. This approach can increase community awareness of both the short- and long-term health risks associated with exposure to extreme winter weather (WHO, 2020).

ACTION: Formalize cooperation agreements with utility providers (both power and water) to ensure that the healthcare organization's facilities are integrated into local emergency management and climate resilience planning efforts.

SUMMARY: Critical facilities, hospitals, and other healthcare building types should be fully integrated into local utilities' emergency management and climate resilience planning efforts. It is particularly important to include facility power and water needs in emergency preparedness and climate resilience planning efforts to ensure that they can continue to provide care during and after extreme winter weather events (McCabe et al., 2023; Van der Heijden, 2022).

ACTION: Integrate legal preparedness into the healthcare organization's emergency management and climate action plans.

SUMMARY: Uncertainty about who has the legal authority to authorize difficult decisions during disasters can slow a healthcare organization's ability to pivot from normal operations to respond to a disaster. Healthcare organizations can enhance the resilience of their emergency management and climate action plans by (1) including parameters that clarify the conditions in which a facility may share information outside of the healthcare organization and administrators may order facility evacuations, (2) clarifying how personnel will reconcile protocol discrepancies (such as different evacuation protocols for healthcare organizations compared with Emergency Medical Services, and (3) authorizing clinical staff from outside organizations to practice in the healthcare facility. These plans may also include a

Climate Resilience Actions, continued

decision framework for deciding how to allocate scarce resources during utility outages (U.S. HHS, 2014; Toner et al., 2017; VanDevanter et al., 2014).

ACTION: Periodically evaluate the roles and responsibilities of healthcare organizations and other partners in responding to extreme winter weather events.

SUMMARY: After-action reviews conducted under the auspices of the local office of emergency management offer an opportunity to revisit and revise (if needed) the roles and responsibilities of healthcare organizations during extreme winter weather events, particularly in regions where events are occurring more often, for longer durations, and at more extreme temperatures (Davies et al., 2019; Parker, 2020).

People and Operations

ACTION: Leverage healthcare facilities as intervention sites for local extreme winter weather action plans.

SUMMARY: Healthcare organizations often serve as community intervention sites for the local cold weather action plan. For example, allowing the Office of Emergency Management to use strategically located hospitals, medical office buildings, and clinics as distribution sites for water bottles, food, portable heaters, warm clothes, etc., can increase community access to health-promoting supplies. Officially designating publicly available spaces in healthcare facilities – such as the cafeteria – as resilience hubs or temporary shelters during climate-related events can help support patients and family members as well as raise awareness in the community that climate-related events are public health emergencies (Hess et al., 2023; IOM, 2012).

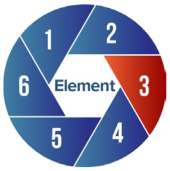
ACTION: Coordinate extreme winter weather syndromic surveillance with the local office of emergency management and the local weather station.

SUMMARY: It can be helpful to add extreme cold and winter-storm-related illnesses and injury to the healthcare organization's syndromic surveillance reports during and immediately following designated emergencies. Aligning the organization's protocol for collecting relevant diagnostic data with the local office of emergency management and weather station's protocol for declaring an emergency will help ensure that the organizational climate resilience action plan deploys in coordination with local alerts (Hess et al., 2023).

Resilience Strategies:
Extreme Winter Weather

CR4HC

Element 3. Assessment and Remediation of Vulnerabilities in Infrastructure and Operations



Many of the actions that healthcare organizations can take to avoid disruption in clinical care during extreme winter weather involve building resilience and redundancy into their facility design and operations. These practices include (1) building and maintaining highly insulated, energy and water efficient buildings that can continue to operate during utility outages; (2) designing resilient supply chains and storage conditions for food and medical supplies; and (3) making plans to protect, house, and possibly provide transportation for staff and their families when roads are impassable due to snow and ice accumulation.

The following sub-elements describe specific ways a healthcare organization can enhance the resilience of its infrastructure and operations to extreme winter weather 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 winter storms and extreme cold events as the facilities in which they work.

3.2 Clinical Considerations: Healthcare facilities experience an influx of patients during the winter season due to various factors like respiratory infection and physical injury from slipping on icy surfaces. On top of this typical seasonal uptick in demand for health care, an additional surge in patients can occur during winter storms due to hypothermia, frostbite, injury from traffic accidents, carbon monoxide poisoning from inappropriate heat sources such as gas stoves and ovens, forced isolation with a lack of adequate resources, exhaustion from cardiac events during snow shoveling, an inability to access medical care, and interruptions in home services (ASPR TRACIE, 2022).

In addition to developing a plan for patient surges and prioritizing essential clinical care, clinical education about risks to patients, such as carbon monoxide poisoning and cold injuries, can be a helpful component of a healthcare organization's extreme winter weather resilience.

3.3 Building and Campus: Design & Construction: Extreme cold events, alongside blizzards and ice storms, can compromise the infrastructure of healthcare facilities and other dependencies. Resilient healthcare facilities are designed to minimize the risk of extreme cold-related failures to the building structure, building materials, and building systems. Many of these design features also reduce facility greenhouse gas emissions.

3.4 Building and Campus: Facility Operations: Loss of power during extreme cold events and winter storms can disrupt healthcare facility operations by compromising heating systems, data centers, and critical systems reliant on electricity, plumbing, and natural gas. Enhancing infrastructure and preparedness can ensure the continuous operation of critical systems and mitigate the impacts of power outages and freezing temperatures.

3.5 Supply Chain: Extreme cold events and winter storms can disrupt transportation routes due to iced or blocked roadways and reduced visibility. In addition, these events cause power outages and direct damage to production facilities that contribute to healthcare supply chains.

Enhancing transportation infrastructure and supply chain resilience can mitigate disruptions during extreme cold events. Healthcare organizations are encouraged to develop contingency plans to ensure supply chain continuity during extreme cold events. This includes securing alternative transportation routes, maintaining adequate stockpiles of critical supplies, and coordinating with suppliers to manage delivery schedules in adverse weather conditions.

Resilience Strategies:
Extreme Winter Weather

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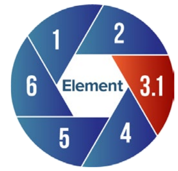
Element 3.1 Staff Support



Healthcare organizations depend on clinicians, administrators, and facilities and operations staff to deliver care. Staff and their families are often impacted by the same winter storms and extreme cold events as the facilities in which they work. For example, during the 2022 blizzard in Buffalo, NY, many healthcare staff were unable to return home for days due to white-out conditions and dangerous roads, and were worried for family members they could not reach (Carr et al., 2024; Erie County, 2022).

At Trinity Hospital in North Dakota, when a "Code White" (an extreme weather advisory) is in effect, staff know that when they come in for their shift, they should be prepared to stay at the facility until further notice (Brown, 2022).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 3.1: Staff Support

Planning

ACTION: Set staff expectations for their role during severe storms.

SUMMARY: Clearly define expectations with healthcare facility staff related to working during and after severe storms – particularly under circumstances that lead to power disruptions or outages, and those that may require staff to remain at work for extended periods. Share with staff a list of personal items that they should bring with them to an anticipated multi-day response effort, such as food, water, personal medication, hand sanitizer, extra clothes, and sleeping gear. Co-create policies and programs with staff establishing a flexible and supportive approach to staffing, accommodations, and transportation during and after severe storms. For example, it may be necessary to shorten staff shifts during emergency operations to give them the ability to rest mentally and physically. Include daycare, shelter, and other accommodations for staff family members, as needed (Danna et al., 2010; Toner et al., 2017; WHO, 2020).

ACTION: Train clinical staff in alternative procedures for delivering care during disasters.

SUMMARY: Healthcare organizations can support staff in preparing for disaster response by offering training in alternative procedures for intake and triage if inpatients are transferred from other facilities without their medical records, as well as training in alternative procedures for delivering care in situations with limited access to electricity and water, such as manually counting intravenous pump drips, manually suctioning intubated patients, and manually taking blood pressure readings (U.S. HHS, 2014).

People and Operations

ACTION: Integrate regular winter weather emergency preparedness employee training into the healthcare organization's continuing education program.

SUMMARY: Implementing a regular winter weather emergency preparedness employee training program prior to the first cold snap of the season can increase awareness of relevant risks to the healthcare organization, as well as protocols and procedures designed to enhance resilience in the face of increasingly frequent and severe winter weather-related events (Hilton, 2015; WHO, 2020). Include training on how key staff roles will be assigned during winter weather emergencies and consider developing checklists for each department breaking

Climate Resilience Actions, continued

down key tasks according to when they should occur – pre-event, during response, and post-event (U.S. HHS, 2014).

ACTION: During transportation disruptions, coordinate across the healthcare system to redistribute staff to facilities they can access – even if they are not at their "home" facility.

SUMMARY: It may be necessary immediately following events that damage infrastructure – such as blizzards, hurricanes, severe inland storms, and floods – to temporarily redistribute the healthcare system's staff to facilities they can access (Morris et al., 2016). Establish a tracking system so that staff can report to supervisors who are physically located in different facilities (Wyte-Lake et al., 2018). Cross-training staff so that they can fulfill multiple roles can benefit the overall healthcare system by ensuring that essential clinical services are offered by a mixture of permanent and temporary staff (Hilton et al., 2015).

ACTION: Ensure that staff who are supporting a winter weather response have access to clothing, a place to sleep, routine medications, and wellness services.

SUMMARY: Given the often-rapid evolution of winter storms and their impacts on community infrastructure, staff may be required to stay at their place of work for more than 24 hours without access to basic necessities such as a change of clothes and daily medications. Healthcare organizations can increase the resilience of their clinical services by ensuring that staff have access to clothing, a place to sleep, routine medications, and wellness services while they support patients in the midst of a disaster (Evans, 2017; Hilton et al., 2015; Morris et al., 2016; Toner et al., 2017).

ACTION: Establish a culture that acknowledges the personal challenges staff are facing during a disaster.

SUMMARY: Acknowledging the personal challenges faced by staff during a climate change-related disaster can increase a healthcare facility's resilience by increasing the willingness of staff who are able to report to work. It also creates space for staff to request tangible assistance (such as a hotel room or childcare) that would make it possible for them to support the disaster response (Morris et al., 2016; Toner et al., 2017).

ACTION: Provide alternative transportation and housing for healthcare staff during severe winter storms.

SUMMARY: Consider establishing agreements with nearby transportation providers and temporary housing facilities (such as hotels) to support employees and their immediate families (including pets) in the event that transportation pathways and/or utilities are disrupted during a severe winter storm. This may also involve preparing for staff to stay at healthcare facilities before the storm begins to mitigate potential transportation interruptions (Morris et al., 2016; 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 severe storm – 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 (Dana et al., 2010; WHO, 2020). Immediate support for staff who have experienced a major loss can also increase their ability and willingness to return to work after the event (Morris et al., 2016).

ACTION: Provide staff with post-disaster safety information for their homes.

SUMMARY: After extreme winter weather events, healthcare organizations can share information with staff about how to inspect their homes for elevated carbon monoxide levels and damage from snow and ice, how to safely remove and repair damaged building materials, how to reduce the risk of mold growth, and how to find funding opportunities to support rebuilding efforts (CDC, 2019 a.).

Physical Infrastructure

ACTION: Establish alternative communications channels for contacting staff during utility outages.

SUMMARY: Staffing during and immediately following climate change-related disasters that cause utility outages can be complicated by disruptions to telecommunications infrastructure. Establishing alternative communications channels (such as multiple cell phone providers, satellite phones, walkie-talkies, and installing a generator-powered cell tower on the roof of the facility) can increase a healthcare organization's resilience to these events by making it possible to share important information with staff – such as facility closures and requests that staff report to the facility closest to their home (U.S. HHS, 2014; Morris et al., 2016; Wyte-Lake et al., 2018).

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Resilience Strategies:
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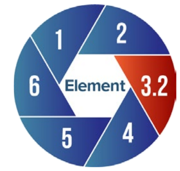
Element 3.2 Clinical Considerations



Healthcare facilities experience an influx of patients during the winter season due to various factors like respiratory infection and physical injury from slipping on icy surfaces. On top of this typical seasonal uptick in demand for health care, an additional surge in patients can occur during winter storms due to hypothermia, frostbite, injury from traffic accidents, carbon monoxide poisoning from inappropriate heat sources such as gas stoves and ovens, forced isolation with a lack of adequate resources, exhaustion from cardiac events during snow shoveling, an inability to access medical care, and interruptions in home services (ASPR TRACIE, 2022).

In addition to developing a plan for patient surges and prioritizing essential clinical care, clinical education about risks to patients, such as carbon monoxide poisoning and cold injuries, can be a helpful component of a healthcare organization's extreme winter weather resilience. For example, Alaska's Cold Injuries Guidelines and updated Frostbite Guidelines are intended as reference materials for treating cold-related injuries, developing local or regional standing orders, and standardizing care across the state (Zafren & Giesbrecht, 2014; Brownson et al., 2024).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 3.2: Clinical Considerations

Planning

ACTION: Integrate epidemiological and meteorological data into extreme winter weather 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 winter weather events (Patel et al., 2022).

ACTION: Develop a continuity of care plan listing essential clinical services that will be provided at different tiers of utility disruption.

SUMMARY: Many healthcare facilities are designed to function at full or partial capacity under a variety of environmental stressors. Organizations can increase resilience to extreme winter weather by creating and training staff to implement a continuity of care plan outlining essential clinical services that will be provided at different tiers of utility disruption (Toner et al., 2017).

ACTION: Add winter weather-related illness screening to the healthcare organization's EMR system.

SUMMARY: Consider including in the healthcare organization's winter weather resilience and preparedness plan a protocol for activating hazard-related illness screening questions in the electronic medical record (EMR) system when local authorities activate the emergency operations center to respond to an approaching winter storm (Hess et al., 2023). Sensitive patient groups that might be flagged for additional screening during and after winter weather events include unhoused individuals, children, adults over 65 years of age (especially those who live alone), low-income populations, and patients with chronic conditions. Early identification through EMR screening allows healthcare providers to flag sensitive patient groups for further evaluation and intervention, ultimately improving patient outcomes during extreme winter weather events.

Climate Resilience Actions, continued

ACTION: Enhance syndromic surveillance during extreme winter weather.

SUMMARY: Consider enhancing the healthcare system's syndromic surveillance during extreme winter weather events by submitting hazard-related illness data to the Electronic Surveillance System for the Early Notification of Community-Based Epidemics (Burkom et al., 2021). Work with local public health partners to interpret and act on real-time hazard-related illness and all-cause morbidity and mortality data during and immediately following extreme winter weather events.

ACTION: Integrate epidemiological and meteorological data into extreme winter weather 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 winter weather events (Patel et al., 2022).

People and Operations

ACTION: Adjust normal procedures and standards of care ahead of forecasted winter storms to expedite patient discharges, when possible, and to adjust the timing of routine treatment.

SUMMARY: Consider establishing protocols triggering an adjustment to the healthcare organization's clinical procedures (e.g., in pharmacy, drug treatment, dialysis, etc.) ahead of forecasted winter storms to create contingency plans to extend the amount of time existing patients can go without routine treatment. When possible, expedite inpatient discharge to free up bed space ahead of expected patient surges during and immediately following the event (Scott, 2017; Toner et al., 2017).

ACTION: Co-locate critically ill and fragile patients on the same floor of the facility as the emergency command center to maximize staff communication and patient safety.

SUMMARY: Identify the safest floors of the healthcare facility during severe storms. Consider co-locating the most critically ill and fragile patients on those floors alongside the emergency command center to expedite communication between leadership and staff to maximize patient safety (U.S. HHS, 2014).

ACTION: Develop a plan for patient surges and train staff in its implementation, including scenarios for accommodating cascading and simultaneous disasters.

SUMMARY: Many climate change-related events occur simultaneously or in quick succession with other stressors. For example, blizzards can occur during times of high demand for care related to seasonal respiratory viruses. It is, therefore, increasingly important to develop a plan for patient surges and train staff in its implementation. Include procedures for bringing in temporary staff, adapting clinician services to fast-changing conditions, and altering the schedule for routine operating procedures to free up space and staff to provide emergency care (Toner et al., 2017).

ACTION: If it is necessary to evacuate patients during a winter storm, consider sending nurses, nursing assistants, and leadership staff with them to ensure continuity of care.

SUMMARY: Hospitals that evacuated patients alongside care staff and their leadership team during Superstorm Sandy (2012) reported lower rates of anxiety about the evacuation among patients and their families (U.S. HHS, 2014).

ACTION: Recognize the unique needs of at-risk populations in the community during extreme cold weather.

SUMMARY: In the event of extreme winter weather, pay special attention to the unique clinical needs of at-risk groups, including children, the elderly, and individuals with certain medical conditions and medications. For example, alcohol and drugs can impair judgment and reduce the ability to notice temperature changes, increasing the risk of freezing. Additionally, individuals with mental health issues may not fully understand or prepare for the dangers of cold weather, while those who are unhoused or have lower incomes might have inadequate shelter or insufficient winter clothing (CDC, 2024 c.).

Physical Infrastructure

ACTION: Deploy mobile health units to take medical care to high-risk patients in the community during transportation disruptions.

SUMMARY: Consider including in the healthcare organization's list of emergency response assets mobile units that are used to deliver routine care to community members. Use the organization's map of high-risk patients – such as substance use disorder, dialysis, diabetes, and heart disease – (Element 2.1) to prioritize the provision of medical care during transportation disruptions caused by a winter storm (Toner et al., 2017).

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Resilience Strategies:

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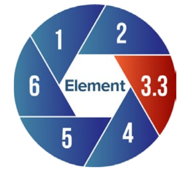
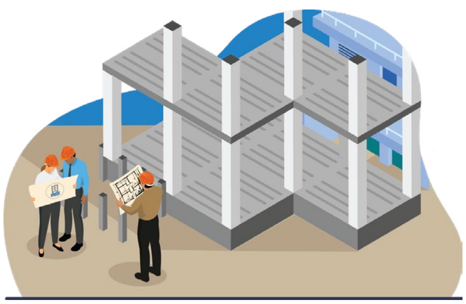
Element 3.3 Building and Campus: Design & Construction





Extreme cold events, alongside blizzards and ice storms, can compromise the infrastructure of healthcare facilities and other dependencies. For example, during an extreme cold event in February 2023, multiple Boston area hospitals closed their emergency departments after pipes burst and caused flooding (Bartlett, 2023; McGrath, 2023). Resilient healthcare facilities are designed to minimize the risk of extreme cold-related failures to the building structure, building materials, and building systems. Many of these design features also reduce facility greenhouse gas emissions.

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 3.3: Building and Campus: Design & 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 extreme winter events.

SUMMARY: Building codes and engineering best practice guides use historical weather trends to set guidelines for the overall capacity of building systems and expectations for "average" temperature and precipitation. 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 installing renewable power microgrids for backup power) in order to extend the functional life of the building as long as possible within the context of 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 & Chan, 2017).

Physical Infrastructure

Structure and Landscaping

ACTION: Design new buildings and reinforce existing structures to withstand future extreme winter weather events as described in the healthcare organization's prospective risk assessment (Element 1).

SUMMARY: Many building codes rely on historical data to set structural requirements for withstanding climate change-related hazards like extreme cold, wind, storm surge, and landslides. Healthcare organizations can reduce the risk of a major disaster causing sufficien physical damage to shut down operations by designing

Climate Resilience Actions, continued

and renovating facilities to withstand future climate change-related exposures as described in their prospective risk assessment (Element 1) (U.S. HHS, 2014).

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

SUMMARY: Providing covered pathways linking the facility's main entrance with transit stops, parking, and other access points can increase the safety and effectiveness of multimodal evacuation plans when they are deployed during a winter weather event (Basu et al., 2022). Working with transportation agencies to build and maintain transit stops with protection from the elements can increase the likelihood that patients, staff, and families will use them.

ACTION: Ensure facilities have winter weather resilient architecture.

SUMMARY: Ensure that pavements and exterior building materials are designed to withstand extreme temperatures including freezing and thawing. Weatherize all utility water piping and install it below frost lines. Consider roof design that can withstand heavy snow/ice loads.

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 at which they can generate sufficient electricity using on-site renewable power (e.g., solar, wind, geothermal). These facilities can continue to provide clinical care during disasters that disrupt regional power grids.

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 cold climates in the Northern Hemisphere should minimize north-facing windows. 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 reduces the transfer of heat or cold into the building. (Sun et al., 2020).

ACTION: Install energy efficient building equipment to extend the length of time during which 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 during which 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.

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 storms and extreme temperatures (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 to on-site power storage capacity can reduce a healthcare facility's reliance on external power sources needed to maintain continuity of care (Isa et al., 2018).

Water Efficiency and Flood Resilience

ACTION: Install protective barriers and elevated and heated walkways/driveways in areas at risk of flooding and ice accumulation.

SUMMARY: Floodgates, floodwalls, and other barriers equipped with crossover stairs can support safe passage across areas on a medical campus that are projected to experience repeated flooding (U.S. HHS, 2014). Pathways that could accumulate ice can be heated or otherwise designed to reduce the risk of slips and falls.

Climate Resilience Actions, continued

ACTION: Maximize water efficiency to reduce demand during low water pressure and boil water notice events.

SUMMARY: Water is critical to the functioning of healthcare facilities – both clinical and building systems. To maximize the availability of potable water for clinical uses, consider minimizing once-through use in equipment such as the HVAC system, sterilizers, and medical equipment. Further, consider installing low-flow toilets, urinals, handwash stations, and showers – except where volume is needed for occupational uses (such as water filling stations and decontamination showers) (Van der Heijden, 2022; WHO, 2015).

ACTION: Protect the permanent and emergency water supply from extreme weather and contamination from flood waters.

SUMMARY: Weatherize water supply pipes, cisterns, and tanks to prevent breakages in extreme cold weather. Place emergency water storage (such as tanks and cisterns) outside of areas at risk of flooding or landslides. Install float valves and overflow outlets that drain away from the facility to avoid flooding interior spaces after a cistern or tank fills up. Install one or more supplementary water pumps (depending on need) and connect them to the emergency power supply to keep water pressure at safe levels when the power goes out (Van der Heijden, 2022; WHO, 2015).

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, and drought) or as a result of infrastructure failures caused by hazards like hurricanes and tornadoes. Healthcare facilities should be designed to operate using on-site water supplies for at least 72 hours. Facilities located in high-risk areas can increase resilience by identifying supplementary water sources (such as connections to allow temporary water supply from trucks or other sources, permanent storage tanks/cisterns, and wells) 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 (Healthcare Environmental Resource Center, 2015; Van der Heijden, 2022; WHO, 2015).

Resilient Critical Operating Systems

ACTION: Install redundant communication systems for use during power and communications outages.

SUMMARY: Extreme weather events can disrupt electricity supply, cell towers, radio transformers, and other community communications networks. Healthcare organizations can reduce the risk of disruption in communications to other facilities in their network, regional healthcare organizations, and local emergency management agencies by installing and maintaining redundant communication systems, such as analog phones, fax machines, handheld two-way radios, ham radios, and solar-powered devices (Hedges et al., 2018).

ACTION: Place redundant IT systems off-site to increase the resilience of EMRs.

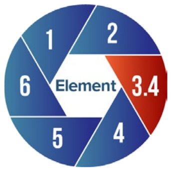
SUMMARY: Placing redundant information technology (IT) systems off-site can reduce the risk of the electronic medical record (EMR) system going offline during flood events (Danna et al., 2010; Toner et al., 2017).

ACTION: Place EMR servers and equipment in climate-controlled spaces and above the flood line.

SUMMARY: To ensure that medical information systems remain functional during power outages and flooding events, place them in storage spaces that are elevated above the risk of flood waters, climate-controlled with a dedicated energy source, and/or off-campus (such as a duplicate paper record storage site) (Swanson et al., 2010; U.S. HHS, 2014).

Resilience Strategies: Extreme Winter Weather

Element 3.4 Building and Campus: Facility Operations



Loss of power during extreme cold events and winter storms can disrupt healthcare facility operations by compromising heating systems, data centers, and critical systems reliant on electricity, plumbing, and natural gas. Enhancing infrastructure and preparedness can ensure the continuous operation of critical systems and mitigate the impacts of power outages and freezing temperatures. For example, regions with limited cold weather may rely on electric systems for heating, leading to blackouts when demand exceeds grid capacity. Inpatients require essential services such as food, clean water, and laundry, which are jeopardized during power outages. ASPR TRACIE provides considerations to maintain facility operations during extreme cold events, supporting healthcare organizations in sustaining essential services (ASPR TRACIE, 2024).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 3.4: Building and Campus: Facility Operations

Planning

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 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 (such as extreme temperatures, exposure to flood waters, etc.) reach dangerous levels (FEMA & ASPR, 2019).

ACTION: For extreme weather events that could result in widespread damage to utilities and community infrastructure, include security considerations in the healthcare facility's emergency preparedness plan.

SUMMARY: Extreme weather events that cause widespread damage to utilities and community infrastructure can result in a temporary need for increased security at a healthcare facility, particularly if it experiences a patient surge and/or acts as a place of respite for community members (Danna et al., 2010).

ACTION: Integrate pre-winter weather 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 enhance 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: Perform a baseline analysis of water usage and categorize usage types into tiers of critical need.

SUMMARY: Water is a critical component of clinical care, including sanitizing medical equipment. Performing a baseline analysis of the healthcare facility's water usage and categorizing usage types into tiers of critical need can help facility managers direct potable water supply to the most important clinical needs during low water pressure and boil water notices while also reducing overall facility water usage (WHO, 2015; Van der Heijden, 2022).

Climate Resilience Actions, continued

People and Operations

ACTION: Conduct regular tests of emergency generators, water supplies, and transportation plans to ensure that they are ready to deploy in the event of an emergency.

SUMMARY: It can be difficult to source fuel, water trucks, and emergency transportation contractors in the immediate run-up to a winter storm. Healthcare organizations can check the status of their resilience to the first 72 hours of anticipated winter storms by performing regular tests and maintenance on emergency generators and on-site sources of emergency water. It can also be helpful to perform regular drills with outside contractors who will be responsible for supplying more fuel, trucked-in water, emergency transportation for staff and patients, and other activities included in the facility's emergency operations plan (U.S. HHS, 2014).

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

SUMMARY: Consider performing regular stress tests of the healthcare facility's ability to function during extreme cold events and winter storms, including scenarios such as brownouts, blackouts, low water pressure, surge of patients experiencing cold-related illness, surge of all-cause complaints, and surge of community members seeking to use the facility as a warming 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 healthcare system and impact delivery of critical care (Ebi et al., 2018). Providing access to the facility from transit stops, parking, and other property access points can increase the safety and effectiveness of multimodal evacuation plans.

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 demands remain at levels that can be met by on-site sources, such as renewable power and recycled process water (Kolokotsa et al., 2012).

Physical Infrastructure

ACTION: Ensure emergency equipment is in hazard protected areas.

SUMMARY: Ensure emergency generators are in areas safe from freezing and moisture penetration to enable functioning and back-up power in the event of a power outage during a winter storm (PDH Star, 2018).

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: Conduct regular walk-throughs of the healthcare facility to confirm compliance with fire safety and evacuation signage requirements.

SUMMARY: Facility evacuation can be impeded if exits are obstructed, signage is missing or confusing, or life safety equipment, like sprinklers and fire extinguishers, is missing or broken. Conducting regular walk-throughs of the healthcare facility to confirm that these essential emergency preparedness components are in place and in working order could be seen as a first level of resilience to any climate change-related hazard that might damage the building structure or result in an eventual evacuation (U.S. HHS, 2014).

ACTION: Prior to an anticipated disaster, walk through the facility to identify locations that might require repair during and immediately following the event and stage the necessary materials and equipment (including pumps) nearby.

SUMMARY: Certain locations in and around the healthcare facility – such as the roof, windows, and lower floors – are more vulnerable to damage from freezing temperatures, wind, flooding, and external soil and water

Climate Resilience Actions, continued

pressure. Healthcare organizations can reduce the risk of disruption to clinical operations by identifying likely repair needs prior to the event and staging the relevant construction materials and equipment within easy reach to minimize the impact of minor leaks, broken windows, and other building damage on regular facility operations (ASPR TRACIE, 2023 b.).

ACTION: During and after winter weather events, monitor the facility, transportation infrastructure, and landscaping for signs of damage.

SUMMARY: Winter weather events can damage a healthcare facility's envelope, structure, and foundation, compromising safety and, in extreme cases, leading to collapse. Healthcare organizations can support continued operations during a winter storm by regularly inspecting the building, transportation infrastructure used by patients to access the facility, and surrounding landscaping for signs of damage and responding as appropriate. Continuing inspections after the storm can help catch moisture and other damage that can lead to deteriorated air quality over time, amongst other impacts (PDH Star, 2018).

ACTION: After an extreme winter weather event, clean hard surfaces and remove absorptive materials as soon as possible to reduce the risk of mold growth.

SUMMARY: Nonstructural damage like mold can become the determining factor regarding whether or not a facility reopens after a climate change-related disaster. Following a winter storm or flooding from burst pipes, cleaning hard surfaces and removing absorptive materials quickly can reduce the risk of mold growth. Steel structure, reinforced concrete, and concrete masonry units covered in water-resistant paint are often easy to clean, dry, and restore. Absorptive materials like carpet, drywall, and composite wood products (like plywood and medium density fiberboard), are more likely to require replacement. (PDH Star, 2018).

Resilience Strategies:

Extreme Winter Weather

CR4HC

Element 3.5 Supply Chain

Extreme cold events and winter storms can disrupt transportation routes due to iced or blocked roadways and reduced visibility. In addition, these events cause power outages and direct damage to production facilities that contribute to healthcare supply chains. For example, following winter storms in Texas in 2021, prolonged power outages caused a shortage of raw materials essential for producing many medical supplies. This shortage of raw materials resulted in shortages and price increases for some critical supplies, such as sharps containers and protective gowns (Matthews et al., 2021).

Enhancing transportation infrastructure and supply chain resilience can mitigate disruptions during extreme cold events. Healthcare organizations are encouraged to develop contingency plans to ensure supply chain continuity during extreme cold events. This includes securing alternative transportation routes, maintaining adequate stockpiles of critical supplies, and coordinating with suppliers to manage delivery schedules in adverse weather conditions.

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 3.5: Supply Chain

Planning

ACTION: Integrate medical supply storage into resilience planning.

SUMMARY: Consider how your organization's prospective risk assessment of extreme winter weather (Element 1) might lead to supply chain disruptions and/or changing needs. Maintain an adequate supply of medical supplies, particularly for products that are most vulnerable to weather-related disruptions in transportation routes (Hedges et al., 2018). Consider separating emergency supplies into two categories: high-volume medical supplies (such as intravenous bags, sharps, and oxygen) and equipment/supplies that would only be needed during a disaster. Establish a timeline for activating the supply chain plan ahead of the anticipated climate change-related event. Include in the timeline when a comprehensive check of both types of inventory should take place and when normal deliveries should be suspended (Maslanka & Hurwitz, 2022).

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).

People and Operations

ACTION: Require suppliers of essential goods and services to provide a continuity of operations plan for extreme winter weather events.

SUMMARY: Healthcare organizations are dependent on a large network of vendors to supply goods and services that are essential to facility operations and continuity of care. Requiring suppliers of essential goods and services to provide a continuity of operations plan is an important first step in building the healthcare organization's resilience

Climate Resilience Actions, continued

to winter weather events and other disasters that disrupt transportation infrastructure (Toner et al., 2017).

ACTION: Stockpile potable water.

SUMMARY: Maintaining a stockpile of potable water, either inside the healthcare organization's storage facilities or through a contract with external vendors, can bridge the gap for both medical procedures and community services (i.e., sharing bottled water with community members) during water shortages (Hedges et al., 2018).

Physical Infrastructure

ACTION: Boost the resilience of refrigerated storage areas.

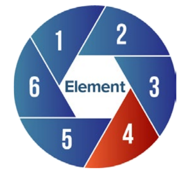
SUMMARY: Consider increasing wall insulation and access to auxiliary power in refrigerated storage areas to extend the shelf life of temperature-sensitive products, like pharmaceuticals and food supplies, during brownouts and blackouts (Lazo et al., 2023).

ACTION: Store essential medical supplies, food, and fuel lasting 5–7 days on or near the healthcare campus to facilitate rapid deployment ahead of extreme weather events that could disrupt supply chains and/or utility and transportation infrastructure.

SUMMARY: One of the hallmarks of climate change is the increased length of utility outages and damage to transportation infrastructure, leading to supply chain disruptions of a week or more. Healthcare organizations can increase their resilience to this changing landscape by stockpiling 5-7 days' worth of medical supplies, food, and fuel on or close to healthcare facility campuses (Danna et al., 2010).

Resilience Strategies: Extreme Winter Weather

Element 4. Collaboration Between Healthcare Organizations



The shifting landscape of patient surges and surges in nonclinical demands on healthcare institutions during extreme cold events and winter storms can stress a healthcare facility's ability to provide high-quality clinical care. Sharing information and resources across the full range of regional healthcare providers during an extreme cold event can increase resilience both at the facility level and system-wide.

During Winter Storm Uri in 2021, the Southeast Texas Regional Advisory Council disseminated to health systems across Texas information from the ASPR EmPOWER program about Medicare-insured patients dependent on electricity-dependent durable medical equipment. This information helped health systems anticipate these patients' need for urgent care during prolonged power outages (ASPR TRACIE, 2021).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 4: Collaboration Between Healthcare Organizations

Planning

ACTION: Create plans to increase the resilience of critical outpatient care during extreme winter weather events.

SUMMARY: Create contingency plans in coordination with regional healthcare partners to ensure that individuals with chronic physical and/or mental health conditions – who are at high risk due to potential interruptions in medication administration or outpatient care – have access to alternative arrangements if their usual care becomes unavailable or inaccessible due to extreme winter weather events (U.S. HHS, 2014; Toner et al., 2017; WHO, 2020).

ACTION: Enhance healthcare organization preparedness for extreme winter weather events through mutual aid MOU.

SUMMARY: A mutual aid memorandum of understanding (MOU) with other healthcare providers in the region that includes the results of a prospective risk assessment (Element 1) can help prepare for circumstances that require patient transfers or referrals – such as utility outages, patient surges, etc. It is important to address legal and reimbursement challenges that can limit a facility's ability to quickly and efficiently transfer patients and/or supplies to other facilities in the region. Consider working with CMS and other healthcare organizations in the region to fill in those gaps over time using an all-hazards approach (U.S. HHS, 2014; Patel et al., 2022).

ACTION: Exchange epidemiological data and health assessments related to extreme winter weather with other healthcare organizations and the local health department.

SUMMARY: Exchanging epidemiological data and health assessments related to extreme winter weather events with other healthcare organizations and the local health department can support regional climate resilience planning efforts. Use these conversations to jointly develop protocols for identifying emerging climate-related health threats in the region, collecting and disseminating data, and coordinating emergency response across the range of facility types in the regional health system – including acute care hospitals, community clinics, and long-term care facilities (Patel, 2022).

ACTION: Integrate an analysis of cross-institutional collaboration in regional after-action reviews of extreme winter weather events.

SUMMARY: As part of an all-hazards emergency management plan, include an after-action analysis of

Climate Resilience Actions, continued

interdisciplinary coordination within the organization, as well as with other regional healthcare organizations and the local office of emergency management to assess how well the emergency response system functioned as a whole. Consider including prospective climate metrics (Element 1) as one indicator of the system's resilience to future events (Davies et al., 2019; Parker, 2020).

ACTION: Perform joint disaster preparedness exercises and drills with other local healthcare organizations, the local health department, and the local office of emergency management.

SUMMARY: Joint disaster preparedness exercises and drills can help healthcare organizations test their readiness for extreme winter weather events (and simultaneous and cascading events), identify areas for improvement in their emergency response plans, and build working relationships with other first responders. Including representation from multiple institutions and professions in the exercise can also help identify emerging at-risk populations who are projected in climate models to require more protection and/or resources as disasters occur more frequently and/or with greater severity (ASPR, 2024; WHO, 2020).

ACTION: Work with other regional healthcare organizations to develop integrated patient evacuation plans.

SUMMARY: Healthcare organizations can increase their own and regional resilience by working together to develop integrated emergency evacuation plans. Consider including contingency plans to address damage to a facility's structure, exposure to contaminated air and/or water damage, power and water outages, destruction of electronic medical records, infrastructure failures, and an ambulance shortage. Contingency plans may involve transferring patients to alternate facilities or establishing temporary medical sites in safer areas (U.S. HHS, 2014; Patel, 2022).

People and Operations

ACTION: Collaborate with regional healthcare organizations on public health education and outreach programs.

SUMMARY: Healthcare institutions can collaboratively develop and disseminate public health education and outreach programs so that the community receives a consistent and coordinated message about climate-related hazards, protective behaviors, and access to resources such as healthcare services (California Department of Public Health, 2022).

ACTION: Consider proactively credentialing neighboring healthcare facility staff to help execute the healthcare organization's emergency preparedness protocol.

SUMMARY: Proactively credentialing staff at neighboring healthcare facilities to prepare for emergencies can contribute to backup care if one facility is unable to provide care due to hazard-related and extreme weather utility interruptions (WHO, 2020).

ACTION: Establish effective communication channels to share real-time information across healthcare organizations during extreme winter weather events.

SUMMARY: Consider working with other healthcare organizations and entities in the region to establish effective real-time communication channels with one another and the public during extreme winter weather events. Examples of critical information that can be shared this way include information about storm or extreme cold progression, which healthcare facilities are open to receive new patients and/or community members seeking refuge, real-time information about the number of beds available in the region and consistent definitions for each bed type, and levels of critical medical supplies needed and available for each facility in the cooperation network (CDC, 2003; California Department of Public Health, 2022; U.S. HHS, 2014).

ACTION: Share resources and coordinate personnel during extreme winter weather events.

SUMMARY: Collaboration between response organizations may involve sharing critical resources and coordinating the deployment of personnel to support impacted communities in areas of greatest need (Patel, 2022). Consider integrating the results of the organization's prospective risk assessment (Element 1) into planning conversations to funnel resources to new and emerging at-risk populations related to the changing climate.

Physical Infrastructure

ACTION: Build out alternative communications channels to help regional healthcare organizations share real-time information with each other during disasters.

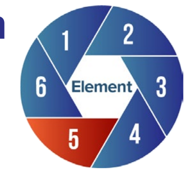
SUMMARY: Interorganizational cooperative agreements for sharing resources and transferring patients during

Climate Resilience Actions, continued

climate change-related disasters depend on real-time communication among facilities in the network. Building out alternative communications channels connecting healthcare organizations with each other (such as multiple cell phone providers, satellite phones, walkie-talkies, and generator-powered cell towers on the roof of key facilities) can increase the effectiveness of the entire network's emergency response (U.S. HHS, 2014).

Resilience Strategies: Extreme Winter Weather

Element 5. Interdisciplinary Planning, Oversight, and Evaluation



Extreme cold and winter storm resilience requires coordination across various critical dependencies within healthcare organizations, that impact clinical care, facilities operations, and community infrastructure. An interdisciplinary approach involving early engagement with staff and community members can enhance awareness and prioritize interventions for cold resilience planning. Aligning operations with climate goals ensures efficient use of resources and minimizes damage during extreme cold events (WHO, 2020).

For example, in anticipation of winter storms Uri and Viola in 2021, Ascension Health System used its digital surveillance platform to effectively prepare and coordinate across its affected Texas facilities (read Ascension's case study in this toolkit). This coordinated, real-time surveillance enabled Ascension facilities to stockpile potable water, maintain water pressure using water tankers obtained from construction teams, and manage response teams.

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 5: Interdisciplinary Planning, Oversight, and Evaluation

Planning

ACTION: Incorporate interdisciplinary approaches into extreme winter weather planning.

SUMMARY: Consider incorporating interdisciplinary approaches into the healthcare organization's hazard planning process since natural disasters and hazard events can impact a range of dependencies – such as infrastructure, clinical care, energy systems, and waste management (Rogers et al., 2020).

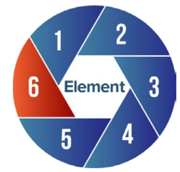
ACTION: Incorporate long-term goals and climate projections into healthcare extreme weather planning and response plans.

SUMMARY: It can be helpful to integrate long-term, interdisciplinary strategic goals into the healthcare organization's extreme weather emergency preparedness and response plans – including community input as outlined in the Justice, Equity, Diversity, and Inclusion (JEDI) framework (American Public Health Association & CDC, 2021).

ACTION: Implement surveillance and interdisciplinary after-action reviews in organizational extreme winter weather action plans.

SUMMARY: Incorporate building surveillance and interdisciplinary after-action reviews into the healthcare organization's extreme winter weather action plan. These measures will help identify and evaluate the elements of the plan that worked during a recent winter weather event; assess whether changing climatic conditions might have influenced aspects of the event (such as its severity); and change the parts of the plan that did not meet expectations (Hess et al., 2023; Parker, 2020).

Element 6. Communications and All-Hazards Approach



Multi-hazard events increase the risk of multiple system failures at the community scale (such as disruptions to water and power utilities) and can result in both direct and indirect harm to population health. Repeated patient surges and cascading infrastructure failures both in the community and within healthcare facilities can temporarily disrupt the entire healthcare system in a region. For example, Houston, Texas, experienced in 2021 the compounding effects of COVID-19 related economic impacts, Hurricane Harvey, and extreme cold and winter storms. These events interacted with systemic inequities to exacerbate health disparities (Fay et al., 2023).

Fortunately, many policy, infrastructure, and communications interventions can increase organizational resilience to more than one climate-related hazard. This is particularly true if emergency management and climate resilience planners use an all-hazards approach to designing, implementing, and testing proposed interventions. By adopting an all-hazards approach, healthcare organizations can improve communication and coordination during extreme cold events, ensuring effective responses to a wide range of emergencies.

For example, the Oregon Health Authority's Risk Communication Toolkit for Winter Weather includes fact sheets, translated into several languages, that can be useful during multiple emergencies. These fact sheets include information about food safety during disasters and prevention of carbon monoxide poisoning (Oregon Health Authority, 2017).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
[Element 6: Communications and All-Hazards Approach]

Planning

ACTION: Collaborate with local partners to coordinate winter weather messaging.

SUMMARY: It can be helpful to collaborate with local public health department partners to coordinate winter weather-related messaging with clinicians and patients, such as through prompts in the healthcare organization's electronic health record, e-newsletter, and patient texting system. This approach can increase community awareness of both the short- and long-term health risks associated with exposure to extreme winter weather (WHO, 2020).

ACTION: Use simultaneous disasters as an opportunity for education about the co-benefits of taking an all-hazards approach to resilience.

SUMMARY: Simultaneous and cascading disasters can be opportunities to educate the community, staff, and emergency management partners about the value associated with using a co-benefit approach to risk assessment, emergency planning, emergency response, and rebuilding efforts (National Academies of Sciences, 2022).

People and Operations

ACTION: Broadcast winter weather alerts using culturally appropriate language and communication pathways.

SUMMARY: Broadcasting alerts about winter weather vulnerability and protective behaviors to patients, staff, and community partners using culturally appropriate language and communication pathways can help amplify the local public health department and office of emergency management's communication efforts (Hasan et al., 2021; O'Neill et al., 2009).

Climate Resilience Actions, continued

ACTION: **Establish two-way communication systems with at-risk patient populations.**

SUMMARY: Implementing two-way communication systems, like Reverse 911 and wireless emergency alerts (National Academies of Sciences, 2018), can aid in connecting sensitive populations with protective measures before extreme winter weather occurs and direct them to community services during the event. With the assistance of community groups and local health departments, designated community leaders can deliver culturally sensitive messages. These messages would inform residents about safeguarding themselves and their neighbors and provide guidance on actions to take if they experience health harms (Steinberg & Sprigg, 2016; Toner et al., 2017).

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Climate Resilience for Health Care: Flooding

CR4HC

Impact of Flooding on Healthcare Organizations

Flooding can damage healthcare buildings and affect critical supplies and infrastructure, such as information technology (IT) equipment and operation systems, resulting in patient and staff transfers or evacuation. In addition, flooding can damage transportation infrastructure and production facilities, resulting in supply chain disruptions. Flooding can directly harm community health through drowning, injury from debris, chemical hazards, or electrical injury. The aftermath of flooding events can bring continued health impacts from waterborne and vector-borne illnesses, contaminated drinking water, and mold. Surges in healthcare demand, in addition to infrastructure, supply chain, and staffing disruptions, can stress healthcare delivery systems during and after floods. Flash flooding, caused by heavy rainfall over a short period of time, can occur with little warning, and can be especially dangerous because of the force of rushing water and debris swept into their flow.

In 2019, Missouri River and North Central flooding caused injuries from drowning, chemical exposures, electrical shock, and debris. In its aftermath, contaminated water created infectious disease risks, mold- an allergen-exacerbated respiratory illness, and loss of property and displacement caused significant mental and emotional distress. At the same time, multiple healthcare facilities were forced to evacuate, and disrupted infrastructure, such as flooded roads, impeded community members' access to health care (Lancet Countdown, 2020).

Important Considerations

Health Effects of Flooding: Drowning, injury from debris, electrical injury, illness from contaminants including chemicals and sewage, vector-borne illness, respiratory effects from mold, carbon monoxide poisoning (e.g., from damage to boilers, indoor use of portable generators), mental health effects

Populations at Risk: Low-income populations, people with disabilities, older adults (especially those living alone), children, people with chronic respiratory illness, people with immune deficiency

Risks to Facility Operations: Supply chain disruption, patient surge, staff shortage, evacuation risk

Infrastructure Risk: Damage to building infrastructure, power outages, disruptions to transportation systems

Elements of a Climate-Resilient Healthcare Organization: Flooding

The following six elements characterize a flood-resilient healthcare organization. Review each element section to explore more detail.

1. Prospective Risk Assessment

Climate change is increasing exposure to flooding in three ways. First, as temperatures rise, rain clouds can store greater quantities of moisture, resulting in more intense rain events. Second, slow-moving storms are becoming more frequent, which increases the accumulated rainfall in affected communities. Third, sea level rise raises the baseline of exposure to coastal flooding and storm surge. Flood risk to critical infrastructure, like healthcare facilities in the United States, is expected to increase most dramatically in counties bordering the Gulf of Mexico and the Atlantic Ocean due to a combination of sea level rise and increased storm surge. Adding forward-facing climate projections to flooding risk assessment can help healthcare organizations plan for changing exposures and vulnerabilities, such as the changing geographic distribution of flood risks and increased frequency and severity of flooding.

2. Health Equity and Community Engagement

Disparities in the social determinants of health are related to disparities in health harms caused by hazards and environmental exposures, such as flooding. For example, low-income populations are more likely to reside in areas vulnerable to flooding, and may lack resources to recover from damage to housing and other financial losses.

Local offices of emergency management should work with healthcare organizations to synchronize flooding emergency planning protocols with other weather-related emergency protocols to ensure coordination during emergency response operations.

3. Assessment and Remediation of Vulnerabilities in Infrastructure and Operations

Flooding is the most destructive natural disaster in the United States in terms of infrastructure damage, injury, and death (Sadiq and Noonan, 2015). To save lives, protect property, and reduce the risk of disruptions in clinical care, healthcare organizations can build resilience and redundancy in their facility design and operations. Building resilience and redundancy involves (1) building and maintaining efficient buildings that can continue to operate during power outages, water service disruption, and infrastructure damages; (2) designing resilient supply chains and storage conditions for food and medical supplies that require constant refrigeration; and (3) making plans to protect, house, and provide transportation for staff and their families during extreme weather events so that 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 compounding impacts of flooding.

The most cost-effective way to integrate flood resilience into a healthcare organization's infrastructure and operations is to plan for it from the beginning, starting with a hazard vulnerability assessment to pinpoint the highest risk exposures.

4. Collaboration Between Healthcare Organizations

Disruption in one part of the healthcare ecosystem can result in stress on another part of the system. For example, a patient surge in acute care facilities can result from disruptions in outpatient care, behavioral health services, or residential facilities. In addition, flooding may necessitate evacuation of healthcare facilities, or a shift in location of essential healthcare services. Therefore, resilience to flood emergencies requires collaboration between regional healthcare organizations to plan, prepare, and respond. Key aspects of collaboration include: communication and information sharing; resource coordination; patient evacuation and transfers; medical staff deployment; data sharing; joint public health outreach efforts; and joint disaster preparedness drills.

5. **Interdisciplinary Planning, Oversight, and Evaluation**

   Flooding can affect various critical dependencies within healthcare organizations, such as administration, IT, electricity, natural gas, water, wastewater and waste disposal, communications, transportation, and critical products. An interdisciplinary approach to planning, oversight, and evaluation across critical dependencies is essential for comprehensive flooding emergency preparedness planning. Healthcare organizations are encouraged to align their facility operations, procurement, and capital expenditures with climate change mitigation and resilience goals.

6. **Communications and All-Hazards Approach**

   Communication strategies promoting flood resilience are most effective when they take into account whether the flood risk is chronic or episodic. Preparedness communications in areas with chronic flood risk include signage in flash flood-prone locations and social media posts reminding community members about how to prepare for seasonal flooding. Effective communications around episodic flooding often benefit from strong collaboration and engagement with community members.

   Flooding events often occur simultaneously or in quick succession with other climate change-related hazards, such as severe storms and extreme temperatures. In addition, drought conditions prior to a significant precipitation event in an area can increase the likelihood of severe flooding.

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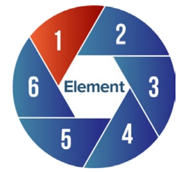
Resilience Strategies: Flooding

CR4HC

Element 1. Prospective Risk Assessment



Climate change is increasing exposure to flooding – in both inland and coastal areas – in three ways: First, as temperatures rise, rain clouds can store greater quantities of moisture, resulting in more intense rain events. Second, slow-moving storms are becoming more frequent, which increases the accumulated rainfall in affected communities. Third, sea level rise raises the baseline of exposure to coastal flooding and storm surge. Sea level along the U.S. coastline is predicted to rise 12 inches by 2050, which is equivalent to the total sea level rise from 1920–2020. This is predicted to result in 10 times more damaging coastal flooding than today (NOAA, 2023). Flood risk to critical infrastructure, like healthcare facilities in the United States, is expected to increase most dramatically in counties bordering the Gulf of Mexico and the Atlantic Ocean due to a combination of sea level rise and increased storm surge. For example, by 2050, flood risk to critical infrastructure is expected to increase more than 20% in Beaufort County, South Carolina; Calhoun County, Texas; Camden County, North Carolina; Norfolk City, Virginia; and Poquoson City, Virginia (Porter et al., 2021).

Adding forward-facing climate projections to flooding risk assessments can help healthcare organizations plan for changing exposures and vulnerabilities, such as the changing geographic distribution of flood risks and increased frequency and severity of flooding. A set of sea level rise table top exercises in Charleston, South Carolina and Morehead City, North Carolina, identified several gaps in healthcare emergency preparedness plans and the local hazard mitigation plan – such as protecting nursing homes, community health clinics, pharmacies and other critical infrastructure from flood risk in addition to acute care hospitals. After the exercise, local healthcare organizations added future flooding risks to their all/multiple hazards emergency preparedness, response, and recovery plans (Allen et al., 2019).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 1: Prospective Risk Assessment

Planning

ACTION: Add a prospective risk assessment and impact forecasting to the local flood mitigation plan.

SUMMARY: It can be helpful to work with public health and local emergency management partners to add a prospective risk assessment and impact forecasting to the local flood warning system, flood risk assessments, and flooding action plan (Merz, 2020).

ACTION: Add projected precipitation and flooding measures to hurricane, flooding, and storm risk assessments.

SUMMARY: Consider adding one or more of the projected precipitation and flooding measures from the CDC's National Environmental Public Health Tracking Network data portal to your organization's risk assessment (Hess et al., 2017).

ACTION: Consider both historical trends and climate projections to estimate the healthcare organization's long-term flooding risk.

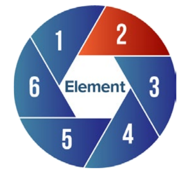
SUMMARY: As a result of the climate changing, historical trend lines are not necessarily an accurate predictor of the future. Incorporating both historical trends and climate projections when developing flood mitigation strategies can thus help organizations future-proof the planning, response, and recovery process (Ponce Manangan et al., 2014). Healthcare organizations can further enhance flood resilience by planning for lower probability flooding than indicated in the current FEMA flood maps. For example,

Climate Resilience Actions, continued

a hospital located in a 100-year floodplain should plan for 500-year floods (PDH Star, 2018). Boulder Community Foothills Hospital in Boulder, Colorado, which is located in the Boulder Creek floodplain, integrated both current and potential future flood risks into the site planning process. The 17-acre hospital campus was elevated above the 100-year floodplain, and the remaining 22 acres were designated as a conservation area. All patient rooms were located on the 2nd and 3rd floors. Below-grade floors were flood-proofed two feet above the 500-year floodplain and surrounded by a moat. And, the hospital keeps a supply of sandbags ready to protect the two most vulnerable locations on the campus – the ramp to the parking garage and the air handling unit – both of which are located several feet above the 500-year floodplain (PDH Star, 2018). The 2015 Boulder Creek Restoration Master Plan proposes further protecting access to the campus during 500-year flooding events by adding a secondary emergency paved access drive at a higher elevation than the main entrance route (ICON Engineering, 2015).

Resilience Strategies: Flooding

Element 2. Health Equity and Community Engagement



Disparities in social determinants of health (SDOH) are related to disparities in health harms caused by multiple hazards and environmental exposures, including flooding. For example, low-income populations are more likely to reside in areas vulnerable to flooding, and may lack resources to recover from damage to housing and other financial losses.

Local offices of emergency management should work with healthcare organizations to synchronize flooding emergency planning protocols with other weather-related emergency protocols to ensure coordination during emergency response operations.

The following sub-elements describe specific ways in which a healthcare organization can integrate health equity and community engagement into their flood resilience planning.

2.1 **Community Input:** Frameworks like SDOH and vulnerability assessments can help identify populations in a healthcare organization's catchment area who may be at higher risk of negative health outcomes during flooding events (U.S. HHS, n.d.). Seeking community input can be helpful for refining and validating the organization's initial assessment and for clarifying which services – either on campus or in the community – increase the likelihood of protecting the health of community members who are at highest risk of flood-related injury and illness (Patel et al., 2022).

2.2 **Community Infrastructure:** Flooding can cause damage to buildings and other critical community infrastructure, including transportation infrastructure and communication systems. In addition, flooding can degrade transmission along power lines, and can affect generators and other electricity transmission infrastructure. Water systems can be contaminated by overflow of sewage, and, in coastal areas, saltwater contamination. It may not be practical to locate all of a healthcare organization's facilities outside of the floodplain. Instead, organizations may prioritize ensuring that their facilities remain accessible to community members during and after flooding events. Thoughtful resilience measures on the healthcare campus can both protect patients and staff and also enhance community resilience to flooding.

2.3 **Community Services:** Partnering with community organizations to mitigate risk factors (such as housing or utility insecurity) before a flooding event, coordinating outreach efforts to locate and evacuate at-risk individuals from high-risk flood zones, and providing essential community-based services during and after a flood, can increase healthcare organization resilience by reducing the surge in demand for healthcare services. Essential services can include distribution of food, water, and medication; and access to emergency power for people who rely on electricity-dependent durable medical equipment.

2.4 **Coordination with Local Office of Emergency Management:** Synchronizing your healthcare organization's flood emergency plan with peer organization plans, the local office of emergency management, and the local utility can result in a more efficient and effective coordinated response during and after flooding events. It can also shine a light on current gaps and redundancies that, if addressed, could increase the effectiveness of responders during an emergency. Coordination also supports the development of personal relationships across organizations and agencies – an important factor during an emergency response (FEMA, 2023 b.). Real-time data sharing between healthcare organizations, emergency management, and public health officials is an essential component of a coordinated response to flood emergencies.

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Resilience Strategies: Flooding

CR4HC

Element 2.1 Community Input

Frameworks like social determinants of health and vulnerability assessments can help identify populations in a healthcare organization's catchment area who may be at higher risk of negative health outcomes during flooding events (U.S. HHS, n.d.). Seeking community input can be helpful for refining and validating the organization's initial assessment and for clarifying which services – either on campus or in the community – increase the likelihood of protecting the health of community members who are at highest risk of flood-related injury and illness (Patel et al., 2022).

For example, Resilient Baton Rouge (RBR), a disaster recovery program designed to promote community mental wellness and decrease the burden of depression, was formed in the aftermath of Louisiana's Great Flood of 2016. RBR sought input from community organizations and residents about strengths, gaps, and priorities in addressing community mental health and used this information to design collaborative, community-based disaster behavioral health services. Activities included training community health workers and other healthcare providers in the collaborative care model for mental health care. Stakeholders in this collaborative network reported that RBR fostered connections that could contribute more generally to community resilience and recovery (Keegan et al., 2018).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 2.1: Communty Input

Planning

ACTION: Consider using available floodplain management tools to minimize harm.

SUMMARY: Consider using available tools, such as the FEMA Community Rating System, to promote comprehensive community floodplain management. This includes measures to reduce flood damage to properties and minimize associated risks (FEMA, 2023 a.).

ACTION: Map patient populations who are at risk for flooding-related health harms.

SUMMARY: Collaborating with community partners to map patient populations who are at high risk of negative health outcomes after flooding exposure can increase organizational and community resilience by helping to ensure that protocols supporting healthcare access during and after flooding events are tailored to those populations' needs (Patel et al., 2022).

ACTION: Use the JEDI framework to structure community input.

SUMMARY: Consider following the Justice, Equity, Diversity, and Inclusion (JEDI) framework to integrate community input into the development and operation of the healthcare organization's climate resilience plan (American Public Health Association & CDC, 2021).

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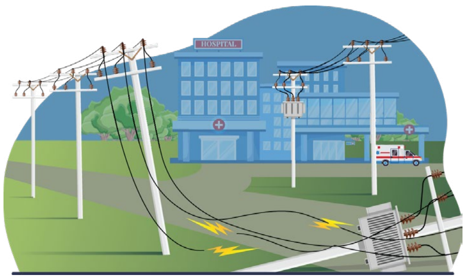
Resilience Strategies:

Flooding

CR4HC

Element 2.2 Community Infrastructure



Flooding can cause damage to buildings and other critical community infrastructure, including transportation infrastructure and communication systems. In addition, flooding can degrade transmission along power lines and can affect generators and other electricity transmission infrastructure. Water systems can be contaminated by overflow of sewage, and, in coastal areas, saltwater contamination. Flood waters can also cause degradation to earthen canals and damage to farmlands and open land, leading to crop loss, soil erosion, and spread of invasive species (CISA 2023; EPA, 2019 c.; EPA, 2021).

It may not be practical to locate all of a healthcare organization's facilities outside of the floodplain. Instead, organizations may prioritize ensuring that their facilities remain accessible to community members during and after flooding events. Thoughtful resilience measures on the healthcare campus can both protect patients and staff and also enhance community resilience to flooding. For example, in 2019, Tampa General, a Florida hospital that has over 1,000 beds and is the region's only level 1 trauma center, invested in a temporary floodwall made of modules that can be linked, and have straps that anchor the wall to the ground during high winds. The hospital deployed the floodwall to protect its main campus during Hurricanes Helene and Milton in 2024, and moved first floor occupants to higher ground as an added protective measure. These measures allowed the hospital to continue its critical operations, and ensured the safety of patients and staff (Toussaint, 2024; Raza, 2024).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
[Element 2.2: Community Infrastructure](#)

People and Operations

ACTION: **Provide publicly available resources to patients, staff, and community members.**

SUMMARY: Ensure that all community members have access to information and resources for flood insurance programs and community floodplain management, including the National Flood Insurance Program and FEMA Community Rating System (FEMA, 2021 a.; FEMA, 2023 b.).

ACTION: **Support and direct patients to local programs that increase adaptive capacity in the home environment.**

SUMMARY: Connect low-income residents and other high-risk groups (like those over 65 and those with chronic illness) with programs that can help them prepare for and recover from floods (Patel et al., 2022). Examples include elevation assistance for flood-prone homes, access to emergency supply kits, provisions for backup generators or charged batteries for medical equipment, and emergency preparedness workshops.

Physical Infrastructure

ACTION: **Catalyze the development of resilient infrastructure at the neighborhood and community level.**

SUMMARY: As anchor institutions, healthcare campuses and public health institutions can catalyze neighborhood and community-scale efforts to increase resilience against storms and flooding. Examples include supporting multiple modes of transportation (which can double as evacuation routes), green infrastructure, neighborhood microgrids, and neighborhood water retention and treatment systems (Pastor & Morello-Frosch, 2014; Hacke & Deane, 2017).

Climate Resilience Actions, continued

ACTION: **Enhance community resilience by remediating contaminated sites for healthcare installations.**

SUMMARY: Strategically placing healthcare facilities on sites in need of environmental remediation (such as brownfields) can accelerate the clean-up process, thereby reducing the risk of community exposure to toxin-laden dust and flood waters after storm and flooding events (Ballogg, 2015; ATSDR, 2021).

ACTION: **Ensure existing infrastructure is sound.**

SUMMARY: Ensure that the capacity of the existing stormwater management system is adequate for anticipated flood events to minimize contamination of community water systems (Borgaonkar & Marhaba, 2021).

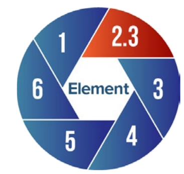
ACTION: **Work with local and regional partners to lower barriers to travel for patients and staff during storms and flooding events.**

SUMMARY: Transportation infrastructure failures can prevent staff from reporting to work and patients from traveling to healthcare facilities to receive needed care during storms and flooding events. Healthcare organizations can support regional climate change resilience by working with local and regional partners to lower barriers to travel (WHO, 2020). For example, limited public transit service could be offered to patients and essential workers, and medical workers could be granted priority access to gas stations (U.S. HHS, 2014).

Resilience Strategies: Flooding

CR4HC

Element 2.3 Community Services



Partnering with community organizations to mitigate risk factors (such as housing or utility insecurity) before a flooding event, coordinating outreach efforts to locate and evacuate at-risk individuals from high-risk flood zones, and providing essential community-based services during and after a flood, can increase healthcare organization resilience by reducing the surge in demand for healthcare services.

Essential services can include distribution of food, water, and medication; and access to emergency power for people who rely on electricity-dependent durable medical equipment (DME). For example in the immediate aftermath of a devastating 2022 flood event, University of Kentucky (UK) and UK HealthCare staff coordinated with emergency responders to rescue their neighbors in Eastern Kentucky. Teams of healthcare providers carried tetanus shots, medication, drinking water, and first aid supplies to survivors trapped in inaccessible locations. Teams also shared with survivors information about how to access additional resources such as FEMA funding. Three months after the flood, UK's Center of Excellence in Rural Health recruited volunteer staff members to conduct a needs assessment of impacted rural areas. The results were compiled into a central database and used to develop an organized approach to deliver long-term community services in difficult-to-reach communities (Smith et al., 2016). Another regional health system, Appalachian Regional Healthcare, headquartered in Lexington, distributed donated essential supplies, such as food and diapers, and administered tetanus and hepatitis vaccines in affected communities (Gunnerson, 2024).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 2.3: Community Services

Planning

ACTION: Consider preemptive planning for patients who use electricity-dependent DME.

SUMMARY: Proactively help patients who rely on electricity-dependent DME to ensure that they have a backup power source or another contingency plan in the event of power shutoffs during a flood (Pacific ADA Center, 2017).

ACTION: Partner with local EMS providers to convey guidance to patients in the community about ways to increase their resilience to hurricanes, storms, and flooding events.

SUMMARY: Coordinate with Emergency Medical Services (EMS) providers to identify high-risk patients during flooding events. This may involve gathering information about flood plain locations and building characteristics to identify neighborhoods that are more prone to flooding, storm surge, and/or wind damage. Help EMS identify patients who require evacuation or who rely on critical medical equipment that may be compromised during a flooding event, hurricane, or storm. Provide resources to support patients who could remain at home rather than travel to healthcare facilities for treatment (O'Meara et al., 2016).

People and Operations

ACTION: Coordinate with community partners to create a multi-sector protocol for the delivery of mental health services during and after storms and flooding events.

SUMMARY: The mental health impact of storms and flooding events can be severe. Healthcare organizations

Climate Resilience Actions, continued

can help increase community resilience by supporting crisis response planning among community partners in the public and private sectors who provide mental health care for survivors of natural disasters (WHO, 2020).

ACTION: Fill gaps in local services to increase resilience, such as acting as a place of refuge during storms and flooding events.

SUMMARY: Healthcare facilities equipped to continue operations during power outages can enhance local resilience by offering their facilities as refuges for community members during storms and flooding events (Johns & Rosenthal, 2024; Toner et al., 2017). It is important to formalize this role with the Office of Emergency Management ahead of the event so that the facility receives extra fuel, supplies, and staff to manage non-medical emergency services (U.S. HHS, 2014).

ACTION: Integrate community resilience needs into healthcare organization flood management plans.

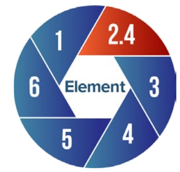
SUMMARY: Include provisions in the healthcare organization's flood emergency plan to accommodate community members who may seek to use the facility as a refuge and patients who require access to electrical power to charge their medical devices and/or refrigeration for their medications. Consider creating a registry of patients needing this kind of assistance and setting up a two-way communications protocol (such as a Reverse 911 or wireless emergency alert system [National Academies of Sciences, 2018]) to contact them in the event of a power disruption or outage (Patel et al., 2022).

Physical Infrastructure

ACTION: Provide community members with post-disaster safety information for their homes.

SUMMARY: After floods, healthcare organizations can share information with community members about how to inspect their homes for flood damage, how to remove water-logged and contaminated building materials, how to reduce the risk of mold growth, and how to find opportunities for funding to support demolition and rebuilding efforts (CDC, 2019 a.).

Element 2.4 Coordination with Local Office of Emergency Management



Synchronizing your healthcare organization's flood emergency plan with peer organization plans, the local office of emergency management, and the local utility can result in a more efficient and effective coordinated response during and after flooding events. It can also shine a light on current gaps and redundancies that, if addressed, could increase the effectiveness of responders during an emergency. Coordination also supports the development of personal relationships across organizations and agencies – an important factor during an emergency response (FEMA, 2023 b.).

Real-time data sharing between healthcare organizations, emergency management, and public health officials is an essential component of a coordinated response to flood emergencies. For example, the Southeast Texas Regional Advisory Council's patient evacuation tracking system, which is integrated with public health and state-level data systems, ensures that medical records are transferred along with evacuated patients, and that patients and family members' locations are accurately tracked and coordinated. This tracking system helps to improve regional situational awareness and inform coordination and deployment of resources by local, regional, and state authorities (Institute of Medicine, 2015).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 2.4: Coordination with Local Office of Emergency Management

Planning

ACTION: Add local and regional climate change vulnerability assessments to the healthcare organization's emergency preparedness plan.

SUMMARY: Consider adding local and regional climate change vulnerability assessments to the healthcare organization's emergency preparedness plan to integrate projections of how the region's exposure to storms and flooding events may change in coming decades compared with historical trends (Marinucci et al., 2014).

ACTION: Collaborate with local partners to coordinate storm and flood-event messaging.

SUMMARY: It can be helpful to collaborate with local public health department partners to coordinate flood-related messaging with clinicians and patients, such as through prompts in the healthcare organization's electronic health record, e-newsletter, and patient texting system. This approach can increase community awareness of both the short- and long-term health risks associated with exposure to storms and flooding (WHO, 2020).

ACTION: Formalize cooperation agreements with utility providers (both power and water) to ensure that the healthcare organization's facilities are integrated into local emergency management and climate resilience planning efforts.

SUMMARY: Critical facilities, hospitals, and other healthcare building types should be fully integrated into local utilities' emergency management and climate resilience planning efforts. It is particularly important to include facility power and water needs in emergency preparedness and climate resilience planning efforts to ensure that they can continue to provide care during and after floods (McCabe et al., 2023; Van der Heijden, 2022).

Climate Resilience Actions, continued

ACTION: Integrate legal preparedness into the healthcare organization's emergency management and climate action plans.

SUMMARY: Uncertainty about who has the legal authority to authorize difficult decisions during disasters can slow a healthcare organization's ability to pivot from normal operations to respond to a disaster. Healthcare organizations can enhance the resilience of their emergency management and climate action plans by (1) including parameters that clarify the conditions in which a facility may share information outside of the healthcare organization and administrators may order facility evacuations, (2) clarifying how personnel will reconcile protocol discrepancies (such as different evacuation protocols for healthcare organizations compared with Emergency Medical Services, and (3) authorizing clinical staff from outside organizations to practice in the healthcare facility. These plans may also include a decision framework for deciding how to allocate scarce resources during utility outages (U.S. HHS, 2014; Toner et al., 2017; VanDevanter et al., 2014).

People and Operations

ACTION: Coordinate flood warnings and action protocols with the local office of emergency management and local weather stations.

SUMMARY: Coordinate with the local office of emergency management and the local weather station's flood warning protocols and action plans to ensure the healthcare organization can enhance its baseline syndromic surveillance reports with information on drowning and flood-related illnesses during and immediately after flooding events (Hess et al., 2023).

ACTION: Coordinate flood-related syndromic surveillance with the local office of emergency management and the local weather station.

SUMMARY: It can be helpful to add flood-related illnesses to the healthcare organization's syndromic surveillance reports during and immediately following designated emergencies. Aligning the organization's protocol for collecting relevant diagnostic data with the local office of emergency management and weather station's protocol for declaring a climate-related emergency will help ensure that the organizational climate resilience action plan deploys in coordination with local alerts (Hess et al., 2023).

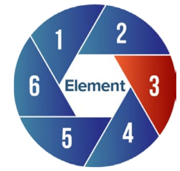
ACTION: Leverage healthcare facilities as intervention sites for local hazard action plans.

SUMMARY: Healthcare organizations often offer their locations as community intervention sites for the local hazard action plan. For example, allowing the Office of Emergency Management to use strategically located hospitals, medical office buildings, and clinics as distribution sites for water bottles, food, etc., can increase community access to health-promoting supplies. Officially designating publicly available spaces in healthcare facilities – such as the cafeteria – as resilience hubs or temporary shelters during flooding events can help support patients and family members as well as raise awareness in the community that climate-related events are public health emergencies (Hess et al., 2023; IOM, 2012).

Resilience Strategies:
Flooding

CR4HC

Element 3. Assessment and Remediation of Vulnerabilities in Infrastructure and Operations



Flooding is the most destructive natural disaster in the United States in terms of infrastructure damage, injury, and death (Sadiq and Noonan, 2015). In Florida – the state with the greatest exposure to floodplains per capita in the United States – 12% of hospitals are located in floodplains and 22% are estimated to be at high flood risk.

To save lives, protect property, and reduce the risk of disruptions in clinical care, healthcare organizations can build resilience and redundancy in their facility design and operations, which involves (1) building and maintaining efficient buildings that can continue to operate during power outages, water service disruption, and infrastructure damages; (2) designing resilient supply chains and storage conditions for food and medical supplies that require constant refrigeration; and (3) making plans to protect, house, and provide transportation for staff and their families during extreme weather events so that 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 compounding impacts of flooding.

The most cost-effective way to integrate flood resilience into a healthcare organization's infrastructure and operations is to plan for it from the beginning, starting with a hazard vulnerability assessment to pinpoint the highest risk exposures. Memorial Sloan Kettering built on the lessons learned from Superstorm Sandy (2012) to bring a holistic approach to flood resilience in the David H. Koch Center for Cancer Care – a 760,000 sq. ft. outpatient facility entirely located within the 100-year floodplain. Mechanical and electrical equipment are located either above the designated flood elevation or inside a flood-proofed underground vault. Exterior walls are equipped with a continuous flood barrier, water-proofing, and structural reinforcement designed to resist storm surge. The building foundation is also engineered to withstand hydrostatic soil pressure in flooded conditions (Burmahl, 2020).

The following sub-elements describe specific ways in which a healthcare organization can enhance its facility infrastructure and operations' resilience to flooding events.

3.1 Staff Support: Healthcare organizations depend on clinicians, administrators, and facilities and operations staff to deliver care. Integrating protections and accommodations for staff into the flooding 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. Access to healthcare can also be impaired by flooding, with transportation routes blocked by flood waters, debris, and downed power lines. Plans are needed to ensure that the facility is adequately staffed and that both staff and patients have ways to safely access the facility. There may be staffing shortages if healthcare workers cannot access the facility (ASPR TRACIE, 2022).

3.2 Clinical Considerations: Flooding events can cause a surge in healthcare demand – for both flood-related illness and all-cause morbidity and mortality. Flooding can also increase the risk of waterborne and vector-borne infectious disease, particularly gastrointestinal illness, and direct skin exposure can lead to soft tissue and wound infection (CDC, 2019 b.; WHO, 2023). Exposures to mold and allergens in the aftermath of a flooding event can exacerbate respiratory conditions (CDC, 2019, b.). Displacement and financial losses due to flooding can lead to mental and emotional distress (Alderman et al., 2012). Messaging to the public and healthcare providers can help raise awareness of flood-related illnesses, which can both help the public to take protective measures, and increase the index of suspicion for otherwise unusual conditions that require timely intervention.

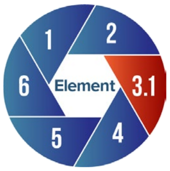
3.3 Building and Campus – Design & Construction: While building codes require structural redundancies that harden buildings against potential environmental hazards, facilities in floodplains may still be prone to damage or complete destruction during flooding. Healthcare buildings are vulnerable to power outages because they rely on electricity, plumbing systems, and energy sources, like natural gas, to operate 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). Inpatients also require food service, access to clean water, and laundry and custodial services (FEMA, 2023 b.). Flood resilience is best tailored to the unique needs of each location.

3.4 Building and Campus – Facility Operations: Flood-resilient facility operations are region-specific, meaning that they are responsive to the kinds of flood exposure projected for the region in which they are located. Healthcare organizations in regions experiencing chronic flooding can enhance resilience by moving all equipment and functions that could be damaged by contact with flood waters above the design flood elevation, flood-proofing areas below that line, and integrating flood-proofing into the facility’s preventive maintenance program. Facility managers play a key role in ensuring that flood resilience planning is implemented effectively during the response and recovery phases of a flood event. During the event, facility managers coordinate with emergency managers and clinical leaders to implement emergency protocols such as switching the facility to emergency energy and water sources; converting clinical areas into flex spaces that accommodate patient surge and/or community members seeking shelter; and, safely evacuating patients. After the event, facility managers regularly inspect the building and grounds to identify and address long-term flood damage, which can lead to mold growth and other nonstructural harm that can require the facility to temporarily cease operations.

3.5 Supply Chain: Flooding can disrupt supply chains at their source (e.g., where products are made) and at their destination. Transportation may also be impacted during flooding, inhibiting delivery of critical medications and supplies (Rublee et al, 2021). Many items in a healthcare organization’s supply chain - both clinical and non-clinical - require refrigeration. Managing a refrigerated supply chain and on-site storage during flooding-related regional power outages is crucial to the resilience of healthcare facilities. Furthermore, treatments for flooding-related illness may require specific supplies that are not available in large quantities under normal circumstances. To prevent facilities running out of certain medications during a flood, facilities may need additional supplies to treat the surge of case and severe illness appropriately.

Resilience Strategies: Flooding

Element 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, and these impacts can lead to staffing shortages (ASPR TRACIE, 2022). Integrating protections and accommodations for staff into the flooding 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. Access to healthcare can also be impaired by flooding, with transportation routes blocked by flood waters, debris, and downed power lines. Plans are needed to ensure that the facility is adequately staffed and that both staff and patients have ways to safely access the facility.

For example, University of Texas MD Anderson Cancer Center in Houston provides a disaster preparedness booklet for its employees that includes creating a disaster plan and kit, preparing homes for storms, arranging for the care of pets, and evacuation contraflow routes for the city of Houston. Clear expectations about staff roles during disasters are in place; the hospital has a ride-out team and a recovery team responsible for critical patient care. Members of these teams are required to understand their responsibilities during storms and other severe weather events. Finally, the hospital is a shelter-in-place facility, with a roof management system and wind-resistant windows (FEMA, 2021).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 3.1: Staff Support

Planning

ACTION: Set staff expectations for their role during severe storms and flooding.

SUMMARY: Clearly define expectations with healthcare facility staff related to working during and after severe storms and flooding events – particularly under circumstances that lead to power disruptions or outages, and those that may require staff to remain at work for extended periods. Share with staff a list of personal items that they should bring with them to an anticipated multi-day response effort, such as food, water, personal medication, hand sanitizer, extra clothes, and sleeping gear. Co-create policies and programs with staff establishing a flexible and supportive approach to staffing, accommodations, and transportation during and after severe storms. For example, it may be necessary to shorten staff shifts during emergency operations to give them the ability to rest mentally and physically. Include daycare, shelter, and other accommodations for staff family members, as needed (Danna et al., 2010; Toner et al., 2017; WHO, 2020).

ACTION: Train clinical staff in alternative procedures for delivering care during disasters.

SUMMARY: Healthcare organizations can support staff in preparing for disaster response by offering training in alternative procedures for intake and triage if inpatients are transferred from other facilities without their medical records, as well as training in alternative procedures for delivering care in situations with limited access to electricity and water, such as manually counting intravenous pump drips, manually suctioning intubated patients, and manually taking blood pressure readings (U.S. HHS, 2014).

Climate Resilience Actions, continued

People and Operations

ACTION: During transportation disruptions, coordinate across the healthcare system to redistribute staff to facilities they can access – even if they are not at their "home" facility.

SUMMARY: It may be necessary immediately following events that damage infrastructure – such as severe storms and floods – to temporarily redistribute the healthcare system's staff to facilities they can access (Morris et al., 2016). Establish a tracking system so that staff can report to supervisors who are physically located in different facilities (Wyte-Lake et al., 2018). Cross-training staff so that they can fulfill multiple roles can benefit the overall healthcare system by ensuring that essential clinical services are offered by a mixture of permanent and temporary staff (Hilton et al., 2015).

ACTION: Ensure that staff who are supporting a flood response have access to clothing, a place to sleep, routine medications, and wellness services.

SUMMARY: Given the often-rapid evolution of storms and floods, and their impacts on community infrastructure, staff may be required to stay at their place of work for more than 24 hours without access to basic necessities such as a change of clothes and daily medications. Healthcare organizations can increase the resilience of their clinical services by ensuring that staff have access to clothing, a place to sleep, routine medications, and wellness services while they support patients in the midst of a disaster (Evans, 2017; Hilton et al., 2015; Morris et al., 2016; Toner et al., 2017).

ACTION: Establish a culture that acknowledges the personal challenges staff are facing during a disaster.

SUMMARY: Acknowledging the personal challenges faced by staff during a climate change-related disaster can increase a healthcare facility's resilience by increasing the willingness of staff who are able to report to work. It also creates space for staff to request tangible assistance (such as a hotel room or childcare) that would make it possible for them to support the disaster response (Morris et al., 2016; Toner et al., 2017).

ACTION: Integrate regular emergency preparedness employee training into the healthcare organization's continuing education program.

SUMMARY: Implementing a regular emergency preparedness employee training program can increase awareness of climate change-related risks to the healthcare organization, as well as protocols and procedures designed to enhance resilience in the face of increasingly frequent and severe climate change-related events, including flooding (Hilton, 2015; WHO, 2020).

ACTION: Provide alternative transportation and housing for healthcare staff during flood events.

SUMMARY: Consider establishing agreements with nearby transportation providers and temporary housing facilities (such as hotels) to support employees and their immediate families (including pets) in the event that transportation pathways and/or utilities are disrupted during a storm or flood. This may also involve preparing for staff to stay at healthcare facilities before the extreme weather event begins to mitigate potential transportation interruptions (Morris et al., 2016; 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 severe storm or flood – 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 (Danna et al., 2010; WHO, 2020). Immediate support for staff who have experienced a major loss (such as their home) can also increase their ability and willingness to return to work after the event (Morris et al., 2016).

ACTION: Provide staff with post-disaster safety information for their homes.

SUMMARY: After floods and storms, healthcare organizations can share information with staff about how to inspect their homes for flood damage, how to remove water-logged and contaminated building materials, how to reduce the risk of mold growth, and how to find funding opportunities to support demolition and rebuilding efforts (CDC, 2019 a.).

Physical Infrastructure

ACTION: Establish alternative communications channels for contacting staff during utility outages.

SUMMARY: Staffing during and immediately following climate change-related disasters that cause utility outages can be complicated by disruptions to telecommunications infrastructure. Establishing alternative communications channels (such as multiple cell phone providers, satellite phones, walkie-talkies, and installing a generator-powered cell tower on the roof of the facility) can increase a

Climate Resilience Actions, continued

healthcare organization's resilience to these events by making it possible to share important information with staff – such as facility closures and requests that staff report to the facility closest to their home (U.S. HHS, 2014; Morris et al., 2016; Wyte-Lake et al., 2018).

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Resilience Strategies: Flooding

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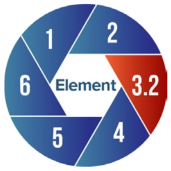
Element 3.2 Clinical Considerations



Flooding events can cause a surge in healthcare demand – for both flood-related illness and all-cause morbidity and mortality. Flooding can directly threaten health through drowning, with drowning accounting for up to 75% of deaths after floods (WHO, 2023). Emergency Medical Services responders to the 2022 floods in Kentucky reported treating a wide range of medical needs, including skin abrasions, heat-related injury, bodily trauma after coming into contact with debris in flood waters, exacerbated chronic conditions like diabetes, and patients experiencing mental distress. First responders often also require medical care related to abrasions and blunt trauma, insect and snake bites, sunburn, and dehydration (Bassett, 2022).

Flooding can also increase the risk of waterborne and vector-borne infectious disease, particularly gastrointestinal illness, and direct skin exposure can lead to soft tissue and wound infection (CDC, 2019 b.; WHO, 2023). Exposures to mold and allergens in the aftermath of a flooding event can exacerbate respiratory conditions (CDC, 2019 b.). Displacement and financial losses due to flooding can lead to mental and emotional distress (Alderman et al., 2012).

Messaging to the public and healthcare providers can help raise awareness of flood-related illnesses, which can both help the public to take protective measures, and increase the index of suspicion for otherwise unusual conditions that require timely intervention. For example, following a coastal storm surge and flooding with brackish water, there can be a greater risk of infections caused by *Vibrio* bacteria. *Vibrio vulnificus* can cause potentially life-threatening wound infections, and requires prompt, aggressive wound care and antibiotic administration. Following Hurricane Ian in 2022, the Florida Department of Public Health issued public health messaging alerting the public to a vibriosis outbreak attributed to the flooding and advising residents to avoid coming in contact with flood waters (Sodders et al., 2023).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
[Element 3.2: Clinical Considerations]

Planning

ACTION: Enhance flood preparedness by adding flood-related illness screening to the healthcare organization's EMR system.

SUMMARY: Consider including in your organization's flood resilience and preparedness plan a protocol for activating flood-related illness screening questions in the electronic medical record (EMR) system when local authorities activate the emergency operations center to respond to a flood (Hess et al., 2023). Sensitive patient groups that might be flagged for additional screening during and after flood events include unhoused individuals, children, adults over 65 years of age (especially those who live alone), low-income populations, and patients with chronic conditions. Early identification through EMR screening allows healthcare providers to flag sensitive patient groups for further evaluation and intervention, which may improve patient outcomes.

ACTION: Enhance syndromic surveillance during flood events.

SUMMARY: Consider enhancing the healthcare system's syndromic surveillance during flood events by submitting flooding-related illness data to the Electronic Surveillance System for the Early Notification of Community-Based

Climate Resilience Actions, continued

Epidemics (Burkom et al., 2021), bearing in mind that the health effects of flooding, including respiratory symptoms related to mold exposure and the spread of waterborne and vector-borne diseases, can persist in the aftermath of the acute event. Work with local public health partners to interpret and act on real-time flooding-related illness and all-cause morbidity and mortality data during and immediately following flood events.

ACTION: Integrate epidemiological and meteorological data into storm and flooding 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 storm and flooding events (Patel et al., 2022).

People and Operations

ACTION: Adjust normal procedures and standards of care ahead of forecasted floods to expedite patient discharges, when possible, and to adjust the timing of routine treatment.

SUMMARY: Consider establishing protocols triggering an adjustment to the healthcare organization's clinical procedures (e.g., in pharmacy, drug treatment, dialysis, etc.) ahead of forecasted floods to create contingency plans to extend the amount of time existing patients can go without routine treatment. When possible, expedite inpatient discharge to free up bed space ahead of expected patient surges during and immediately following the event (Scott, 2017; Toner et al., 2017).

ACTION: Develop a plan for patient surges and train staff in its implementation, including scenarios for accommodating cascading and simultaneous climate change-related disasters.

SUMMARY: Many climate change-related events occur simultaneously or in quick succession. For example, wildfires, drought, flooding, and landslides often trigger or exacerbate each other. It is, therefore, increasingly important to develop a plan for patient surges and train staff in its implementation. Include procedures for bringing in temporary staff, adapting clinician services to fast-changing conditions, and altering the schedule for routine operating procedures to free up space and staff to provide emergency care (Toner et al., 2017).

ACTION: If it is necessary to evacuate patients during a disaster, consider sending nurses, nursing assistants, and leadership staff with them to ensure continuity of care.

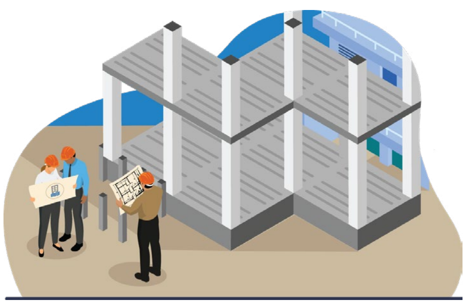
SUMMARY: Hospitals that evacuated patients alongside care staff and their leadership team during Superstorm Sandy (2012) reported lower rates of anxiety about the evacuation among patients and their families (U.S. HHS, 2014).

Physical Infrastructure

ACTION: Deploy mobile health units to take medical care to high-risk patients in the community during transportation disruptions.

SUMMARY: Consider including in the healthcare organization's list of emergency response assets mobile units that are used to deliver routine care to community members. Use the organization's map of high-risk patients – such as substance use disorder, dialysis, diabetes, and heart disease – (Element 2.1) to prioritize the provision of medical care during transportation disruptions caused by a climate change-related event (Toner et al., 2017).

Element 3.3 Building and Campus: Design & Construction



While building codes require structural redundancies that harden buildings against potential environmental hazards, facilities in floodplains may still be prone to damage or complete destruction during flooding. Healthcare buildings are vulnerable to power outages because they rely on electricity, plumbing systems, and energy sources, like natural gas, to operate 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) (FEMA & ASPR, 2019). Inpatients also require food service, access to clean water, and laundry and custodial services (FEMA, 2023 b.).

Flood resilience is best tailored to the unique needs of each location. University of Florida Health, in Gainesville, Florida, has prioritized resilience to wind, storm surge, and street flooding due to the combined risk of sea level rise and hurricanes. In addition to increasing the redundancy of utilities and the HVAC systems campus-wide, the health system has fitted out new facilities with hurricane-resistant windows and walls, structural flood protection, and a flexible layout to accommodate patient surge during and after disasters (Burmahl, 2020).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 3.3: Building and Campus: Design & Construction

Planning

ACTION: Avoid building healthcare facilities in floodplains.

SUMMARY: The populations served by healthcare facilities are at higher risk of injury or disease if they come in contact with flood waters than the general population. Some facilities, such as hospitals, are also considered critical infrastructure and must remain operational and accessible to the public during natural disasters. Building outside of the floodplain reduces the risk that the facility will be impacted by a flood, which could disrupt clinical operations, require evacuating patients, and cut off the facility from community members seeking care. If building in a floodplain is unavoidable, healthcare organizations can enhance resilience by raising the lowest occupied floor above the design flood elevation (PDH Star, 2018).

ACTION: Use regional climate models to future-proof the efficiency and redundancy of building systems in the face of projected increases in the frequency, severity, and duration of flood risk.

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 and wind speed at which they will function, whether they will continue to function in flooded conditions, 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 efficienc and identify opportunities for diversifying their energy supply (such as installing renewable power microgrids for backup power) in order to extend the functional life of the building as long as possible within the context of a rapidly changing climate (Casanueva et al., 2019).

Climate Resilience Actions, continued

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 & Chan, 2017).

Physical Infrastructure

Structure and Landscaping

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., 2023).

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 multimodal evacuation plans when they are deployed during a climate change-related event (Basu et al., 2022).

ACTION: Design new buildings and reinforce existing structures to withstand future flooding exposures as described in the healthcare organization's prospective risk assessment (Element 1).

SUMMARY: Many building codes rely on historical data to set structural requirements for withstanding climate change-related hazards like wind, flooding, fire, heat, and landslides. Flooding exposures include the projected depth and velocity of flood waters, potential impacts from debris and ice floating in the flood waters, the potential for flood waters and/or wave action to erode and scour the soil around the structure, and the duration of the flood (PDH Star, 2018). Healthcare organizations can reduce the risk of a major disaster causing sufficien physical damage that shuts down operations by designing and renovating facilities to withstand future climate change-related exposures as described in their prospective risk assessment (Element 1) (U.S. HHS, 2014).

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 at which they can generate sufficient electricity using on-site renewable power (e.g., solar, wind, geothermal). These facilities can continue to provide clinical care during disasters that disrupt regional power grids.

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

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 storms and flooding (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 to on-site power storage capacity can reduce a healthcare facility's reliance on external power sources needed to maintain continuity of care (Isa et al., 2018).

ACTION: Install energy efficient building equipment to extend the length of time during which 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 during which the

Climate Resilience Actions, continued

facility can function on back-up power systems (Carvallo et al., 2022).

Water Efficiency and Flood Resilience

ACTION: Reinforce, anchor, and stabilize external walls and foundations to counter hydrostatic and hydrodynamic loads and potential impact from flood debris.

SUMMARY: Hydrostatic loads refer to water placing pressure on the exterior of a structure – either through flood waters or in the form of saturated soil placing additional pressure on the sides and bottom of a structure's foundation. Hydrostatic forces can cause building walls, floors, structure, and foundations to deflect, displace, or, in extreme cases, fail. Hydrodynamic loads refer to the different pressures placed on a structure by moving water: frontal pressure on the upstream side, negative pressure or suction on the downstream side, and drag effects along the building sides. Healthcare organizations can counter these forces by reinforcing and stabilizing the structure and by dissipating the pressure with openings located below the flood elevation. Considering the entire potential wind and water load path from roof to foundation when designing connections can help ensure that the building responds to simultaneous wind and flood forces as a unified system (PDH Star, 2018).

ACTION: Design all areas below the design flood elevation to be resistant to flood damage.

SUMMARY: Designing all areas below the design flood elevation with the assumption that they will be exposed to flood damage can prompt the healthcare organization to move critical building systems, laboratories, and other flood-sensitive operations above the expected flood line. Areas below the line can be flood-proofed by avoiding absorptive materials, using water-proof paints, and installing physical barriers such as a moat, floodgates, and flood doors (PDH Star, 2018).

ACTION: Install protective barriers and elevated walkways/driveways in areas at risk of flooding.

SUMMARY: Floodgates, floodwalls, levees, and other barriers equipped with crossover stairs can support safe passage across areas on a medical campus that are projected to experience repeated flooding (U.S. HHS, 2014).

ACTION: Maximize water efficiency to reduce demand during low water pressure and boil water notice events and to reduce the burden placed on the community sanitary sewer system during flood events.

SUMMARY: Water is critical to the functioning of healthcare facilities – both clinical and building systems. To maximize the availability of potable water for clinical uses, consider minimizing once-through use in process equipment – such as the HVAC system, sterilizers, and medical equipment. Further, consider installing low-flow toilets, urinals, handwash stations, and showers – except where volume is needed for occupational uses (such as water filling stations and decontamination showers) (Van der Heijden, 2022; WHO, 2015).

ACTION: Install backflow prevention valves to prevent sanitary sewage from backing up into the hospital during flood events.

SUMMARY: Healthcare facilities located in communities with combined sanitary and storm sewers may experience sewage backup during extreme flood events. Facilities can enhance resilience by installing backflow prevention valves and capping drains on lower floors during flooding events (Van der Heijden, 2022; WHO, 2015). New and replacement sanitary sewer lines should also be designed to avoid both discharging into flood waters and allowing flood waters to infiltrate the system (PDH Star, 2018).

ACTION: Protect the permanent and emergency water supply from extreme weather and contamination from flood waters.

SUMMARY: Weatherize water supply pipes, cisterns, and tanks to prevent breakages in extreme cold weather. Place emergency water storage (such as tanks and cisterns) outside of areas at risk of flooding. Install float valves and overflow outlets that drain away from the facility to avoid flooding interior spaces after a cistern or tank fills up. Install one or more supplementary water pumps (depending on need) and connect them to the emergency power supply to keep water pressure at safe levels when the power goes out (Van der Heijden, 2022; WHO, 2015).

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).

Climate Resilience Actions, continued

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) coupled with 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).

Resilient Critical Operating Systems

ACTION: Install redundant communication systems for use during power and communications outages.

SUMMARY: Extreme weather events can disrupt electricity supply, cell towers, radio transformers, and other community communications networks. Healthcare organizations can reduce the risk of disruption in communications to other facilities in their network, regional healthcare organizations, and local emergency management agencies by installing and maintaining redundant communication systems, such as analog phones, fax machines, handheld two-way radios, ham radios, and solar-powered devices (Hedges et al., 2018).

ACTION: Place redundant IT systems off-site to increase the resilience of EMRs.

SUMMARY: Placing redundant IT systems off-site can reduce the risk of the electronic medical record (EMR) system going offline during flood events (Danna et al., 2010; Toner et al., 2017).

ACTION: Place EMR servers and equipment in climate-controlled spaces and above the flood line.

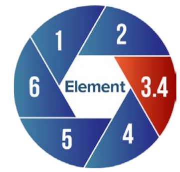
SUMMARY: To ensure that medical information systems remain functional during power outages and flooding events, place them in storage spaces that are elevated above the risk of flood waters, climate-controlled with a dedicated energy source, and/or off-campus (such as a duplicate paper record storage site) (Swanson et al., 2010; HHS, 2014).

ACTION: Place the healthcare organization's critical infrastructure above the level of projected flood risk.

SUMMARY: Placing equipment crucial to research, education, and patient care (such as labs, medical equipment, and IT equipment) and building systems (such as emergency generators, pumps, and electrical switches) above the level of projected flood risk can reduce the likelihood of disruptions to patient care and research resulting from facility flooding (U.S. HHS, 2014; Scott, 2017).

Resilience Strategies:
Flooding

Element 3.4 Building and Campus: Facility Operations



Flood-resilient facility operations are region-specific, meaning that they are responsive to the kinds of flood exposure projected for the region in which they are located. Healthcare organizations in regions experiencing chronic flooding can enhance resilience by moving all equipment and functions that could be damaged by contact with flood waters above the design flood elevation, flood-proofing areas below that line, and integrating flood-proofing into the facility's preventive maintenance program.

Facility managers play a key role in ensuring that flood resilience planning is implemented effectively during the response and recovery phases of a flood event. During the event, facility managers coordinate with emergency managers and clinical leaders to implement emergency protocols such as switching the facility to emergency energy and water sources; converting clinical areas into flex spaces that accommodate patient surge and/or community members seeking shelter; and, safely evacuating patients. After the event, facility managers regularly inspect the building and grounds to identify and address long-term flood damage, which can lead to mold growth and other nonstructural harm that can require the facility to temporarily cease operations.

Facility staff at the Pungo District Hospital in Belhaven, North Carolina, are central to the success of the hospital's flood resilience retrofit, which required a full evacuation from the facility before the installation of flood gates and flood-proofing panels across all building openings. When the system was activated in advance of Hurricane Isabel in 2003, hospital staff worked together to evacuate patients to a facility 30 miles inland, shut down the building systems, activate emergency generators to run sump pumps in the crawl space, and install the flood panels in 12 hours. In spite of the hurricane causing the highest flooding on record in Belhaven, the hospital was undamaged (PDH Star, 2018).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 3.4: Building and Campus: Facility Operations

Planning

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 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 (such as extreme temperatures, exposure to flood waters, etc.) reach dangerous levels (FEMA & ASPR, 2019).

ACTION: For storms and flooding events that could result in widespread damage to utilities and community infrastructure, include security considerations in the healthcare facility's emergency preparedness plan.

SUMMARY: Flooding and wind events that cause widespread damage to utilities and community infrastructure can result in a temporary need for increased security at a healthcare facility, particularly if it experiences a patient surge and/or acts as a place of respite for community members (Danna et al., 2010).

Climate Resilience Actions, continued

ACTION: Integrate pre-flood 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 enhance 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: Perform a baseline analysis of water usage and categorize usage types into tiers of critical need.

SUMMARY: Water is a critical component of clinical care, including sanitizing medical equipment. Performing a baseline analysis of the healthcare facility's water usage and categorizing usage types into tiers of critical need can help facility managers direct potable water supply to the most important clinical needs during low water pressure and boil water notices while also reducing overall facility water usage (WHO, 2015; Van der Heijden et al., 2022).

People and Operations

ACTION: Conduct regular tests of emergency generators, water supplies, and transportation plans to ensure that they are ready to deploy in the event of an emergency.

SUMMARY: It can be difficult to source fuel, water trucks, and emergency transportation contractors in the immediate run-up to a storm or flood. Healthcare organizations can check the status of their resilience to the first 72 hours of anticipated severe storms or flooding by performing regular tests and maintenance on emergency generators and on-site sources of emergency water. It can also be helpful to perform regular drills with outside contractors who will be responsible for supplying more fuel, trucked-in water, emergency transportation for staff and patients, and other activities included in the facility's emergency operations plan (U.S. HHS, 2014).

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 demands 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 flooding events.

SUMMARY: Consider performing regular stress tests of the healthcare facility's ability to continue providing clinical care during flooding events. Incorporate scenarios that involve power outages, low water pressure, a surge of patients experiencing flood-related illness, a surge of all-cause complaints, and a surge of community members seeking to use the facility as a resilience hub and safe place to charge electrical devices (including medical equipment). Stress tests can help identify critical systems (such as vacuum suction systems and electricity-dependent medication delivery systems) whose failure would result in cascading effects across the facility and impact delivery of critical care (Ebi et al., 2018).

Physical Infrastructure

ACTION: Conduct regular walk-throughs of the healthcare facility to confirm compliance with fire safety and evacuation signage requirements.

SUMMARY: Facility evacuation can be impeded if exits are obstructed, signage is missing or confusing, or life safety equipment, like sprinklers and fire extinguishers, is missing or broken. Conducting regular walk-throughs of the healthcare facility to confirm that these essential emergency preparedness components are in place and in working order could be seen as a first level of resilience to any climate change-related hazard that might damage the building structure or result in an eventual evacuation (U.S. HHS, 2014).

ACTION: Ensure emergency equipment is in flood-protected areas.

SUMMARY: Ensure emergency generators are in areas safe from flooding to enable functioning and back-up power in the event of a flood (PDH Star, 2018).

ACTION: Ensure interior construction is flood-resistant.

SUMMARY: Review interior construction to ensure it is water resistant below 500-year flood elevations so that it continues to function in the setting of severe flooding (PDH Star, 2018).

Climate Resilience Actions, continued

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: **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: **Prior to an anticipated flooding and/or wind event, walk through the facility to identify locations that might require repair during and immediately following the event and stage the necessary materials and equipment (including pumps) nearby.**

SUMMARY: Certain locations in and around the healthcare facility – such as the roof, windows, and lower floors – are more vulnerable to damage from a flooding and/or wind event. Healthcare organizations can reduce the risk of disruption to clinical operations by identifying likely repair needs prior to the event and staging the relevant construction materials and equipment within easy reach to minimize the impact of minor leaks, broken windows, and other building damage on regular facility operations (ASPR TRACIE, 2023 b.).

ACTION: **During and after flood events, monitor the facility, transportation infrastructure, and landscaping for signs of flood damage.**

SUMMARY: Flood events can damage a healthcare facility's structure and foundation, compromising safety and, in extreme cases, leading to collapse. Healthcare organizations can support continued operations during a flood by regularly inspecting the building, transportation infrastructure used by patients to access the facility, and surrounding landscaping for signs of damage and responding as appropriate. Continuing inspections after the flood can help catch moisture and other damage that can lead to deteriorated air quality over time, amongst other impacts (PDH Star, 2018).

ACTION: **After flood waters recede, clean hard surfaces and remove absorptive materials as soon as possible to reduce the risk of mold growth.**

SUMMARY: Nonstructural damage like mold can become the determining factor regarding whether or not a facility reopens after a climate change-related disaster. If a facility did not sustain severe structural damage from the flood, cleaning hard surfaces and removing absorptive materials quickly can reduce the risk of mold growth. Steel structure, reinforced concrete, and concrete masonry units covered in water-resistant paint are often easy to clean, dry, and restore to pre-flood uses. Absorptive materials, like carpet, drywall, and composite wood products (like plywood and medium density fiberboard), are more likely to require replacement (PDH Star, 2018).

Resilience Strategies: Flooding

Element 3.5 Supply Chain

Flooding can disrupt supply chains at their source (e.g., where products are made) and at their destination. An example of supply chain disruption at a product's source was the decision by Baxter International, the company that supplies 60% of intravenous (IV) fluid bags in the United States, to close its North Carolina plant in response to the widespread flooding caused by Hurricane Helene in 2024. Healthcare organizations across the country were dramatically affected by this decision – even in regions that did not experience the hurricane directly. The IV fluid bag shortage was so severe in some areas that healthcare organizations made the difficult decision to cancel elective procedures until they found a substitute supplier (Valentino, 2024).

Many items in a healthcare organization's supply chain – both clinical and non-clinical – require refrigeration. Managing a refrigerated supply chain and on-site storage during flooding-related regional power outages is crucial to the resilience of healthcare facilities. Furthermore, treatments for flooding-related illness may require specific supplies that are not available in large quantities under normal circumstances. To prevent facilities running out of certain medications during a flood, facilities may need additional supplies to treat the surge of cases and severe illness appropriately. Transportation may also be impacted during flooding, inhibiting delivery of critical medications and supplies (Rublee et al., 2021).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 3.5: Supply Chain

Planning

ACTION: Integrate medical supply storage into resilience planning.

SUMMARY: Consider how your organization's prospective risk assessment of flooding (Element 1) might lead to supply chain disruptions and/or changing needs. Maintain an adequate supply of medical supplies, particularly for products that are most vulnerable to weather-related disruptions in transportation routes (Hedges et al., 2018). Consider separating emergency supplies into two categories: high-volume medical supplies (such as IV bags, sharps, and oxygen) and equipment/supplies that would only be needed during a disaster. Establish a timeline for activating the supply chain plan ahead of the anticipated climate change-related storm or flood event. Include in the timeline when a comprehensive check of both types of inventory should take place and when normal deliveries should be suspended (for example, 120 hours and 12 hours ahead of an anticipated storm or flood, respectively) (Maslanka & Hurwitz, 2022).

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).

Climate Resilience Actions, continued

People and Operations

ACTION: Require suppliers of essential goods and services to provide a continuity of operations plan for storms and floods.

SUMMARY: Healthcare organizations are dependent on a large network of vendors to supply goods and services that are essential to facility operations and continuity of care. Requiring suppliers of essential goods and services to provide a continuity of operations plan is an important first step in building the healthcare organization's resilience to storms, floods, and other disasters that disrupt transportation infrastructure (Toner et al., 2017).

ACTION: Stockpile potable water.

SUMMARY: Maintaining a stockpile of potable water, either inside the healthcare organization's storage facilities or through a contract with external vendors, can bridge the gap for both medical procedures and community services (i.e., sharing bottled water with community members) during water shortages (Hedges et al., 2018).

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).

ACTION: Store essential medical supplies, food, and fuel lasting 5–7 days on or near the healthcare campus to facilitate rapid deployment ahead of extreme weather events that could disrupt supply chains and/or utility and transportation infrastructure.

SUMMARY: One of the hallmarks of climate change is the increased length of utility outages and damage to transportation infrastructure, leading to supply chain disruptions of a week or more. Healthcare organizations can increase their resilience to this changing landscape by stockpiling 5-7 days' worth of medical supplies, food, and fuel on or close to healthcare facility campuses (Danna et al., 2010).

Element 4. Collaboration Between Healthcare Organizations

Disruption in one part of the healthcare ecosystem can result in stress on another part of the system. For example, a patient surge in acute care facilities can result from disruptions in outpatient care, behavioral health services, or residential facilities. In addition, flooding may necessitate evacuation of healthcare facilities, or a shift in location of essential healthcare services. Therefore, resilience to flood emergencies requires collaboration between regional healthcare organizations to plan, prepare, and respond. Key aspects of collaboration include: communication and information sharing; resource coordination; patient evacuation and transfers; medical staff deployment; data sharing; joint public health outreach efforts; and joint disaster preparedness drills.

For example, Grady Memorial Hospital experienced flooding in 2022 that required diversion of incoming patients to regional facilities. During this time, Grady worked with the local Emergency Medical Services (EMS) office and all Atlanta hospitals to create a Regional Coordinating Center. This Center instructed local EMS providers on where to take patients and ensured transparency in the management of regional hospitals' patient volumes and staffing (The Joint Commission, 2024). Although this flood emergency was due to a broken pipe in the hospital building, this approach to real-time coordination between area hospitals and local EMS is applicable to flooding related to weather events.

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 4: Collaboration Between Healthcare Organizations

Planning

ACTION: Create plans to increase the resilience of critical outpatient care during severe storms and flooding events.

SUMMARY: Create contingency plans in coordination with regional healthcare partners to ensure that individuals with chronic physical and/or mental health conditions – who are at high risk due to potential interruptions in medication administration or outpatient care – have access to alternative arrangements if their usual care becomes unavailable or inaccessible due to severe storms or flooding (U.S. HHS, 2014; Toner et al., 2017; WHO, 2020).

ACTION: Enhance healthcare organization preparedness for storms and flooding through mutual aid MOU.

SUMMARY: A mutual aid memorandum of understanding (MOU) with other healthcare providers in the region that includes the results of a prospective risk assessment (Element 1) can help prepare for circumstances that require patient transfers or referrals – such as utility outages, patient surges, etc. Pay particular attention to current gaps in preparedness for climate-related events that are projected to increase in frequency and/or severity in the region. It is important to address legal and reimbursement challenges that can limit a facility's ability to quickly and efficiently transfer patients and/or supplies to other facilities in the region. Consider working with CMS and other healthcare organizations to fill in those gaps over time using an all-hazards approach (U.S. HHS, 2014; Patel et al., 2022).

ACTION: Exchange epidemiological data and health assessments related to severe storms and flooding with other healthcare organizations and the local health department.

SUMMARY: Exchanging epidemiological data and health assessments related to severe storms and flooding with other healthcare organizations and the local health

Climate Resilience Actions, continued

department can support regional climate resilience planning efforts. Use these conversations to jointly develop protocols for identifying emerging climate-related health threats in the region, collecting and disseminating data, and coordinating emergency response across the range of facility types in the regional health system – including acute care hospitals, community clinics, and long-term care facilities (Patel, 2022).

ACTION: Integrate an analysis of cross-institutional collaboration in regional after-action reviews of storms and floods.

SUMMARY: As part of an all-hazards emergency management plan, include an after-action analysis of interdisciplinary coordination within the organization, as well as with other regional healthcare organizations and the local office of emergency management to assess how well the emergency response system functioned as a whole. Consider including prospective climate metrics (Element 1) as one indicator of the system's resilience to future events (Davies et al., 2019; Parker, 2020).

ACTION: Perform joint disaster preparedness exercises and drills with other local healthcare organizations, the local health department, and the local office of emergency management.

SUMMARY: Joint disaster preparedness exercises and drills can help healthcare organizations test their readiness for flooding (and simultaneous and cascading events), identify areas for improvement in their emergency response plans, and build working relationships with other first responders. Including representation from multiple institutions and professions in the exercise can also help identify emerging at-risk populations who are projected in climate models to require more protection and/or resources as floods occur more frequently and/or with greater severity (ASPR, 2024; WHO, 2020).

ACTION: Work with other regional healthcare organizations to develop integrated patient evacuation plans.

SUMMARY: Healthcare organizations can increase their own and regional resilience by working together to develop integrated emergency evacuation plans. Consider including contingency plans to address damage to a facility's structure, exposure to contaminated air and/or water damage, power and water outages, destruction of electronic medical records, infrastructure failures, and an ambulance shortage. Contingency plans may involve transferring patients to alternate facilities or establishing temporary medical sites in safer areas (U.S. HHS, 2014; Patel et al., 2022).

People and Operations

ACTION: Share resources and coordinate personnel during floods.

SUMMARY: Collaboration between response organizations may involve sharing critical resources and coordinating the deployment of personnel to support impacted communities in areas of greatest need (Patel et al, 2022). Consider integrating the results of the organization's prospective risk assessment (Element 1) into planning conversations to funnel resources to new and emerging at-risk populations related to the changing climate.

ACTION: Collaborate with regional healthcare organizations on public health education and outreach programs.

SUMMARY: Healthcare institutions can collaboratively develop and disseminate public health education and outreach programs so that the community receives a consistent and coordinated message about climate-related hazards, protective behaviors, and access to resources such as healthcare services (California Department of Public Health, 2022).

ACTION: Consider proactively credentialing neighboring healthcare facility staff to help execute the healthcare organization's emergency preparedness protocol.

SUMMARY: Proactively credentialing staff at neighboring healthcare facilities to prepare for emergencies can contribute to backup care if one facility is unable to provide care due to flooding-related interruptions (WHO, 2020).

ACTION: Establish effective communication channels to share real-time information across healthcare organizations during floods.

SUMMARY: Consider working with other healthcare organizations and entities in the region to establish effective real-time communication channels with one another and the public during flooding events. Examples of critical information that can be shared this way include information about the progression of the flood, who should evacuate, where evacuees should go, which healthcare facilities are open to receive new patients and/or community members seeking refuge, real-time information about the number of beds available in the region and consistent definitions for each bed type, and levels of critical medical supplies needed and available for each facility in the cooperation network (CDC, 2003; California Department of Public Health, 2022; HHS, 2014).

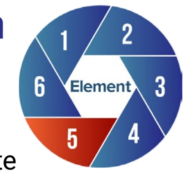
Climate Resilience Actions, continued

Physical Infrastructure

ACTION: Build out alternative communications channels to help regional healthcare organizations share real-time information with each other during floods.

SUMMARY: Interorganizational cooperative agreements for sharing resources and transferring patients during climate change-related disasters depend on real-time communication among facilities in the network. Building out alternative communications channels connecting healthcare organizations with each other (such as multiple cell phone providers, satellite phones, walkie-talkies, and installing generator-powered cell towers on the roof of key facilities) can increase the effectiveness of the entire network's emergency response (U.S. HHS, 2014).

Element 5. Interdisciplinary Planning, Oversight, and Evaluation



Flooding can affect various critical dependencies within healthcare organizations, such as administration, information technology (IT), electricity, natural gas, water, wastewater and waste disposal, communications, transportation, and critical products. An interdisciplinary approach to planning, oversight, and evaluation across critical dependencies is essential for comprehensive flooding emergency preparedness planning. Healthcare organizations are encouraged to align their facility operations, procurement, and capital expenditures with climate change mitigation and resilience goals.

For example, following Superstorm Sandy in 2012, NYU Langone Health took an interdisciplinary approach to prioritizing flood resilience measures in its rebuilding effort (read NYU Langone Health's case study in this toolkit). The hospital invested in stormwater management systems, flood barriers, and energy efficiency and resilience. It also elevated critical medical and research equipment, IT infrastructure, and building management systems above the projected 500-year flood level. At the same time, the hospital developed an emergency preparedness employee training and exercise program that has helped to optimize equipment use and operational efficiency.

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 5: Interdisciplinary Planning, Oversight, and Evaluation

Planning

ACTION: Implement surveillance and interdisciplinary after-action reviews in organizational flood action plans.

SUMMARY: Incorporate building surveillance and interdisciplinary after-action reviews into the healthcare organization's flood action plan. These measures will help identify and evaluate the elements of the plan that worked during a recent event; assess whether changing climatic conditions might have influenced aspects of the event (such as its severity); and change the parts of the plan that did not meet expectations (Hess et al., 2023; Parker, 2020).

ACTION: Incorporate interdisciplinary approaches into flood planning.

SUMMARY: Consider incorporating interdisciplinary approaches into the healthcare organization's flood planning process since flooding events can impact a range of dependencies – such as infrastructure, clinical care, energy systems, and waste management (Rogers et al., 2020).

ACTION: Incorporate long-term goals and climate projections into flood preparedness and response plans.

SUMMARY: It can be helpful to integrate long-term, interdisciplinary strategic goals into the healthcare organization's flood emergency preparedness and response plans – including community input as outlined in the Justice, Equity, Diversity, and Inclusion (JEDI) framework (American Public Health Association & CDC, 2021).

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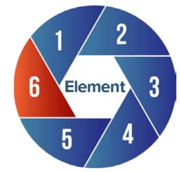
Resilience Strategies:
Flooding

CR4HC

Element 6. Communications and All-Hazards Approach



Communication strategies promoting flood resilience are most effective when they take into account whether the flood risk is chronic (such as flash flooding in Central Texas or tidal flooding in Florida) or episodic (such as the devastating floods in the Red River Valley of North Dakota, in 1997 and 2009). Preparedness communications in areas with chronic flood risk include signage in flash flood-prone locations and social media posts reminding community members about how to prepare for seasonal flooding.

Effective communications around episodic flooding often benefit from strong collaboration and engagement with community members. For example, in March, 2009, the city of Fargo, North Dakota, successfully protected itself from the risk of catastrophic flooding by mobilizing 85,000 volunteers to fill, stack, and monitor sandbags placed on top of the levees along the Red River over the course of a month. During that time, 1,200 hospital patients and residents at long-term care facilities were evacuated from the area. Civic leaders used daily briefings to both evoke a sense of calm and issue specific instructions to community members to focus their efforts on goal-oriented actions. A 24-hour call-in radio program was launched to give community members an outlet to share resources, request assistance, and share information with each other. A city flood hotline acted as the central hub for coordinating over 100,000 local and out-of-town volunteers. Neighborhoods also self-mobilized – caring for each other's children and pets, preparing meals for each other, and sandbagging and patrolling the dikes protecting their homes. Local behavioral health providers and trusted nonprofits, like the American Red Cross, issued guidance on how to retain emotional resilience through the duration of the emergency. Following the flood, city leaders further honed their communications strategy as part of an effort to enhance planning for future flood events. In a parallel effort, a volunteer-led initiative, "Red River Resilience," was founded after the flood with the goal of "giving voice to individual and community resilience" (O'Neill at al., 2009).

Flooding events often occur simultaneously or in quick succession with other climate change-related hazards, such as severe storms and extreme temperatures. In addition, drought conditions prior to a significant precipitation event in an area can increase the likelihood of severe flooding. These concurrent and cascading hazards can result in both direct and indirect harm to population health that could lead to repeated patient surges and infrastructure failures both in the community and in healthcare facilities (Clarke et al., 2018).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 6: Communications and All-Hazards Approach

Planning

ACTION: Collaborate with local partners to coordinate storm and flood-event messaging.

SUMMARY: It can be helpful to collaborate with local public health department partners to coordinate flood-related messaging with clinicians and patients, such as through prompts in the healthcare organization's electronic health record, e-newsletter, and patient texting system. This approach can increase community awareness of both the short- and long-term health risks associated with exposure to storms and flooding (WHO, 2020).

Climate Resilience Actions, continued

ACTION: Use simultaneous disasters as an opportunity for education about the co-benefits of taking an all-hazards approach to resilience.

SUMMARY: Simultaneous and cascading disasters can be opportunities to educate the community, staff, and emergency management partners about the value associated with using a co-benefit approach to risk assessment, emergency planning, emergency response, and rebuilding efforts (National Academies of Sciences, 2022).

People and Operations

ACTION: Broadcast flood alerts using culturally appropriate language and communication pathways.

SUMMARY: Broadcasting alerts about flood vulnerability and protective behaviors to patients, staff, and community partners using culturally appropriate language and communication pathways can help amplify the local public health department and office of emergency management's communication efforts (Hasan et al., 2021; O'Neill et al., 2009).

ACTION: Establish two-way communication systems with at-risk patient populations.

SUMMARY: Implementing two-way communication systems, like Reverse 911 and wireless emergency alerts (National Academies of Sciences, 2018), can aid in connecting sensitive populations with protective measures before a flood occurs, and direct them to community services during the event. With the assistance of community groups and local health departments, designated community leaders can deliver culturally sensitive messages. These messages would inform residents about safeguarding themselves and their neighbors and provide guidance on actions to take if they experience health harms (Steinberg and Sprigg, Ed., 2016; Toner et al., 2017).

Climate Resilience for Health Care: Hurricanes

CR4HC

Impact of Hurricanes on Healthcare Organizations

Hurricanes can damage buildings and other critical infrastructure, disrupt communication and power, compromise water quality, and lead to evacuations of healthcare facilities. High winds and flooding can cause acute injury and death. For example, 96% of the 68 deaths that were directly attributed to Hurricane Harvey in 2017 were caused by drowning (Chambers et al., 2020). A surge of patients seeking care for blunt trauma, exposure to waterborne pathogens, and other health concerns directly related to a hurricane can strain healthcare resources and staff. Power outages and supply chain disruptions can further exacerbate surges in healthcare demand, particularly for those reliant on electricity-dependent equipment, medication, and specialized supplies to manage chronic conditions. These concurrent challenges collectively impact patient care and healthcare facility operations immediately following the event. In some cases, regional healthcare needs are altered for many months after the hurricane. A review of 50 hurricane-related public health studies found that only 7.5% of related diagnoses – consisting of environmental diseases, infectious diseases, unintentional injuries, and mental health concerns – occurred during the first month after the hurricane, 49.2% of diagnoses occurred from 1 to 6 months after the event, and the remaining 43.3% of diagnoses took place from 6 to 36 months after the event (Waddell et al., 2021).

Important Considerations

Health Effects of Hurricanes: Drowning, injury, infectious disease, mental health effects

Populations at Risk: Children, older adults (especially those who live alone), coastal communities, people who rely on electricity-dependent durable medical equipment, people with disabilities, low-income populations, minority and marginalized populations, people without access to a personal vehicle

Risks to Facility Operations: Supply chain disruption, patient surge, staff shortage, evacuation risk

Infrastructure Risk: Damage to building infrastructure, rolling blackouts/power loss, low water pressure, drinking water contamination, disruptions to transportation systems

Elements of a Climate-Resilient Healthcare Organization: Hurricanes

Integrating the following climate resilience elements into the healthcare organization's emergency management plan presents an opportunity to enhance its ability to respond to increasingly frequent and severe hurricane events.

The following six elements characterize a hurricane-resilient healthcare organization. Review each element section to explore it in more detail.

1. Prospective Risk Assessment

Climate change is leading to changes in the incidence, distribution, and severity of tropical storms, resulting in more damaging hurricanes, the effects of which can include wind damage, coastal storm surge, and flooding. Healthcare organizations can increase their resilience to worsening hurricane seasons by incorporating prospective hurricane risk assessments in their emergency preparedness plans.

2. Health Equity and Community Engagement

Health systems can mitigate the inequitable health impacts of hurricanes and their aftermath by proactively identifying and addressing patient and community-level risk factors – an approach that requires collaboration with community partners. Climate resilience plans should incorporate prioritized interventions to provide resources to patient populations most at risk of negative health outcomes during and after a hurricane. Community engagement and partnerships can (1) strengthen the healthcare organization's resilience plan to prevent health harms and operational disruptions from future hurricanes and other disasters and (2) build trust, communication networks, and connections with community resources that provide on-going benefits to the healthcare organization and its patients.

3. Assessment and Remediation of Vulnerabilities in Infrastructure and Operations

Tropical storms, like hurricanes, often leave in their wake a long trail of destruction to buildings and infrastructure. High winds can tear roofs off buildings and turn trees and cars into projectiles. The resulting damage compromises roads, electrical lines, cell towers, and buildings of all sizes. Storm surge follows a similar pattern. Strong currents can pick up large floating objects, like boats, and ram them into bridges and flooded buildings. Slow-moving hurricanes increase the chance of widespread flooding in the short term, as well as the risk of mold and mosquitoes a few weeks after the event. Finally, tropical storms often occur during summer months, placing occupants of under-insulated buildings and buildings without operable windows at risk of heat-related illness if power is not quickly restored.

4. Collaboration Between Healthcare Organizations

Sharing information and resources across the full range of regional healthcare providers before, during, and after a hurricane can increase resilience both at the facility level and system-wide. Hurricane effects may lead to (1) a disruption in care delivery in an outpatient facility, resulting in a patient surge in an acute care setting, (2) displacement, resulting in people requiring health care far from home, and (3) evacuation and transfers between facilities. Collaboration between healthcare facilities to increase hurricane resilience can include communication and information sharing, resource coordination, plans for potential evacuation and transfers, medical staff deployment, data sharing, joint public health outreach efforts, and joint disaster preparedness drills.

5. Interdisciplinary Planning, Oversight, and Evaluation

Planning for hurricane resilience requires an interdisciplinary team and coordination across a range of critical functions, including administration, emergency management, information technology, facility operations (e.g., power, water, waste disposal, food service, custodial services, etc.), communications, transportation, and purchasing. It is important to raise awareness among staff and community members about the interconnected effects of hurricanes and coastal flooding (during both the acute storm event and its aftermath) on clinical care, facilities operations, and community infrastructure, and to seek input from all key stakeholder groups about which risk-mitigating interventions should be prioritized.

Aligning facilities operations, procurement, and capital expenditures to balance climate change mitigation (i.e., reducing greenhouse gas emissions) goals and resilience goals can help the organization chart a climate-positive and cost-neutral path towards hurricane resilience. Facilities will use less energy and water, sustain less damage, and have a lower risk of evacuating patients during and after storms.

6. Communications and All-Hazards Approach

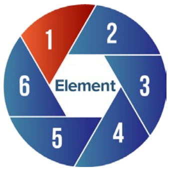
Hurricanes and flooding events often occur simultaneously or in quick succession with other climate change-related hazards, such as extreme heat, which increases the risk of multisystem failures at the community scale (including disruptions to water and power utilities). This can result in both direct and indirect harm to population health. Repeated patient surges and cascading infrastructure failures both in the community and within healthcare facilities can temporarily disrupt the entire healthcare system in a region. Fortunately, many policy, infrastructure, and communications interventions can increase organizational resilience to more than one climate-related hazard. This is particularly true if emergency management and climate resilience planners use an all-hazards approach to designing, implementing, and testing proposed interventions.

Link to the Fifth National Climate Assessment, Chapter 18, for more information.

Office of
Climate Change
and Health Equity

Resilience Strategies:
Hurricanes

Element 1. Prospective Risk Assessment



Climate change is leading to changes in the incidence, distribution, and severity of tropical storms, resulting in more damaging hurricanes, the effects of which can include wind damage, coastal storm surge, and flooding. Healthcare organizations can increase their resilience to worsening hurricane seasons by incorporating prospective hurricane risk assessments in their emergency preparedness plans. For example, Oschner Health in New Orleans, Louisiana, has prepared for increasingly frequent flooding and hurricanes by purchasing a fleet of eight flat-bottomed boats and eight high-water trucks to transport supplies, staff, and patients to and from the hospital during high water events. The hospital also dug wells to create a supplemental supply of process water for their building systems during water outages (Boyle, 2022).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 1: Prospective Risk Assessment

Planning

ACTION: **Consider both historical trends and climate projections to estimate the healthcare organization's long-term hurricane risk.**

SUMMARY: Healthcare organizations can increase their resilience to changes in the incidence and severity of hurricanes by incorporating prospective climate risk assessments in their emergency preparedness plans.

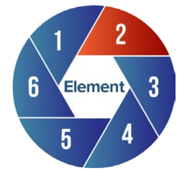
ACTION: **Add a prospective risk assessment and impact forecasting to the local hazard mitigation plan.**

SUMMARY: It can be helpful to work with public health and local emergency management partners to add a prospective risk assessment and impact forecasting to the local hazard mitigation plan (Hess et al., 2017).

ACTION: **Add projected precipitation and flooding measures to hurricane, flooding, and storm risk assessments.**

SUMMARY: Consider adding one or more of the projected precipitation and flooding measures from the CDC's National Environmental Public Health Tracking Network data portal to your organization's risk assessment (Hess et al., 2017).

Element 2. Health Equity and Community Engagement



Health systems can mitigate the inequitable health impacts of hurricanes and their aftermath by proactively identifying and addressing patient and community-level risk factors – an approach that requires collaboration with community partners. A study in Charlestown, South Carolina, comparing empirical hurricane vulnerability data at the neighborhood level with community members' self-perception of their vulnerability found discrepancies that could be overcome by synthesizing the two approaches (Rickless et al., 2019). Climate resilience plans should incorporate prioritized interventions to provide resources to patient populations most at risk of negative health outcomes during and after a hurricane. Community engagement and partnerships can (1) strengthen the healthcare organization's resilience plan to prevent health harms and operational disruptions from future hurricanes and other disasters and (2) build trust, communication networks, and connections with community resources that provide on-going benefits to the healthcare organization and its patients.

The following sub-elements describe specific ways in which a healthcare organization can integrate health equity and community engagement into their hurricane resilience planning.

2.1 Community Input: Frameworks like social determinants of health (U.S. HHS, n.d.) and vulnerability assessments can help identify subgroups in a healthcare organization's patient population and community who may be at higher risk of negative health outcomes during and after a hurricane. Community health workers, social workers, and community-based organizations are often essential partners in identifying priority patient groups and connecting them with emergency resources, such as mobile clinics, emergency power, food distribution, housing and utility assistance.

2.2 Community Infrastructure: Hurricanes' high winds, intense precipitation, and flooding can damage buildings, roads, transportation routes (including commercial shipping), and utility infrastructure (leading to power, gas, and water outages), as well as pollute drinking water supplies. Healthcare organizations can enhance community resilience by supporting programs that increase redundancy in local utilities, increase adaptive capacity in home environments, and provide emergency distribution of essential goods and services to affected areas.

2.3 Community Services: Partnering with community organizations to (1) mitigate risk factors (such as housing or utility insecurity) before a hurricane, (2) coordinate outreach efforts to locate and evacuate at-risk individuals from hurricane and high-risk flood zones, and (3) provide essential community-based services (such as emergency power and food distribution) during and after a hurricane, can increase healthcare organization resilience by reducing the surge in demand for healthcare services. During power outages, individuals relying on electricity-dependent durable medical equipment, or who take medications requiring refrigeration, such as insulin, may turn to healthcare facilities for help.

2.4 Coordination with Local Office of Emergency Management: Synchronizing a healthcare organization's hurricane emergency plan with peer organization plans, the local office of emergency management, and the local utility can result in a more efficient and effective coordinated response during and after hurricane and coastal flooding events. It can also reveal gaps and redundancies that, if addressed, could increase the effectiveness of responders during an emergency. Coordination also supports the development of personal relationships across organizations and agencies – an important factor during emergency response.

Resilience Strategies: Hurricanes

CR4HC

Element 2.1 Community Input

Frameworks like social determinants of health (U.S. HHS, n.d.) and vulnerability assessments can help identify subgroups in a healthcare organization's patient population and community that may be at higher risk of negative health outcomes during and after a hurricane. Community health workers, social workers, and community-based organizations are often essential partners in identifying priority patient groups and connecting them with emergency resources, such as mobile clinics, emergency power, food distribution, housing and utility assistance. For example, following Hurricane Katrina in 2005, a group of religious institutions in New Orleans, Louisiana, founded Churches Supporting Churches, a coalition that used community-enhanced Geographic Information System methods to map the recovery needs of individual neighborhoods based on a combination of empirical data and community input (Duval-Diop et al., 2010).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 2.1: Community Input

Planning

ACTION: Map patient populations who are sensitive to hurricanes.

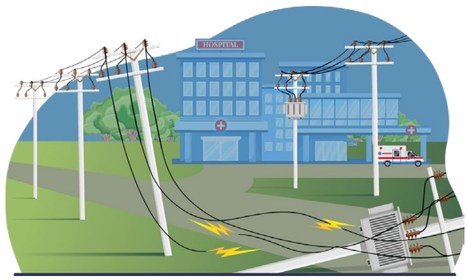
SUMMARY: Collaborating with community partners to map patient populations who are at high risk of negative health outcomes after exposure to hurricanes can increase organizational and community resilience by helping to ensure that protocols supporting healthcare access during and after the storm are tailored to those populations' needs (Patel et al., 2022).

ACTION: Use the Justice, Equity, Diversity, and Inclusion (JEDI) framework to structure community input.

SUMMARY: Consider following the Justice, Equity, Diversity, and Inclusion (JEDI) framework to integrate community input into the development and operation of the healthcare organization's climate resilience plan (American Public Health Association & CDC, 2021).

Resilience Strategies:
Hurricanes

Element 2.2 Community Infrastructure



Hurricanes' high winds, intense precipitation, and flooding can damage buildings, roads, transportation routes (including commercial shipping), and utility infrastructure (leading to power, gas, and water outages), as well as pollute drinking water supplies. Healthcare organizations can enhance community resilience by supporting programs that increase redundancy in local utilities, increase adaptive capacity in home environments, and provide emergency distribution of essential goods and services to affected areas. One way to increase the resilience of community infrastructure is to build a network of microgrid-powered resilience hubs. A survey of 32 health centers in Florida found that 60% do not have backup power systems. Of the locations with on-site backup power, only one reported a solar + battery installation; 84% of respondents expressed a desire to expand their backup power capabilities, but only 19% had identified a potential financial partner for such a project. CrescentCare Health Center partnered with local nonprofit Together New Orleans to become Louisiana's first Community Lighthouse. The Community Lighthouse Project is a community-led initiative that is building a network of solar-powered resilience hubs backed up with on-site battery storage in 85 religious institutions and community-based organizations in New Orleans to increase community resilience to power outages during hurricanes and other disasters (Van Winkle et al., 2023).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 2.2: Community Infrastructure

People and Operations

ACTION: Support and direct patients to local programs that increase adaptive capacity in the home environment.

SUMMARY: Connect low-income residents and other high-risk groups (like those over 65 and those with chronic illness) with programs that can help them prepare for and recover from hurricanes and floods (Patel et al., 2022). Examples include free or subsidized hurricane shutters, storm door reinforcement programs, elevation assistance for flood-prone homes, access to emergency supply kits, provisions for backup generators or charged batteries for medical equipment, and emergency preparedness workshops.

Physical Infrastructure

ACTION: Catalyze the development of resilient infrastructure at the neighborhood and community level.

SUMMARY: As anchor institutions, healthcare campuses and public health institutions can catalyze neighborhood and community-scale efforts to increase resilience against hurricanes, storms, and flooding. Examples include supporting multiple modes of transportation which can double as evacuation routes, green infrastructure, neighborhood microgrids, and neighborhood water retention and treatment systems (Pastor & Morello-Frosch, 2014; Hacke & Deane, 2017).

ACTION: Enhance community resilience by remediating contaminated sites for healthcare installations.

SUMMARY: Strategically placing healthcare facilities on sites in need of environmental remediation (such as brownfields) can accelerate the clean-up process, thereby

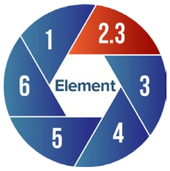
Climate Resilience Actions, continued

reducing the risk of community exposure to toxin-laden dust and flood waters after hurricanes and flooding events (Ballogg, 2015; ATSDR, 2021).

ACTION: Work with local and regional partners to lower barriers to travel for patients and staff during hurricanes, storms, and flooding events.

SUMMARY: Transportation infrastructure failures can prevent staff from reporting to work and patients from traveling to healthcare facilities to receive needed care during hurricanes, storms, and flooding events. Healthcare organizations can support regional climate change resilience by working with local and regional partners to lower barriers to travel (WHO, 2020). For example, limited public transit service could be offered to patients and essential workers, and medical workers could be granted priority access to gas stations (U.S. HHS, 2014).

Element 2.3 Community Services



Partnering with community organizations to mitigate risk factors (such as housing or utility insecurity) before a hurricane, coordinating outreach efforts to locate and evacuate at-risk individuals from hurricane and high-risk flood zones, and providing essential community-based services (such as emergency power and food distribution) during and after a hurricane, can increase healthcare organization resilience by reducing the surge in demand for healthcare services. During power outages, individuals relying on electricity-dependent durable medical equipment (DME), or who take medications requiring refrigeration, such as insulin, may turn to healthcare facilities for help. For example, the closure of dialysis outpatient clinics during Superstorm Sandy in 2012 led to a surge of hemodialysis patients at hospitals in Brooklyn, New York, 2-7 days after landfall – 92% of impacted hospitals reported that patients arrived without necessary dialysis documentation, 53% were not able to communicate with the patients' home dialysis providers, and 50% were short of staff to perform the necessary procedures (Lin, et al., 2014).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 2.3: Community Services

Planning

ACTION: Consider preemptive planning for patients who use electricity-dependent DME.

SUMMARY: Proactively help patients who rely on electricity-dependent DME to ensure that they have a backup power source or another contingency plan in the event of power shutoffs during a hurricane, flood, or storm (Pacific ADA Center, 2017).

ACTION: Partner with local EMS providers to convey guidance to patients in the community about ways to increase their resilience to hurricanes, storms, and flooding events.

SUMMARY: Coordinate with Emergency Medical Services (EMS) providers to identify high-risk patients during hurricanes, inland storms, and flooding events. This may involve gathering information about flood plain locations and building characteristics to identify neighborhoods that are more prone to flooding, storm surge, and/or wind damage. Help EMS identify patients who require evacuation or who rely on critical medical equipment that may be compromised during a flooding event, hurricane, or storm. Provide resources to support patients who could remain at home rather than travel to healthcare facilities for treatment (O'Meara et al., 2016).

People and Operations

ACTION: Integrate community resilience needs into healthcare organization emergency management plans.

SUMMARY: Include provisions in the healthcare organization's emergency plan to accommodate community members who may seek to use the facility as a refuge and patients who require access to electrical power to charge their medical devices and/or refrigeration for their medications. Consider creating a registry of patients needing this kind of assistance and setting up a two-way communications protocol (such as a Reverse 911 or wireless emergency alert system [National Academies of Sciences, 2018]) to contact them in the event of a power disruption or outage (Patel et al., 2022).

Climate Resilience Actions, continued

ACTION: Coordinate with community partners to create a multi-sector protocol for the delivery of mental health services during and after hurricanes, storms, and flooding events.

SUMMARY: The mental health impact of hurricanes, storms, and flooding events can be severe. Healthcare organizations can help increase community resilience by supporting crisis response planning among community partners in the public and private sectors who provide mental health care for survivors of natural disasters (WHO, 2020).

ACTION: Fill gaps in local services to increase resilience, such as acting as a place of refuge during hurricanes, storms, or flooding events.

SUMMARY: Healthcare facilities equipped to continue operations during power outages can enhance local resilience by offering their facilities as refuges for community members during hurricanes, storms, or flooding events (Johns & Rosenthal, 2024; Toner et al., 2017). It is important to formalize this role with the Office of Emergency Management ahead of the event so that the facility receives extra fuel, supplies, and staff to manage non-medical emergency services (U.S. HHS, 2014).

Element 2.4 Coordination with Local Office of Emergency Management

Synchronizing a healthcare organization's hurricane emergency plan with peer organization plans, the local office of emergency management, and the local utility can result in a more efficient and effective coordinated response during and after hurricane and coastal flooding events. It can also reveal gaps and redundancies that, if addressed, could increase the effectiveness of responders during an emergency. Coordination also supports the development of personal relationships across organizations and agencies – an important factor during emergency response. For example, 16 of 19 hospitals impacted by Superstorm Sandy in 2012 that reported not experiencing significant challenges during the event response attributed their success to effective emergency planning ahead of the event (U.S. HHS, 2014).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 2.4: Coordination with Local Office of Emergency Management

Planning

ACTION: Add local and regional climate change vulnerability assessments to the healthcare organization's emergency preparedness plan.

SUMMARY: Consider adding local and regional climate change vulnerability assessments to the healthcare organization's emergency preparedness plan to integrate projections of how the region's exposure to hurricanes, storms, and flooding events may change in coming decades compared with historical trends (Marinucci et al., 2014).

ACTION: Collaborate with local partners to coordinate hurricane, storm, and flood-event messaging.

SUMMARY: It can be helpful to collaborate with local public health department partners to coordinate climate-related hazard messaging with clinicians and patients, such as through prompts in the healthcare organization's electronic health record, e-newsletter, and patient texting system. This approach can increase community awareness of both the short- and long-term health risks associated with exposure to hurricanes, storms, and flood events (WHO, 2020).

ACTION: Formalize cooperation agreements with utility providers (both power and water) to ensure that the healthcare organization's facilities are integrated into local emergency management and climate resilience planning efforts.

SUMMARY: Critical facilities, hospitals, and other healthcare building types should be fully integrated into local utilities' emergency management and climate resilience planning efforts. It is particularly important to include facility power and water needs in emergency preparedness and climate resilience planning efforts to ensure that they can continue to provide care during and after climate change-related disasters (McCabe et al., 2023; Van der Heijden, 2022).

ACTION: Integrate legal preparedness into the healthcare organization's emergency management and climate action plans.

SUMMARY: Uncertainty about who has the legal authority to authorize difficult decisions during disasters can slow a healthcare organization's ability to pivot from normal operations to respond to a disaster. Healthcare organizations can enhance the resilience of their emergency management and climate action plans by (1) including

Climate Resilience Actions, continued

parameters that clarify the conditions in which a facility may share information outside of the healthcare organization and administrators may order facility evacuations, (2) clarifying how personnel will reconcile protocol discrepancies (such as different evacuation protocols for healthcare organizations compared with Emergency Medical Services, and (3) authorizing clinical staff from outside organizations to practice in the healthcare facility. These plans may also include a decision framework for deciding how to allocate scarce resources during utility outages (U.S. HHS, 2014; Toner et al., 2017; VanDevanter et al., 2014).

ACTION: Periodically evaluate the roles and responsibilities of healthcare organizations and other partners in responding to hurricanes.

SUMMARY: After-action reviews conducted under the auspices of the local office of emergency management offer an opportunity to revisit and revise (if needed) the roles and responsibilities of healthcare organizations during hurricanes, particularly in regions where events are occurring more often and at higher intensity (Davies et al., 2019; Parker, 2020).

People and Operations

ACTION: Leverage healthcare facilities as intervention sites for local hazard action plans.

SUMMARY: Healthcare organizations often offer their locations as community intervention sites for the local hazard action plan. For example, allowing the Office of Emergency Management to use strategically located hospitals, medical office buildings, and clinics as distribution sites for water bottles, food, etc., can increase community access to health-promoting supplies. Officiall designating publicly available spaces in healthcare facilities – such as the cafeteria – as resilience hubs or temporary shelters during climate-related events can help support patients and family members as well as raise awareness in the community that climate-related events are public health emergencies (Hess et al., 2023; Institute of Medicine, 2012).

ACTION: Coordinate hurricane-, storm-, and flood-related syndromic surveillance with the local office of emergency management and the local weather station.

SUMMARY: It can be helpful to add hurricane-, storm-, and flood-related illnesses to the healthcare organization's syndromic surveillance reports during and immediately following designated emergencies. Aligning the organization's protocol for collecting relevant diagnostic data with the local office of emergency management and weather station's protocol for declaring a climate-related emergency will help ensure that the organizational climate resilience action plan deploys in coordination with local alerts (Hess et al., 2023).

Element 3. Assessment and Remediation of Vulnerabilities in Infrastructure and Operations

Tropical storms, like hurricanes, often leave in their wake a long trail of destruction to buildings and infrastructure. High winds can tear roofs off buildings and turn trees and cars into projectiles. The resulting damage compromises roads, electrical lines, cell towers, and buildings of all sizes. Storm surge follows a similar pattern. Strong currents can pick up large floating objects, like boats, and ram them into bridges and flooded buildings. Slow-moving hurricanes increase the chance of widespread flooding in the short term, as well as the risk of mold and mosquitoes a few weeks after the event. Finally, tropical storms often occur during summer months, placing occupants of under-insulated buildings and buildings without operable windows at risk of heat-related illness if power is not quickly restored.

Building codes identify many types of healthcare facilities as critical infrastructure. As a result, modern facilities are designed to withstand structural damage from high winds and flood waters. They are also required to install sufficient on-site emergency power and water storage to maintain clinical operations for several days of utility outages.

Climate-resilient healthcare organizations at risk of exposure to tropical storms can add to this baseline by planning for a future of more frequent and severe events and increased risk of extended power outages, boil water notices, and unsafe travel conditions. Planning efforts will include developing protocols supporting staff and their families during and after hurricanes, developing a spatial and clinical plan to accommodate surges of both patients and community members seeking a place of refuge, as well as the purchasing and supply storage considerations that will make it possible to pivot to emergency operations when an event occurs. The facility itself can also be upgraded to minimize energy and water use and protect key equipment from flood waters. Additionally, installing a supplemental on-site renewable power supply – such as a cogeneration plant and/or campus microgrid – will greatly reduce the risk of disruption to facility operations during utility outages.

For example, while infrastructural and operational emergency preparedness measures at the University of Texas Medical Branch in Galveston, Texas, protected the majority of patients, staff, animal research subjects, and infrastructure from Hurricane Ike (2008), 90% of the medical campus facilities sustained some level of damage, and almost all of the animal research documentation was destroyed. In total, the institution lost its blood bank, pharmacy, radiology department, and food service. While generators were tested weekly before the storm, several were destroyed by the storm, others were not functional because their switchgear flooded, and the natural gas-fired generator failed when its supply line was severed. Pre-staged, trailer-mounted auxiliary chillers and generators were also flooded by the storm surge. Lessons learned included placing emergency exits above the 500-year flood line (so that staff can enter and exit the facility when the flood gates are closed), staging emergency auxiliary equipment in a sheltered location away from direct wind and storm surge impact, and maximizing flexible working conditions so that staff can support the facility's emergency response from the safety of their homes or evacuation site (Goodwin et al., 2010).

The following sub-elements describe specific ways in which a healthcare organization can enhance its facility infrastructure and operations' resilience to hurricanes.

3.1 **Staff Support:** Healthcare organizations depend on dedicated clinicians, administrators, and facilities and operations staff to deliver care. Many staff are highly motivated to deliver care in response to an emergency. However, staff and their families are often impacted by the same climate change-related hazards as the facilities in which they work. Practical considerations like transportation, childcare, and concern for their family may prevent them from fully participating in the response effort. By integrating staff protections and accommodations into hurricane emergency planning, healthcare organizations can alleviate logistical difficulties to allow staff to get to work during and after hurricanes.

3.2 Clinical Considerations: Hurricanes can cause a surge in healthcare demand due not only to acute injury during the event, but also to disruption in routine care and hazards that persist after the storm event. The majority of hurricane-related direct health outcomes in the United States can be traced to disruption in routine medical care for existing patients in the days and weeks post-disaster. These conditions can be prevented by ensuring that displaced patients are connected with nearby services until they return home (Toner et al., 2017). Storm surge (caused by strong winds pushing water to shore) is historically the leading cause of hurricane-related deaths in the U.S (U.S. Department of Commerce, n.d.).

3.3 Building and Campus – Design & Construction: While building codes require structural redundancies that harden buildings against potential environmental hazards, facilities in the path of hurricanes are at risk of damage from high winds, intense precipitation, and flooding.

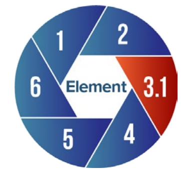
Hurricane-resilient healthcare facilities incorporate features such as energy efficiency and on-site power generation, water efficiency and emergency water supplies, and protective siting of critical building systems to minimize infrastructure damage from wind, flood waters, and storm surge.

3.4 Building and Campus – Facility Operations: Healthcare buildings are vulnerable to power outages because they rely on electricity, plumbing systems, and energy sources, like natural gas, to operate 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) (FEMA & ASPR, 2019). Most hospitals are sealed buildings, and loss of power during hurricanes can cause internal temperatures to rise or fall to dangerous levels (Patel et al., 2022). Many hospitals do not connect their facility systems to their backup power supply. Therefore, if electricity supply is disrupted during a hurricane, facility ventilation may function without access to heating or cooling systems, leading to dysregulated internal temperatures (Balbus et al., 2016).

3.5 Supply Chain: Many items in a healthcare organization's supply chain – both clinical and non-clinical – require refrigeration. Furthermore, hurricanes can also cause shortages of vital medical supplies and pharmaceuticals due to transportation disruptions and damaged production facilities. Healthcare organizations can enhance resilience by developing and implementing a plan for managing their refrigerated supply chain and on-site storage during power outages (Rublee et al., 2021). In addition, hurricane emergency planning should include additional assessment of supply chain vulnerabilities, with contingencies that can be implemented in the event of regional transportation or production disruptions.

Resilience Strategies: Hurricanes

Element 3.1 Staff Support



Healthcare organizations depend on dedicated clinicians, administrators, and facilities and operations staff to deliver care. Many staff are highly motivated to deliver care in response to an emergency. A study in Hawai'i found that both physicians and nurses showed particularly strong commitment to staffing major natural disasters like hurricanes compared with other emergencies, such as explosions or chemical events (83% compared with 52%–67% for other incidence types) (Lanzilotti et al., 2002).

However, staff and their families are often impacted by the same climate change-related hazards as the facilities in which they work. Practical considerations like transportation, childcare, and concern for their family may prevent them from fully participating in the response effort. For example, a survey of over 6,000 healthcare workers in New York City found that 53% had childcare responsibilities, 63% of whom had children under the age of 13; 27% reported elder care responsibilities, and 29% reported that their spouse also had work responsibilities during disasters (Qureshi, 2005). By integrating staff protections and accommodations into hurricane emergency planning, healthcare organizations can alleviate logistical difficulties to allow staff to get to work during and after hurricanes. Hurricanes are often forecasted several days in advance. As a result, emergency management plans can be deployed early enough for administration and staff to jointly decide which staff will remain at work through the duration of the event and who would benefit from staying at home with their family until roads become passable and power is restored. These measures also reduce mental strain caused by worrying about loved ones at home, allowing staff to focus on providing essential patient care. For example, 100 personnel from the U.S. VA New York Harbor Healthcare System's Manhattan campus slept at least one night at a VA facility during Superstorm Sandy (2012) so that they could continue providing care during the event (Wyte-Lake et al., 2018).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
[Element 3.1: Staff Support]

Planning

ACTION: Set staff expectations for their role during severe storms.

SUMMARY: Clearly define expectations with healthcare facility staff related to working during and after severe storms – particularly under circumstances that lead to power disruptions or outages, and those that may require staff to remain at work for extended periods. Share with staff a list of personal items that they should bring with them to an anticipated multi-day response effort, such as food, water, personal medication, hand sanitizer, extra clothes, and sleeping gear. Co-create policies and programs with staff establishing a flexible and supportive approach to staffing, accommodations, and transportation during and after severe storms. For example, it may be necessary to shorten staff shifts during emergency operations to give them the ability to rest mentally and physically. Include daycare, shelter, and other accommodations for staff family members, as needed (Danna et al., 2010; Toner et al., 2017; WHO, 2020).

ACTION: Train clinical staff in alternative procedures for delivering care during disasters.

SUMMARY: Healthcare organizations can support staff in preparing for disaster response by offering training in alternative procedures for intake and triage if

Climate Resilience Actions, continued

inpatients are transferred from other facilities without their medical records, as well as training in alternative procedures for delivering care in situations with limited access to electricity and water, such as manually counting intravenous pump drips, manually suctioning intubated patients, and manually taking blood pressure readings (U.S. HHS, 2014).

People and Operations

ACTION: Integrate regular emergency preparedness employee training into the healthcare organization's continuing education program.

SUMMARY: Implementing a regular emergency preparedness employee training program can increase awareness of climate change-related risks to the healthcare organization, as well as protocols and procedures designed to enhance resilience in the face of increasingly frequent and severe climate change-related events (Hilton, 2015; WHO, 2020). Include training on how key staff roles will be assigned during emergencies, and consider developing checklists for each department that break down key tasks according to when they should occur – pre-event, during response, and post-event (U.S. HHS, 2014).

ACTION: Provide alternative transportation and housing for healthcare staff during severe storms.

SUMMARY: Consider establishing agreements with nearby transportation providers and temporary housing facilities (such as hotels) to support employees and their immediate families (including pets) in the event that transportation pathways and/or utilities are disrupted during a severe storm. This may also involve preparing for staff to stay at healthcare facilities before the storm begins to mitigate potential transportation interruptions (Morris et al., 2016; WHO, 2020).

ACTION: During transportation disruptions, coordinate across the healthcare system to redistribute staff to facilities they can access – even if they are not at their "home" facility.

SUMMARY: It may be necessary immediately following events that damage infrastructure – such as hurricanes, severe inland storms, and floods – to temporarily redistribute the healthcare system's staff to facilities they can access (Morris et al., 2016). Establish a tracking system so that staff can report to supervisors who are physically located in different facilities (Wyte-Lake et al., 2018). Cross-training staff so that they can fulfill multiple roles can benefit the overall healthcare system by ensuring that essential clinical services are offered by a mixture of permanent and temporary staff (Hilton et al., 2015).

ACTION: Ensure that staff who are supporting a hurricane response have access to clothing, a place to sleep, routine medications, and wellness services.

SUMMARY: Given the often-rapid evolution of hurricanes and their impacts on community infrastructure, staff may be required to stay at their place of work for more than 24 hours without access to basic necessities such as a change of clothes and daily medications. Healthcare organizations can increase the resilience of their clinical services by ensuring that staff have access to clothing, a place to sleep, routine medications, and wellness services while they support patients in the midst of a disaster (Evans, 2017; Hilton et al., 2015; Morris et al., 2016; Toner et al., 2017).

ACTION: Establish a culture that acknowledges the personal challenges staff are facing during a disaster.

SUMMARY: Acknowledging the personal challenges faced by staff during a climate change-related disaster can increase a healthcare facility's resilience by increasing the willingness of staff who are able to report to work. It also creates space for staff to request tangible assistance (such as a hotel room or childcare) that would make it possible for them to support the disaster response (Morris et al., 2016; Toner et al., 2017).

ACTION: Provide staff support post-disaster.

SUMMARY: Creating a post-disaster employee assistance program for staff and their families in the aftermath of a severe storm – 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 (Dana et al., 2010; WHO, 2020). Immediate support for staff who have experienced a major loss (such as their home) can also increase their ability and willingness to return to work after the event (Morris et al., 2016).

ACTION: Provide staff with post-disaster safety information for their homes.

SUMMARY: After floods and hurricanes, healthcare organizations can share information with staff about how to inspect their homes for flood damage, how to remove water-logged and contaminated building materials, how to reduce the risk of mold growth, and how to find funding opportunities to support demolition and rebuilding efforts (CDC, 2019 a.).

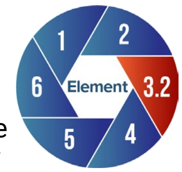
Climate Resilience Actions, continued

Physical Infrastructure

ACTION: Establish alternative communications channels for contacting staff during utility outages.

SUMMARY: Staffing during and immediately following climate change-related disasters that cause utility outages can be complicated by disruptions to telecommunications infrastructure. Establishing alternative communications channels (such as multiple cell phone providers, satellite phones, walkie-talkies, and installing a generator-powered cell tower on the roof of the facility) can increase a healthcare organization's resilience to these events by making it possible to share important information with staff – such as facility closures and requests that staff report to the facility closest to their home (U.S. HHS, 2014; Morris et al., 2016; Wyte-Lake et al., 2018).

Element 3.2 Clinical Considerations



Hurricanes can cause an increase in healthcare demand due not only to acute injury during the event, but also to disruption in routine care and hazards that persist after the storm event. The majority of hurricane-related direct health outcomes in the United States can be traced to disruption in routine medical care for existing patients in the days and weeks post-disaster. These conditions can be prevented by ensuring that displaced patients are connected with nearby services until they return home (Toner et al., 2017).

Following Hurricane Katrina in 2005, a mobile hospital deployed from North Carolina reduced the risk of patient surge in southern Mississippi by successfully treating 7,400 patients (Blackwell & Bosse, 2007). Storm surge (caused by strong winds pushing water to shore) is historically the leading cause of hurricane-related deaths in the U.S. (NIST, 2024). Flooding can result in outbreaks of waterborne illness, and mold in its aftermath can trigger allergies and asthma. Power outages can increase the risk of extreme temperature exposure and put at risk those who depend on medications requiring refrigeration or electricity-dependent durable medical equipment. Mental and behavioral health conditions can also be caused and exacerbated by the loss of loved ones, homes, and community infrastructure.

For example, following Hurricane Maria (2017), youth in Puerto Rico reported high rates of post-traumatic stress disorder and depressive symptoms (Orengo-Aguayo et al., 2019). After Hurricane Harvey (2017), BlueCross and BlueShield of Texas reported that the number of diagnoses for infectious and parasitic diseases doubled in counties impacted by the hurricane. Diagnosis of substance abuse, pneumonia, and COPD all increased 3%. Use of telemedicine to access care also doubled, although the total number of medical visits was 20% lower than expected immediately following the event (BlueCross and BlueShield of Texas, 2018). Healthcare organizations can increase resiliency to hurricanes by integrating hurricane-specific clinical considerations into their emergency preparedness plans and adjusting normal procedures and standards of care ahead of forecasted events.

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 3.2: Clinical Considerations

Planning

ACTION: Integrate epidemiological and meteorological data into hurricane 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 category hurricanes and different levels of storm surge (Patel et al., 2022).

ACTION: Develop a continuity of care plan listing essential clinical services that will be provided at different tiers of utility disruption.

SUMMARY: Many healthcare facilities are designed to function at full or partial capacity under a variety of environmental stressors. Organizations can increase resilience to climate change-related events by creating and training staff to implement a continuity of care plan outlining essential clinical services that will be provided at different tiers of utility disruption (Toner et al., 2017).

Climate Resilience Actions, continued

ACTION: Add hurricane-related illness screening to the healthcare organization's EMR system.

SUMMARY: Consider including in the healthcare organization's hurricane resilience and preparedness plan a protocol for activating hazard-related illness screening questions in the electronic medical record (EMR) system when local authorities activate the emergency operations center to respond to an approaching hurricane (Hess et al., 2023). Sensitive patient groups that might be flagged for additional screening during and after hurricane events include unhoused individuals, children, adults over 65 years of age (especially those who live alone), coastal communities, low-income populations, and patients with chronic conditions. Early identification through EMR screening allows healthcare providers to flag sensitive patient groups for further evaluation and intervention, ultimately improving patient outcomes during hurricanes.

ACTION: Enhance syndromic surveillance during severe storm and flooding events.

SUMMARY: Consider enhancing the healthcare system's syndromic surveillance during storm and flooding events by submitting hazard-related illness data to the Electronic Surveillance System for the Early Notification of Community-Based Epidemics (Burkom et al., 2021). Work with local public health partners to interpret and act on real-time hazard-related illness and all-cause morbidity and mortality data during and immediately following severe storms and floods.

ACTION: Integrate epidemiological and meteorological data into storm and flooding 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 storm and flooding events (Patel et al., 2022).

ACTION: Integrate mosquito-borne and water-borne infectious disease protocols into the healthcare organization's hurricane emergency plans.

SUMMARY: Consider including triage and syndromic surveillance protocols for mosquito-borne and water-borne infectious diseases in the healthcare organization's hurricane emergency plan to streamline appropriate clinical responses and public health reporting during and after tropical storm events (Hedges et al., 2018). Keep the protocol in place for several days or weeks after the hurricane passes, because incidence of both classes of disease is often associated with the after-effects of infrastructure damage, such as standing water, power outages, and boil water notices.

People and Operations

ACTION: Adjust normal procedures and standards of care ahead of forecasted hurricanes to expedite patient discharges, when possible, and to adjust the timing of routine treatment.

SUMMARY: Consider establishing protocols triggering an adjustment to the healthcare organization's clinical procedures (e.g., in pharmacy, drug treatment, dialysis, etc.) ahead of forecasted hurricanes to create contingency plans to extend the amount of time existing patients can go without routine treatment. When possible, expedite inpatient discharge to free up bed space ahead of expected patient surges during and immediately following the event (Scott, 2017; Toner et al., 2017).

ACTION: Develop a plan for patient surges and train staff in its implementation, including scenarios for accommodating cascading and simultaneous climate change-related disasters.

SUMMARY: Many climate change-related events occur simultaneously or in quick succession. For example, hurricanes often occur during heat waves. Wildfires, drought, flooding, and landslides often trigger or exacerbate each other. It is, therefore, increasingly important to develop a plan for patient surges and train staff in its implementation. Include procedures for bringing in temporary staff, adapting clinician services to fast-changing conditions, and altering the schedule for routine operating procedures to free up space and staff to provide emergency care (Toner et al., 2017).

ACTION: Co-locate critically ill and fragile patients on the same floor of the facility as the emergency command center to maximize staff communication and patient safety.

SUMMARY: Identify the safest floors of the healthcare facility during severe storms. Consider co-locating the most critically ill and fragile patients on those floors alongside the emergency command center to expedite communication between leadership and staff to maximize patient safety (U.S. HHS, 2014).

ACTION: If it is necessary to evacuate patients during a disaster, consider sending nurses, nursing assistants, and leadership staff with them to ensure continuity of care.

SUMMARY: Hospitals that evacuated patients alongside care staff and their leadership team during Superstorm Sandy (2012) reported lower rates of anxiety about the evacuation among patients and their families (U.S. HHS, 2014).

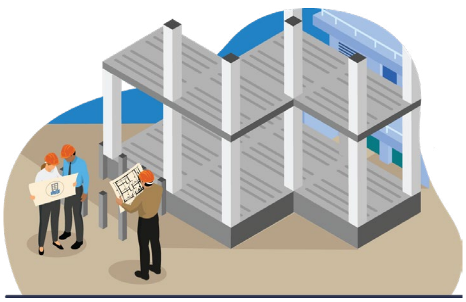
Physical Infrastructure

ACTION: Deploy mobile health units to take medical care to high-risk patients in the community during transportation disruptions.

SUMMARY: Consider including in the healthcare organization's list of emergency response assets mobile units that are used to deliver routine care to community members. Use the organization's map of high-risk patients – such as patients who need dialysis or those with a substance use disorder, diabetes, or heart disease – (Element 2.1) to prioritize the provision of medical care during transportation disruptions caused by a hurricane (Toner et al., 2017).

Resilience Strategies: Hurricanes

Element 3.3 Building and Campus: Design & Construction



Although building codes require structural redundancies that harden buildings against potential environmental hazards, facilities in the path of hurricanes are at risk of damage from high winds, intense precipitation, and flooding. A 2022 study estimated that a Category 2 hurricane would put over half of hospitals in 1/3 of urban areas along the Atlantic and Gulf Coasts of the United States at risk of flooding at current sea levels. By 2100, that risk was estimated to increase by 22% due to anticipated sea level rise (Tarabochia-Gast et al., 2022).

Hurricane-resilient healthcare facilities incorporate features such as energy efficiency and on-site power generation, water efficiency and emergency water supplies, and protective siting of critical building systems to minimize infrastructure damage from wind, flood waters, and storm surge. For example, in response to Hurricane Harvey (2017), Lyndon B. Johnson Hospital in Houston, Texas, reorganized interior spaces, creating a "quick care" flex area to process low-acuity patients and setting up an annex to house 183 community members seeking shelter from the storm, which lasted for five days. Some of those sheltering in the hospital required ambulatory medical care or access to their regularly prescribed medications (Chambers et al., 2020).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 3.3: Building and Campus: Design & Construction

Planning

ACTION: Use regional climate models to future-proof the efficiency and redundancy of building systems in the face of projected changes in the frequency and severity of hurricanes.

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 installing renewable power microgrids for backup power) in order to extend the functional life of the building as long as possible within the context of 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 & Chan, 2017).

Physical Infrastructure

Structure and Landscaping

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,

Climate Resilience Actions, continued

and other access points can increase the safety and effectiveness of multimodal evacuation plans when they are deployed during a hurricane (Basu 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., 2023).

ACTION: Design new buildings and reinforce existing structures to withstand future climate change-related exposures as described in the healthcare organization's prospective risk assessment (Element 1).

SUMMARY: Many building codes rely on historical data to set structural requirements for withstanding climate change-related hazards like wind, flooding, fire, heat, and landslides. Healthcare organizations can reduce the risk of a major disaster causing sufficient physical damage that shuts down operations by designing and renovating facilities to withstand future climate change-related exposures as described in their prospective risk assessment (Element 1) (U.S. HHS, 2014).

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 at which they can generate sufficien electricity using on-site renewable power (e.g., solar, wind, geothermal). These facilities can continue to provide clinical care during disasters that disrupt regional power grids.

ACTION: Install energy efficient building equipment to extend the length of time during which 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 during which 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.

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 storms and flooding (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).

Water Efficiency and Flood Resilience

ACTION: Maximize water efficiency to reduce demand during low water pressure and boil water notice events.

SUMMARY: Water is critical to the functioning of healthcare facilities – both clinical and building systems. To maximize the availability of potable water for clinical uses, consider minimizing once-through use in process equipment – such as the HVAC system, sterilizers, and medical equipment. Further, consider installing low-flow toilets, urinals, handwash stations, and showers – except where volume is needed for occupational uses (such as water filling stations and decontamination showers) (Van der Heijden, 2022; WHO, 2015).

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, and drought) or as a result of infrastructure failures caused by hazards like hurricanes and tornadoes. Healthcare facilities should be designed to operate using on-site water supplies for at least 72 hours. Facilities located in high-risk areas can increase resilience by identifying supplementary water sources (such as connections to allow temporary water supply from trucks or other sources, permanent storage tanks/cisterns, and wells) that can be used to maintain water pressure during

Climate Resilience Actions, continued

low pressure events. Facilities with the ability to separate process water systems from potable water systems are particularly resilient to water outages (Healthcare Environmental Resource Center, 2015; Van der Heijden, 2022; WHO, 2015).

ACTION: Protect the permanent and emergency water supply from extreme weather and contamination from flood waters.

SUMMARY: Weatherize water supply pipes, cisterns, and tanks to prevent breakages in extreme cold weather. Place emergency water storage (such as tanks and cisterns) outside of areas at risk of flooding or landslides. Install float valves and overflow outlets that drain away from the facility to avoid flooding interior spaces after a cistern or tank fills up. Install one or more supplementary water pumps (depending on need) and connect them to the emergency power supply to keep water pressure at safe levels when the power goes out (Van der Heijden, 2022; WHO, 2015).

ACTION: Install backflow prevention valves to prevent sanitary sewage from backing up into the hospital during flood events.

SUMMARY: Healthcare facilities located in communities with combined sanitary and storm sewers may experience sewage backup during extreme flood events. Facilities can enhance resilience by installing backflow prevention valves and capping drains on lower floors during flooding events (Van der Heijden, 2022; WHO, 2015).

ACTION: Install protective barriers and elevated walkways/driveways in areas at risk of flooding.

SUMMARY: Floodgates, floodwalls, and other barriers equipped with crossover stairs can support safe passage across areas on a medical campus that are projected to experience repeated flooding (U.S. HHS, 2014).

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).

Resilient Critical Operating Systems

ACTION: Place the healthcare organization's critical infrastructure above the level of projected flood risk.

SUMMARY: Placing equipment crucial to research, education, and patient care (such as labs, medical equipment, and information technology [IT] equipment) and building systems (such as emergency generators, pumps, and electrical switches) above the level of projected flood risk can reduce the likelihood of disruptions to patient care and research resulting from facility flooding (U.S. HHS, 2014; Scott, 2017).

ACTION: Place redundant IT systems off-site to increase the resilience of EMRs.

SUMMARY: Placing redundant IT systems off-site can reduce the risk of the electronic medical record (EMR) system going offline during flood events (Danna et al., 2010; Toner et al., 2017).

ACTION: Place EMR servers and equipment in climate-controlled spaces and above the flood line.

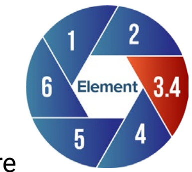
SUMMARY: To ensure that medical information systems remain functional during power outages and flooding events, place them in storage spaces that are elevated above the risk of flood waters, climate-controlled with a dedicated energy source, and/or off-campus (such as a duplicate paper record storage site) (Swanson et al., 2010; U.S. HHS, 2014).

ACTION: Install redundant communication systems for use during power and communications outages.

SUMMARY: Extreme weather events can disrupt electricity supply, cell towers, radio transformers, and other community communications networks. Healthcare organizations can reduce the risk of disruption in communications to other facilities in their network, regional healthcare organizations, and local emergency management agencies by installing and maintaining redundant communication systems, such as analog phones, fax machines, handheld two-way radios, ham radios, and solar-powered devices (Hedges et al., 2018).

Resilience Strategies: Hurricanes

Element 3.4 Building and Campus: Facility Operations



Healthcare buildings are vulnerable to power outages because they rely on electricity, plumbing systems, and energy sources, like natural gas, to operate 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) (FEMA & ASPR, 2019). Most hospitals are sealed buildings, and loss of power during hurricanes can cause internal temperatures to rise or fall to dangerous levels (Patel et al., 2022). Many hospitals do not connect their facility systems to their backup power supply. Therefore, if electricity supply is disrupted during a hurricane, facility ventilation may function without access to heating or cooling systems, leading to dysregulated internal temperatures (Balbus et al., 2016). Inpatients also require food service, access to clean water, and laundry and custodial services (FEMA & ASPR, 2019). 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 hazards like flooding (Element 3.3). Healthcare organizations can enhance climate resilience in operational facilities by updating protocols for preventive maintenance and plans for cycling down systems during power outages to reflect the results of the organization's prospective risk assessment (Element 1).

For example, Lee Health System in Florida prepared for Hurricane Ian (2022) by stockpiling supplies and generator fuel ten days prior to the storm. They also halted all construction three days prior to the storm, performed a walk-through of all facilities to minimize loose debris that could be picked up by hurricane winds and cause damage, and staged repair materials and equipment in locations that were at greatest risk of physical damage. Even with all of their precautions, the health system faced an extended period of low and no water pressure across many of their facilities. They responded by activating their fire watch plan (due to low water pressure in their sprinkler system), reducing the number of toilets in use, rationing drinking water to critical functions, and working with local offices of emergency management to access backup water tankers (ASPR TRACIE, 2023 a.).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
[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 enhance 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: 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

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 (such as extreme temperatures, exposure to flood waters, etc.) reach dangerous levels (FEMA & ASPR, 2019).

ACTION: Perform a baseline analysis of water usage and categorize usage types into tiers of critical need.

SUMMARY: Water is a critical component of clinical care, including sanitizing medical equipment. Performing a baseline analysis of the healthcare facility's water usage and categorizing usage types into tiers of critical need can help facility managers direct potable water supply to the most important clinical needs during low water pressure and boil water notices while also reducing overall facility water usage (WHO, 2015; Van der Heijden, 2022).

ACTION: For hurricanes that could result in widespread damage to utilities and community infrastructure, include security considerations in the healthcare facility's emergency preparedness plan.

SUMMARY: Extreme weather events that cause widespread damage to utilities and community infrastructure can result in a temporary need for increased security at a healthcare facility, particularly if it experiences a patient surge and/or acts as a place of respite for community members (Danna et al., 2010).

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 demands remain at levels that can be met by on-site sources, such as renewable power and recycled process water (Kolokotsa et al., 2012). 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 weather events.

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

ACTION: Conduct regular tests of emergency generators, water supplies, and transportation plans to ensure that they are ready to deploy in the event of an emergency.

SUMMARY: It can be difficult to source fuel, water trucks, and emergency transportation contractors in the immediate run-up to a hurricane. Healthcare organizations can check the status of their resilience to the first 72 hours of anticipated hurricanes by performing regular tests and maintenance on emergency generators and on-site sources of emergency water. It can also be helpful to perform regular drills with outside contractors who will be responsible for supplying more fuel, trucked-in water, emergency transportation for staff and patients, and other activities included in the facility's emergency operations plan (U.S. HHS, 2014).

Physical Infrastructure

ACTION: Ensure emergency equipment is in hazard protected areas.

SUMMARY: Ensure emergency generators are in areas safe from flooding to enable functioning and back-up power in the event of a flood (PDH Star, 2018).

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: Conduct regular walk-throughs of the healthcare facility to confirm compliance with fire safety and evacuation signage requirements.

SUMMARY: Facility evacuation can be impeded if exits are obstructed, signage is missing or confusing, or life safety equipment, like sprinklers and fire extinguishers, is missing or broken. Conducting regular walk-throughs of the healthcare facility to confirm that these essential

Climate Resilience Actions, continued

emergency preparedness components are in place and in working order could be seen as a first level of resilience to any climate change-related hazard that might damage the building structure or result in an eventual evacuation (U.S. HHS, 2014).

ACTION: Prior to an anticipated flooding and/or wind event, walk through the facility to identify locations that might require repair during and immediately following the event and stage the necessary materials and equipment (including pumps) nearby.

SUMMARY: Certain locations in and around the healthcare facility are more vulnerable to damage from a flooding and/or wind event, such as the roof, windows, and lower floors. Healthcare organizations can reduce the risk of disruption to clinical operations by identifying likely repair needs prior to the event and staging the relevant construction materials and equipment within easy reach to minimize the impact of minor leaks, broken windows, and other building damage on regular facility operations (ASPR TRACIE, 2023 b.).

ACTION: During and after wind and flood events, monitor the facility, transportation infrastructure, and landscaping for signs of flood damage.

SUMMARY: Flood events can damage a healthcare facility's structure and foundation, compromising safety and, in extreme cases, leading to collapse. Healthcare organizations can support continued operations during a flood by regularly inspecting the building, transportation infrastructure used by patients to access the facility, and surrounding landscaping for signs of damage and responding as appropriate. Continuing inspections after the flood can help catch moisture and other damage that can lead to deteriorated air quality over time, amongst other impacts (PDH Star, 2018).

ACTION: After floodwaters recede, clean hard surfaces and remove absorptive materials as soon as possible to reduce the risk of mold growth.

SUMMARY: Nonstructural damage like mold can become the determining factor regarding whether or not a facility reopens after a climate change-related disaster. If a facility did not sustain severe structural damage from the flood, cleaning hard surfaces and removing absorptive materials quickly can reduce the risk of mold growth. Steel structure, reinforced concrete, and concrete masonry units covered in water-resistant paint are often easy to clean, dry, and restore to pre-flood uses. Absorptive materials, like carpet, drywall, and composite wood products (like plywood and medium density fiberboard), are more likely to require replacement (PDH Star, 2018).

Element 3.5 Supply Chain

Many items in a healthcare organization's supply chain – both clinical and non-clinical – require refrigeration. Hurricanes can cause shortages of vital medical supplies and pharmaceuticals due to storage and transportation disruptions and damaged production facilities. Healthcare organizations can enhance resilience by developing and implementing a plan for managing their refrigerated supply chain and on-site storage during power outages (Rublee et al., 2021). For example, an alternative care site in Louisiana stores a 14-day Emergency Inventory Package in a warehouse on-site to ensure that the facility has enough inventory to serve 240 patients over a two week supply chain disruption (Maslanka & Hurwitz, 2022). In addition, hurricane emergency planning should include an additional assessment of supply chain vulnerabilities, with contingencies that can be implemented in the event of regional transportation or production disruptions. For example, in addition to stockpiling supplies for patients and staff in the run-up to Hurricane Maria in 2017, Ponce Health Sciences University also stockpiled several days of food and water for animals in the institution's vivarium. In the days following the event, they transferred 3,500 tumor tissue samples to the H. Lee Moffitt Cancer Center in Tampa, Florida, to protect them from intermittent power outages (Hedges et al., 2018).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
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 medical supply storage into resilience planning.

SUMMARY: Consider how your organization's prospective risk assessment of hurricanes (Element 1) might lead to supply chain disruptions and/or changing needs. Maintain an adequate supply of medical supplies, particularly for products that are most vulnerable to weather-related disruptions in transportation routes (Hedges et al., 2018). Consider separating emergency supplies into two categories: high-volume medical supplies (such as intravenous bags, sharps, and oxygen) and equipment/supplies that would only be needed during a disaster. Establish a timeline for activating the supply chain plan ahead of the anticipated climate change-related event. Include in the timeline when a comprehensive check of both types of inventory should take place and when normal deliveries should be suspended (for example, 120 hours and 12 hours ahead of an anticipated hurricane, respectively) (Maslanka & Hurwitz, 2022).

People and Operations

ACTION: Require suppliers of essential goods and services to provide a continuity of operations plan for hurricanes.

SUMMARY: Healthcare organizations are dependent on a large network of vendors to supply goods and services

Climate Resilience Actions, continued

that are essential to facility operations and continuity of care. Requiring suppliers of essential goods and services to provide a continuity of operations plan is an important first step in building the healthcare organization's resilience to hurricanes and other disasters that disrupt transportation infrastructure (Toner et al., 2017).

ACTION: Stockpile potable water.

SUMMARY: Maintaining a stockpile of potable water, either inside the healthcare organization's storage facilities or through a contract with external vendors, can bridge the gap for both medical procedures and community services (i.e., sharing bottled water with community members) during water shortages (Hedges et al., 2018).

Physical Infrastructure

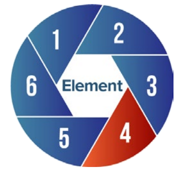
ACTION: Boost the resilience of refrigerated storage areas.

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).

ACTION: Store essential medical supplies, food, and fuel lasting 5–7 days on or near the healthcare campus to facilitate rapid deployment ahead of hurricanes.

SUMMARY: As the severity of hurricanes and duration of related disruptions increase due to the effects of climate change, it has become increasingly important to stockpile medical supplies, food, and fuel on or close to a healthcare facility campus in case utilities and transportation infrastructure are disrupted for multiple days (Danna et al., 2010).

Element 4. Collaboration Between Healthcare Organizations



Sharing information and resources across the full range of regional healthcare providers before, during, and after a hurricane can increase resilience both at the facility level and system-wide. Hurricane effects may lead to (1) a disruption in care delivery in an outpatient facility, resulting in a patient surge in an acute care setting, (2) displacement, resulting in people requiring health care far from home, and (3) evacuation and transfers between facilities. Collaboration between healthcare facilities to increase hurricane resilience can include communication and information sharing, resource coordination, plans for potential evacuation and transfers, medical staff deployment, data sharing, joint public health outreach efforts, and joint disaster preparedness drills. For example, when low water pressure in the aftermath of Hurricane Ian prompted patient evacuation from Florida hospitals in 2022, joint disaster preparedness exercises and collaboration through the Florida Hospital Association helped to ensure the seamless execution of safe and coordinated patient transfers to other hospitals in the region (ASPR TRACIE, 2022). In 2016, staff at the Ralph Johnson U.S. VA Medical Center in Charlestown, South Carolina, coordinated the pre-hurricane evacuation of outpatient military veterans with spinal cord injuries and disorders to a VA facility outside of the path of Hurricane Matthew (Scott, 2017).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
[Element 4: Collaboration Between Healthcare Organizations]

Planning

ACTION: Exchange epidemiological data and health assessments related to severe storms and flooding with other healthcare organizations and the local health department.

SUMMARY: Exchanging epidemiological data and health assessments related to severe storms and flooding with other healthcare organizations and the local health department can support regional climate resilience planning efforts. Use these conversations to jointly develop protocols for identifying emerging climate-related health threats in the region, collecting and disseminating data, and coordinating emergency response across the range of facility types in the regional health system – including acute care hospitals, community clinics, and long-term care facilities (Patel, 2022).

ACTION: Perform joint disaster preparedness exercises and drills with other local healthcare organizations, the local health department, and the local office of emergency management.

SUMMARY: Joint disaster preparedness exercises and drills can help healthcare organizations test their readiness for hurricanes (and simultaneous and cascading events), identify areas for improvement in their emergency response plans, and build working relationships with other first responders. Including representation from multiple institutions and professions in the exercise can also help identify emerging at-risk populations who are projected in climate models to require more protection and/or resources as hurricanes occur more frequently and/or with greater severity (ASPR, 2024; WHO, 2020).

ACTION: Create plans to increase the resilience of critical outpatient care during severe storms and flooding events.

SUMMARY: Create contingency plans in coordination with regional healthcare partners to ensure that individuals with chronic physical and/or mental health conditions–who are at high risk due to potential interruptions in medication

Climate Resilience Actions, continued

administration or outpatient care–have access to alternative arrangements if their usual care becomes unavailable or inaccessible due to severe storms or flooding (U.S. HHS, 2014; Toner et al., 2017; WHO, 2020).

ACTION: Enhance healthcare organization preparedness for hurricanes through mutual aid MOU.

SUMMARY: A mutual aid memorandum of understanding (MOU) with other healthcare providers in the region that includes the results of a prospective risk assessment (Element 1) can help prepare for circumstances that require patient transfers or referrals – such as utility outages, patient surges, etc. It is important to address legal and reimbursement challenges that can limit a facility's ability to quickly and efficiently transfer patients and/or supplies to other facilities in the region. Consider working with CMS and other healthcare organizations in the region to fill in those gaps over time using an all-hazards approach (U.S. HHS, 2014; Patel et al., 2022).

ACTION: Integrate an analysis of cross-institutional collaboration in regional after-action reviews of hurricanes.

SUMMARY: As part of an all-hazards emergency management plan, include an after-action analysis of interdisciplinary coordination within the organization, as well as with other regional healthcare organizations and the local office of emergency management to assess how well the emergency response system functioned as a whole. Consider including prospective climate metrics (Element 1) as one indicator of the system's resilience to future events (Davies et al., 2019; Parker, 2020).

ACTION: Work with other regional healthcare organizations to develop integrated patient evacuation plans.

SUMMARY: Healthcare organizations can increase their own and regional resilience by working together to develop integrated emergency evacuation plans. Consider including contingency plans to address damage to a facility's structure, exposure to contaminated air and/or water damage, power and water outages, destruction of electronic medical records, infrastructure failures, and an ambulance shortage. Contingency plans may involve transferring patients to alternate facilities or establishing temporary medical sites in safer areas (U.S. HHS, 2014; Patel, 2022).

People and Operations

ACTION: Collaborate with regional healthcare organizations on public health education and outreach programs.

SUMMARY: Healthcare institutions can collaboratively develop and disseminate public health education and outreach programs so that the community receives a consistent and coordinated message about hurricanes, protective behaviors, and access to resources such as healthcare services (California Department of Public Health, 2022).

ACTION: Consider proactively credentialing neighboring healthcare facility staff to help execute the healthcare organization's emergency preparedness protocol.

SUMMARY: Proactively credentialing staff at neighboring healthcare facilities to prepare for emergencies can contribute to backup care if one facility is unable to provide care due to hurricane-related utility interruptions (WHO, 2020).

ACTION: Share resources and coordinate personnel during hurricanes.

SUMMARY: Collaboration between response organizations may involve sharing critical resources and coordinating the deployment of personnel to support impacted communities in areas of greatest need (Patel, 2022). Consider integrating the results of the organization's prospective risk assessment (Element 1) into planning conversations to funnel resources to new and emerging at-risk populations related to the changing climate.

ACTION: Establish effective communication channels to share real-time information across healthcare organizations during hurricanes.

SUMMARY: Consider working with other healthcare organizations and entities in the region to establish effective real-time communication channels with one another and the public during hurricanes. Examples of critical information that can be shared this way include information about hurricane progression, who should evacuate, where evacuees should go, which healthcare facilities are open to receive new patients and/or community members seeking refuge, real-time information about the number of beds available in the region and consistent definitions for each bed type, and levels of critical medical supplies needed and available for each facility in the cooperation network (CDC, 2003; California Department of Public Health, 2022; U.S. HHS, 2014).

Climate Resilience Actions, continued

Physical Infrastructure

ACTION: Build out alternative communications channels to help regional healthcare organizations share real-time information with each other during disasters.

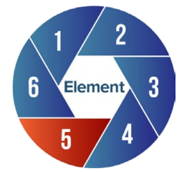
SUMMARY: Interorganizational cooperative agreements for sharing resources and transferring patients during climate change-related disasters depend on real-time communication among facilities in the network. Building out alternative communications channels connecting healthcare organizations with each other (such as multiple cell phone providers, satellite phones, walkie-talkies, and generator-powered cell towers on the roof of key facilities) can increase the effectiveness of the entire network's emergency response (U.S. HHS, 2014).

Resilience Strategies:

Hurricanes

CR4HC

Element 5. Interdisciplinary Planning, Oversight, and Evaluation



Planning for hurricane resilience requires an interdisciplinary team and coordination across a range of critical functions, including administration, emergency management, information technology, facility operations (e.g., power, water, waste disposal, food service, custodial services, etc.), communications, transportation, and purchasing. For example, in the lead-up to Hurricane Harvey (2017), Lyndon B. Johnson Hospital in Houston, Texas, was unable to ensure sufficient medical staff to work through the storm. Flooded roads prevented senior medical personnel from reaching the facility after the storm. As a result, junior staff inside the facility received virtual support from off-site supervisors for five days until replacements were transported to the facility in high-water vehicles (Chambers et al., 2020).

It is important to raise awareness among staff and community members about the interconnected effects of hurricanes and coastal flooding (during both the acute storm event and its aftermath) on clinical care, facilities operations, and community infrastructure, and to seek input from all key stakeholder groups about which risk-mitigating interventions should be prioritized (WHO, 2020). Aligning facilities operations, procurement, and capital expenditures to balance climate change mitigation (i.e., reducing greenhouse gas emissions) goals and resilience goals can help the organization chart a climate-positive and cost-neutral path towards hurricane resilience. Facilities will use less energy and water, sustain less damage, and operate at a lower risk of evacuating patients during and after storms (WHO, 2020).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 5: Interdisciplinary Planning, Oversight, and Evaluation

Planning

ACTION: Incorporate interdisciplinary approaches into hurricane emergency planning.

SUMMARY: Consider incorporating interdisciplinary approaches into the healthcare organization's hazard planning process since hurricanes can impact a range of dependencies – such as infrastructure, clinical care, energy systems, and waste management (Rogers et al., 2020).

ACTION: Incorporate long-term goals and climate projections into healthcare extreme weather planning and response plans.

SUMMARY: It can be helpful to integrate long-term, interdisciplinary strategic goals into the healthcare organization's extreme weather emergency preparedness and response plans – including community input as outlined in the Justice, Equity, Diversity, and Inclusion (JEDI) framework (American Public Health Association & CDC, 2021).

ACTION: Implement surveillance and interdisciplinary after-action reviews in hurricane action plans.

SUMMARY: Incorporate building surveillance and interdisciplinary after-action reviews into the healthcare organization's hazard action plan. These measures will help identify and evaluate the elements of the plan that worked during a recent hurricane, assess whether changing climatic conditions might have influenced aspects of the event (such as its severity), and change the parts of the plan that did not meet expectations (Hess et al., 2023; Parker, 2020).

Element 6. Communications and All-Hazards Approach

Hurricanes and flooding events often occur simultaneously or in quick succession with other climate change-related hazards, such as extreme heat, which increases the risk of multisystem failures at the community scale (including disruptions to water and power utilities). This can result in both direct and indirect harm to population health. Repeated patient surges and cascading infrastructure failures both in the community and within healthcare facilities can temporarily disrupt the entire healthcare system in a region (Clarke et al., 2018). Fortunately, many policy, infrastructure, and communications interventions can increase organizational resilience to more than one climate-related hazard. This is particularly true if emergency management and climate resilience planners use an all-hazards approach to designing, implementing, and testing proposed interventions. For example, a study of residents along the Gulf Coast in Mississippi and Southwest Alabama who experienced Hurricane Katrina in 2005 recommended that local healthcare providers and community-based organizations regularly communicate their status (e.g., if they are operational, what types of supplies they have in stock, etc.) via multiple public communications pathways following a hurricane. They also recommended creating a network of community-based organizations and credentialed volunteers ahead of the disaster who could distribute medication, emergency supplies, and low-level medical care within neighborhoods – which would reduce the need for patients to travel to receive low acuity care. These locations could also distribute up-to-date information to the neighborhood via word of mouth (Arrieta et al., 2007).

Link to the Fifth National Climate Assessment, Chapter 18, for more information.

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 6: Communications and All-Hazards Approach

Planning

ACTION: Collaborate with local partners to coordinate hurricane messaging.

SUMMARY: It can be helpful to collaborate with local public health department partners to coordinate hurricane messaging with clinicians and patients, such as through prompts in the healthcare organization's electronic health record, e-newsletter, and patient texting system. This approach can increase community awareness of both t he short- and long-term health risks associated with exposure to climate-related disasters (WHO, 2020).

ACTION: Use simultaneous disasters as an opportunity for education about the co-benefits of taking an all-hazards approach to resilience.

SUMMARY: Simultaneous and cascading disasters can be opportunities to educate the community, staff, and emergency management partners about the value associated with using a co-benefit approach to risk assessment, emergency planning, emergency response, and rebuilding efforts (National Academies of Sciences, 2022).

People and Operations

ACTION: Broadcast hurricane alerts using culturally appropriate language and communication pathways.

SUMMARY: Broadcasting alerts about hurricane vulnerability and protective behaviors to patients, staff,

Climate Resilience Actions, continued

and community partners using culturally appropriate language and communication pathways can help amplify the local public health department and office of emergency management's communication efforts (Hasan et al., 2021; O'Neill et al., 2009).

ACTION: Establish two-way communication systems with at-risk patient populations.

SUMMARY: Implementing two-way communication systems, like Reverse 911 and wireless emergency alerts (National Academies of Sciences, 2018), can aid in connecting sensitive populations with protective measures before a hurricane occurs, and direct them to community services during the event. With the assistance of community groups and local health departments, designated community leaders can deliver culturally sensitive messages. These messages would inform residents about safeguarding themselves and their neighbors and provide guidance on actions to take if they experience health harms (Steinberg & Sprigg, 2016; Toner et al., 2017).

Climate Resilience for Health Care:

Thunderstorms and Tornadoes

CR4HC

Impact of Thunderstorms and Tornadoes on Healthcare Organizations

The effects of climate change on the incidence and severity of thunderstorms and tornadoes are complex and still being studied. Warmer air holds more moisture, which leads to more intense precipitation events. In addition, a modeling study estimated that the frequency of lightning strikes in the contiguous United States will increase by about 12% of every degree the average global air temperature rises. The model looked at the effects of increasing global temperatures on precipitation rates and the energy available to make air rise in the atmosphere (Romps et al., 2014).

Like hurricanes and coastal storms, thunderstorms and tornadoes can damage buildings and other critical infrastructure, disrupt communication and power, compromise water quality, and lead to evacuations of healthcare facilities. High winds, lightning strikes, and flooding can cause acute injury and death. The aftermath of storms can include waterborne illness, flood-related damage and mold, and mental health conditions in affected communities. Further, power disruptions can affect community health, especially for those who rely on refrigerated medications or electricity-dependent durable medical equipment (DME). A surge in demand for healthcare services for acute injury and longer-term health harms from severe thunderstorms and tornadoes can stress healthcare organizations, which can also experience direct damage to infrastructure and operations. For example, tornadoes in late April 2024 injured over 100 people in Oklahoma and caused a rural hospital to close due to storm damage (Taylor, 2024).

Healthcare supply chains can also be disrupted by severe storms. In July 2023, a tornado in North Carolina damaged a Pfizer factory that manufactures critical medications used across the country. This caused anxiety about medication shortages and raised concerns that health systems might contribute to shortages by increasing their short-term purchases and stockpiling supplies (Lupkin, 2023).

These concurrent challenges during an acute storm event and its aftermath can collectively stress healthcare delivery, facility operations, and community health.

Important Considerations

Health Effects of Thunderstorms and Tornadoes: Drowning, injury, infectious disease, mental health effects

Populations at Risk: Children, older adults (especially those who live alone), people who rely on electricity-dependent DME, people with disabilities, low-income populations, minority and marginalized populations, people without access to a personal vehicle

Risks to Facility Operations: Supply chain disruption, patient surge, staff shortage, evacuation risk

Infrastructure Risk: Damage to building infrastructure, rolling blackouts/power loss, low water pressure, boil water notice, disruption to transportation systems

Elements of a Climate-Resilient Healthcare Organization: Thunderstorms and Tornadoes

The following six elements characterize a storm-resilient healthcare organization. Review each element section to explore it in more detail.

1. Prospective Risk Assessment

While the relationship between climate change and the intensity of rain events is clear, its relationship with thunderstorms and tornadoes is less certain. Thunderstorms are becoming more frequent and longer-lasting in the age of climate change. Tornado outbreaks are increasing in frequency, and tornado power is increasing. The level of tornado activity is increasing in the fall and shifting eastwards from the region traditionally called "Tornado Alley." These changing conditions are exposing healthcare organizations unaccustomed to tornadoes and intense thunderstorms to new and compound extreme weather events (Su et al., 2023). Supercells, intense thunderstorms defined by rotating updrafts, are responsible for most deadly tornadoes. Likely changes to the geographic and temporal incidence of severe storms and tornadoes suggest that healthcare organizations must plan for resilience to future storms, even if historically they have not had frequent experiences with these events.

Given the changing exposures to severe storms and tornadoes, healthcare organizations can increase resilience by including climate model trend lines in their short-, medium-, and long-term risk assessments.

2. Health Equity and Community Engagement

Severe thunderstorms and tornadoes can disproportionately threaten the health of at-risk populations, such as people with disabilities, people who rely on DME, older adults living alone, low-income communities, and others. Seeking community input helps to ensure that healthcare organizations specifically protect the health of at-risk populations in their preparedness and response to severe storms. Healthcare organizations should collaborate with community partners and synchronize their thunderstorm and tornado emergency planning protocols with their local office of emergency management. This enhances cross-organizational coordination during response operations and ensures minimal disruption to critical supplies and services during storm events.

3. Assessment and Remediation of Vulnerabilities in Infrastructure and Operations

High winds from thunderstorms and tornadoes can damage healthcare buildings directly, and send large debris flying. Wind from convective storms and tornadoes, unlike typical straight-line wind, moves at high speed close to the ground and changes direction rapidly. Wind near the center of a tornado blows upward, and fast-moving wind over a building can decrease the air pressure and create a strong upward force above a roof.

Building codes identify many types of healthcare facilities as critical infrastructure, requiring modern facilities to include measures that confer protection from flooding and high winds. Climate-resilient healthcare organizations can add to these baseline code requirements by planning for the possibility of more frequent and severe future storm events and greater risks for power grid and water utility disruptions. In addition, planning for patient surge, supporting staff and their families, enhancing water efficiency, and evaluating and improving supply chain resilience can all improve healthcare organizations' operating effectiveness during severe storm events.

Building design features that decrease healthcare organizations' contribution to climate change by decreasing greenhouse gas emissions, such as energy efficiency and renewable energy investments, can also confer increased resilience to severe storms and tornadoes.

4. Collaboration Between Healthcare Organizations

When one healthcare organization's operation is disrupted by a severe storm or tornado, other organizations in the region may experience a surge in patients needing to seek care elsewhere. Sharing information and resources across the full range of regional healthcare providers during severe storm events can increase the resilience of the regional healthcare system and ensure that patients retain timely and seamless access to essential care.

5. Interdisciplinary Planning, Oversight, and Evaluation

Severe thunderstorms and tornadoes can affect various critical dependencies within healthcare organizations, such as administration, information technology, electricity, natural gas, water, wastewater and waste disposal, communications, transportation, and critical products. Healthcare organizations are encouraged to align facility operations, procurement, and capital expenditures with climate change mitigation and resilience goals.

6. Communications and All-Hazards Approach

Thunderstorms and tornadoes often occur simultaneously or in quick succession with other climate change-related hazards, such as flooding and extreme heat. Multi-hazard events increase the risk of multiple system failures at the community scale, such as disruptions to the water and power utilities. As a result, population health can be directly or indirectly harmed. Repeated patient surges and cascading infrastructure failures, both in the community and within healthcare facilities, can temporarily disrupt the entire healthcare system in a region. Fortunately, many policy, infrastructure, and communication interventions can increase organizational resilience to more than one climate-related hazard. This is particularly true if emergency management and climate resilience planners use an all-hazards approach to designing, implementing, and testing proposed interventions.

Resilience Strategies:

Thunderstorms and Tornadoes

CR4HC

Element 1. Prospective Risk Assessment

While the relationship between climate change and the intensity of rain events is clear, its relationship with thunderstorms and tornadoes is less certain. Thunderstorms are becoming more frequent and longer-lasting in the age of climate change. Tornado outbreaks are increasing in frequency, and tornado power is increasing. The level of tornado activity is increasing in the fall and shifting eastwards from the region traditionally called "Tornado Alley." These changing conditions are exposing healthcare organizations unaccustomed to tornadoes and intense thunderstorms to new and compound extreme weather events (Su et al., 2023). Supercells, intense thunderstorms defined by rotating updrafts, are responsible for most deadly tornadoes. Supercells are projected to become more frequent in regions of the eastern United States and to occur outside of the traditional severe storm season, becoming more likely in late winter and early spring (Ashley et al., 2023). Likely changes to the geographic and temporal incidence of severe storms and tornadoes suggest that healthcare organizations must plan for resilience to future storms, even if historically they have not had frequent experiences with these events.

Given the changing exposures to severe storms and tornadoes, healthcare organizations can increase resilience by including climate model trend lines in their short-, medium-, and long-term risk assessments. For example, after the city of Greensburg, Kansas, experienced an EF-5 tornado in 2007, Kiowa County Memorial, the local critical access hospital, worked with community partners to future-proof their replacement hospital with a structure that could withstand more frequent and higher-powered thunderstorms and tornadoes. The new facility, which is designed to continue operations even if the local power and water systems are disrupted, runs on 100% renewable energy (including an on-site wind turbine), uses captured rainwater to flush toilets, and connects to a newly dug well that serves as a secondary water source (U.S. Climate Resilience Toolkit, n.d.c.).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 1: Prospective Risk Assessment

Planning

ACTION: **Add a prospective risk assessment and impact forecasting to the local severe storm mitigation plan.**

SUMMARY: It can be helpful to work with public health and local emergency management partners to add a prospective risk assessment and impact forecasting to the local tornado and severe storm warning system and hazard mitigation plan (Hess et al., 2017).

ACTION: **Add projected precipitation and flooding measures to severe storm and tornado risk assessments.**

SUMMARY: Consider adding one or more of the projected precipitation, flooding, and tornado measures from the CDC's National Environmental Public Health Tracking Network data portal to your organization's risk assessment (Hess et al., 2017).

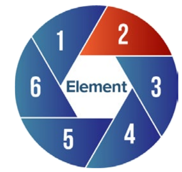
ACTION: **Consider both historical trends and climate projections to estimate the healthcare organization's long-term risk of severe thunderstorms and tornadoes.**

SUMMARY: Healthcare facilities in regions at risk of increasingly severe thunderstorms and tornadoes can

Climate Resilience Actions, continued

increase resilience by preparing for more intense rain and wind events, longer-term power outages, and the possibility that critical infrastructure – including, but not limited to, power, water, fire, and even brick and mortar – may be damaged beyond repair. For example, after an EF-5 tornado hit Joplin, Missouri, in 2011, the replacement hospital, Mercy Hospital Joplin, hardened its structure and exterior envelope and installed redundant communications systems, fiber optic networks, a second set of backup lighting, and connected to the hospital through an underground tunnel, a self-contained central utility plant that includes two power systems and an emergency generator with the capacity to function independently for 96 hours (Burmahl, 2020).

Element 2. Health Equity and Community Engagement



Severe thunderstorms and tornadoes can disproportionately threaten the health of at-risk populations, such as people with disabilities, people who rely on electricity-dependent durable medical equipment (DME), older adults living alone, low-income communities, and others. Seeking community input helps to ensure that healthcare organizations specifically protect the health of at-risk populations in their preparedness and response to severe storms. For example, in response to increasing storms and resulting flood damages, Harris County, Texas, established a Community Flood Resilience Task Force (CFRTF) composed of community members, local government, and technical experts. The CFRTF serves in an advisory capacity to inform Harris County's flood resilience plan, which includes measures to prioritize protection of vulnerable communities and to address past inequities (Harris County Community Flood Resilience Task Force, 2024). Healthcare organizations should collaborate with community partners and synchronize their thunderstorm and tornado emergency planning protocols with their local office of emergency management. This enhances cross-organizational coordination during response operations and ensures minimal disruption to critical supplies and services during storm events.

The following sub-elements describe specific ways in which a healthcare organization can integrate health equity and community engagement into their storm resilience planning.

2.1. Community Input: Frameworks like social determinants of health and vulnerability assessments can help identify populations in a healthcare organization's catchment area who may be at higher risk of negative health outcomes from severe storms (U.S. HHS, n.d.). Community input is vital for refining public messaging, validating assessments, and clarifying which services, either on campus or in the community, increase the likelihood of protecting the health of community members at the highest risk of storm-related health harms.

2.2. Community Infrastructure: Thunderstorms and tornadoes can cause significant damage to facilities and critical infrastructure, affecting communication, electrical power, and overall community operations. Tornadoes and high winds can uproot objects, leave debris, and damage utilities, which can lead to poor sanitation and increased disease spread. A small percentage of debris contains constituents of potential concern (e.g., lead, mercury) that can harm human health if improperly managed (EPA et al., 2019). Additionally, thunderstorms and tornadoes can damage transportation infrastructure, disrupting access to healthcare facilities, other essential services, and egress routes. Enhancing infrastructure resilience and preparedness can mitigate the impacts of severe storms on community and healthcare services.

Healthcare organizations can serve as trusted access points for patients and community members affected by disrupted community infrastructure.

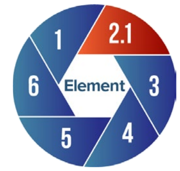
2.3. Community Services: Partnering before a severe storm event with community organizations to mitigate risk factors (such as housing or utility insecurity), coordinating outreach efforts to locate and evacuate at-risk individuals from high-risk flood zones, and providing essential community-based services (such as emergency power and food distribution) during and after a storm can increase a healthcare organization's resilience by reducing the surge in demand for healthcare services. In addition, individuals who rely on electricity-dependent DME or who take medications requiring refrigeration, such as insulin, may turn to healthcare facilities during power outages for help.

2.4. Coordination with Local Office of Emergency Management: Synchronizing healthcare organizations' emergency plans for severe storms and tornadoes with peer organization plans, the local office of emergency management, and the local utilities can result in a more efficient and effective coordinated response during and after thunderstorms and tornadoes. Synchronization helps identify current gaps and redundancies that, if addressed, could increase the responders' effectiveness during an emergency. This collaboration also supports the development of personal relationships across organizations and agencies – an important factor during an emergency response.

Resilience Strategies:

Thunderstorms and Tornadoes

Element 2.1 Community Input



Frameworks like social determinants of health and vulnerability assessments can help identify populations in a healthcare organization's catchment area who may be at higher risk of negative health outcomes from severe storms (U.S. HHS, n.d.). Community input is vital for refining public messaging, validating assessments, and clarifying which services, either on campus or in the community, increase the likelihood of protecting the health of community members at the highest risk of storm-related health harms.

For example, Missouri's Christian County Mitigation Planning Team worked with trusted community partners, such as schools and faith-based leaders, to obtain public feedback about both self-perceived flooding risks and support for potential risk-mitigating solutions (FEMA, 2024 b.). This team of local mitigation planners invested time in building these community partnerships and leveraged these partnerships to understand the best way to communicate with diverse community members. These lessons can inform healthcare organizations' approaches to community engagement.

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:

Element 2.1: Community Input

Planning

ACTION: Map patient populations who are sensitive to storms and flooding.

SUMMARY: Collaborating with community partners to map patient populations who are at high risk of negative health outcomes after severe storms and flooding can increase organizational and community resilience by ensuring that tailored protocols will support their healthcare access and needs during these emergencies (Patel et al., 2022).

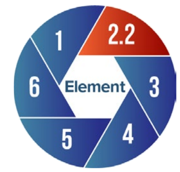
ACTION: Use the JEDI framework to structure community input.

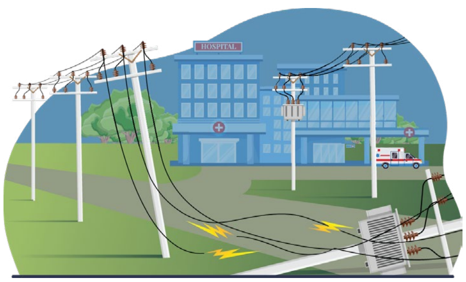
SUMMARY: Consider following the Justice, Equity, Diversity, and Inclusion (JEDI) framework to integrate community input into the development and operation of the healthcare organization's climate resilience plan (American Public Health Association & CDC, 2021).

Office of Climate Change and Health Equity

Resilience Strategies:
Thunderstorms and Tornadoes

Element 2.2 Community Infrastructure





Thunderstorms and tornadoes can cause significant damage to facilities and critical infrastructure, affecting communication, electrical power, and overall community operations. Tornadoes and high winds can uproot objects, leave debris, and damage utilities, which can lead to poor sanitation and increased disease spread. A small percentage of debris contains constituents of potential concern (e.g., lead, mercury) that can harm human health if improperly managed (EPA et al., 2019). Additionally, thunderstorms and tornadoes can damage transportation infrastructure, disrupting access to healthcare facilities, other essential services, and egress routes. Enhancing infrastructure resilience and preparedness can mitigate the impacts of severe storms on community and healthcare services.

Healthcare facilities can serve as trusted access points for patients and community members affected by disrupted community infrastructure. For example, during prolonged power outages in northeast Ohio following severe storms in August 2024, two Cleveland health centers offered emergency device charging, access to Wi-Fi, and air conditioning (Morita & Sackor, 2024).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
[Element 2.2: Community Infrastructure]

People and Operations

ACTION: Support and direct patients to local programs that increase adaptive capacity in the home environment.

SUMMARY: Connect low-income residents and other high-risk groups (like those over age 65 and those with chronic illness) with programs that can help them prepare for and recover from thunderstorms and tornadoes (Patel et al., 2022). Examples include free or subsidized shutters, storm door reinforcement programs, elevation assistance for flood-prone homes, access to emergency supply kits, provisions for backup generators or charged batteries for medical equipment, and emergency preparedness workshops.

Physical Infrastructure

ACTION: Catalyze the development of resilient infrastructure at the neighborhood and community level.

SUMMARY: As anchor institutions, healthcare campuses and public health institutions can catalyze neighborhood- and community-scale efforts to increase resilience against storms and flooding. Examples include supporting multiple modes of transportation that can double as evacuation routes, green infrastructure, neighborhood microgrids, and neighborhood water retention and treatment systems (Pastor & Morello-Frosch, 2014; Hacke & Deane, 2017).

ACTION: Enhance community resilience by remediating contaminated sites for healthcare installations.

SUMMARY: Strategically placing healthcare facilities on sites in need of environmental remediation (such as brownfields) can accelerate the cleanup process, thereby reducing the risk of community exposure to toxin-laden dust and floodwaters after storm events (Ballogg, 2015; ATSDR, n.d.).

ACTION: Work with local and regional partners to lower barriers to travel for patients and staff during storms and flooding events.

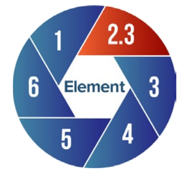
SUMMARY: Transportation infrastructure failures can prevent staff from reporting to work and patients

Climate Resilience Actions, continued

from traveling to healthcare facilities to receive needed care during storms and flooding events. Healthcare organizations can support regional climate change resilience by working with local and regional partners to lower barriers to travel (WHO, 2020). For example, limited public transit service could be offered to patients and essential workers, and medical workers could be granted priority access to gas stations (U.S. HHS, 2014).

Resilience Strategies: Thunderstorms and Tornadoes

Element 2.3 Community Services



Partnering before a severe storm event with community organizations to mitigate risk factors (such as housing or utility insecurity), coordinating outreach efforts to locate and evacuate at-risk individuals from high-risk flood zones, and providing essential community-based services (such as emergency power and food distribution) during and after a storm can increase healthcare organization resilience by reducing the surge in demand for healthcare services. For example, following Hurricane Francine in September 2024, DePaul Community Health Centers collaborated with a local food bank to host a free food pantry in New Orleans (Gambit, n.d.). In addition, individuals who rely on electricity-dependent durable medical equipment or who take medications requiring refrigeration, such as insulin, may turn to healthcare facilities during power outages for help.

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
[Element 2.3: Community Services](#)

Planning

ACTION: Consider preemptive planning for patients who use electricity-dependent DME.

SUMMARY: Proactively help patients who rely on electricity-dependent durable medical equipment (DME) to ensure that they have a backup power source or other contingency plan in the event of power shutoffs during a storm (Pacific ADA Center, 2017).

ACTION: Partner with local EMS providers to convey guidance to patients in the community about ways to increase their resilience to severe storm events.

SUMMARY: Coordinate with Emergency Medical Services (EMS) providers to identify high-risk patients during thunderstorm and tornado events. This may involve gathering information about floodplain locations and building characteristics to identify neighborhoods that are more prone to flooding and/or wind damage. Help EMS identify patients who require evacuation or who rely on critical medical equipment that may be compromised during a severe storm (e.g., electricity-dependent DME users). Provide resources to support patients who could remain at home rather than travel to healthcare facilities for treatment (O'Meara et al., 2016).

People and Operations

ACTION: Coordinate with community partners to create a multi-sector protocol for the delivery of mental health services during and after severe storms.

SUMMARY: The mental health impact of severe thunderstorms and tornadoes can be significant. Healthcare organizations can help increase community resilience by supporting crisis response planning among community partners in the public and private sectors that provide mental health care for survivors of natural disasters (WHO, 2020).

ACTION: Fill gaps in local services to increase resilience, such as acting as a place of refuge during severe storms.

SUMMARY: Healthcare facilities equipped to continue operations during power outages can enhance local resilience by offering their facilities as refuges for community members during thunderstorm and tornado events (Johns & Rosenthal, 2024; Toner et al., 2017). It is important to formalize this role with the Office of Emergency Management ahead of the event so that the facility receives extra fuel, supplies, and staff to manage nonmedical emergency services (U.S. HHS, 2014).

Climate Resilience Actions, continued

ACTION: **Integrate community resilience needs into healthcare organization emergency management plans.**

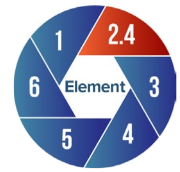
SUMMARY: Include provisions in the healthcare organization's severe storm emergency plan to accommodate community members who may seek to use the facility as a refuge and patients who require access to electrical power to charge their medical devices and/or refrigeration for their medications. Consider creating a registry of patients who need this kind of assistance and setting up a two-way communications protocol (such as a Reverse 911 or wireless emergency alert system [National Academies of Sciences, 2018]) to contact them in the event of a power disruption or outage (Patel et al., 2022).

Physical Infrastructure

ACTION: **Provide community members with post-disaster safety information for their homes.**

SUMMARY: After floods and storms, healthcare organizations can share information with community members about how to inspect their homes for flood damage, remove waterlogged and contaminated building materials, reduce the risk of mold growth, and find funding opportunities to support demolition and rebuilding efforts (CDC, 2019 a.).

Element 2.4 Coordination with Local Office of Emergency Management



Synchronizing healthcare organizations' emergency plans for severe storms and tornadoes with peer organization plans, the local office of emergency management, and the local utilities can result in a more efficient and effective coordinated response during and after thunderstorms and tornadoes. Synchronization helps identify current gaps and redundancies that, if addressed, could increase the responders' effectiveness during an emergency. This collaboration also supports the development of personal relationships across organizations and agencies – an important factor during an emergency response.

For example, following tornadoes in Western Kentucky in December 2021, strong relationships between area healthcare organizations and emergency responders were forged to facilitate coordinated responses to extreme storms. Jackson Purchase Medical Center in Mayfield, Kentucky, collaborated with the Mayfield fire chief to safely dispatch medical personnel to injured community members who sought refuge in the fire station (Rural Health Information Hub, n.d.b.).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
[Element 2.4: Coordination with Local Office of Emergency Management]

Planning

ACTION: **Add local and regional climate change vulnerability assessments to the healthcare organization's emergency preparedness plan.**

SUMMARY: Consider adding local and regional climate change vulnerability assessments to the healthcare organization's emergency preparedness plan to integrate projections of how the region's exposure to storms and flooding events may change in coming decades compared with historical trends (Marinucci et al., 2014).

ACTION: **Collaborate with local partners to coordinate storm and flood-event messaging.**

SUMMARY: It can be helpful to collaborate with local public health department partners to coordinate severe storm-related messaging with clinicians and patients, such as through prompts in the healthcare organization's electronic health record, e-newsletter, and patient texting system. This approach can increase community awareness of both the short- and long-term health risks associated with exposure to storms and flooding (WHO, 2020)

ACTION: **Formalize cooperation agreements with utility providers (both power and water) to ensure that the healthcare organization's facilities are integrated into local emergency management and climate resilience planning efforts.**

SUMMARY: Critical facilities, hospitals, and other healthcare building types should be fully integrated into local utilities' emergency management and climate resilience planning efforts. It is particularly important to include facility power and water needs in emergency preparedness and climate resilience planning efforts to ensure that they can continue to provide care during and after severe storms and tornadoes (McCabe et al., 2023; Van der Heijden, 2022).

ACTION: **Integrate legal preparedness into the healthcare organization's emergency management and climate action plans.**

SUMMARY: Uncertainty about who has the legal authority to authorize difficult decisions during disasters can slow a healthcare organization's ability to pivot from normal operations to respond to a disaster. Healthcare

Climate Resilience Actions, continued

organizations can enhance the resilience of their emergency management and climate action plans by (1) including parameters that clarify the conditions in which a facility may share information outside of the healthcare organization and administrators may order facility evacuations, (2) clarifying how personnel will reconcile protocol discrepancies (such as different evacuation protocols for healthcare organizations compared with Emergency Medical Services, and (3) authorizing clinical staff from outside organizations to practice in the healthcare facility. These plans may also include a decision framework for deciding how to allocate scarce resources during utility outages (U.S. HHS, 2014; Toner et al., 2017; VanDevanter et al., 2014).

People and Operations

ACTION: Coordinate storm- and flood-related syndromic surveillance with the local office of emergency management and the local weather station.

SUMMARY: It can be helpful to add storm- and flood-related illnesses to the healthcare organization's syndromic surveillance reports during and immediately following designated emergencies. Aligning the organization's protocol for collecting relevant diagnostic data with the local office of emergency management's and weather station's protocols for declaring a climate-related emergency will help ensure that the organizational climate resilience action plan deploys in coordination with local alerts (Hess et al., 2023).

ACTION: Leverage healthcare facilities as intervention sites for local hazard action plans.

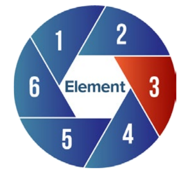
SUMMARY: Healthcare organizations often offer their locations as community intervention sites for the local hazard action plan. For example, allowing the Office of Emergency Management to use strategically located hospitals, medical office buildings, and clinics as distribution sites for water bottles, food, etc., can increase community access to health-promoting supplies. Officially designating publicly available spaces in healthcare facilities – such as the cafeteria – as resilience hubs or temporary shelters during and following severe storms can help support patients and family members as well as raise awareness in the community that climate-related events are public health emergencies (Hess et al., 2023; IOM, 2012).

Resilience Strategies:

Thunderstorms and Tornadoes

CR4HC

Element 3. Assessment and Remediation of Vulnerabilities in Infrastructure and Operations



High winds from thunderstorms and tornadoes can damage healthcare buildings directly and send large debris flying. Wind from convective storms and tornadoes, unlike typical straight-line wind, moves at high speed close to the ground and changes direction rapidly. Wind near the center of a tornado blows upward, and fast-moving wind over a building can decrease the air pressure and create a strong upward force above a roof. The 2024 version of the International Building Code, which is widely used to inform local code requirements, was updated to include a section on tornado resilience for the first time (NIST, 2024).

Building codes identify many types of healthcare facilities as critical infrastructure, requiring modern facilities to include measures that confer protection from flooding and high winds. Climate-resilient healthcare organizations can add to these baseline code requirements by planning for the possibility of more frequent and severe future storm events and greater risks for power grid and water utility disruptions. In addition, planning for patient surge, supporting staff and their families, enhancing water efficiency, and evaluating and improving supply chain resilience can all improve healthcare organizations' operating effectiveness during severe storm events.

Building design features that decrease healthcare organizations' contribution to climate change by decreasing greenhouse gas emissions, such as energy efficiency and renewable energy investments, can also confer increased resilience to severe storms and tornadoes. For example, solar microgrids with battery storage decrease healthcare organizations' reliance on electricity generated from fossil fuels, decrease operating costs, and allow continued operations when there are power grid disruptions and barriers to accessing fuel for diesel generators. A modeling study of a solar microgrid and battery installation in a California hospital found that estimating the dollar value of avoided disruptions from power outages resulted in an increase of up to 80% in the net present value of the microgrid installation compared to valuing decreased operating costs alone (Hervás-Zaragoza et al., 2022).

The following sub-elements describe specific ways in which a healthcare organization can integrate health equity and community engagement into its storm resilience planning.

3.1. Staff Support: Healthcare organizations depend on clinicians, administrators, and facilities and operations staff to deliver care. Staff and their families are impacted by the same severe storms as the facilities in which they work. When a severe storm is forecasted, emergency plans can include information for staff about safe sheltering, emergency provisions, and water and transportation safety. Integrating protections and accommodations for staff into the emergency plan can help alleviate logistical difficulties associated with commuting to and from the facility as well as mental preoccupation about the safety of loved ones who remain at home.

3.2. Clinical Considerations: Severe storms and tornadoes can cause direct traumatic injury as well as longer-term health consequences related to flooding, compromised housing, and power outages. Thunderstorms are associated with increased emergency department visits for respiratory conditions, especially when there is a concurrent power outage. In addition, exposure to tornadoes is associated with mental and behavioral health effects, both immediately following and years after an event.

3.3. Building and Campus: Design & Construction: Facilities in areas of thunderstorms and tornadoes, especially with concomitant risks of surge flooding and extreme winds, can be prone to infrastructure damage. Building codes require structural redundancies that harden buildings against potential environmental hazards. Resilient healthcare facilities are designed to minimize the risk of floods or wind-related failures to the building structure, materials, and systems. Many of the same design features also reduce facility greenhouse gas emissions, as do water-saving design features that also reduce energy use.

3.4. Building and Campus: Facility Operations: Healthcare buildings rely on electricity, plumbing, and natural gas for critical operations. The loss of power during thunderstorms and tornadoes can disrupt needed power sources, cause internal temperatures to rise or fall to dangerous levels, interfere with air quality, and strain water supplies. Implementing strategies to maintain essential services during thunderstorms and tornadoes can mitigate the impact on healthcare facility operations. Connecting HVAC systems to backup power supplies can help maintain stable internal temperatures during power outages. Without a backup power supply, disrupted electricity supply during thunderstorms and tornadoes could cause the facility ventilation to function without access to heating or cooling systems, which could lead to dysregulated internal temperatures (FEMA & ASPR, 2019). Additionally, if the ventilation system in a healthcare facility doesn't work without power, levels of pollutants in the indoor air, particularly carbon monoxide, could increase (EPA, 2021). Developing resilience plans to ensure a safe water supply, maintain comfortable indoor temperatures, keep air healthy, and secure energy resources is essential to ensuring continuous patient care and safety (FEMA & ASPR, 2019).

3.5. Supply Chain: Thunderstorms and tornadoes can significantly disrupt a healthcare organization's supply chain in both clinical and nonclinical areas. Developing alternative methods and contingency plans can help maintain supply chain integrity during storms. Managing a refrigerated supply chain and on-site storage during regional power outages is a key consideration for the resilience of healthcare facilities. Transportation may also be impacted due to flooding and debris, inhibiting delivery of critical medications and supplies (National Academies of Sciences et al., 2020; Lawrence et al., 2020). Healthcare organizations can develop strategies and contingency plans to manage refrigerated supply chains, ensure adequate stock of critical supplies, and maintain reliable transportation routes to support continuous operations during thunderstorms and tornadoes.

Resilience Strategies:

Thunderstorms and Tornadoes

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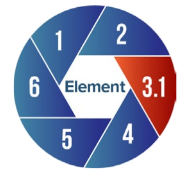
Element 3.1 Staff Support



Healthcare organizations depend on clinicians, administrators, and facilities and operations staff to deliver care. Staff and their families are impacted by the same severe storms as the facilities in which they work. When a severe storm is forecasted, emergency plans can include information for staff about safe sheltering, emergency provisions, and water and transportation safety. Integrating protections and accommodations for staff into the emergency plan can help alleviate logistical difficulties associated with commuting to and from the facility as well as mental preoccupation about the safety of loved ones who remain at home.

A survey of healthcare workers two years after the 2011 Joplin, Missouri, tornado found that staff were more willing to report to work the week after the event if their house had not been destroyed, the hospital where they worked had not been damaged, attendance at work would not impact their childcare responsibilities, and their employment status was full-time. The survey further found that providing alternative childcare through the healthcare organization would increase the willingness of staff with family caregiving responsibilities to report to work following a future disaster (Charney et al., 2014).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 3.1: Staff Support

Planning

ACTION: Set staff expectations for their role during severe storms.

SUMMARY: Clearly define expectations with healthcare facility staff related to working during and after severe storms – particularly under circumstances that lead to power disruptions or outages and require staff to remain at work for extended periods. Share with staff a list of personal items that they should bring with them to an anticipated multiday response effort, such as food, water, personal medication, hand sanitizer, extra clothes, and sleeping gear. Co-create policies and programs with staff to establish a flexible and supportive approach to staffing, accommodations, and transportation during and after severe storms. For example, during emergency operations, it may be necessary to shorten staff shifts to give them the ability to rest mentally and physically. Emergency plans may need to include daycare, shelter, and other accommodations for staff family members, as needed (Danna et al., 2010; Toner et al., 2017; WHO, 2020).

ACTION: Train clinical staff in alternative procedures for delivering care during severe storms.

SUMMARY: Healthcare organizations can support staff in preparing for storm and tornado responses by offering training in alternative intake and triage procedures for inpatients who transfer from other facilities without their medical records. Additional alternative procedure training, such as manually counting intravenous pump drips, manually suctioning intubated patients, and manually taking blood pressure readings, can prepare staff for delivering care in situations with limited access to electricity and water (U.S. HHS, 2014).

People and Operations

ACTION: During transportation disruptions, coordinate across the healthcare system to redistribute staff to facilities they can access – even if staff need to go outside their "home" facility.

SUMMARY: Immediately following events that damage infrastructure – such as severe storms and floods – it

Climate Resilience Actions, continued

may be necessary to temporarily redistribute the healthcare system's staff to facilities they can access (Morris et al., 2016). Establish a tracking system so that staff can report to supervisors who are physically located in different facilities (Wyte-Lake et al., 2018). Cross-training staff to fulfill multiple roles can benefit the overall healthcare system by ensuring that essential clinical services are offered by a mixture of permanent and temporary staff (Hilton et al., 2015).

ACTION: Ensure that staff supporting a storm response have access to clothing, a place to sleep, routine medications, and wellness services.

SUMMARY: Given the often-rapid evolution of thunderstorms and tornadoes and their impacts on community infrastructure, staff may be required to stay at their place of work for more than 24 hours without access to basic necessities, such as a change of clothes and daily medications. Healthcare organizations can increase the resilience of their clinical services by ensuring that staff have access to clothing, a place to sleep, routine medications, and wellness services while they support patients in the midst of a disaster (Evans, 2017; Hilton et al., 2015; Morris et al., 2016; Toner et al., 2017).

ACTION: Establish a culture that acknowledges the personal challenges staff are facing during a disaster.

SUMMARY: Acknowledging the personal challenges faced by staff during and after a severe storm can increase a healthcare facility's resilience by increasing the willingness of available staff to work. This acknowledgment also creates space for staff to request tangible assistance (such as a hotel room or childcare) that makes it possible for them to support the disaster response (Morris et al., 2016; Toner et al., 2017).

ACTION: Integrate regular emergency preparedness employee training into the healthcare organization's continuing education program.

SUMMARY: Increase awareness of climate change-related risks in the healthcare organization by implementing a regular emergency preparedness employee training program as well as protocols and procedures designed to enhance resilience in the face of increasingly frequent and severe storms (Hilton, 2015; WHO, 2020).

ACTION: Provide alternative transportation and housing for healthcare staff during severe storms.

SUMMARY: Consider establishing agreements with nearby transportation providers and temporary housing facilities (such as hotels) to support employees and their immediate families (including pets) in the event transportation pathways and/or utilities are disrupted by a storm or tornado. This may also involve preparing 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-storm.

SUMMARY: Creating a post-disaster employee assistance program – including mental health services – for staff and their families in the aftermath of a severe storm can help them build the long-term physical, mental, and social resilience that will be needed to respond to the next disaster (Danna et al., 2010; WHO, 2020). Immediate support for staff who have experienced a major loss (such as losing their home) can also increase their ability and willingness to return to work after the event (Morris et al., 2016).

ACTION: Provide staff with post-storm safety information for their homes.

SUMMARY: After storms and floods, healthcare organizations can share information with staff about how to inspect their homes for flood damage, remove waterlogged and contaminated building materials, reduce the risk of mold growth, and find funding opportunities to support demolition and rebuilding efforts (CDC, 2019 a.).

Physical Infrastructure

ACTION: Establish alternative communications channels for contacting staff during utility outages.

SUMMARY: Staffing during and immediately following storms that cause utility outages can be complicated by disruptions to telecommunications infrastructure. Establishing alternative communications channels (such as multiple cell phone providers, satellite phones, walkie-talkies, and a generator-powered cell tower on the roof of the facility) can increase a healthcare organization's resilience to these events by making it possible to share important information with staff – such as facility closures and requests that staff report to the facility closest to their homes (U.S. HHS, 2014; Morris et al., 2016; Wyte-Lake et al., 2018).

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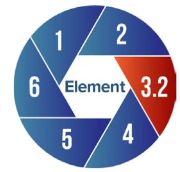
Resilience Strategies:
Thunderstorms and Tornadoes

CR4HC

Element 3.2 Clinical Considerations



Severe storms and tornadoes can cause direct traumatic injury as well as longer-term health consequences related to flooding, compromised housing, and power outages. Thunderstorms are associated with increased emergency department (ED) visits for respiratory conditions, especially when there is a concurrent power outage. In New York State, up to an approximately 40% increase in ED visits for respiratory conditions was observed during concurrent thunderstorm and power outage events, with disproportionate risk to rural and Hispanic populations, and to children and older adults (Lin et al., 2024). In addition, exposure to tornadoes is associated with mental and behavioral health effects, both immediately following and years after an event. These effects can include depression, anxiety, post-traumatic stress disorder, increased alcohol and other substance abuse, and increased interpersonal violence (Lee & First, 2022).

Temporary mobile clinics can bring care to community members if a severe storm decommissions key healthcare facilities. For example, following a tornado in rural Rolling Fork, Mississippi, in March 2024, Delta Health Center (DHC) was able to continue operations with the help of a mobile solar microgrid, providing mobile medical and behavioral health care. DHC staff including doctors, nurses, and a psychologist, rode in a van to provide home- and shelter-based care for acute injuries, chronic medical conditions, and mental health concerns (Lewis, 2023). After a nursing home, medical office building, and the only community hospital in Louisville, Mississippi, were destroyed by a combination of thunderstorms, EF-4 tornadoes, and flooding in 2014, the National Mobile Disaster Hospital (MDH) was deployed from North Carolina to Mississippi to provide care to local residents immediately after the disaster. Over the ensuing months, a temporary facility was constructed adjacent to the MDH to ensure long-term continuity of care while permanent facilities were constructed (Kearns et al., 2017).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
[Element 3.2: Clinical Considerations]

Planning

ACTION: Enhance storm preparedness by adding hazard-related illness screening to the healthcare organization's EMR.

SUMMARY: Consider including in your organization's storm resilience and preparedness plan a protocol for activating hazard-related illness screening questions in the electronic medical record (EMR) system when local authorities activate the emergency operations center to respond to a storm (Hess et al., 2023). Sensitive patient groups who might be flagged for additional screening include infants and children, pregnant women, older adults (especially those who live alone), low-income populations (particularly those who do not have the means to evacuate or live in mobile or temporary homes), and people with chronic conditions, such as cardiovascular disease and respiratory diseases.

ACTION: Enhance syndromic surveillance during severe storm and flooding events.

SUMMARY: Consider enhancing the healthcare system's syndromic surveillance during storm and flooding events by submitting hazard-related illness data to the Electronic Surveillance System for the Early Notification of Community-Based Epidemics (Burkom et al., 2021). Work with local

Climate Resilience Actions, continued

public health partners to interpret and act on real-time hazard-related illness and all-cause morbidity and mortality data during and immediately following severe storms and floods.

ACTION: Integrate epidemiological and meteorological data into storm and flooding 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 storm and flooding events (Patel et al., 2022).

People and Operations

ACTION: Adjust normal procedures and standards of care ahead of forecasted storms to expedite patient discharges, when possible, and to adjust the timing of routine treatment.

SUMMARY: Consider establishing protocols triggering an adjustment to the healthcare organization's clinical procedures (e.g., in pharmacy, drug treatment, dialysis, etc.) ahead of forecasted storms to create contingency plans that extend the amount of time existing patients can go without routine treatment. When possible, expedite inpatient discharge to free up bed space ahead of expected patient surges during and immediately following the event (Scott, 2017; Toner et al., 2017).

ACTION: Co-locate critically ill and fragile patients on the same floor of the facility as the emergency command center to maximize staff communication and patient safety.

SUMMARY: Identify the safest floors of the healthcare facility during severe storms. Consider co-locating the most critically ill and fragile patients on those floors alongside the emergency command center in order to expedite communication between leadership and staff to maximize patient safety (U.S. HHS, 2014).

ACTION: Develop a plan for patient surges and train staff in its implementation, including scenarios for accommodating cascading and simultaneous climate change-related disasters.

SUMMARY: Many climate change-related events occur simultaneously or in quick succession. For example, storms can cause flash flooding and can occur during heat waves. Therefore, it is increasingly important to develop a plan for patient surges and train staff in the plan's implementation. Include procedures for bringing in temporary staff, adapting clinician services to fast-changing conditions, and altering the schedule for routine operating procedures to free up space and staff for emergency care (Toner et al., 2017).

ACTION: If it is necessary to evacuate patients during a storm, consider sending nurses, nursing assistants, and leadership staff with them to ensure continuity of care.

SUMMARY: Hospitals that evacuated patients alongside care staff and their leadership team during Superstorm Sandy (2012) reported lower rates of anxiety about the evacuation among patients and their families (U.S. HHS, 2014).

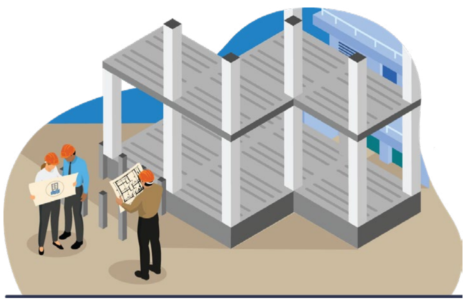
Physical Infrastructure

ACTION: Deploy mobile health units to take medical care to high-risk patients in the community during transportation disruptions.

SUMMARY: Consider including in the healthcare organization's list of emergency response assets mobile units that are used to deliver routine care to community members. Use the organization's map of high-risk patients – such as those who need dialysis or those who have substance use disorders, diabetes, and heart disease – (Element 2.1) to prioritize the provision of medical care during transportation disruptions caused by a climate change-related event (Toner et al., 2017).

Resilience Strategies:
Thunderstorms and Tornadoes

Element 3.3 Building and Campus: Design & Construction



Facilities in areas of thunderstorms and tornadoes, especially with concomitant risks of surge flooding and extreme winds, can be prone to infrastructure damage. Building codes require structural redundancies that harden buildings against potential environmental hazards. Resilient healthcare facilities are designed to minimize the risk of floods or wind-related failures to the building structure, materials, and systems. Many of the same design features also reduce facility greenhouse gas emissions, as do water-saving design features that also reduce energy use.

When Mercy Hospital in Joplin, Missouri, rebuilt following a devastating tornado strike in 2011, the design of the new facility reflected input from physicians, nurses, patients, and community members. The new hospital is hardened with windows designed to withstand 250 mph winds, fortified safe zones on every floor, and partially buried generators located at a distance from the main building (Mercy St. Louis, 2021).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 3.3: Building and Campus: Design & 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 storms.

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 and wind speed at which they will function, whether they will continue to function in flooded conditions, 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. Therefore, it is 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 installing renewable power microgrids for backup power) in order to extend the functional life of the building as long as possible within the context of 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 & Chan, 2017).

Physical Infrastructure

Structure and Landscaping

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

SUMMARY: Installing native 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

Climate Resilience Actions, continued

reduce flood risk by filtering stormwater and slowing its movement across the property (Chu et al., 2023).

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 multimodal evacuation plans when they are deployed during a climate change-related event (Basu et al., 2022).

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 at which they can generate sufficient electricity using on-site renewable power (e.g., solar, wind, geothermal). These facilities can continue to provide clinical care during disasters that disrupt regional power grids.

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

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 storms and flooding (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 to on-site power storage capacity can reduce a healthcare facility's reliance on external power sources needed to maintain continuity of care (Isa et al., 2018).

ACTION: Install energy-efficient building equipment to extend the length of time during which 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 during which the facility can function on back-up power systems (Carvallo et al., 2022).

Water Efficiency and Flood Resilience

ACTION: Install backflow prevention valves to prevent sanitary sewage from backing up into the hospital during flood events.

SUMMARY: Healthcare facilities located in communities with combined sanitary and storm sewers may experience sewage backup during extreme flood events. Facilities can enhance resilience by installing backflow prevention valves and capping drains on lower floors during flooding events (Van der Heijden, 2022; WHO, 2015).

ACTION: Install protective barriers and elevated walkways/driveways in areas at risk of flooding.

SUMMARY: Floodgates, floodwalls, and other barriers equipped with crossover stairs can support safe passage across areas on a medical campus that are projected to experience repeated flooding (U.S. HHS, 2014).

ACTION: Maximize water efficiency to reduce demand during low water pressure and boil water notice events and to reduce the burden placed on the community sanitary sewer system during disasters.

SUMMARY: Water is critical to the functioning of healthcare facilities – for both clinical and building systems. To maximize the availability of potable water for clinical uses, consider minimizing once-through use in process equipment – such as in the HVAC system, sterilizers, and medical equipment. Further, consider installing low-flow toilets, urinals, handwash stations, and showers – except where volume is needed for occupational uses (such as water filling stations and decontamination showers) (Van der Heijden, 2022; WHO, 2015).

ACTION: Protect the permanent and emergency water supply from extreme weather and contamination from floodwaters.

SUMMARY: Weatherize water supply pipes, cisterns, and tanks to prevent breakages in extreme cold weather. Place

Climate Resilience Actions, continued

emergency water storage (such as tanks and cisterns) outside of areas at risk of flooding or landslides. Install float valves and overflow outlets that drain away from the facility to avoid flooding interior spaces after a cistern or tank fills up. Install one or more supplementary water pumps (depending on need) and connect them to the emergency power supply to keep water pressure at safe levels when the power goes out (Van der Heijden, 2022; WHO, 2015).

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) coupled with 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).

Resilient Critical Operating Systems and Life Safety

ACTION: Design new buildings and reinforce existing structures to withstand future storm and tornado exposures, as described in the healthcare organization's prospective risk assessment (Element 1).

SUMMARY: Many building codes rely on historical data to set structural requirements for withstanding climate change-related hazards, like wind, flooding, fire, heat, and landslides. Thunderstorm and tornado exposures include projected wind speeds, depth and velocity of floodwaters, potential impacts from debris and ice floating in tornado storms and floodwaters, the potential for floodwaters and/or wave action to erode and scour the soil around the structure, and the duration of the thunderstorm (FEMA, 2011; PDH Star, 2018). Healthcare organizations can reduce the risk of a major disaster causing sufficien physical damage that shuts down operations by designing and renovating facilities to withstand future climate change-related exposures as described in their prospective risk assessment (Element 1) (U.S. HHS, 2014).

ACTION: Protect sensitive equipment on the top floors of the facility from rain damage.

SUMMARY: Tornadoes can cause moisture damage when they damage a facility's roof. Moisture intrusion, either during the tornado storm or afterward, can damage or destroy building and other sensitive equipment located in elevated parts of the facility. Healthcare organizations can enhance resilience to both flooding and tornadoes by protecting equipment installed at high elevations with a reinforced roofing system and/or by installing a waterproofed false ceiling between the equipment room and the roof (FEMA, 2011).

ACTION: Install vertical wind- and debris-resistant walls around exterior HVAC equipment and secure them to the roof with wind-resistant connections.

SUMMARY: The heat exchanger component of the healthcare facility's HVAC systems is usually located outside the building to avoid introducing hot air to a conditioned space. Healthcare organizations can reduce the risk that a tornado causes the HVAC system to fail by installing vertical wind- and debris-resistant walls around the equipment and attaching them to the roof using wind-resistant connections (FEMA, 2011).

ACTION: Incorporate one or more safe rooms in new facilities and perform a vulnerability assessment in existing facilities to identify and clearly label the best available refuge areas to protect occupants from exposure to a tornado.

SUMMARY: Safe rooms are designed to protect occupants from wind, flying debris, and structural collapse during tornadoes. New healthcare facilities can enhance resilience to tornadoes by incorporating one or more safe rooms large enough to accommodate the expected number of occupants in the building. Existing facilities can enhance resilience by performing a vulnerability assessment to identify and reinforce the best available refuge areas – which are often interior rooms and corridors with short-span roof systems (FEMA, 2011).

ACTION: Install wind- and impact-resistant glass on the building exterior and in interior spaces used as safe rooms or refuge areas.

SUMMARY: Exterior glass supports key goals in healthcare facility design, such as the therapeutic benefits

Climate Resilience Actions, continued

of daylight and views of nature. Interior glass reduces the noise pollution inside patient rooms and allows clinicians to check on patients without disturbing them. However, unreinforced glass can be vulnerable to tornado-force winds. Healthcare organizations can maintain the therapeutic benefits of exterior and interior glass while simultaneously enhancing the facility's resilience to tornadoes by installing or retrofitting wind- and impact-resistant glass (FEMA, 2011).

ACTION: Install redundant communication systems for use during power and communications outages.

SUMMARY: Extreme weather events can disrupt electricity supply, cell towers, radio transformers, and other community communications networks. Healthcare organizations can reduce the risk of disruption in communications to other facilities in their network, regional healthcare organizations, and local emergency management agencies by installing and maintaining redundant communication systems, such as analog phones, fax machines, handheld two-way radios, ham radios, and solar-powered devices (Hedges et al., 2018).

ACTION: Place redundant IT systems off-site to increase the resilience of EMRs.

SUMMARY: Placing redundant IT systems off-site can reduce the risk of the electronic medical record (EMR) system going offline during flood events (Danna et al., 2010; Toner et al., 2017).

ACTION: Place EMR servers and equipment in climate-controlled spaces and above the flood line.

SUMMARY: To ensure that medical information systems remain functional during power outages and flooding events, place them in storage spaces that are elevated above the risk of floodwaters, climate-controlled rooms with a dedicated energy source, and/or off campus (such as at a duplicate paper record storage site) (Swanson et al., 2010; U.S. HHS, 2014).

ACTION: Place the healthcare organization's critical infrastructure above the level of projected flood risk.

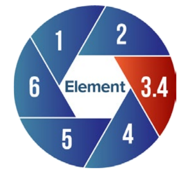
SUMMARY: Placing equipment crucial to research, education, and patient care (such as labs, medical equipment, and information technology [IT] equipment) and building systems (such as emergency generators, pumps, and electrical switches) above the level of projected flood risk can reduce the likelihood of disruptions to patient care and research resulting from facility flooding (U.S. HHS, 2014; Scott, 2017).

Resilience Strategies:

Thunderstorms and Tornadoes

CR4HC

Element 3.4 Building and Campus: Facility Operations



Healthcare buildings rely on electricity, plumbing, and natural gas for critical operations. The loss of power during thunderstorms and tornadoes can disrupt needed power sources, cause internal temperatures to rise or fall to dangerous levels, interfere with air quality, and strain water supplies. Implementing strategies to maintain essential services during thunderstorms and tornadoes can mitigate the impact on healthcare facility operations. Connecting HVAC systems to backup power supplies can help maintain stable internal temperatures during power outages. Without a backup power supply, disrupted electricity supply during thunderstorms and tornadoes could cause the facility ventilation to function without access to heating or cooling systems, which could lead to dysregulated internal temperatures (FEMA & ASPR, 2019). Additionally, if the ventilation system in a healthcare facility doesn't work without power, levels of pollutants in the indoor air, particularly carbon monoxide, could increase (EPA, 2021). Developing resilience plans to ensure a safe water supply, maintain comfortable indoor temperatures, keep air healthy, and secure energy resources is essential to ensuring continuous patient care and safety (FEMA & ASPR, 2019).

Moore Medical Center in Moore, Oklahoma, activated procedures for monitoring and responding to tornadoes starting about 1.5 hours before the facility sustained a direct hit from an EF-5 tornado in 2013. The Medical Center's Manager of Safety issued stepped-up emergency notifications roughly every 30 minutes, which gave staff time to prepare for and then move patients to interior hallways and move ambulatory patients and visitors to the cafeteria, which was designated as a "protected area." The Managers of Family Birth and Medical Surgical/Pediatrics/Progressive Care Unit exceeded the emergency protocol by moving patients to interior corridors on the ground floor. The Executive Secretary also exceeded the emergency protocol by asking physicians sheltering in the cafeteria to shelter in the walk-in refrigerator to increase their security, in case their skills were required after the event. The Medical Center also expanded the scope of its emergency protocol, designating hallways surrounding the cafeteria as locations where community members could seek shelter. While the tornado damaged the facility so severely that it was demolished, the combination of protected areas and effective emergency response protected about 300 people from serious injury or death (NIST, 2024).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 3.4: Building and Campus: Facility Operations

Planning

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 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 (such as extreme temperatures, exposure to floodwaters, etc.) reach dangerous levels (FEMA & ASPR, 2019).

ACTION: Include security considerations in the healthcare facility's emergency preparedness plan for storms and flooding events that could result in widespread damage to utilities and community infrastructure.

Climate Resilience Actions, continued

SUMMARY: Flooding and wind events that cause widespread damage to utilities and community infrastructure can result in a temporary need for increased security at a healthcare facility, particularly if the facility experiences a patient surge and/or acts as a place of respite for community members (Danna et al., 2010)

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 enhance 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: Perform a baseline analysis of water usage and categorize usage types into tiers of critical need.

SUMMARY: Water is a critical component of clinical care, including its use to sanitize medical equipment. Performing a baseline analysis of the healthcare facility's water usage and categorizing usage types into tiers of critical need can help facility managers direct potable water supply to the most important clinical needs during low water pressure and boil water notices while also reducing overall facility water usage (WHO, 2015; Van Der Heijden, 2022).

People and Operations

ACTION: Conduct regular tests of emergency generators, water supplies, and transportation plans to ensure that they are ready to deploy in the event of an emergency.

SUMMARY: It can be difficult to source fuel, water trucks, and emergency transportation contractors in the immediate run-up to a thunderstorm or tornado. Healthcare organizations can check the status of their resilience to the first 72 hours of anticipated severe storms by performing regular tests and maintenance on emergency generators and on-site sources of emergency water. It can also be helpful to perform regular drills with outside contractors who will be responsible for supplying more fuel, trucked-in water, emergency transportation for staff and patients, and other activities included in the facility's emergency operations plan (U.S. HHS, 2014).

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

SUMMARY: Consider performing regular stress tests of the healthcare facility's ability to continue providing clinical care during extreme weather events. Incorporate scenarios that involve power outages, low water pressure, a surge of patients experiencing hazard-related illness, a surge of all-cause complaints, and a surge of community members seeking to use the facility as a resilience hub and safe place to charge electrical devices (including medical equipment). Stress tests can help identify critical systems (such as vacuum suction systems and electricity-dependent durable medication delivery systems) whose failure would result in cascading effects across the facility and impact delivery of critical care (Ebi et al., 2018).

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 demands remain at levels that can be met by on-site sources, such as renewable power and recycled process water (Kolokotsa et al., 2012).

Physical Infrastructure

ACTION: Conduct regular walk-throughs of the healthcare facility to confirm compliance with fire safety and evacuation signage requirements.

SUMMARY: Facility evacuation can be impeded if exits are obstructed, signage is missing or confusing, or safety equipment, like sprinklers and fire extinguishers, is missing or broken. Conducting regular walk-throughs of the healthcare facility to confirm that these essential emergency preparedness components are in place and in working order could be seen as a first level of resilience to any climate change-related hazard that might damage the building structure or result in an eventual evacuation (U.S. HHS, 2014).

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

Climate Resilience Actions, continued

on external sources for electricity needed to maintain continuity of care (Lazo et al., 2023).

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: Prior to an anticipated flooding and/or wind event, walk through the facility to identify locations that might require repair during and immediately following the event and stage the necessary materials and equipment (including pumps) nearby.

SUMMARY: Certain locations in and around the healthcare facility are more vulnerable to damage from a flood and/or wind event, such as the roof, windows, and lower floors. Healthcare organizations can reduce the risk of disruption to clinical operations by identifying likely repair needs prior to the event and staging the relevant construction materials and equipment within easy reach. This preparation will minimize the impact of minor leaks, broken windows, and other building damage on regular facility operations (ASPR TRACIE, 2023 b.).

Element 3.5 Supply Chain

Thunderstorms and tornadoes can significantly disrupt a healthcare organization's supply chain in both clinical and nonclinical areas. Developing alternative methods and contingency plans can help maintain supply chain integrity during storms. Managing a refrigerated supply chain and on-site storage during regional power outages is a key consideration for the resilience of healthcare facilities. For example, treatments for disaster-related injuries or illness may require specific supplies that may not be available in large quantities under normal circumstances, or facilities may run out of needed supplies (ASPR TRACIE, 2024). Transportation may also be impacted due to flooding and debris, inhibiting delivery of critical medications and supplies (National Academies of Sciences et al., 2020; Lawrence et al., 2020). Healthcare organizations can develop strategies and contingency plans to manage refrigerated supply chains, ensure adequate stock of critical supplies, and maintain reliable transportation routes to support continuous operations during thunderstorms and tornadoes.

For example, following Hurricane Maria's 2018 impact on a major producer of intravenous bags in Puerto Rico, Ochsner Health in Louisiana worked with their group purchasing organization to create an essential medications list comprised of critical drugs that were vulnerable to shortages from natural disasters and other potential supply chain disruptions. They developed a protocol to predict the need for these critical medications and to enhance inventory of these drugs (Vizient, 2021).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 3.5: Supply Chain

Planning

ACTION: Integrate medical supply storage into resilience planning.

SUMMARY: Consider how your organization's prospective risk assessment of thunderstorms and tornadoes (Element 1) might lead to supply chain disruptions and/or changing needs. Maintain an adequate supply of medical supplies, particularly for products that are most vulnerable to weather-related disruptions in transportation routes (Hedges et al., 2018). Consider separating emergency supplies into two categories: (1) high-volume medical supplies (such as IV bags, sharps, and oxygen) and (2) equipment and/or supplies that would only be needed during a disaster. Establish a timeline for activating the supply chain plan ahead of the anticipated climate change-related event. Include in the timeline when a comprehensive check of both inventory types should take place and when normal deliveries should be suspended (for example, 120 hours and 12 hours ahead of an anticipated storm, respectively) (Maslanka & Hurwitz, 2022).

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).

Climate Resilience Actions, continued

People and Operations

ACTION: Require suppliers of essential goods and services to provide a continuity of operations plan for thunderstorms and tornadoes.

SUMMARY: Healthcare organizations are dependent on a large network of vendors to supply goods and services that are essential to facility operations and continuity of care. Requiring suppliers of essential goods and services to provide a continuity of operations plan is an important first step in building the healthcare organization's resilience to thunderstorms, tornadoes and other disasters that disrupt transportation infrastructure (Toner et al., 2017).

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).

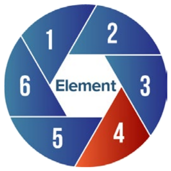
ACTION: Store essential medical supplies, food, and fuel lasting 5–7 days on or near the healthcare campus to facilitate rapid deployment ahead of extreme weather events that could disrupt supply chains and/or utility and transportation infrastructure.

SUMMARY: One of the hallmarks of climate change is the increased length of utility outages and damage to transportation infrastructure, which can lead to supply chain disruptions of a week or more. Healthcare organizations can increase their resilience to this changing landscape by stockpiling 5–7 days' worth of medical supplies, food, and fuel on or close to healthcare facility campuses (Danna et al., 2010).

Office of Climate Change and Health Equity

Resilience Strategies:
Thunderstorms and Tornadoes

Element 4. Collaboration Between Healthcare Organizations



When one healthcare organization's operation is disrupted by a severe storm or tornado, other organizations in the region may experience a surge in patients needing to seek care elsewhere. Sharing information and resources across the full range of regional healthcare providers during severe storm events can increase the resilience of the regional healthcare system and ensure that patients retain timely and seamless access to essential care. For example, a web-based tracking system in Mississippi was established to allow real-time sharing of available medical resources, including generator capacity and the availability of staffed inpatient beds. Following a deadly tornado in rural Winston, Mississippi, in 2014, Winston Medical Center was able to leverage existing relationships with healthcare coalition partners and use Mississippi's web-based available bed data to safely and efficiently evacuate its inpatients and nursing home residents (NACCHO, 2014).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 4: Collaboration Between Healthcare Organizations

Planning

ACTION: **Create plans to increase the resilience of critical outpatient care during severe storms and flooding events.**

SUMMARY: Create contingency plans in coordination with regional healthcare partners to ensure that individuals with chronic physical and/or mental health conditions – who are at high risk due to potential interruptions in medication administration or outpatient care – have access to alternative arrangements if their usual care becomes unavailable or inaccessible due to severe storms or flooding (U.S. HHS, 2014; Toner et al., 2017; WHO, 2020).

ACTION: **Enhance healthcare organization preparedness for severe storms through mutual aid MOU.**

SUMMARY: A mutual aid memorandum of understanding (MOU) with other healthcare providers in the region, which includes the results of a prospective risk assessment (Element 1), can help prepare for circumstances that require patient transfers or referrals – such as during utility outages, patient surges, etc. Pay particular attention to current gaps in preparedness for climate-related events that are projected to increase in frequency and/or severity in the region. It is important to address legal and reimbursement challenges that can limit a facility's ability to quickly and efficiently transfer patients and/or supplies to other facilities in the region. Consider working with other healthcare organizations to fill in those gaps over time using an all-hazards approach (U.S. HHS, 2014; Patel et al., 2022).

ACTION: **Exchange epidemiological data and health assessments related to severe storms and flooding with other healthcare organizations and the local health department.**

SUMMARY: Exchanging epidemiological data and health assessments related to severe storms and flooding with other healthcare organizations and the local health department can support regional climate resilience planning efforts. Use these conversations to jointly develop protocols for identifying emerging climate-related health threats in the region, collecting and disseminating data, and coordinating emergency response across the range of facility types in the regional health system – including acute care hospitals, community clinics, and long-term care facilities (Patel et al., 2022).

Climate Resilience Actions, continued

ACTION: Integrate an analysis of cross-institutional collaboration in regional after-action reviews of severe storms.

SUMMARY: As part of an all-hazards emergency management plan, include an after-action analysis of interdisciplinary coordination within the organization, with other regional healthcare organizations, and with the local office of emergency management. This analysis should assess how well the emergency response system functioned as a whole. Consider including prospective climate metrics (Element 1) as one indicator of the system's resilience to future events (Davies et al., 2019; Parker, 2020).

ACTION: Perform joint disaster preparedness exercises and drills with other local healthcare organizations, the local health department, and the local office of emergency management.

SUMMARY: Joint disaster preparedness exercises and drills can help healthcare organizations test their readiness for severe storms and tornadoes (and simultaneous and cascading events), identify areas for improvement in emergency response plans, and build working relationships with other first responders. Including representation from multiple institutions and professions in the exercise can also help identify emerging at-risk populations who are projected in climate models to require more protection and/or resources as the (geographic and temporal) incidence and severity of storms and flooding evolve (ASPR, 2024; WHO, 2020).

ACTION: Work with other regional healthcare organizations to develop integrated patient evacuation plans.

SUMMARY: Healthcare organizations can increase their own and regional resilience by working together to develop integrated emergency evacuation plans. Consider including contingency plans that would address damage to a facility's structure, exposure to contaminated air, water damage, power and water outages, destruction of electronic medical records, infrastructure failures, and an ambulance shortage. Contingency plans may involve transferring patients to alternate facilities or establishing temporary medical sites in safer areas (U.S. HHS, 2014; Patel et al., 2022).

People and Operations

ACTION: Collaborate with regional healthcare organizations on public health education and outreach programs.

SUMMARY: Healthcare institutions can collaboratively develop and disseminate public health education and outreach programs so that the community receives a consistent and coordinated message about climate-related hazards, protective behaviors, and access to resources, such as healthcare services (California Department of Public Health, 2022).

ACTION: Consider proactively credentialing neighboring healthcare facility staff to help execute the healthcare organization's emergency preparedness protocol.

SUMMARY: Proactively credentialing staff at neighboring healthcare facilities to prepare for emergencies can contribute to backup care if one facility is unable to provide care due to storm-related direct or indirect damage (WHO, 2020).

ACTION: Establish effective communication channels to share real-time information across healthcare organizations during severe storms.

SUMMARY: Consider working with other healthcare organizations and entities in the region to establish effective real-time communication channels with one another and the public during severe storms. Examples of critical information shared this way include the progression of the storm, who should evacuate, where evacuees should go, which healthcare facilities are open to receive new patients and/or community members seeking refuge, the number of beds available in the region (with consistent definitions for each bed type), and the levels of critical medical supplies needed and available for each facility in the cooperation network (CDC, 2003; California Department of Public Health, 2022; HHS, 2014).

ACTION: Share resources and coordinate personnel during severe storms.

SUMMARY: Collaboration between response organizations may involve sharing critical resources and coordinating the deployment of personnel to support impacted communities in areas of greatest need (Patel, 2022). Consider integrating the results of the organization's prospective risk assessment (Element 1) into planning conversations in order to funnel resources to new and emerging at-risk populations related to the changing climate.

Climate Resilience Actions, continued

Physical Infrastructure

ACTION: Build out alternative communication channels to help regional healthcare organizations share real-time information with each other during severe storms and tornadoes.

SUMMARY: Interorganizational cooperative agreements for sharing resources and transferring patients during severe storms depend on real-time communication among facilities in the network. Building out alternative communications channels that connect healthcare organizations with each other (such as multiple cell phone providers, satellite phones, walkie-talkies, and generator-powered cell towers on the roof of key facilities) can increase the effectiveness of the entire network's emergency response (U.S. HHS, 2014).

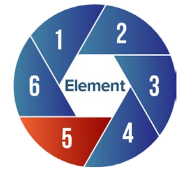
OASH | Office of Climate Change and Health Equity

Resilience Strategies:

Thunderstorms and Tornadoes

CR4HC

Element 5. Interdisciplinary Planning, Oversight, and Evaluation



Severe thunderstorms and tornadoes can affect various critical dependencies within healthcare organizations, such as administration, information technology (IT), electricity, natural gas, water, wastewater and waste disposal, communications, transportation, and critical products. Healthcare organizations are encouraged to align facilities operations, procurement, and capital expenditures with climate change mitigation and resilience goals.

For example, clinical and operational considerations along with security and disaster preparedness goals were integrated in the 2010 IT investments made by American Family Care (AFC), a Federally Qualified Health Center in Joplin, Missouri (Shin & Jacobs, 2012). Their off-site data center was in a reinforced location that withstood the deadly tornado that struck Joplin in 2012, and they had a plan in place with their service provider to establish on-site intranet access following the disaster. As a result, AFC was able to continue caring for their own patients, provide medical triage and medication refills for community residents in need, and assist their own staff and staff families. In the wake of the local hospital's destruction by the tornado, AFC's resilient IT systems helped them to function as a critical component of the regional response and recovery effort (Shin & Jacobs, 2012).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 5: Interdisciplinary Planning, Oversight, and Evaluation

Planning

ACTION: Incorporate interdisciplinary approaches into storm resilience planning.

SUMMARY: Consider incorporating interdisciplinary approaches into the healthcare organization's hazard planning process since severe storms can impact a range of dependencies – such as infrastructure, clinical care, energy systems, and waste management (Rogers et al., 2020).

ACTION: Incorporate long-term goals and climate projections into severe storm preparedness and response plans.

SUMMARY: It can be helpful to integrate long-term, interdisciplinary strategic goals into the healthcare organization's extreme weather emergency preparedness and response plans – including community input as outlined in the Justice, Equity, Diversity, and Inclusion (JEDI) framework (American Public Health Association & CDC, 2021).

ACTION: Implement surveillance and interdisciplinary after-action reviews in organizational severe storm action plans.

SUMMARY: Incorporate building surveillance and interdisciplinary after-action reviews into the healthcare organization's severe storm action plan. These measures will help identify and evaluate the elements of the plan that worked during a recent storm; assess whether changing climatic conditions might have influenced aspects of the storm event (such as its severity); and change the parts of the plan that did not meet expectations (Hess et al., 2023; Parker, 2020).

Resilience Strategies:
Thunderstorms and Tornadoes

Element 6. Communications and All-Hazards Approach

Thunderstorms and tornadoes often occur simultaneously or in quick succession with other climate change-related hazards, such as flooding and extreme heat. Multi-hazard events increase the risk of multiple system failures at the community scale, such as disruptions to the water and power utilities. As a result, population health can be directly or indirectly harmed. Repeated patient surges and cascading infrastructure failures, both in the community and within healthcare facilities, can temporarily disrupt the entire healthcare system in a region. Fortunately, many policy, infrastructure, and communication interventions can increase organizational resilience to more than one climate-related hazard. This is particularly true if emergency management and climate resilience planners use an all-hazards approach to designing, implementing, and testing proposed interventions.

For example, a global review of communication systems' performances during disasters revealed a set of key system and technology attributes that are associated with effectiveness during crises (El Khaled & Mcheik, 2019). Several of these attributes are relevant for healthcare organizations' communication systems and for healthcare organizations' regional communication networks, helping to ensure reliable communication during severe storms and all-hazard events to patients, the public, clinicians, staff, peer organizations, and regional partners. These relevant attributes include scalability, the ability to prioritize communication traffic, interoperability, capacity, and coverage (El Khaled & Mcheik, 2019).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 6: Communications and All-Hazards Approach

Planning

ACTION: Collaborate with local partners to coordinate storm, tornado, and flood messaging.

SUMMARY: It can be helpful to collaborate with local public health department partners to coordinate severe storm-related messaging with clinicians and patients, such as through prompts in the healthcare organization's electronic health record, e-newsletter, and patient texting system. This approach can increase community awareness of both the short- and long-term health risks associated with exposure to storms and flooding (WHO, 2020).

ACTION: Use simultaneous disasters as an opportunity for education about the co-benefits of taking an all-hazards approach to resilience.

SUMMARY: Simultaneous and cascading disasters can be opportunities to educate the community, staff, and emergency management partners about the value associated with using a co-benefit approach to risk assessment, emergency planning, emergency response, and rebuilding efforts (National Academies of Sciences, 2022).

People and Operations

ACTION: Broadcast thunderstorm and tornado alerts using culturally appropriate language and communication pathways.

SUMMARY: Broadcasting alerts about storm and flood vulnerability and protective behaviors to patients, staff, and community partners using culturally appropriate language and communication pathways can help amplify the local public health department and office of emergency management's communication efforts (Hasan et al., 2021; O'Neill et al., 2009).

Climate Resilience Actions, continued

ACTION: Establish two-way communication systems with at-risk patient populations.

SUMMARY: Implementing two-way communication systems, like Reverse 911 and wireless emergency alerts (National Academies of Sciences, 2018), can aid in connecting sensitive populations with protective measures before a storm occurs and direct them to community services during the event. With the assistance of community groups and local health departments, designated community leaders can deliver culturally sensitive messages. These messages would inform residents about safeguarding themselves and their neighbors and provide guidance on actions to take if they experience health harms (Steinberg & Sprigg, 2016; Toner et al., 2017).

Climate Resilience for Health Care: Wildfire

CR4HC

Impact of Wildfire on Healthcare Organizations

Climate change influences the frequency, severity, and distribution of wildfires. At-risk populations can be injured and displaced by wildfires and exposed to wildfire smoke, leading to both immediate and sustained health consequences. Among those most affected by smoke exposure are older adults, infants, children, pregnant women, individuals with chronic health conditions, and outdoor workers.

Wildfires can cause structural damage to healthcare facilities; disrupt fire suppression systems if water pressure drops; compromise indoor and outdoor air quality; and interrupt communication systems, electrical power, and supply chains. Additionally, wildfires can lead to direct injury, exacerbate chronic medical conditions from smoke exposure, and lead to mental health symptoms, all of which can result in a surge of patients seeking care, causing potential strain on healthcare resources and staff. Power outages can stress healthcare operations and can put at risk community members who are reliant on electricity-dependent durable medical equipment and specialized supplies to manage chronic conditions worsened by smoke and wildfires.

Important Considerations

Health Effects of Wildfire: Multi-system effects of air pollution (e.g., eye and respiratory tract irritation, exacerbation of cardiovascular and pulmonary disease, increased susceptibility to respiratory infections), water pollution, burns and direct trauma, evacuation and displacement, mental health effects, food insecurity

Populations at Risk: Infants and children, pregnant women, older adults (especially those who live alone), low-income populations (particularly those who do not have the means to evacuate), people with chronic conditions such as cardiovascular disease and respiratory disease, outdoor workers, emergency response personnel, firefighters

Risks to Facility Operations: Clinical supplies, supply chain disruption, patient surge, evacuation required if there is a prolonged power outage

Infrastructure Risk: Compromise of transportation and building infrastructure, rolling blackouts/power loss, inefficiency of utilities

Elements of a Climate-Resilient Healthcare Organization: Wildfire

The following six elements characterize a wildfire-resilient healthcare organization. Review each element section to explore it in more detail.

1. Prospective Risk Assessment

Adding forward-facing climate projections to wildfire risk assessment can help healthcare organizations plan for changing exposures and vulnerabilities, such as more frequent and severe wildfires. To adjust to this new normal, healthcare organizations must increasingly plan for potentially complex evacuation scenarios and invest in facility infrastructure that allows staff and patients to shelter in place.

2. Health Equity and Community Engagement

Wildfires can cause immediate, local harm (such as the evacuation and destruction of healthcare facilities) and longer-term, far-reaching harm (such as degraded air quality caused by fires burning hundreds of miles away). Healthcare organizations can support community resilience to wildfires – which is influenced by risk perception – by tailoring outreach to the needs of specific patient populations.

3. Assessment and Remediation of Vulnerabilities in Infrastructure and Operations

The healthcare infrastructure is often the first line of defense against wildfire. Similar to hurricane evacuation protocols, healthcare facilities' wildfire evacuation protocols should be developed in concert with facility operations protocols so that patients are protected from immediate harm from fire and structural damage, as well as from long-term harm from exposure to wildfire smoke originating hundreds of miles from the facility and potentially lasting for weeks at a time. Healthcare organizations can build resilience and redundancy into their facility design and operations to avoid wildfire-related disruptions in clinical care. Implementing efficient building designs and maintaining operations during power and water outages, designing resilient supply chains and storage conditions for refrigerated food and medical supplies, and planning for staff and family protection and transportation during extreme weather events are crucial measures. Healthcare organizations can enhance their facility infrastructure and operations' resilience by adopting efficient building practices, ensuring reliable supply chains, and creating comprehensive emergency plans to support both clinical care and community refuge during wildfires.

4. Collaboration Between Healthcare Organizations

Multiple healthcare facilities within a geographic region may be threatened by a single wildfire event. Therefore, collaboration between healthcare organizations is important for joint planning and training for potentially complex evacuation scenarios.

5. Interdisciplinary Planning, Oversight, and Evaluation

An interdisciplinary approach to planning, oversight, and evaluation across critical dependencies is essential for comprehensive wildfire emergency preparedness planning. Planning requires collaboration between multiple functions in the healthcare organization, such as administrative leadership, facilities, clinical operations, emergency management, supply chain, and purchasing. Sustained collaboration between these functions is required to evaluate and refine plans following wildfire events. Furthermore, different facility types may need to fill different gaps in wildfire emergency preparedness.

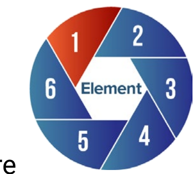
6. Communications and All-Hazards Approach

Wildfire events often occur simultaneously or in quick succession with other climate change-related hazards, such as heat waves and drought. In addition, damage from wildfires can exacerbate the effects of other disasters by contributing to water and soil contamination, erosion, and flooding. These coinciding and cascading events can increase the risk of multisystem failures at the community scale (such as disruptions to water and power utilities), causing both direct and indirect harm to population health. Taking an all-hazards approach to emergency management and climate resilience planning can enhance organizational resilience to multiple climate-related hazards.

Resilience Strategies: Wildfire

CR4HC

Element 1. Prospective Risk Assessment



Adding forward-facing climate projections to wildfire risk assessment can help healthcare organizations plan for changing exposures and vulnerabilities, such as more frequent and severe wildfires. Changes in land use, such as increased development in undeveloped, wildfire-prone areas – the so-called "wildland-urban interface" (WUI) – have increased societal exposure to wildfire risk in many parts of the country (Scalingi, 2021). Today, one-third of the U.S. population lives in the WUI, even though that land use occupies less than one-tenth of the conterminous land mass (Radeloff et al., 2018). California is experiencing increasingly frequent and intense wildfires, with 15 of the 20 most destructive wildfires in the state's history occurring in the past 10 years (McFadden, 2024). It is estimated that 95% of inpatient hospital beds are now within 3.7 miles of a fire threat zone (Bedi et al., 2023). To adjust to this new normal, healthcare organizations must increasingly plan for potentially complex evacuation scenarios and invest in facility infrastructure that allows staff and patients to shelter in place.

For example, health system Kaiser Permanente has integrated the expected increase in wildfire risk in many regions they serve into its overall approach to emergency management in those locations. In addition to planning for direct exposure to fire, Kaiser Permanente's approach to wildfire preparedness includes plans for responding to (1) pre-emptive utility power grid shutdowns which can impact facility operations and patients who are dependent on electrically powered medical equipment, (2) smoke damage to building materials and equipment, (3) regional soil and water contamination from wildfire dust, and (4) evacuation protocols that do not wait for official evacuation notices (Fink, 2022 b.).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 1: Prospective Risk Assessment

Planning

ACTION: Add a prospective wildfire risk assessment and impact forecasting to the local hazard mitigation plan.

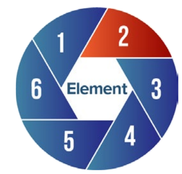
SUMMARY: It can be helpful to work with public health and local emergency management partners to add a prospective wildfire risk assessment and impact forecasting to the local hazard mitigation plan, particularly because wildfire often occurs simultaneously or in quick succession alongside other climate change-related hazards such as heat, drought, and landslides (Hess et al., 2017). Include a critical assessment of how current land use and future projected development in the wildland-urban interface (WUI) could affect energy, water, and transportation system vulnerability (Belongia et al., 2023).

ACTION: Consider both historical trends and climate projections to identify regional wildfire risks.

SUMMARY: As a result of the climate changing, historical trend lines are not necessarily an accurate predictor of the future. Incorporating both historical trends and climate projections when developing wildfire emergency management strategies can help healthcare organizations future-proof the planning, response, and recovery process (Ponce Manangan et al., 2014).

Resilience Strategies: Wildfire

Element 2. Health Equity and Community Engagement



Wildfires can cause immediate, local harm (such as the evacuation and destruction of healthcare facilities) and longer-term, far-reaching harm (such as degraded air quality caused by fires burning hundreds of miles away). Given the variety of potential impacts, preparedness relies on a combination of individual actions and social networks to build awareness and enable action at multiple scales (Prior & Eriksen, 2013). Healthcare organizations can support community resilience – which is influenced by risk perception – by tailoring outreach to the needs of specific patient populations. For example, local emergency evacuation services might prioritize older adults, people with disabilities, and households with children – three groups who have been found to exhibit relatively delayed evacuation during wildfires (Sun et al., 2024). Patients at higher risk for health harms from wildfire smoke – such as pregnant women, people with asthma, and people with cardiovascular disease – may benefit from targeted, protective messaging and recommendations to reduce smoke exposure (EPA, 2019 b.). By collaborating with community-based organizations representing these groups, healthcare organizations can support a culture of collective problem-solving around a hazard that is increasingly recognized as a threat to all communities in the United States, not only rural areas (Prior & Eriksen, 2013). Healthcare organizations are also encouraged to collaborate with local emergency management to align wildfire plans with other emergency protocols for coordinated responses.

The following sub-elements describe specific ways in which a healthcare organization can integrate health equity and community engagement into their wildfire resilience planning.

2.1 **Community Input:** Engagement with community members, patients, and community organizations can help to effectively tailor healthcare organizations' wildfire planning and response to the needs of at-risk populations.

2.2 **Community Infrastructure:** Wildfire-resilient communities plan for three phases: (1) reducing risk ahead of a wildfire, (2) responding during the wildfire, which may occur close enough to disrupt utility and transportation infrastructure, or alternatively may occur hundreds of miles away, and (3) cleaning up after the event (Hertelendy et al., 2024). Healthcare organizations are encouraged to enhance resilience by supporting community programs that include backup power, air filtration systems, and coordinated emergency responses.

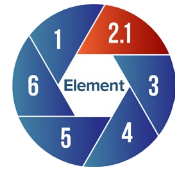
2.3 **Community Services:** Disruptions in community services during wildfires can lead to increased respiratory issues due to smoke exposure and additional healthcare demands from individuals relying on medical equipment or refrigerated medications during power outages (EPA, 2019 a.). To minimize a surge of patients seeking care for respiratory problems and other fire-related health issues, healthcare organizations should (1) partner with community services to provide supports that reduce wildfire risks (Smith et al., 2016) and (2) conduct proactive community outreach to evacuate people from wildfire paths and minimize smoke exposure (Patel et al., 2022; Stone et al., 2019).

2.4 **Coordination with Local Office of Emergency Management:** Alignment of healthcare wildfire resilience planning with the local office of emergency management can help identify local and regional assets that can help manage potential disruptions in healthcare delivery. Effective coordination across agencies ahead of fire season can also help distribute staff, supplies, and financial resources across agency partners so that healthcare organizations and their public and community partners can continue to provide core social services to at-risk populations and engage in crisis response.

Resilience Strategies: Wildfire

CR4HC

Element 2.1 Community Input



Engagement with community members, patients, and community organizations can help to effectively tailor healthcare organizations' wildfire planning and response to the needs of at-risk populations. For example, a study of the 2011 wildfire season in New Mexico provided important information that can help New Mexico healthcare organizations identify patients with preexisting, high-risk conditions and design outreach resilience programs tailored to their location and needs. The study found that during days with high exposure to wildfire smoke, emergency department (ED) visits among adults over age 65 increased 73% for asthma and 56% for diseases of the veins, lymphatic, and circulatory systems. The same study found that ED visits among adults aged 20–64 increased 142% for diseases of pulmonary circulation and 69% for cerebrovascular disease.

University of California Davis' Wildfire Population Health model relies on collaboration with community organizations to identify and engage with populations with chronic obstructive pulmonary disease or asthma who have clinical and social risk factors for disease exacerbation (Khun & Gupta, 2024). This model allows effective delivery of wildfire preparedness interventions for these at-risk populations, mitigating the inequitable health harms of wildfire smoke exposure.

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
[Element 2.1: Community Input](#)

Planning

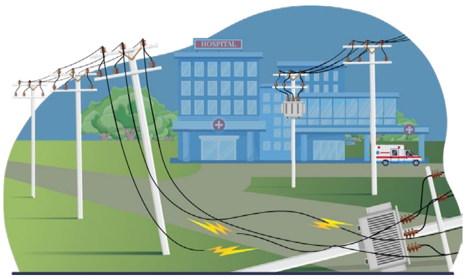
ACTION: Map patient populations who are sensitive to wildfires and wildfire smoke.

SUMMARY: Collaborating with community partners to map patient populations who are at high risk of negative health outcomes from wildfires and wildfire smoke can increase organizational and community resilience by helping to ensure that protocols supporting healthcare access during and after wildfire events are tailored to those populations' needs (Patel et al., 2022). Given the wide range of wildfire exposures, it can be helpful to consider which populations within the healthcare organization's catchment area are most sensitive to each type of exposure so that healthcare and community resources can be tailored to their needs at the appropriate time. For example, people living in mobile homes, renters, and people living in the wildland-urban interface may be at greater risk of direct exposure to wildfire. People reliant on others for transportation may be at higher risk if an evacuation order is issued. People with preexisting respiratory or cardiovascular disease may require additional assistance cleaning up after a wildfire-related poor air quality event.

ACTION: Use the JEDI framework to structure community input.

SUMMARY: Consider following the Justice, Equity, Diversity, and Inclusion (JEDI) framework to integrate community input into the development and operation of the healthcare organization's climate resilience plan (American Public Health Association & CDC, 2021).

Element 2.2 Community Infrastructure



Wildfire-resilient communities plan for three phases: (1) reducing risk ahead of a wildfire, (2) responding during the wildfire, which may occur close enough to disrupt utility and transportation infrastructure, or alternatively may occur hundreds of miles away, and (3) cleaning up after the event (Hertelendy et al., 2024). Wildfires can reach extreme temperatures, causing significant damage to community infrastructure, such as buildings, power systems, and communication networks (Hertelendy et al., 2024). Power lines are also increasingly cited as a major source of ignition. For example, a study of wildfire in California from 1919-2016 found that 95% were caused by humans, with power line ignitions representing the only source that has increased in frequency after 1980 (Keeley & Syphard, 2018).

Implementing advanced protective measures and establishing clear evacuation protocols can help mitigate the impact of wildfires on critical infrastructure and public health. Community infrastructure upgrades that can reduce the risk of fire damage include creating and maintaining fire breaks around the community, removing brush around critical facilities (including healthcare facilities), and establishing multiple access routes to and from the community to ensure evacuation routes are accessible, if needed, and that supplies can reach the community after the event (Hertelendy et al., 2024). Preparedness strategies for regional fires include building out resilient power and water supply systems to service the community if the regional system is damaged by the wildfire or proactively shutting down to prevent fire spread (Belongia et al., 2023; McWethy et al., 2019). Communities may also consider upgrading critical facilities (including hospitals) and buildings used as emergency shelters to protect occupants from fire-related air pollution. See Elements 3.3 and 3.4 for specific recommendations on wildfire-resilient design and operations strategies.

Communities at high risk of exposure to wildfire and/or wildfire smoke may also consider upgrading their building code to require all building types – particularly residential buildings – to be designed for fire resilience. A study of three jurisdictions in Boulder County, Colorado, following the extremely destructive Marshall Fire in December 2021, found that the jurisdiction that had adopted fire-resilient components in their residential building code prior to the wildfire expanded those requirements to more neighborhoods after the fire, indicating that increasing familiarity with the requirements and associated costs can influence public opinion in support of enhancing a community's wildfire resilience (Ellery et al., 2023). A fire-resilient community infrastructure supports healthcare resilience by allowing residents to shelter in place, and freeing up clinicians to treat the most highly sensitive populations during and after the fire (Hertelendy et al., 2024).

The Blue Lake Ranchería Tribe microgrid in Humboldt County, California, is another example of a protective measure to mitigate the impact of wildfires. The microgrid, which combines a 420 kilowatt (kW) alternating current solar electric system with a 500 kW/950 kWh battery energy storage system and a conventional diesel backup generator, successfully islanded the microgrid campus, including a certified American Red Cross emergency shelter and other critical infrastructure, during a 2017 wildfire (Carter et al., 2019). Healthcare organizations are encouraged to enhance wildfire resilience by supporting community programs that include backup power, air filtration systems, and coordinated emergency responses.

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
[Element 2.2: Community Infrastructure]

People and Operations

ACTION: Support and direct patients to local programs that increase adaptive capacity in the home environment.

SUMMARY: Connect low-income residents and other high-risk groups (like those over 65 and those with chronic illness) with programs that can help them prepare for and respond to wildfires (Patel et al., 2022). Examples include home hardening initiatives, free or subsidized smoke alarms and fire extinguishers, evacuation planning workshops, access to emergency supply kits, provisions for backup generation or charged batteries for medical equipment, and financial assistance for wildfire safety upgrades.

ACTION: Collaborate with local partners to assess and remediate compromised utility and transportation systems after a wildfire event.

SUMMARY: Wildfires can severely damage and contaminate community infrastructure, including roads, electrical lines, soil, and water systems. For example, the toxic chemicals released during the 2018 Camp Fire in California infiltrated the municipal water system in Butte County when the system was temporarily depressurized to support firefighting operations (Western Forestry Leadership Coalition, 2022). As major consumers of utilities and also trusted voices in the community, healthcare organizations can support remediation efforts by reducing their demand for energy and water through enhanced efficiency measures, extending their reliance on emergency utilities while utilities are being repaired, providing technical expertise during the testing phase after repairs, and coordinating messaging with local partners to ensure that community members feel informed about the remediation process.

Physical Infrastructure

ACTION: Catalyze the development of resilient infrastructure at the neighborhood and community level.

SUMMARY: As anchor institutions, healthcare campuses and public health institutions can catalyze neighborhood and community-scale efforts to increase resilience against wildfires, including maintaining fire breaks around the community, removing brush around critical facilities (including healthcare facilities), burying power lines, installing islanding power and water systems, and establishing multiple access routes to and from the community to ensure evacuation routes are accessible if needed and that supplies can reach the community after the event (Belongia et al., 2023; Hertelendy et al., 2024; McWethy et al., 2019; Scalingi, 2021).

ACTION: Work with local and regional partners to lower barriers to travel for patients and staff during wildfire events.

SUMMARY: Transportation infrastructure failures can prevent staff from reporting to work and patients from traveling to healthcare facilities to receive needed care during wildfire events. Healthcare organizations can support regional wildfire resilience by working with local and regional partners to lower barriers to travel (WHO, 2020). For example, limited public transit service could be offered to patients and essential workers, and medical workers could be granted priority access to gas stations (U.S. HHS, 2014).

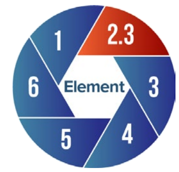
ACTION: Collaborate with the local housing authority and other funding sources to accelerate housing repairs and new housing construction after wildfire events.

SUMMARY: While housing is not generally thought of as community infrastructure, its destruction during a wildfire can lead to permanent displacement, which reduces the pool of potential staff available to work at healthcare facilities. For example, the 2023 wildfire in Lahaina, Hawai'i, destroyed 2,000 homes (roughly 3% of the entire housing stock on the island of Maui). The proportion of fire-affected community members either living with friends/relatives or unhoused doubled in the first year following the event. And those who had found replacement housing were paying 43% higher rents on average than before the event (Bond-Smith et al., 2023; Bond-Smith et al., 2024). As the largest employers in many communities, healthcare organizations are often uniquely placed to advocate for expedited repair and replacement of wildfire-damaged housing. Many healthcare organizations are affiliated with philanthropies that are already taking a housing-first approach to social determinants of health. Consider leveraging this type of connection to accelerate housing renovation and construction in impacted communities.

Resilience Strategies:
Wildfire

CR4HC

Element 2.3 Community Services



Disruptions in community services during wildfires can lead to increased respiratory issues due to smoke exposure and additional healthcare demands from individuals relying on medical equipment or refrigerated medications during power outages (EPA, 2019 b.). To minimize a surge of patients seeking care for respiratory problems and other fire-related health issues, healthcare organizations should (1) partner with community services to provide supports that reduce wildfire risks (Smith et al., 2016) and (2) conduct proactive community outreach to evacuate people from wildfire paths and minimize smoke exposure (Patel et al., 2022; Stone et al., 2019).

For example, during the 2020 August Complex fire in California, the California Department of Forestry and Fire Protection educated residents with tips to limit fire hazards, elected officials sent personal protective equipment when supplies were running low, and the Indian Health Service provided air purifiers. These supports helped to ensure that Round Valley Health remained operational during this wildfire event (Rural Health Information Hub, n.d.a.). Wildfire can also risk the physical and mental health of agricultural communities. In response to the 2024 wildfires in the Texas Panhandle, which destroyed 1.2 million acres of farming and ranchland and killed more than 12,000 cattle (Fannin, 2024), the nonprofit AgriSafe Network raised awareness about their wildfire-specific resource page and mental health hotline designed to support people in crisis due to agricultural losses. Their website also offers continuing education and digital badges to healthcare providers to expand their training on the specific health needs of people working in agriculture. Their "Total Farmer Health Model," which emphasizes the relationship between mental and physical health in supporting total health, includes weather as a significant underlying determinant of health.

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
[Element 2.3: Community Services]

Planning

ACTION: **Consider preemptive planning for patients who use electricity-dependent DME.**

SUMMARY: Proactively help patients who rely on electricity-dependent durable medical equipment (DME) to ensure that they have a backup power source or another contingency plan in the event of power shutoffs during wildfire events (Pacific ADA Center, 2017).

People and Operations

ACTION: **Coordinate with community partners to create a multi-sector protocol for the delivery of mental health services during and after wildfires.**

SUMMARY: The mental health impact of wildfires can be severe. Healthcare organizations can help increase community resilience by supporting crisis response planning among community partners in the public and private sectors who provide mental health care for survivors of wildfires (WHO, 2020).

Climate Resilience Actions, continued

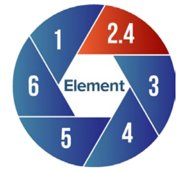
ACTION: Fill gaps in local services to increase resilience, such as acting as a place of refuge during wildfire events.

SUMMARY: Healthcare facilities equipped to continue operations during power outages can enhance local resilience by offering their facilities as refuges for community members during wildfire events (Johns & Rosenthal, 2024; Toner et al., 2017). It is important to formalize this role with the Office of Emergency Management ahead of the event so the facility receives extra fuel, supplies, and staff to manage non-medical emergency services (U.S. HHS, 2014).

ACTION: Integrate community resilience needs into healthcare organization emergency management plans.

SUMMARY: Include provisions in the healthcare organization's hazard emergency plan to accommodate community members who may seek to use the facility as a refuge and patients who require access to electrical power to charge their medical devices and/or refrigeration for their medications. Consider creating a registry of patients needing this kind of assistance and setting up a two-way communications protocol (such as a Reverse 911 or wireless emergency alert system (National Academies of Sciences, 2018) to contact them in the event of a power disruption or outage (Patel et al., 2022).

Element 2.4 Coordination with Local Office of Emergency Management



Alignment of healthcare wildfire resilience planning with the local office of emergency management can help to identify local and regional assets that can help to manage potential disruptions in healthcare delivery. For example, coordination with city and county agencies helped healthcare organizations in Southeast Colorado manage patient evacuations during a significant wildfire event in summer 2018. This coordination allowed the healthcare organizations to (1) identify alternate care sites in the community to manage a surge in patients, (2) establish memoranda of understanding with regional transportation agencies to ensure availability of vehicles for potential evacuations, and (3) have a process in place for sharing information in real time with the county Emergency Operations Center and local and state health departments and regulatory agencies (ASPR TRACIE, 2020). Public healthcare providers in California have reported spending time immediately after wildfires attempting to locate regular patients to check in on their status and provide nonreimbursable services, which strained their finances and reduced their ability to provide needed medical and behavioral health services (Rosenthal et al., 2021). Effective coordination across agencies ahead of fire season can help distribute staff, supplies, and financial resources across agency partners so that healthcare organizations and their public and community partners can both continue to provide core social services to at-risk populations and engage in crisis response.

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 2.4: Coordination with Local Office of Emergency Management

Planning

ACTION: Add local and regional climate change vulnerability assessments to the healthcare organization's emergency preparedness plan.

SUMMARY: Consider adding local and regional climate change vulnerability assessments to the healthcare organization's emergency preparedness plan to integrate projections of how the region's exposure to wildfires may change in coming decades compared with historical trends (Marinucci et al., 2014).

ACTION: Include regular reviews of interdependent critical infrastructure – including healthcare infrastructure – in coordinated emergency management and climate resilience planning around wildfire.

SUMMARY: Cross-disciplinary risk management and climate resilience assessment planning can increase resilience to wildfire by strengthening coordination across interdependent, critical infrastructure and social services (such as housing) before, during, and after wildfire events (Scalingi, 2021).

ACTION: Coordinate inter-agency situational awareness, wildfire prediction, and alert systems so that healthcare facilities are prepared to offer clinical care during wildfire events and able to direct concerned community members to relevant off-site resources.

SUMMARY: Coordinating wildfire response across a network of emergency management organizations allows each partner to focus on their area of expertise. Coordinating inter-agency situational awareness and alert systems is one way to maximize each partner's contribution in real time under rapidly changing circumstances (Belongia et al., 2023; Scalingi, 2021).

Climate Resilience Actions, continued

ACTION: Collaborate with local partners to coordinate wildfire-related messaging.

SUMMARY: It can be helpful to collaborate with local public health department partners to coordinate wildfire-related messaging with clinicians and patients, such as through prompts in the healthcare organization's electronic health record, e-newsletter, and patient texting system. This approach can increase community awareness of both the short- and long-term health impacts of wildfires (WHO, 2020).

ACTION: Formalize cooperation agreements with utility providers (both power and water) to ensure that the healthcare organization's facilities are integrated into local wildfire emergency management and climate resilience planning efforts.

SUMMARY: Critical facilities, hospitals, and other healthcare building types should be fully integrated into local utilities' wildfire emergency management and climate resilience planning efforts. It is particularly important to include facility power and water needs in emergency preparedness and climate resilience planning efforts to ensure that they can continue to provide care during and after wildfire events (McCabe et al., 2023; Van der Heijden, 2022).

ACTION: Integrate legal preparedness into the healthcare organization's emergency management and climate action plans.

SUMMARY: Uncertainty about who has the legal authority to authorize difficult decisions during disasters can slow a healthcare organization's ability to pivot from normal operations to respond to a disaster. Healthcare organizations can enhance the resilience of their emergency management and climate action plans by (1) including parameters that clarify the conditions in which a facility may share information outside of the healthcare organization and administrators may order facility evacuations, (2) clarifying how personnel will reconcile protocol discrepancies (such as different evacuation protocols for healthcare organizations compared with Emergency Medical Services, and (3) authorizing clinical staff from outside organizations to practice in the healthcare facility. These plans may also include a decision framework for deciding how to allocate scarce resources during utility outages (U.S. HHS, 2014; Toner et al., 2017; VanDevanter et al., 2014).

People and Operations

ACTION: Coordinate wildfire-related syndromic surveillance with the local office of emergency management and the local weather station.

SUMMARY: It can be helpful to add wildfire-related illness to your organization's syndromic surveillance reports during and immediately following wildfire events. Aligning the organization's protocol for collecting relevant diagnostic data with the local office of emergency management and weather station's protocol for declaring a climate-related emergency will help ensure that your organizational climate resilience action plan deploys in coordination with local alerts (Hess et al., 2023).

ACTION: Leverage healthcare facilities as intervention sites for local wildfire action plans.

SUMMARY: Healthcare organizations often offer their locations as community intervention sites for the local wildfire action plan. For example, allowing the Office of Emergency Management to use strategically located hospitals, medical office buildings, and clinics as distribution sites for water bottles, food, etc., can increase community access to health-promoting supplies. Officially designating publicly available spaces in healthcare facilities – such as the cafeteria – as resilience hubs or temporary shelters during wildfires and smokewaves can help support patients and family members as well as raise awareness in the community that climate-related events are public health emergencies (Hess et al., 2023; IOM, 2012).

Element 3. Assessment and Remediation of Vulnerabilities in Infrastructure and Operations

The healthcare infrastructure is often the first line of defense against wildfire. A healthcare facility's location; the type of structural, roofing, and exterior envelope materials used in its construction; the ways in which centralized utilities are protected from fire; and the extent to which landscaping practices maintain a fuel-free defensible space around the campus will contribute to how well the facility weathers direct threat from a wildfire (Schulze et al., 2020). Wildfire evacuation protocols should be developed in concert with facility operations protocols so that patients are protected from immediate harm from fire and structural damage, as well as from long-term harm from exposure to wildfire smoke originating hundreds of miles from the facility and potentially lasting for weeks at a time.

During the Thomas Fire (California, 2017), Ventura County Medical Center activated its internal Incident Command Center, which coordinates preparedness and response actions across clinical, logistics, operations, and public information departments. Several key areas of facility infrastructure and operations contributed to the administration's decision not to evacuate, including effective air filtration, functioning sealants on the building exterior, moving automatic doors to manual operation, sufficient daily and medical supply stockpiles, and the ability of the hospital to run off of emergency generators for five days (Sandoval, 2018). Healthcare organizations can build resilience and redundancy into their facility design and operations to avoid wildfire-related disruptions in clinical care. For example, Estes Park Health, a Critical Access Hospital in Estes Park, Colorado, partnered with a local fuel provider during the 2020 East Troublesome Fire to establish an agreement for emergency power generation to mitigate concerns about power outages affecting their equipment (Rural Health Information Hub, n.d.a.).

Implementing efficient building designs and maintaining operations during power and water outages, designing resilient supply chains and storage conditions for refrigerated food and medical supplies, and planning for staff and family protection and transportation during extreme weather events are crucial measures. Healthcare organizations can enhance their facility infrastructure and operations' resilience by adopting efficient building practices, ensuring reliable supply chains, and creating comprehensive emergency plans to support both clinical care and community refuge during wildfires.

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

3.1 Staff Support: Transportation routes to healthcare facilities may be disrupted by wildfires. Ensuring adequate staffing and safe access to healthcare facilities for both staff and patients is crucial, as wildfires may cause staffing shortages if healthcare workers are personally affected (ASPR TRACIE, 2022; Lichter 2024). Healthcare staff members' homes and loved ones may be under direct threat from a wildfire event. Healthcare organizations are encouraged to develop comprehensive wildfire emergency plans that include providing staff protections and accommodations (including providing the opportunity for staff members to shelter in place and/or providing emergency housing after the wildfire if needed), ensuring safe commuting, reducing mental stress, and maintaining adequate staffing levels during wildfire events.

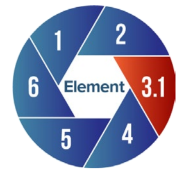
3.2 Clinical Considerations: Wildfires can cause a surge in healthcare demand both in the communities directly impacted by fire and hundreds of miles away in communities exposed to airborne contaminants. Given the lengthy rebuilding process after many wildfire events, cross-organizational coordination may stretch into months and years following a given event. Healthcare systems are encouraged to consider these potential sources of acute and longer-term patient surge in preparing facilities and staff for wildfire events, and to incorporate screening and outreach for at-risk patient populations in wildfire risk mitigation planning.

3.3 Building and Campus – Design & Construction: Facilities located in or near wildfire-prone areas are susceptible to damage or destruction from wildfires, windblown embers, transportation disruptions, and the transformation of wildland fires into structure fires, impacting safety, functionality, and accessibility. Healthcare organizations can adopt advanced design and construction practices that enhance building resilience, protect against windblown embers, ensure functional transportation routes, and prevent wildland fires from becoming structure fires. Design features that improve facilities' ability to withstand disruptions in the power grid can increase resilience to wildfire events.

3.4 Building and Campus – Facility Operations: Healthcare buildings are vulnerable to power outages because they rely on electricity, plumbing systems, and energy sources, like natural gas, to operate critical systems for patient care and occupant safety, such as lighting, air conditioning, medical equipment, and electronic medical records. Connecting facility systems to backup power supplies and implementing measures to maintain essential services during power disruptions can enhance resilience during wildfire events. Healthcare organizations can ensure that facility systems are connected to reliable backup power supplies, maintain cooling and ventilation systems during power outages, and provide essential services, like food, clean water, and custodial care, to inpatients during wildfire events.

3.5 Supply Chain: Many clinical and non-clinical items in a healthcare organization's supply chain require refrigeration. Healthcare organizations can enhance resilience by developing and implementing a plan for managing their refrigerated supply chain and on-site storage during wildfire-related regional power outages (Rublee et al., 2021). In addition, damage to transportation routes and production facilities can disrupt supply chains. Diversification of supply sourcing for critical products is one critical feature of increasing healthcare supply chain resilience to wildfires and other hazards (Write et al., 2024).

Element 3.1 Staff Support



Transportation routes to healthcare facilities may be disrupted by wildfires. Ensuring adequate staffing and safe access to healthcare facilities for both staff and patients is crucial, as wildfires may cause staffing shortages if healthcare workers are personally affected (ASPR TRACIE, 2022; Lichter, 2024). Healthcare staff members' homes and loved ones may be under direct threat from a wildfire event. For example, multiple healthcare staff members at Kaiser Hospital Santa Rosa who were on shift during an evacuation necessitated by a 2017 wildfire were simultaneously fielding calls from their families about their homes being surrounded by fire. Many of these staff members ultimately lost their homes (ASPR TRACIE, 2019). The housing crisis that follows many wildfires can lead to staffing shortages if staff members lose their homes and are displaced to other communities. Two years after the Camp Fire destroyed much of Paradise, California, the health clinic – which only sustained smoke damage – could only continue to function at 70% capacity due, in part, to post-wildfire staffing shortages (Schulze et al., 2020). Healthcare organizations are encouraged to develop comprehensive wildfire emergency plans that include providing staff protections and accommodations (including providing the opportunity for staff members to shelter in place and/or providing emergency housing after the wildfire if needed), ensuring safe commuting, reducing mental stress, and maintaining adequate staffing levels during wildfire events.

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 3.1: Staff Support

Planning

ACTION: **Set staff expectations for their role during wildfire events.**

SUMMARY: Clearly define expectations with healthcare facility staff related to working during and after wildfires – particularly under circumstances that lead to power disruptions or outages, and those that may require staff to remain at work for extended periods. Share with staff a list of personal items that they should bring with them to an anticipated multi-day response effort, such as food, water, personal medication, hand sanitizer, extra clothes, and sleeping gear. Co-create policies and programs with staff establishing a flexible and supportive approach to staffing, accommodations, and transportation during and after wildfires. For example, it may be necessary to shorten staff shifts during emergency operations to give them the ability to rest mentally and physically. Include daycare, shelter, and other accommodations for staff family members, as needed (Danna et al., 2010; Toner et al., 2017; WHO, 2020).

People and Operations

ACTION: **Integrate regular emergency preparedness employee training into the healthcare organization's continuing education program.**

SUMMARY: Implementing a regular emergency preparedness employee training program can increase awareness of climate change-related risks to the healthcare organization, as well as protocols and procedures designed to enhance resilience in the face of increasingly frequent and severe climate change-related events (Hilton et al., 2015; WHO, 2020). Include training on how key staff roles will be assigned during emergencies, and consider developing checklists for each department that break down key tasks according to when they should occur – pre-event, during response, and post-event (U.S. HHS, 2014).

Climate Resilience Actions, continued

ACTION: Ensure that staff who are supporting a wildfire response have access to clothing, a place to sleep, routine medications, and wellness services.

SUMMARY: Given the often-rapid evolution of wildfires and their impacts on community infrastructure, staff may be required to stay at their place of work for longer than a typical shift, without access to basic necessities such as a change of clothes and daily medications. Healthcare organizations can increase the resilience of their clinical services by ensuring that staff have access to clothing, a place to sleep, routine medications, and wellness services while they support patients in the midst of a disaster (Evans, 2017; Hilton et al., 2015; Morris et al., 2016; Toner et al., 2017).

ACTION: If wildfires destroy or cause long-term damage to facilities offering specific types of care, coordinate across the healthcare system to redistribute staff to facilities they can access – even if they are not at their "home" facility.

SUMMARY: It may be necessary following wildfire events that damage infrastructure to redistribute the healthcare system's staff to facilities they can access (Morris et al., 2016). Depending on the damage, facilities may need to expand or shift their services for months or even years following the event (Schulze et al., 2020). Establish a tracking system so that staff can report to supervisors who are physically located in different facilities (Wyte-Lake et al., 2018). Cross-training staff so that they can fulfill multiple roles can benefit the overall healthcare system by ensuring that essential clinical services are offered by a mixture of permanent and temporary staff (Hilton et al., 2015).

ACTION: Provide emergency housing for healthcare staff.

SUMMARY: Shelter is one of the greatest needs after a wildfire. Since many staff live in the community, they are likely to be both disaster survivors and responders. Consider establishing agreements with temporary housing facilities (such as hotels) to support employees and their immediate families (including pets) if their housing is affected by wildfire (either through direct damage or increased rental costs), so staff can safely return to work (Rosenthal et al., 2021; WHO, 2020).

ACTION: Establish a culture that acknowledges the personal challenges staff are facing during and after wildfires.

SUMMARY: Rebuilding after a wildfire can be an extended process, including in the realm of mental health. Some survivors may not experience mental health challenges until months or years after the event. Others may be retraumatized every time a wildfire ignites in the region (Rosenthal et al., 2021). Acknowledging the personal challenges faced by staff during and after a wildfire can increase a healthcare facility's resilience by increasing the willingness of staff who are able to report to work. It also creates space for staff to request tangible assistance (such as a hotel room, childcare, or mental health support) that would make it possible for them to support the disaster response (Morris et al., 2016; Toner et al., 2017).

ACTION: Provide staff support post-wildfire.

SUMMARY: Creating a post-disaster employee assistance program for staff and their families in the aftermath of a wildfire – including financial assistance when the clinic is not operating and 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 (Rosenthal et al., 2021; WHO, 2020). Immediate support for staff who have experienced a major loss (such as their home) can also increase their ability and willingness to return to work after the event (Morris et al., 2016). Consider offering permanent, wildfire-resilient housing options to full-time staff in areas where climate models predict worsening wildfire conditions over time and where economic models link wildfire with populations moving away from the area.

ACTION: Provide staff with wildfire resilience information for their homes.

SUMMARY: Prior to the start of wildfire season, healthcare organizations can share information with staff about how to inspect their homes and surrounding landscaping to ensure that they have cleared enough vegetation to create a so-called "defensible space" around the home, installed fireproof materials where possible on exterior walls and roofs, and removed roof spaces where embers could be sucked into the roof (Schulze et al., 2020).

Physical Infrastructure

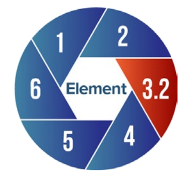
ACTION: Establish alternative communications channels for contacting staff during utility outages.

SUMMARY: Staffing during and immediately following wildfires that cause utility outages can be complicated by disruptions to telecommunications infrastructure. Establishing alternative communications channels (such as multiple cell phone providers, satellite phones, walkie-talkies, and installing a generator-powered cell tower on the roof of the facility) can increase a healthcare organization's resilience to these events by making it

Climate Resilience Actions, continued

possible to share important information with staff – such as facility closures and requests that staff report to the facility closest to their home (U.S. HHS, 2014; Morris et al., 2016; Wyte-Lake et al., 2018).

Element 3.2 Clinical Considerations



Wildfires can cause a surge in healthcare demand both in the communities directly impacted by fire and hundreds of miles away in communities exposed to airborne contaminants. First responders such as firefighters and emergency personnel who are working in hazardous conditions to contain the wildfire are at particular risk for both direct injury and long-term mental health challenges (SAMHSA, 2018). Communities that have been directly impacted by wildfire can experience long-term collective trauma, dramatically increasing demand for mental health services. For example, in the month following the Fort McMurray wildfire in 2016 in Alberta, Canada, mental health referrals jumped from an average of 1,200 per year to 20,000 per year (KPMG Canada, 2017). A qualitative analysis of evacuees three months and three years after the event found little change amongst respondents who reported anxiety/fear, hypervigilance, trouble sleeping, and other symptoms of post-traumatic stress disorder (Thériault et al., 2021).

Medical services hundreds of miles away from a fire can become stressed for weeks at a time due to widespread exposure to wildfire smoke in their community (Lichter et , 2024). During the Canadian wildfires in the summer of 2023, smoke from fires burning in Quebec affected air quality in New York City. Daily emergency department (ED) visits for asthma in New York City increased by 44% during this smoke wave period, compared with periods immediately before and after the event (Chen et al., 2023). In addition, wildfire smoke exposure has been found to be associated with increases in ED visits for anxiety (Zhu et al., 2024), underscoring the potential for a surge in mental and behavioral healthcare demand related to wildfire events.

Given the lengthy rebuilding process after many wildfire events, cross-organizational coordination may stretch into months and years following a given event. For example, following the 2018 Camp Fire in California, Adventist Health System redistributed the type of care offered by their hospitals and clinics in communities surrounding Paradise, the community that was most directly affected by the fire. Similarly, Canyon View Clinic, which primarily offered medical services before the fire, expanded its services after the fire to include behavioral health (Schulze et al., 2020).

Healthcare systems are encouraged to consider these potential sources of acute and longer-term patient surge in preparing facilities and staff for wildfire events, and to incorporate screening and outreach for at-risk patient populations in wildfire risk mitigation planning.

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
[Element 3.2: Clinical Considerations]

Planning

ACTION: **Develop a continuity of care plan listing essential clinical services that will be provided at different tiers of utility disruption.**

SUMMARY: Many healthcare facilities are designed to function at full or partial capacity under a variety of environmental stressors. Organizations can increase resilience to climate change-related events by creating and training staff to implement a continuity of care plan outlining essential clinical services that will be provided at different tiers of utility disruption (Toner et al., 2017).

Climate Resilience Actions, continued

ACTION: Enhance syndromic surveillance during and after wildfire events.

SUMMARY: Consider enhancing the healthcare system's syndromic surveillance during and after wildfire events by submitting wildfire-related illness data to the Electronic Surveillance System for the Early Notification of Community-Based Epidemics (Burkom et al., 2021), bearing in mind that the health effects of wildfire smoke can affect a wide geography, and persist over time. Exposure to wildfire can result in mental health challenges months and years after the event (Rosenthal et al., 2021). Long-term syndromic surveillance of post-traumatic stress disorder, anxiety, and other related mental health conditions in a community that experienced direct damage from a wildfire, as well as in communities where wildfire survivors relocated after the event, can be used by healthcare organizations and local public health officials to assess whether post-disaster services are meeting the long-term needs of survivors. In addition to the acute effects of wildfires, wildfire-related air pollution can trigger or exacerbate cardiovascular and respiratory disease, increase susceptibility to respiratory infections, and cause pregnancy complications. Work with local public health partners to interpret and act on real-time wildfire-related illness and all-cause morbidity and mortality data during and immediately following wildfire events.

ACTION: Enhance wildfire resilience by adding fire-, smoke-, air pollution-, mold-, and mental health-related screening to the healthcare EMR system.

SUMMARY: Consider including in your organization's wildfire preparedness plans a protocol for activating screening questions about fire-, smoke-, air pollution-, mold-, and mental health-related illnesses in the electronic medical record (EMR) system when a wildfire occurs (Hess at al., 2023). Acknowledge the different phases of health impacts from wildfire by including a timeline indicating which screening questions should be asked during the event, immediately following the event, and three months and beyond. Sensitive patient groups who might be flagged for additional screening and proactive outreach during wildfires include infants and children, pregnant women, people who work outside, older adults (especially those who live alone), low-income populations (particularly those who live in mobile homes and/or do not have the means to evacuate), people experiencing homelessness, and people with chronic conditions such as cardiovascular disease and respiratory disease. Identification through EMR screening allows healthcare providers to flag sensitive patient groups for appropriate intervention, including connection to social services, early symptom evaluation and therapeutics.

People and Operations

ACTION: Adjust normal procedures and standards of care ahead of wildfire exposure to expedite patient discharges, when possible, and to adjust the timing of routine treatment.

SUMMARY: Consider establishing protocols triggering an adjustment to the healthcare organization's clinical procedures (e.g., in pharmacy, drug treatment, dialysis, etc.) ahead of wildfire exposure to create contingency plans extending the amount of time existing patients can go without routine treatment if they are displaced by the wildfire. When possible, expedite inpatient discharge to free up bed space ahead of expected patient surges during and immediately following the event (Scott, 2017; Toner et al., 2017).

ACTION: Develop a plan for patient surges and train staff in its implementation that includes scenarios for accommodating cascading and simultaneous climate change-related disasters and acknowledges that surges may last for months.

SUMMARY: Many climate change-related events occur simultaneously or in quick succession. For example, wildfires, extreme heat, and drought often coincide. Additionally, wildfires can destroy primary care infrastructure, resulting in surges of patients using hospitals for primary care services for months or years after the event. Similarly, some of the physical and mental health challenges caused by the wildfire could persist in the community as chronic conditions (Rosenthal et al., 2021). It is, therefore, increasingly important to develop a plan for multifactorial and long-term patient surges and train staff in its implementation. Include procedures for bringing in temporary staff, adapting clinician services to fast-changing conditions, and altering the schedule for routine operating procedures to free up space and staff to provide emergency care (Toner et al., 2017).

ACTION: If it is necessary to evacuate patients during a disaster, consider sending nurses, nursing assistants, and leadership staff with them to ensure continuity of care.

SUMMARY: Hospitals that evacuated patients alongside care staff and their leadership team during Superstorm Sandy (2012) reported lower rates of anxiety about the evacuation among patients and their families (U.S. HHS, 2014).

Climate Resilience Actions, continued

ACTION: Plan for a potential uptick in primary care patients at hospitals and other critical facilities for months after a wildfire event.

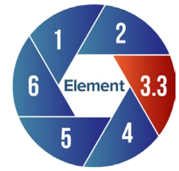
SUMMARY: Medical office buildings and physician offices can close permanently or for many months following direct exposure to a wildfire. Hospitals and other critical facilities often fill the gap in access to primary care until staffing levels are restored across the community (Rosenthal et al., 2021). Healthcare organizations at risk of wildfire can increase resilience by including a plan for managing a sustained surge in primary care patients in their emergency management plan.

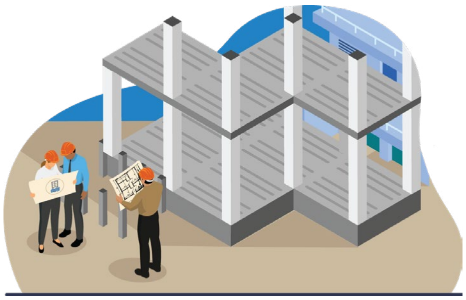
Physical Infrastructure

ACTION: Deploy mobile health units to take medical care to high-risk patients in the community during power and transportation disruptions.

SUMMARY: Consider including in the healthcare organization's list of emergency response assets mobile units that are used to deliver routine care to community members. For example, during rolling blackouts designed to reduce wildfire risk, mobile clinics could help patients dependent on electrically powered medical devices like oxygen compressors charge their backup batteries (Rosenthal et al., 2021). Use the organization's map of high-risk patients – such as patients who need dialysis or those with a substance use disorder, diabetes, or heart disease – (Element 2.1) to prioritize the provision of medical care during transportation disruptions caused by a wildfire event (Toner et al., 2017).

Element 3.3 Building and Campus: Design & Construction





Facilities located in or near wildfire-prone areas are susceptible to damage or destruction from wildfires, windblown embers, transportation disruptions, and the transformation of wildland fires into structure fires, impacting safety, functionality, and accessibility. Building codes require structural redundancies to protect against wildfires, but additional measures are needed for facilities in high-risk areas to withstand the specific threats posed by wildfires (Bedi et al., 2023). For example, buildings on the Feather River Hospital campus in Paradise, California, experienced both structural and nonstructural damage from the Camp Fire in 2018. Several buildings with light-gauge steel joist floor framing partially collapsed during the fire even though their walls were constructed out of concrete masonry unit block. Campus buildings that had not sustained structural damage were prevented from resuming clinical care after the fire because the roof of the main utility building collapsed, damaging the central energy and water supply to all buildings on campus. Roof damage to other buildings on campus further compromised building-specific HVAC systems and emergency generators. Rains after the event caused moisture damage and, eventually, mold growth in buildings whose roofs were damaged by falling embers (Schulze et al., 2020).

Healthcare organizations can adopt advanced design and construction practices that enhance building resilience, protect against windblown embers, ensure functional transportation routes, and prevent wildland fires from becoming structure fires. Design features that improve facilities' ability to withstand disruptions in the power grid can increase resilience to wildfire events. For example, Valley Children's Hospital in Madera, California, is regularly affected by regional power outages from wildfires. To combat this challenge, the hospital is installing a solar microgrid with on-site battery storage that will keep the hospital running even when the traditional grid fails (U.S. HHS OCCHE, 2024).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 3.3: Building and Campus: Design & Construction

Planning

ACTION: When constructing a new healthcare facility in a community at risk of wildfire, select a location that minimizes exposure to risk.

SUMMARY: Critical infrastructure like hospitals and health clinics are less likely to sustain damage from wildfire if they are separated from dense vegetation that could act as fuel, are built far from the top of steep slopes, are connected to multiple access routes, and have reliable, on-site water supplies that could be used by firefighters (International Code Council, 2021).

ACTION: In regions at high risk of wildfire, consider requiring all new construction and major renovations to comply with the IWUIC.

SUMMARY: The International Wildland Urban Interface Code (IWUIC) supplement of the International Building Code sets minimum standards for building design and location on a property in a region at high risk of wildfire. Healthcare organizations in regions at high risk of wildfire – particularly structures that have been designated by the local office of emergency management as critical infrastructure – can increase resilience to wildfire by adopting the IWUIC model code for all new construction and major renovations (Schulze et al., 2020).

Climate Resilience Actions, continued

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 wildfires.

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, identify opportunities for diversifying their energy supply (such as installing renewable power microgrids for backup power), and enhance their filtration systems to extend the functional life of the building as long as possible within the context of 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 & Chan, 2017).

Physical Infrastructure

Structure and Landscaping

ACTION: Install native, drought- and wildfire-resistant landscaping at an appropriate distance from the building to reduce the production of fuel before a wildfire and the risk of erosion afterward.

SUMMARY: Installing native, drought-resistant landscaping can reduce utility costs (both energy and water), increase the length of time a facility can rely on emergency water supplies during a wildfire, reduce risk that a wildfire will destroy the healthcare facility, and reduce the risk of erosion after a wildfire event (Belongia et al., 2023; Chu et al., 2023).

ACTION: Use green infrastructure practices to absorb rainwater on-site and reduce the risk of erosion.

SUMMARY: Wildfire can cause erosion if it destroys enough vegetation on steep slopes (Agbeshie et al., 2022). Healthcare organizations in areas at risk of wildfire-related erosion can enhance resilience by using green infrastructure practices, like rain gardens that maximize the amount of rainfall absorbed on-site instead of leaving the site as stormwater (U.S. Climate Resilience Toolkit, n.d.a.).

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 multimodal evacuation plans when they are deployed during a wildfire event (Basu et al., 2022).

ACTION: Design healthcare facilities in wildfire-prone areas with fireproof roof and exterior wall materials, eaves and vents that resist wildfire embers, and defensible space around facilities.

SUMMARY: Healthcare facility design can reduce the risk of harm from wildfire by instituting a three-pronged approach: fireproof building materials, envelope details that reduce the risk of embers entering the building, and design landscaping to leave a defensible space around the building to reduce the risk of wildfire fuel accumulating next to the building (Scalingi, 2021).

ACTION: Fireproof healthcare facilities to increase their resilience to wildfire.

SUMMARY: New healthcare facilities must be designed with noncombustible materials that have adequate fire resistance ratings and do not emit toxic gasses or smoke during fires. Retrofitting existing facilities may involve replacing flammable materials like light-framed wooden walls with fire-resistant alternatives, such as gypsum or concrete board. To establish continuous fireproof partitions, commonly referred to as fire compartments, boards should connect with solid concrete floors, walls, and other elements. Flammable materials must be protected, removed, or replaced with fire-retardant alternatives. Glass doors and windows, ceiling tiles, and floor finishes should also be fire retardant. Fire doors must be installed between compartments and at stairwell landings and must be self-closing to enhance safety during wildfire events (PAHO, 2014).

Climate Resilience Actions, continued

ACTION: Design new buildings and reinforce existing structures to withstand exposure to both wildfire and wildfire smoke.

SUMMARY: Wildfire can damage or even destroy healthcare facilities and supporting infrastructure, particularly if it coincides with low water levels due to drought. Wildfire smoke can contaminate healthcare facility ventilation systems and leave a residue on surface materials. Its aftermath can lead to flooding, landslides, and ongoing challenges with quantity and quality in water distribution systems (Belongia et al., 2023; Scalingi, 2021). Healthcare organizations can reduce the risk of wildfire causing sufficient physical damage to shut down operations by designing and renovating facilities to withstand future climate change-related exposures as described in their prospective risk assessment (Element 1) (U.S. HHS, 2014).

ACTION: Install fire-safety barriers between key zones of larger buildings like hospitals to prevent damage to the entire facility if one area sustains damage.

SUMMARY: Separating key functions within a healthcare facility with fire-safety barriers can protect portions of the building that do not experience direct combustion from a falling ember or approaching wildfire. For example, the roof of the emergency department (ED) at the Adventist Health Feather River Hospital in Paradise, California, collapsed during the Camp Fire. However, the fire-safety double doors separating that department from the main hospital protected the remainder of the facility from sustaining structural damage from the fire (Schulze et al., 2020).

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 at which they can generate sufficien electricity using on-site renewable power (e.g., solar, wind, and geothermal). These facilities can continue to provide clinical care during disasters that disrupt regional power grids.

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

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 disasters (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 to on-site power storage capacity can reduce a healthcare facility's reliance on external power sources needed to maintain continuity of care (Isa et al., 2018).

ACTION: Install energy efficient building equipment to extend the length of time the facility can function on backup 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 during which the facility can function on backup power systems (Carvallo et al., 2022).

Water Efficiency

ACTION: Maximize water efficiency to reduce demand during low water pressure and boil water notice events.

SUMMARY: Water is critical to the functioning of healthcare facilities – both clinical and building systems. To maximize the availability of potable water for clinical uses, consider minimizing once-through use in process equipment – such as the HVAC system, sterilizers, and medical equipment. Further, consider installing low-flow toilets, urinals, handwash stations, and showers – except where volume is needed for occupational uses (such as water filling stations and decontamination showers) (Van der Heijden, 2022; WHO, 2015).

ACTION: Protect the permanent and emergency water supply from extreme weather and contamination from wildfire.

SUMMARY: Weatherize water supply pipes, cisterns, and tanks to prevent wildfire-related contamination. Place emergency water storage (such as tanks and cisterns) outside of or buried beneath areas at risk of flooding, landslides, or wildfire risk. Install float valves and overflow outlets that drain away from the facility to avoid flooding

Climate Resilience Actions, continued

interior spaces after a cistern or tank fills up. Install one or more supplementary water pumps (depending on need) and connect them to the emergency power supply to keep water pressure at safe levels when the power goes out (Van der Heijden, 2022; WHO, 2015).

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 and after wildfires, particularly if they co-occur alongside droughts. Healthcare facilities in regions that climate models have indicated are at risk of increased exposure to wildfire can build resilience by developing supplementary water sources (such as connections to allow temporary water supply from trucks or other sources, permanent storage tanks/cisterns, and wells) that can be used to maintain water pressure during low pressure events. Separating process water systems from potable water systems further enhances resilience by allowing supplementary potable water sources to serve occupant-facing plumbing fixtures while separate non-potable water sources serve process uses (such as the air conditioning system) (Belongia et al., 2023; Healthcare Environmental Resource Center, 2015; Van der Heijden, 2022; WHO, 2015).

Thermal Comfort and Indoor Air Quality

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) coupled with 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).

ACTION: Isolate ventilation systems during poor air quality events.

SUMMARY: Certain areas of healthcare facilities need to maintain extremely clean air to avoid harming patients. For example, patients in surgical suites, bone marrow transplant wards, and intensive care units are often at high risk of infection. Designing and maintaining the ventilation system in these areas so they can isolate from the rest of the facility could increase the facility's resilience to poor air quality events like dust storms and wildfires by providing more highly filtered air to the highest risk patients (U.S. Climate Resilience Toolkit, n.d.b.).

Resilient Critical Operating Systems

ACTION: Place EMR servers and equipment in climate-controlled spaces that are protected from wildfire.

SUMMARY: To ensure that medical information systems remain functional during wildfire-related power outages, place them in climate-controlled spaces that are hardened against wildfire, connected to an emergency generator, and/or off-campus (such as a duplicate paper record storage site) ((Swanson et al., 2010; U.S. HHS, 2014).

ACTION: Install redundant communication systems for use during power and communications outages.

SUMMARY: Extreme weather events can disrupt electricity supply, cell towers, radio transformers, and other community communications networks. Healthcare organizations can reduce the risk of disruption in communications to other facilities in their network, regional healthcare organizations, and local emergency management agencies by installing and maintaining redundant communication systems, such as analog phones, fax machines, handheld two-way radios, ham radios, and solar-powered devices (Hedges et al., 2018).

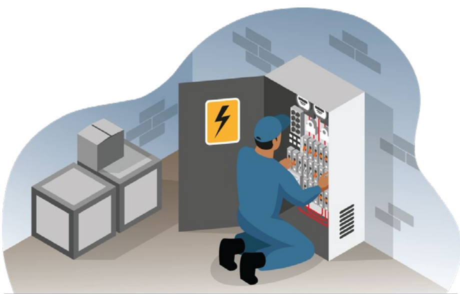
ACTION: Place redundant IT systems off-site to increase the resilience of EMRs.

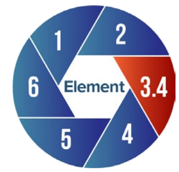
SUMMARY: Placing redundant information technology (IT) systems off-site can reduce the risk of the electronic medical record (EMR) system going offline during wildfire events (Danna et al., 2010; Toner et al., 2017).

ACTION: Place the healthcare organization's critical infrastructure in spaces hardened against wildfire.

SUMMARY: Placing equipment crucial to research, education, and patient care (such as labs, medical equipment, and IT equipment) and building systems (such as emergency generators, pumps, and electrical switches) in climate-controlled spaces that are hardened against wildfire and connected to an emergency generator can reduce the likelihood of disruptions to patient care and research resulting from wildfire (U.S. HHS, 2014; Scott, 2017).

Element 3.4 Building and Campus: Facility Operations





Healthcare buildings are vulnerable to power outages because they rely on electricity, plumbing systems, and energy sources, like natural gas, to operate critical systems for patient care and occupant safety, such as lighting, air conditioning, medical equipment, and electronic medical records. Connecting facility systems to backup power supplies and implementing measures to maintain essential services during power disruptions can enhance resilience during wildfire events. For example, most hospitals are sealed buildings, and the loss of power during wildfires can cause internal temperatures to rise to dangerous levels. Additionally, many hospitals do not connect their HVAC systems to backup power, leading to increased indoor temperatures and compromised patient care during power outages (Patel et al., 2022; Balbus et al., 2016). Healthcare organizations can ensure that facility systems are connected to reliable backup power supplies, maintain cooling and ventilation systems during power outages, and provide essential services, like food, clean water, and custodial care to, inpatients during wildfire events.

Southern California's Providence Holy Cross Medical Center was able to remain operational during two major 2008 wildfires, the Sesnon and Sayre fires, through proactive use of High Efficiency Particulate Air (HEPA) filters initially purchased for pandemic flu preparedness (Thomas, 2011). This approach allowed the hospital to maintain indoor air quality and continue treating patients despite outdoor air pollution from the encroaching fires.

During the 2017 Thomas Fire in California, Ventura County Medical Center implemented advanced air filtration systems and established clear evacuation protocols to maintain operations and protect patients and staff (Jones et al., 2020). When wildfires caused significant smoke pollution in interior Alaska in summer 2024, Fairbanks Memorial Hospital converted two conference rooms into clean-air respite rooms for community members, by running HEPA filters that made these spaces freely available (Bengel, 2024).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 3.4: Building and Campus: Facility Operations

Planning

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

SUMMARY: Pre-wildfire resilience measures include: (1) maintaining building systems to maximize the efficient use of energy and water to enhance filtration; (2) maintaining building envelope and roofing sealants; (3) diversifying the energy and water supply; (4) increasing insulation and solar reflection for the facility walls and roof; and (5) performing routine maintenance to cut back wildfire fuel and maintain a defensible space around buildings (Casanueva et al., 2019; Schulze et al., 2020).

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

SUMMARY: Utilities in wildfire-prone regions like California preemptively shut down power in communities at risk of igniting wildfires. For example, electric utility PG&E cut power nine times in the state in 2019, sometimes for up to one week (Scalingi, 2021). Healthcare facilities can increase resilience to power outages by creating a load-shedding protocol that powers down building

Climate Resilience Actions, continued

systems based on their level of importance to clinical care. Facilities relying on solar photovoltaic (PV) panels to offset some or all of their emergency power can increase resilience to wildfire by reducing their expectations of electricity generation during wildfire events due to atmospheric smoke and dust reducing the amount of solar radiation reaching the panels. Connecting the facility's microgrid to an energy storage system further enhances resilience by addressing the "wiggle effect," which occurs when the output from a PV array changes suddenly (Bošnjaković et al., 2023). Consider cross-referencing the protocol with stages of evacuation preparation so that patient transfers to partner facilities take place before conditions (such as extreme temperatures, exposure to flood waters, etc.) reach dangerous levels (FEMA & ASPR, 2019).

ACTION: To mitigate the risk of widespread wildfire-related damage to utilities and community infrastructure, include security considerations in the healthcare facility's emergency preparedness plan.

SUMMARY: Wildfires that cause widespread damage to utilities and community infrastructure can result in a temporary need for increased security at a healthcare facility, particularly if it experiences a patient surge and/or acts as a place of respite for community members (Danna et al., 2010).

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

SUMMARY: Pre-wildfire event resilience measures in healthcare facilities include maintaining building systems to maximize energy efficienc and high efficiency filtration, diversifying the energy and water supply (such as installing renewable power and battery storage for backup power and sourcing an emergency water supply), increasing insulation in facility walls and roof, maximizing the use of fireproof materials on the building exterior, and performing routine maintenance to seal cracks that could allow wildfire embers to infiltrate the building structure and/or particulate matter to infiltrate the interior of the facility (Casanueva et al., 2019).

ACTION: Perform a baseline analysis of water usage and categorize usage types into tiers of critical need.

SUMMARY: Water is a critical component of clinical care, including sanitizing medical equipment. Performing a baseline analysis of the healthcare facility's water usage and categorizing usage types into tiers of critical need can help facility managers direct potable water supply to the most important clinical needs during low water pressure and boil water notices while also reducing overall facility water usage (WHO, 2015; Van der Heijden et al., 2022).

People and Operations

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

SUMMARY: Consider performing regular stress tests of the healthcare facility's ability to continue providing clinical care during wildfire and smoke events. Incorporate scenarios that involve power outages, low water pressure, a surge of patients experiencing wildfire-related illness, a surge of all-cause complaints, and a surge of community members seeking to use the facility as a resilience hub and safe place to charge electrical devices (including medical equipment). Stress tests can help identify critical systems (such as vacuum suction systems and electricity-dependent medication delivery systems) whose failure due to extreme temperatures, exposure to smoke particulate matter, and/or power or water outages would result in cascading effects across the facility and impact delivery of critical care (Ebi et al., 2018).

ACTION: Conduct regular tests of emergency generators, water supplies, and transportation plans to ensure that they are ready to deploy in the event of an emergency.

SUMMARY: Healthcare organizations can perform regular tests and maintenance on emergency generators and on-site sources of emergency water. It can also be helpful to perform regular drills with outside contractors who will be responsible for supplying more fuel, trucked-in water, emergency transportation for staff and patients, and other activities included in the facility's emergency operations plan (U.S. HHS, 2014).

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 demands remain at levels that can be met by on-site sources, such as renewable power and recycled process water (Kolokotsa et al., 2012).

Climate Resilience Actions, continued

Physical Infrastructure

ACTION: Conduct regular walk-throughs of the healthcare facility to confirm compliance with fire safety and evacuation signage requirements.

SUMMARY: Facility evacuation can be impeded if exits are obstructed, signage is missing or confusing, or life safety equipment, like sprinklers and fire extinguishers, is missing or broken. Conducting regular walk-throughs of the healthcare facility to confirm that these essential emergency preparedness components are in place and in working order could be seen as a first level of resilience to wildfires that might damage the building structure or result in an eventual evacuation (U.S. HHS, 2014).

ACTION: Implement a wildfire landscape mitigation protocol so that potential fuel is regularly removed from planted areas on the healthcare campus ahead of potential wildfire events.

SUMMARY: Performing active fire management in coordination with regional wildfire control agencies on the healthcare organization's campuses in wildfire-prone areas can significantly enhance the organization's resilience to wildfire, as well as that of the surrounding community (Belongia 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: Install smoke filters in facility air conditioning, heating, and ventilation systems.

SUMMARY: Wildfire smoke contains particles and aerosols that are harmful to human health. Consider installing filters that remove those contaminants from the facility HVAC system, so that indoor air quality remains healthy during wildfire events. Older systems may not be compatible with higher efficiency filtration systems (such as MERV13). In those cases, supplemental plug-in filters may be necessary. Filters should also be replaced quarterly and after major air pollution events such as a wildfire. This may require updates to the system or policies that include using charcoal filters and frequent air filter replacement (U.S. Climate Resilience Toolkit, n.d.b.).

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: Prior to an anticipated wildfire event, walk through the facility to identify locations that might require repair during and immediately following the event and stage the necessary materials and equipment nearby.

SUMMARY: Certain locations in and around the healthcare facility – such as the roof, windows, and lower floors – are especially vulnerable to damage from wildfire. Healthcare organizations can reduce the risk of disruption to clinical operations by identifying likely repair needs prior to the event and staging the relevant construction materials and equipment within easy reach to minimize the impact of minor leaks, broken windows, and other building damage on regular facility operations (ASPR TRACIE, 2023 b.).

ACTION: During poor air quality events, isolate ventilation systems.

SUMMARY: Certain areas of healthcare facilities need to maintain extremely clean air to avoid harming patients. For example, patients in surgical suites, bone marrow transplant wards, and intensive care units are often at high risk of infection. Designing and maintaining the ventilation system in these areas so they can isolate from the rest of the facility could increase the facility's resilience to poor air quality events like dust storms and wildfires by providing more highly filtered air to the highest risk patients (U.S. Climate Resilience Toolkit, n.d.b.).

ACTION: During poor air quality events, use portable air scrubbers when the building ventilation system is shut down.

SUMMARY: Consider placing portable air scrubbers in nursing units to remove harmful particles and aerosols from indoor air if the overall building ventilation system has been shut down to reduce the amount of harmful air pollution entering the building during a wildfire, dust storm, chemical fire, or other air-related disaster (U.S. Climate Resilience Toolkit, n.d.b.).

Climate Resilience Actions, continued

ACTION: During a wildfire event, change the volume of outdoor air introduced to the healthcare facility in response to on-site indoor and outdoor particulate matter (PM2.5) monitors.

SUMMARY: Central air conditioning and enhanced filtration systems have been associated with improved indoor air quality during wildfire events (Liang et al., 2021). Healthcare organizations can enhance resilience to wildfire smoke by installing particulate matter (PM2.5) air monitors both inside and outside their facilities and setting exposure thresholds for limiting the volume of outdoor air introduced into the facility so that wildfire-related particulate matter does not overwhelm the HVAC system.

ACTION: After wildfire smoke events, thoroughly clean hard surfaces, as well as the HVAC systems, and consider replacing soft materials that may have absorbed contaminated smoke particles.

SUMMARY: Wildfire smoke is often contaminated with toxins from building materials and fire suppression chemicals. Once inside a facility, smoke residue can infiltrate building systems and be absorbed (Laguerre & Gall, 2024). Remediation may require multiple rounds of cleaning and air scrubbing before the facility is safe to resume operations. Healthcare organizations can accelerate the cleaning process by enhancing daily cleaning procedures and using enhanced filtration and air scrubbers during the wildfire event to minimize the amount of wildfire residue collecting in the facility. After the event, replacing ongoing sources of wildfire particulate matter (such as soft surfaces like cushions and carpet) with new materials, performing a thorough cleaning of the HVAC system, and continually monitoring indoor and outdoor air can help expedite the process of bringing the facility back to pre-fire indoor air quality levels.

ACTION: After wildfire events, implement a wildfire smoke protocol to repeatedly clean ventilation, filtration, and air distribution systems, as well as soiled surfaces.

SUMMARY: Wildfire smoke can leave a legacy of ongoing indoor air contamination and residue on surfaces throughout a healthcare facility. Consider developing protocols for repeatedly cleaning ventilation, filtration, and air distribution systems, as well as soiled surfaces after wildfire events. Start implementing wildfire smoke cleaning protocols during the event to minimize occupant exposure and continue until occupational health personnel designate the facility free of wildfire smoke residue (Scalingi, 2021).

ACTION: Clean and cool solar arrays during and after wildfire smoke events to reduce the risk of impaired performance caused by smoke residue.

SUMMARY: Solar arrays function at highest capacity when they are clean and not subject to extreme hot or cold temperatures (Bošnjaković et al., 2023). Developing a cleaning and cooling protocol specific to wildfire, extreme heat, and drought events can increase their utility if the facility or campus is islanded from the central electrical grid. For example, the Blue Lake Rancheria Tribe microgrid lost between 4% and 13% in incremental power output due to wildfire residue during the 2017 wildfire season (Carter et al., 2019).

Element 3.5 Supply Chain

Many clinical and non-clinical items in a healthcare organization's supply chain require refrigeration. Healthcare organizations can enhance resilience by developing and implementing a plan for managing their refrigerated supply chain and on-site storage during wildfire-related regional power outages (Rublee et al., 2021). In addition, damage to transportation routes and production facilities can disrupt supply chains. Diversification of supply sourcing for critical products is one critical feature of increasing healthcare supply chain resilience to wildfires and other hazards (Wright et al., 2024). For example, at the onset of the Thomas Fire in 2017, Ventura County Health Care Agency in Southern California activated their internal Incident Command Center. The Command Center worked with the Agency's procurement contractor to enact a respiratory disaster plan so that critical supplies like face masks would be ready for deployment to the hospital should they become necessary. When supplies began to run low, the Chief Executive Officer of Ventura County Medical Center personally called their supply vendor to request additional emergency shipments of face masks, air purifiers, and other respiratory supplies to stock the hospital, partner healthcare organizations, and local first responder organizations. The hospital further managed their supply chain limitations during the emergency by postponing elective surgeries (Sandoval, 2018).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
[Element 3.5: Supply Chain]

Planning

ACTION: Integrate medical supply storage into resilience planning.

SUMMARY: Consider how your organization's prospective risk assessment of wildfires (Element 1) might lead to supply chain disruptions and/or changing needs. Maintain an adequate supply of medical supplies, particularly for products that are most vulnerable to weather-related disruptions in transportation routes (Hedges et al., 2018). Consider separating emergency supplies into two categories: high-volume medical supplies (such as intravenous bags, sharps, and oxygen) and equipment/supplies that would only be needed during a disaster. Establish a timeline for activating the supply chain plan ahead of the wildfire event (Maslanka & Hurwitz, 2022).

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 evolving wildfire risks can inform contingency planning and emergency preparedness planning, including establishing redundancy among providers for critical supplies (Lakatos et al., 2023; Sherman et al., 2023).

People and Operations

ACTION: Require suppliers of essential goods and services to provide a continuity of operations plan for wildfire.

SUMMARY: Healthcare organizations are dependent on a large network of vendors to supply goods and services that are essential to facility operations and continuity of care. Additionally, healthcare facilities in regions at

Climate Resilience Actions, continued

high risk of wildfires may be located in rural areas with only one or two access routes for large scale shipments. Vendors with local supply chains – for example, farm to hospital operations – may be vulnerable to regional wildfire conditions. Requiring suppliers of essential goods and services to provide a continuity of operations plan is an important step in building the healthcare organization's resilience to all climate-related disasters, especially drought (Sandoval, 2018; Toner et al., 2017).

ACTION: Stockpile potable water.

SUMMARY: Maintaining a stockpile of potable water, either inside the healthcare organization's storage facilities or through a contract with external vendors, can bridge the gap for both medical procedures and community services (i.e., sharing bottled water with community members) during water shortages (Hedges et al., 2018).

Physical Infrastructure

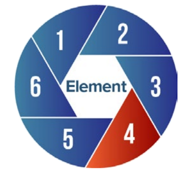
ACTION: Boost the resilience of refrigerated storage areas.

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).

ACTION: Store essential medical supplies, food, and fuel lasting 5–7 days on or near the healthcare campus to facilitate rapid deployment ahead of wildfires.

SUMMARY: As the severity of wildfires and duration of related disruptions increase due to the effects of climate change, it has become increasingly important to stockpile medical supplies, food, and fuel on or close to a healthcare facility campus in case utilities and transportation infrastructure are disrupted for multiple days (Danna et al., 2010).

Element 4. Collaboration Between Healthcare Organizations



Multiple healthcare facilities within a geographic region may be threatened by a single wildfire event. Therefore, collaboration between healthcare organizations is important for joint planning and training for potentially complex evacuation scenarios. For example, in 2018, Colorado's Spanish Peaks Regional Health Center needed to evacuate more than 100 inpatients and nursing home residents during one of the largest wildfires in the state's history. Years of practicing and refining evacuation procedures in partnership with regional healthcare organizations helped Spanish Peaks to identify and mitigate challenges related to transportation and transfer of patient records, and allowed seamless communication and coordination with the receiving facility, a critical access hospital over 100 miles away (ASPR TRACIE, 2020).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
[Element 4: Collaboration Between Healthcare Organizations]

Planning

ACTION: Create plans to increase the resilience of critical outpatient care during and after wildfire events.

SUMMARY: Create contingency plans in coordination with regional healthcare partners to ensure that individuals with chronic physical and/or mental health conditions – who are at high risk due to potential interruptions in medication administration or outpatient care – have access to alternative arrangements if their usual care becomes unavailable or inaccessible due to wildfire damage (Rosenthal et al., 2021; WHO, 2020).

ACTION: Enhance healthcare organization preparedness for wildfires through mutual aid MOU.

SUMMARY: Wildfires can completely destroy one community but leave the town next door relatively free of direct fire damage. As a result, communities near the damage often become the primary source of shelter, social services, and medical aid for survivors. Establishing a mutual aid memorandum of understanding (MOU) with other healthcare providers in the region that includes the results of a prospective risk assessment (Element 1) can help engage all relevant partners well ahead of fire season – recognizing that healthcare organizations may be the primary source of aid one year and its primary recipient the next (Rosenthal et al., 2021). Prepare for circumstances that require patient transfers or referrals – such as utility outages, patient surges, etc. It is important to address legal and reimbursement challenges that can limit a facility's ability to quickly and efficiently transfer patients and/or supplies to other facilities in the region (U.S. HHS, 2014; Patel et al., 2022).

ACTION: Exchange epidemiological data and health assessments related to wildfire risk and exposure to smoke with other healthcare organizations and the local health department.

SUMMARY: Exchanging epidemiological data and health assessments related to wildfire risk and smoke exposure with other healthcare organizations and the local health department can support regional climate resilience planning efforts. Use these conversations to jointly develop protocols for identifying emerging climate-related health threats in the region, collecting and disseminating data, and coordinating emergency response across the range of facility types in the regional health system – including acute care hospitals, community clinics, and long-term care facilities (Patel, 2022).

Climate Resilience Actions, continued

ACTION: Integrate an analysis of cross-institutional collaboration in regional after-action reviews of wildfires.

SUMMARY: As part of a wildfire emergency management plan, include an after-action analysis of interdisciplinary coordination within the organization, as well as with other regional healthcare organizations and the local office of emergency management to assess how well the emergency response system functioned as a whole. Consider including prospective climate metrics (Element 1) as one indicator of the system's resilience to future events (Davies et al., 2019; Parker, 2020).

ACTION: Perform joint disaster preparedness exercises and drills with other local healthcare organizations, the local health department, and the local office of emergency management.

SUMMARY: Joint disaster preparedness exercises and drills can help healthcare organizations test their readiness for wildfires (and simultaneous and cascading events), identify areas for improvement in their emergency response plans, and build working relationships with other first responders. Including representation from multiple institutions and professions in the exercise can also help identify emerging at-risk populations who are projected in climate models to require more protection and/or resources as wildfires occur more frequently and/or with greater severity (ASPR, 2024; WHO, 2020).

ACTION: Share resources and coordinate personnel during wildfires.

SUMMARY: Collaboration between response organizations may involve sharing critical resources and coordinating the deployment of personnel to support impacted communities in areas of greatest need (Patel, 2022). Consider integrating the results of the organization's prospective risk assessment (Element 1) into planning conversations to funnel resources to new and emerging at-risk populations related to the changing climate.

ACTION: Work with other regional healthcare organizations to develop integrated patient evacuation plans.

SUMMARY: Healthcare organizations can increase their own and regional resilience by working together to develop integrated emergency evacuation plans. Consider including contingency plans to address damage to a facility's structure, exposure to contaminated air and/or water damage, power and water outages, destruction of electronic medical records, infrastructure failures, and an ambulance shortage. Contingency plans may involve transferring patients to alternate facilities or establishing temporary medical sites in safer areas (U.S. HHS, 2014; Patel, 2022).

People and Operations

ACTION: Collaborate with regional healthcare organizations on public health education and outreach programs.

SUMMARY: Healthcare institutions can collaboratively develop and disseminate public health education and outreach programs so that the community receives a consistent and coordinated message about wildfires, protective behaviors, and access to resources such as healthcare services (California Department of Public Health, 2022).

ACTION: Consider proactively credentialing neighboring healthcare facility staff to help execute the healthcare organization's emergency preparedness protocol.

SUMMARY: Proactively credentialing staff at neighboring healthcare facilities to prepare for emergencies can contribute to backup care if one facility is unable to provide care due to wildfire-related utility interruptions (WHO, 2020).

ACTION: Establish effective communication channels to share real-time information across healthcare organizations during wildfires.

SUMMARY: Consider working with other healthcare organizations and entities in the region to establish effective real-time communication channels with one another and the public during wildfires. Examples of critical information that can be shared this way include information about wildfire progression, who should evacuate, where evacuees should go, which healthcare facilities are open to receive new patients and/or community members seeking refuge, real-time information about the number of beds available in the region and consistent definitions for each bed type, and levels of critical medical supplies needed and available for each facility in the cooperation network (CDC, 2003; California Department of Public Health, 2022; U.S. HHS, 2014).

ACTION: Share resources and coordinate personnel during and after wildfires.

SUMMARY: Collaboration between response organizations may involve sharing critical resources and coordinating the deployment of personnel to support impacted communities in areas of greatest need (Patel, 2022). Consider integrating the results of the organization's

Climate Resilience Actions, continued

prospective risk assessment (Element 1) into planning conversations to funnel resources to new and emerging at-risk populations related to the changing climate.

Physical Infrastructure

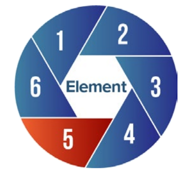
ACTION: Build out alternative communications channels to help regional healthcare organizations share real-time information with each other during wildfires.

SUMMARY: Interorganizational cooperative agreements for sharing resources and transferring patients during wildfires depend on real-time communication among facilities in the network. For example, the 2017 Thomas Fire in California caused outages to both telephone landlines and cell towers, creating barriers to communication both within healthcare organizations and with external partners (Sandoval, 2018). Building out alternative communications channels connecting healthcare organizations with each other (such as multiple cell phone providers, satellite phones, walkie-talkies, and generator-powered cell towers on the roof of key facilities) can increase the effectiveness of the entire network's emergency response (U.S. HHS, 2014).

Office of Climate Change and Health Equity

Resilience Strategies: Wildfire

Element 5. Interdisciplinary Planning, Oversight, and Evaluation



An interdisciplinary approach to planning, oversight, and evaluation across critical dependencies is essential for comprehensive wildfire emergency preparedness planning. Healthcare organizations can learn from the experiences of hospitals affected by direct encroachment and smoke from California wildfires in the 2010s. Lessons learned include the need for (1) the implementation of facilities management and landscaping strategies that mitigate the risk of damage to buildings, (2) contingency plans for power outages, (3) protocols for stockpiling critical supplies and proactively deploying advanced air filtration, and (4) regular evacuation drills (Fink, 2022 b.). These components of wildfire preparedness require collaboration between multiple functions in the healthcare organization, such as administrative leadership, facilities, clinical operations, emergency management, supply chain, and purchasing. Sustained collaboration between these functions is required to evaluate and refine plans following wildfire events.

Furthermore, different facility types may need to fill different gaps in wildfire emergency preparedness. For example, a study of U.S. nursing homes found that nursing homes exposed to wildfire risk in the Mountain West and Pacific Northwest were more likely to exhibit deficiencies in emergency preparedness than unexposed nursing homes. The study also found that the greatest deficiency in nursing home emergency preparedness in the Mountain West, Pacific/Southwest, and Pacific Northwest was conducting testing and emergency preparedness exercises (Festa et al., 2023).

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 5: Interdisciplinary Planning, Oversight, and Evaluation

Planning

ACTION: Implement surveillance and interdisciplinary after-action reviews in organizational hazard action plans.

SUMMARY: Incorporate building surveillance and interdisciplinary after-action reviews into the healthcare organization's wildfire plan. These measures will help identify and evaluate the elements of the plan that worked during a recent event, assess whether changing climatic conditions might have influenced aspects of the event (such as its severity), and change the parts of the plan that did not meet expectations. The after-action review should be tailored to the specific disaster type experienced (Hess et al., 2023; Parker, 2020).

ACTION: Incorporate interdisciplinary approaches into wildfire planning.

SUMMARY: Consider incorporating interdisciplinary approaches into the healthcare organization's wildfire planning process since wildfires can impact a range of dependencies – such as infrastructure, clinical care, energy systems, and waste management (Rogers et al., 2020).

ACTION: Incorporate long-term goals and climate projections into healthcare wildfire planning and response plans.

SUMMARY: It can be helpful to integrate long-term, interdisciplinary strategic goals into the healthcare organization's wildfire emergency preparedness and response plans – including community input as outlined in the Justice, Equity, Diversity, and Inclusion (JEDI) framework (American Public Health Association & CDC, 2021).

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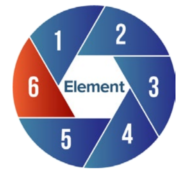
Resilience Strategies: Wildfire

CR4HC

Element 6. Communications and All-Hazards Approach



Wildfire events often occur simultaneously or in quick succession with other climate change-related hazards, such as heat waves and drought. In addition, damage from wildfires can exacerbate the effects of other disasters by contributing to water and soil contamination, erosion, and flooding. These coinciding and cascading events can increase the risk of multisystem failures at the community scale (such as disruptions to water and power utilities), causing both direct and indirect harm to population health. Taking an all-hazards approach to emergency management and climate resilience planning can enhance organizational resilience to multiple climate-related hazards. For example, public-facing messaging that emphasizes protective interventions that can simultaneously mitigate risk from multi-hazard events (such as wildfire smoke and heat exposure) can be helpful to prevent health harms from coincident climate-related hazards (Coker et al., 2024).

Link to the Fifth National Climate Assessment, Chapter 18, for more information.

Climate Resilience Actions

Tools and resources relevant to these actions can be found in the appendix:
Element 6: Communications and All-Hazards Approach

Planning

ACTION: Collaborate with local partners to coordinate wildfire messaging.

SUMMARY: It can be helpful to collaborate with local public health department partners to coordinate wildfire-related messaging with clinicians and patients, such as through prompts in the healthcare organization's electronic health record, e-newsletter, and patient texting system. This approach can increase community awareness of both the short- and long-term health impacts of wildfires (WHO, 2020).

ACTION: Develop a wildfire communications plan that includes different messaging for different stages of a wildfire event.

SUMMARY: Wildfire can be experienced as a direct, life-endangering event, as a near miss that destroys important infrastructure (such as nearby homes and healthcare facilities), and, as a long-term air quality event hundreds of miles away from the center of the wildfire. Similarly, some wildfires occur in tandem with or immediately after an extreme heat event and/or drought. Given the various kinds of risks associated with wildfire, public communications plans should anticipate a wide variety of messaging that can be tailored to the shifting conditions and health needs of the healthcare organization's patient base (Lookadoo et al., 2024).

ACTION: Use simultaneous disasters as an opportunity for education about the co-benefits of taking an all-hazards approach to resilience.

SUMMARY: Simultaneous and cascading disasters can be opportunities to educate the community, staff, and emergency management partners about the value associated with using a co-benefit approach to risk assessment, emergency planning, emergency response, and rebuilding efforts (National Academies of Sciences, 2022).

Climate Resilience Actions, continued

People and Operations

ACTION: Broadcast wildfire alerts using culturally appropriate language and communication pathways.

SUMMARY: Broadcasting alerts about wildfire vulnerability and protective behaviors to patients, staff, and community partners using culturally appropriate language and communication pathways can help amplify the local public health department and office of emergency management's communication efforts (Hasan et al., 2021; O'Neill et al., 2009).

ACTION: Educate communities on crucial adaptation strategies.

SUMMARY: Educate communities on crucial adaptation strategies that help reduce human-caused ignitions and that focus on home hardening practices (i.e., using non-combustible building materials, maintaining debris-free surroundings, and preventing ember intrusion) (Crimmins & Ostoja, 2023).

ACTION: Establish two-way communication systems with patient populations who are sensitive to wildfire hazards.

SUMMARY: Implementing two-way communication systems, like Reverse 911 and wireless emergency alerts (National Academies of Sciences, 2018), can aid in connecting sensitive populations with protective measures before a wildfire or smoke event occurs and direct them to community services during the event. With the assistance of community groups and local health departments, designated community leaders can deliver culturally sensitive messages. These messages would inform residents about safeguarding themselves and their neighbors against wildfire hazards and provide guidance on actions to take if they experience health harms (Steinberg & Sprigg, 2016; Toner et al., 2017).

Climate Resilience for Health Care (CR4HC) Case Studies

The following section highlights climate resilience strategies from the Toolkit that are presented in these case studies. The case studies illustrate how individual healthcare organizations are incorporating elements of climate resilience into their emergency management and strategic planning.

Each case study includes a narrative description of the organization and its specific climate resilience interventions. The information contained in these case studies provides concrete examples of best practices and common challenges in building a culture of climate resilience in the healthcare sector.

OASH | Office of Climate Change and Health Equity

Case Study: Ascension

CR4HC

Weathering the Storm: How a Culture of Resilience Prepared Ascension to Withstand Climate Hazards

New Extreme Winter Weather Challenges

In 2021, winter storms Uri and Viola swept through the continental United States, bringing extreme cold weather to the Midwest, Central Plains, and Southern regions. Several states experienced temperatures more than 30°F below normal (Bolinger et al., 2022).

The polar vortex brought ice and snow to regions of Texas where few mechanisms are in place to clear streets and walkways. Many communities experienced low water pressure when uninsulated pipes burst during sustained freezing temperatures. More than 10 million residents and many businesses lost electricity, some for several days (Busby et al., 2021). Numerous hospitals and healthcare facilities were severely affected, causing them to close their doors and evacuate patients. Overall, the polar vortex resulted in 246 deaths and nearly $130 billion in economic losses from destruction of crops, damage to structures, and loss of life. Throughout this crisis, the Ascension health system continued to care for patients, serve as a refuge for community members, and assist with coordinating response teams.

Coordinated Surveillance and Response

The Ascension health system includes 139 hospitals across 19 states and the District of Columbia. Its global operations center uses digital platforms to communicate and coordinate with local communities, health centers, governments, and medical personnel to continuously scan for emergency events that may impact critical services. Informing these activities is a private meteorological service that provides updates for each of Ascension's registered locations, enabling the operations center to receive accurate and detailed weather warnings up to 48 hours prior to weather events.

This coordinated, real-time surveillance enabled Ascension to act ahead of the polar vortex. Ascension stockpiled potable water ahead of time and maintained water pressure throughout its buildings using water tankers obtained from construction teams. It not only remained operational throughout the disaster, but also leveraged its relationships with other healthcare organizations to coordinate patient transfers from other area hospitals that needed to evacuate.

Integrating Principles of Resilience in Emergency Management Practices

Ascension's service area has experienced an increase in both the number and severity of extreme weather events, such as damaging winds and heat waves, as well as changes to the kinds of weather events that each region has historically experienced. Planning for evolving extreme weather patterns in the setting of climate change has become increasingly important. After the polar vortex, the Ascension team updated the organization's emergency preparedness and response guide to plan for future climate emergencies, in line with the goal of continuously identifying gaps and planning for contingencies.

Ascension creates facility plans and action guides to minimize damage and maximize operability if an extreme event occurs. Ascension incorporates sustainability into its building designs to promote climate resilience, including Dell Children's Medical Center in Austin, Texas, which earned the country's first-ever Leadership in Energy and Environmental Design (LEED) for Healthcare (LEED-HC) Platinum designation (U.S. Department of Energy, n.d.). Sustainable design features include

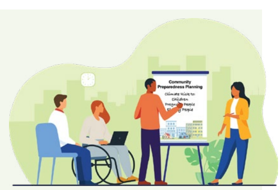
reducing power usage in unoccupied spaces (e.g., lowering lights, adjusting temperature and airflow), incorporating recycled materials into building designs, and preferentially using nontoxic and environmentally sustainable interior materials (Ascension, 2023).

Ascension aims to support resilience activities beyond its own facilities. To support community resilience, Ascension seeks to strengthen relationships within its facilities' local communities. For example, it offers educational programs on emergency preparedness to community members, local health departments, and other healthcare organizations. Health centers and other healthcare and community organizations are incorporated into Ascension's emergency preparedness and response plans. Community partners offer advice and support during local decision-making processes, including while actively responding to emergencies. Community touchpoints and interactions are not limited to crisis response; they are a regular occurrence that builds trust and a shared sense of responsibility for community well-being. This investment in community outreach and engagement strengthens relationships between Ascension, other local healthcare organizations, and the larger community. Ascension also meets regularly with governmental entities to leverage local, state, and federal resources and partnerships to support emergency preparedness and resilience. Ascension's core mission is to treat health care as a right, not a privilege. Taking care of people, especially those at the margins, is at the heart of its actions, including planning for climate resilience. "When they need to stay warm, when they need to get out of the storm – our doors are open."

CR4HC Climate Resilience Strategies

The following section identifies specific climate resilience strategies from the Toolkit that are exemplified in this case study:

Element 2. Health Equity and Community Engagement



2.1 Community Input

- **Regularly engage with community organizations in climate resilience education, communication, and integration sessions:** Ascension offers educational programs on emergency preparedness to community members, local health departments, and other healthcare organizations.

2.3 Community Services

- **Fill gaps in local services to increase resilience, such as acting as a place of refuge during extreme weather events:** The Ascension health system collaborates with local agencies and other partners to care for patients, serve as a refuge for community members, and assist with coordinating response teams during disasters.

2.4 Coordination with Local Office of Emergency Management

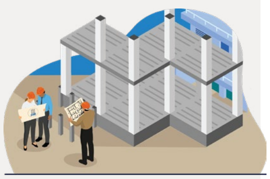
- **Add local and regional climate change vulnerability assessments to the healthcare organization's emergency preparedness plan:** After the polar vortex, the Ascension team updated the organization's emergency preparedness and response guide to plan for future climate emergencies, in line with the goal of continuously identifying gaps and planning for contingencies.

Element 2. Health Equity and Community Engagement, continued

2.4 Coordination with Local Office of Emergency Management, continued

- **Build relationships with the local public health department, other health systems, and the wider community to facilitate coordination around climate resilience and emergency response:** Health centers and other healthcare and community organizations are incorporated into Ascension's emergency preparedness and response plans. Community partners offer advice and support during local decision-making processes, including while actively responding to emergencies. Ascension also meets regularly with governmental entities to leverage local, state, and federal resources and partnerships to support emergency preparedness and resilience.

Element 3. Assessment and Remediation of Vulnerabilities in Infrastructure and Operations



3.3 Building and Campus: Design & Construction

- **Design facilities to promote both environmental sustainability and resilience:** Ascension incorporates sustainability into its building designs to promote climate resilience. Sustainable design features include reducing power usage in unoccupied spaces (e.g., lowering lights, adjusting temperature and airflow), incorporating recycled materials into building designs, and preferentially using nontoxic and environmentally sustainable interior materials.

3.5 Supply Chain

- **Stockpile potable water:** Ascension's real-time surveillance operations enabled it to stockpile potable water ahead of winter storms Uri and Viola in 2021. They also contracted with suppliers to use water tankers to maintain water pressure during the freeze event.

Element 4. Collaboration Between Healthcare Organizations

- **Work with other regional healthcare organizations to develop integrated patient evacuation plans:** Ascension leveraged its relationships with other healthcare organizations to coordinate patient transfers from other area hospitals that needed to evacuate during winter storms Uri and Viola in 2021.

Element 5. Interdisciplinary Planning, Oversight, and Evaluation

- **Develop a system-wide plan for coordinating care across all facility types under different disaster scenarios:** Ascension creates facility plans and action guides to minimize damage and maximize operability if an extreme event occurs.
- **Develop a digital operations center for the healthcare system to monitor potential emergencies that could impact critical services and to coordinate resilience strategies and emergency response:** The Ascension global operations center uses digital platforms to communicate and coordinate with local communities, health centers, governments, and medical personnel to continuously scan for emergency events that may impact critical services.

Case Study:

CommonSpirit

Mission-Driven Climate Resilience

In 2019, the Catholic Health Initiatives and Dignity Health combined to form CommonSpirit, a nonprofit health system that is dedicated to serving the needs of more than 20 million patients across 21 states (CommonSpirit, 2021). As one of the largest providers of Medicaid services in the United States, CommonSpirit recognizes the disproportionate burden that climate change places on populations who experience barriers to medical care and other unmet health-related social needs. Its commitment to climate action aligns with its mission to improve the health of the people it serves, especially at-risk populations (CommonSpirit, 2023).

Recognizing the importance of proactive action, CommonSpirit signed the HHS Health Sector Climate Pledge to achieve net-zero greenhouse gas emissions by 2040 and developed a three-pillar climate resiliency plan (Assistant Secretary for Health, 2022). The first pillar addresses buildings and operations, which accounted for 25% of the health system's greenhouse gas emissions in 2019. CommonSpirit aims to reduce operational emissions by increasing the energy efficiency of existing buildings, requiring new construction to meet net-zero design criteria, and switching to renewable energy sources. It aims to reduce emissions generated by buildings and through daily operations by half by 2030. The second pillar targets the supply chain, which accounts for 71% of the health system's greenhouse gas emissions. CommonSpirit is working with other industry leaders to signal demand for a net-zero supply chain. It is also educating healthcare vendors on how to reduce product emissions. The third pillar focuses on building climate-resilient communities. Activities include

- conducting climate vulnerability mapping across CommonSpirit's 24 states,
- prioritizing Climate Resilient Community strategies (Climate Resilient Communities, 2022),
- including climate vulnerability questions in its Community Health Needs Assessments,
- supporting state and federal initiatives to bolster healthcare's response to climate change, and
- implementing clinical interventions to protect at-risk patients from the health impacts of climate change.

In addition to its three pillars of action, CommonSpirit has created a climate-informed framework to apply to all of its hospitals' emergency response plans. The framework is refined by each hospital to reflect local resources and meet the specific needs of each community. This includes coordinating with local partners and tailoring response plans to local climate hazards. For example, hospitals in Los Angeles may conduct heat drills, those in the Midwest may practice tornado drills, and those on the Gulf Coast may prepare for hurricanes. By being responsive to regional climate hazards, emergency response plans incorporate targeted interventions to safeguard both patients and staff.

Responding to Extreme Heat

CommonSpirit's Dignity Health California Hospital Medical Center (CHMC), located in downtown Los Angeles, serves as an example of increasing resiliency to extreme heat. The hospital is situated five blocks from Skid Row, which includes one of the largest populations of people experiencing homelessness in the United States. Lack of shelter and housing

insecurity are risk factors for heat-related illness, due to increased exposure to extreme temperatures. In recent years, record-breaking heat waves in Los Angeles have led to surges in healthcare usage and emergency visits at CHMC, particularly among at-risk populations such as housing insecure individuals. Extreme heat events also strain hospital infrastructure because building equipment can fail when it overheats. The hospital's unair-conditioned mechanical rooms on the roof operate crucial equipment such as elevators and communications systems, which can malfunction during heat waves, posing a threat to patient transport, safety, and care.

To better identify and address challenges related to extreme heat events, CHMC's Emergency Management Team conducted an extreme heat drill in 2018, the first of its kind on the West Coast. The drill revealed critical gaps in preparedness, including the inability of backup generators to provide cooling on inpatient care floors. To mitigate future risks, the hospital added air conditioning to the rooftop elevator mechanical rooms and collaborated with nonprofit Health Care Without Harm to develop educational materials on extreme heat awareness in both English and Spanish (Health Care Without Harm, n.d.). It also partnered with the Los Angeles Regional Collaborative for Climate Action and Sustainability to launch a heat campaign that issues heat wave alerts to Los Angeles residents and provides information on how to access local cooling centers (places community members can go to escape the heat and access supplies such as fans and bottled water) (Los Angeles Regional Collaborative, n.d.). The hospital is remediating infrastructure vulnerabilities by upgrading backup generators, enhancing energy efficiency strategies, and installing on-site sources of alternative energy to ensure consistent temperature control on patient care floors during power outages. These measures also reduce the hospital's demand on the regional power grid, thereby minimizing its contribution to heat-related rolling brownouts and blackouts.

Lessons learned from the extreme heat drill proved invaluable during subsequent emergencies, such as the COVID-19 pandemic and the threat of hurricane damage in 2023. The hospital ultimately avoided hurricane damage, but a sister hospital experienced power loss, prompting patient evacuations. CHMC not only maintained normal operations during the event but also accepted additional patients, demonstrating the value of its investment in developing a culture of operational and community resilience.

Building Resilience Through Collaboration

CommonSpirit Hospitals prioritize collaboration and community engagement to enhance preparedness and resilience in times of crisis. Its Incident Command Center, a central coordination hub during emergencies, brings together representatives from various hospital departments (e.g., purchasing, facilities, nursing, patient care, admitting, and patient discharge) to ensure that patients and providers are connected to the resources that they need. By fostering interdisciplinary collaboration among departments at every phase of emergency management, CommonSpirit ensures a cohesive and effective response to emergencies.

In addition to internal collaboration, CommonSpirit values community partnerships, understanding their role in building strategic relationships that keep the community safe and enhance access to healthcare services. It works alongside local organizations to increase climate resilience, decrease greenhouse gas emissions, and provide essential services to local communities. For example, the Hope Street Margolis Family Center serves as a vital component of CommonSpirit's Community Benefits Program. The Family Center supports families in need by providing essential food items and baskets, facilitating community communication, and offering childcare services. Moreover, the Family Center serves as a community hub by offering after-school care and adult education and serving as a meeting place for the community. Partnerships such as these help to build community trust, mitigate psychosocial factors that can modulate the risk of climate-related health hazards, and create conduits for communication and delivery of essential services during and after disasters.

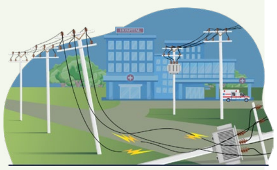
CR4HC Climate Resilience Strategies

The following section identifies specific climate resilience strategies from the Toolkit that are exemplified in this case study:

Element 1. Prospective Risk Assessment

- **Consider both historical trends and climate projections to identify regional climate change-related hazards:** CommonSpirit has signed the HHS Health Sector Climate Pledge to achieve net-zero greenhouse gas emissions by 2040 and developed a three-pillar climate resiliency plan that addresses buildings and operations, supply chain, and climate-resilient communities. The plan includes conducting climate vulnerability mapping across the 24 states in CommonSpirit's network.

Element 2. Health Equity and Community Engagement



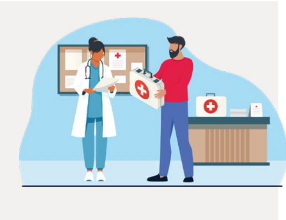
2.2. Community Infrastructure

- **Catalyze the development of resilient infrastructure at the neighborhood and community level:** CommonSpirit's resilience plan prioritizes climate-resilient community strategies and includes climate vulnerability questions in its Community Health Needs Assessments.

2.4. Coordination with Local Office of Emergency Management

- **Add local and regional climate change vulnerability assessments to the healthcare organization's emergency preparedness plan:** CommonSpirit has created a climate-informed framework to apply to all of its hospitals' emergency response plans. The framework is refined by each hospital to reflect local resources and meet the specific needs of each community. This includes coordinating with local partners and tailoring response plans to local climate hazards.
- **Build relationships with the local public health department, other health systems, and the wider community to facilitate coordination during emergency response:** CommonSpirit works alongside local organizations to increase climate resilience, decrease greenhouse gas emissions, and provide essential services to local communities. For example, the Hope Street Margolis Family Center serves as a vital component of CommonSpirit's Community Benefits Program.

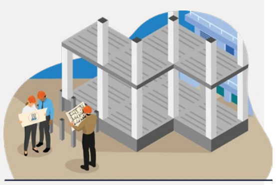
Element 3. Assessment and Remediation of Vulnerabilities in Infrastructure and Operations



3.1 Staff Support

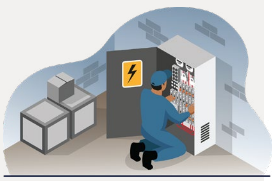
- **Train clinical staff in alternative procedures for delivering care during disasters:** CommonSpirit's resiliency plan implements clinical interventions to protect at-risk patients from the health impacts of climate change.

Element 3. Assessment and Remediation of Vulnerabilities in Infrastructure and Operations, continued



3.3 Building and Campus: Design & Construction

- **Install energy efficient building equipment to extend the length of time the facility can function on back-up power systems:** CommonSpirit's Dignity Health California Hospital Medical Center in Los Angeles, California, is remediating infrastructure vulnerabilities by upgrading backup generators, enhancing energy efficiency strategies, and installing on-site sources of alternative energy to ensure consistent temperature control on patient care floors during power outages. These measures also reduce the hospital's demand on the regional power grid, thereby minimizing its contribution to heat-related rolling brownouts and blackouts.



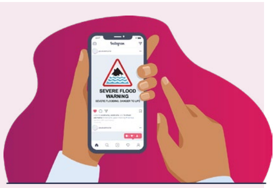
3.4 Building and Campus: Facility Operations

- **Integrate extreme heat drills into the healthcare organization's rotating roster of emergency preparedness activities:** To better identify and address challenges related to extreme heat events, CHMC's Emergency Management Team in Los Angeles, California, conducted an extreme heat drill in 2018, the first of its kind on the West Coast. The drill revealed critical gaps in preparedness, including the inability of backup generators to provide cooling on inpatient care floors. To mitigate future risks, the hospital added air conditioning to the rooftop elevator mechanical rooms.

Element 5. Interdisciplinary Planning, Oversight, and Evaluation

- **Develop a digital operations center for the healthcare system to monitor potential emergencies that could impact critical services and to coordinate resilience strategies and emergency response:** CommonSpirit's Incident Command Center, a central coordination hub during emergencies, brings together representatives from various hospital departments (e.g., purchasing, facilities, nursing, patient care, admitting, and patient discharge) to ensure that patients and providers are connected to the resources that they need.

Element 6. Communications and All-Hazards Approach



- **Broadcast heat alerts using culturally appropriate language and communication pathways:** CommonSpirit collaborated with nonprofit Health Care Without Harm to develop educational materials on extreme heat awareness in both English and Spanish. As part of this process, CommonSpirit partnered with the Los Angeles Regional Collaborative for Climate Action and Sustainability to launch a heat campaign that issues heat wave alerts to Los Angeles residents and provides information on how to access local cooling centers (places community members can go to escape the heat and access supplies such as fans and bottled water).

Case Studies: Kaiser Permanente

Solar Power for Decarbonization and Resilience

Kaiser Permanente is an integrated health system that provides healthcare to more than 12 million people across eight states and the District of Columbia. Aligned with its mission to care for its members' health, the organization strives to minimize its contribution to global greenhouse gas emissions and maximize community resilience. The healthcare system aims to reduce its greenhouse gas emissions by 50% by 2030 and become net-zero by 2050 (Tackling Climate Change to Drive Health and Health Equity, n.d.). In alignment with these goals, Kaiser Permanente operates more than 75 Leadership in Energy and Environmental Design (LEED)-certified facilities, including several that have attained LEED Platinum certification (Leading in Sustainable Building Design, n.d.). In addition, Kaiser Permanente has installed on-site solar generation at more than 100 facilities, which provides about 5% of the company's annual electricity requirement. Kaiser Permanente also seeks to increase its sustainability and ensure continuous operations should an emergency occur. To accomplish this goal, it works with government agencies, local power providers, and energy companies to design and implement green energy alternatives and backup energy solutions. For example, Kaiser Permanente is identifying opportunities to increase solar production and reduce its reliance on diesel-powered back-up generators by incorporating solar and energy storage at both existing and new facilities.

Energy Resilience in Ontario, California

Hospitals require reliable power 24-7 to maintain operations and provide a suitable environment for their patients, providers, and equipment. Reliance on local electrical grids can be costly and prone to disruption. Between 2000 and 2023, nearly 61% of California's 238 major power outages could be attributed to extreme weather such as high winds, wildfires, or heat waves (Freedman, 2024). Hospitals are required to maintain a backup energy source to minimize the impact of power fluctuations and remain functional should an emergency occur, as described in the National Fire Protection Association (NFPA) Health Care Facilities Code 99. Diesel-fueled backup generators are commonly used. However, they cause local air pollution, can be expensive to operate, and can experience fuel delivery disruptions. The 2021 edition of NFPA Code 99 permits the supply of emergency power by alternative energy sources, including microgrid systems (small-scale electrical grids where the sources of electricity can be provided by clean energy technologies). In 2023, the CMS released a categorical waiver aligning with the guidance of the 2021 NFPA Code 99, allowing renewable energy microgrids to be used as backup power systems for healthcare facilities. The Kaiser Permanente hospital in Ontario, California, is incorporating reliable solar power through a collaboration with Faraday Microgrids.

Kaiser Permanente will have a 2-megawatt solar array on parking lot canopies and the top deck of its Ontario hospital parking garage. The advantages of the canopy arrays are twofold: the flat surface enables maximum sun exposure for the solar panels while the canopy provides patients and staff with much needed shade. The arrays are connected to a series of batteries that can store 9 megawatt-hours of energy; this portion of the project was funded by the California Energy Commission. This energy storage enables Kaiser Permanente to reduce its operating costs and greenhouse gas emissions by minimizing grid power requirements during peak periods experienced by the California electrical grid (e.g., when A/C use is greatest). Lowering power draw during peak periods decreases the overall reliance on peaking power plants –

those activated during high-energy requirement periods that commonly generate significant carbon dioxide emissions (California Peaker Power Plants: Energy Storage Replacement Opportunities, 2020). This solar project, in addition to energy management systems that include fuel cells, is estimated to save the Ontario hospital more than $150,000 per year while reducing greenhouse gas emissions. The renewable energy microgrid at the Kaiser Permanente Ontario Medical Center will provide cleaner, more reliable electrical power for day-to-day use and will serve as the emergency power backup system during commercial power outages. Although diesel backup generators stay on site, they serve only as a backup to the microgrid system.

Maintaining Operations in Oahu, Hawai'i

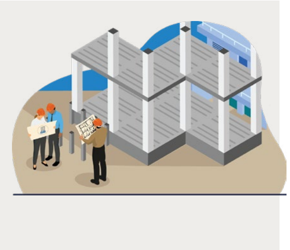
Kaiser Permanente recognizes that most day-to-day healthcare procedures are performed in outpatient facilities. Though outpatient facilities are not required to have emergency power supplies, power disruptions can impair patient access to essential services and can result in patient surges to acute care facilities. At Kaiser Permanente's outpatient facility in Oahu, Hawai'i, solar microgrids decrease emissions and reduce overhead costs.

Through a power purchase agreement, the West Oahu facility now features a series of parking lot canopies that support a 388-kilowatt solar-panel microgrid. Batteries have also been installed, enabling the use of stored solar energy during evenings and storage of excess energy when the panels produce more electricity than the facility can use. With the added benefit of battery storage, the campus obtains 72% of its energy from the solar microgrid. Over a 12-month period, the facility saved approximately $100,000 on energy costs alone. The batteries also serve as a source of backup power during utility disruptions, enabling the facility to continue providing care in emergency situations. This solution has helped the Oahu outpatient facility to further reduce its carbon footprint, save costs on energy that can then be redirected to patient care, increase resilience, and align with Kaiser Permanente's mission to protect the health of the communities it serves. Visitors can follow a walking path that circles the facility's grounds, called "Kealahoolaupa`i" – a path to better health. Along the way are waypoints that share mo`olelo, or stories, about the Kapolei area.

CR4HC Climate Resilience Strategies

The following section identifies specific climate resilience strategies from the Toolkit that are exemplified in this case study:

Element 3. Assessment and Remediation of Vulnerabilities in Infrastructure and Operations



3.3 Building and Campus: Design & Construction

- **Design facilities to promote both environmental sustainability and resilience:** Aligned with its mission to care for its members' health, the organization strives to minimize its contribution to global greenhouse gas emissions and maximize community resilience. The healthcare system aims to reduce its greenhouse gas emissions by 50% by 2030 and become net-zero by 2050.

Element 3. Assessment and Remediation of Vulnerabilities in Infrastructure and Operations, continued

3.3 Building and Campus: Design & Construction, continued

- **Incorporate renewable power generation infrastructure in the design of new facilities and major renovations.:** Kaiser Permanente works with government agencies, local power providers, and energy companies to design and implement green energy alternatives and backup energy solutions. For example, Kaiser Permanente is identifying opportunities to increase solar production and reduce its reliance on diesel-powered back-up generators by incorporating solar and energy storage at both existing and new facilities.
- **Design solar arrays to provide multiple benefits to the healthcare campus, such as solar canopies that also shade pedestrian pathways and parked cars:** Kaiser Permanente is constructing a 2-megawatt solar array on parking lot canopies and the top deck of its Ontario hospital parking garage. The advantages of the canopy arrays are twofold: the flat surface enables maximum sun exposure for the solar panels while the canopy provides patients and staff with much needed shade. The arrays are connected to a series of batteries that can store 9 megawatt-hours of energy.

3.4 Building and Campus: Facility Operations

- **Generate renewable energy on the healthcare campus:** Kaiser Permanente has installed on-site solar generation at more than 100 facilities, which provides about 5% of the company's annual electricity requirement. Through a power purchase agreement, the West Oahu facility now features a series of parking lot canopies that support a 388-kilowatt solar-panel microgrid. Batteries have also been installed, enabling the use of stored solar energy during evenings and storage of excess energy when the panels produce more electricity than the facility can use. With the added benefit of battery storage, the campus obtains 72% of its energy from the solar microgrid.

Case Study:
NYU Langone Health

CR4HC

Turning Storms into Strength for a Climate-Resilient Future

Taking Action

NYU Langone Health (NYU Langone) serves the five boroughs of New York City and surrounding counties. The 3.5 million square foot medical campus in Manhattan includes 10 interconnected buildings that serve as inpatient care centers, medical offices, research laboratories, classrooms, conference rooms, and residential spaces (Performance Excellence Electricity Renewal, 2018). When Superstorm Sandy (2012) made landfall in New York City in October 2012, the campus was flooded with 15 million gallons of water – up to 5 feet in some locations. Medical equipment, power lines, and building utilities were destroyed (Barbanel, 2016). Close to 300 patients were evacuated because of facility-wide blackouts. With no functional elevators, patients were evacuated down staircases. No lives were lost, thanks to the tireless efforts of the dedicated staff at NYU Langone and New York City emergency responders (New York University, 2017). However, the hospital was devastated and closed its doors for almost 2 months.

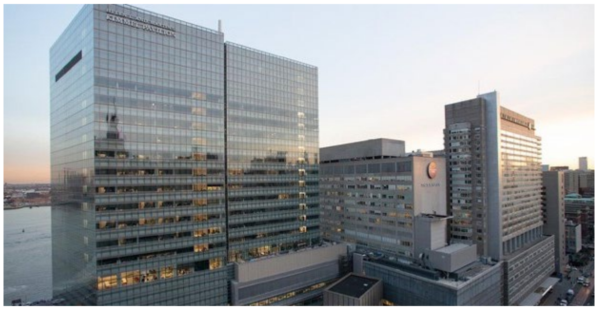
Although the damage was severe, it provided a valuable opportunity for NYU Langone to assess structural vulnerabilities and increase facility resilience so that staff can continue to provide high-quality patient care throughout future severe weather events.

Rethinking the Rebuild

Superstorm Sandy (2012) prompted the NYU Langone development team to creatively rethink preexisting plans to transform its main hospital campus in Manhattan. The team recognized that it is not sufficient to reactively manage unexpected issues as they arise during a crisis. Rather, using evidence-based design strategies that reduce exposure to natural and human-caused disasters, the original renovation plans were updated to incorporate principles of resilience, sustainability, and increased energy efficiency.

Various design strategies were implemented, including

- an on-site energy center that consists of a combined heat and power plant (capable of utilizing natural gas or fuel oil) as well as backup boilers and generators to reduce reliance on external sources;
- medical equipment (e.g., magnetic resonance imaging [MRI] and computed tomography [CT] machines) that are physically elevated above the level of projected flood risk to reduce the likelihood of care disruption during flooding events;
- stormwater management (e.g., flood barriers equipped with crossover stairs to allow safe passage from one side to the other, flood pumps to remove water) and green roofs to increase water retention and slow overflow;
- flood barriers (e.g., perimeter barriers, flood doors) to contain and compartmentalize potential hazards (e.g., rising water);
- redundant information technology [IT] systems, strategically positioned on opposite sides of the campus and elevated above the projected 500-year flood level; and
- elevation above the level of projected flood risk of labs, building systems, and other equipment crucial to research, education, and patient care.



Lessons Learned

The updated medical campus is designed to minimize environmental impact and provide first-rate patient care. Energy resilience is at the core of these objectives. By conserving energy (e.g., choosing efficient equipment, utilizing automation to setback HVAC in areas that are not in use, providing training to optimize energy-efficient plant operations) and reducing reliance on the power grid, facilities are both better able to continue functioning during power outages and reduce their contribution to climate change. The resilient design features included in the medical campus renovation have already proven effective at withstanding unexpected weather events. For instance, upgraded High Efficiency Particulate Air (HEPA) and MERV 13 air filters reduced patient and staff exposure to toxic particulate matter during the ambient air quality crises caused by 2023 Canadian wildfires. These efforts have led to NYU Langone becoming the first healthcare campus to receive the Performance Excellence in Electricity and Renewal (PEER) Platinum-level certification (PEER, n.d.).

NYU Langone's success is due to the culture of resiliency it has built, which includes its infrastructure and its people. NYU Langone conducts an annual hazard vulnerability analysis that has become a core foundation of its preparedness strategy following Superstorm Sandy (2012). The healthcare system follows the framework outlined in the FEMA National Preparedness Report, prioritizing climate hazards based on a combination of historical and prospective climate data (FEMA, 2022). The organization designed procedures to maintain operations during hazardous events after incorporating stakeholder feedback and established protocols to monitor its progress year over year. Additionally, NYU Langone developed an emergency preparedness employee training and exercise program to increase awareness and responsiveness across its facilities. The implementation of these measures has proven extremely effective in optimizing equipment use, minimizing waste, and increasing operational efficiency.

NYU Langone openly shares its knowledge and experiences with peers and colleagues. The healthcare system is forging partnerships and sharing information and resources with healthcare organizations in New York City and across the country.

Since the reopening of its medical campus, NYU Langone has received awards and recognition for its dedication to environmental stewardship and sustainability on more recent projects. For example, the Kimmel Pavilion and Science Building were awarded the Leadership in Energy and Environmental Design (LEED) Platinum certification in 2019 in recognition of its energy efficient design, use of recycled materials, and innovative stormwater runoff systems (NYU Langone Health Receives Top Environmental Awards, 2019). NYU Langone's dedication to sustainability and resilience is the cornerstone of its activities and will continue to enable it to weather new storms.

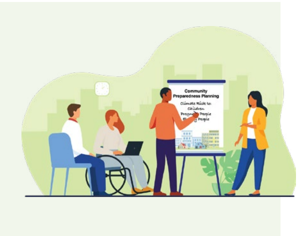
CR4HC Climate Resilience Strategies

The following section identifies specific climate resilience strategies from the Toolkit that are exemplified in this case study:

Element 1. Assessment and Remediation of Vulnerabilities in Infrastructure and Operations

- **Consider both historical trends and climate projections to identify regional climate change-related hazards:** NYU Langone follows the framework outlined in the FEMA National Preparedness Report, prioritizing climate hazards based on a combination of historical and prospective climate data.

Element 2. Health Equity and Community Engagement



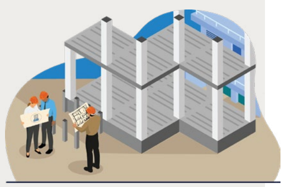
2.1 Community Input

- **Integrate community input into conversations about the implications of regional climate projections on a healthcare organization's emergency planning process, future clinical needs, and opportunities to support community resilience:** NYU Langone designed procedures to maintain operations during hazardous events after incorporating stakeholder feedback and established protocols to monitor its progress year over year.

Element 3. Assessment and Remediation of Vulnerabilities in Infrastructure and Operations

3.1 Staff Support

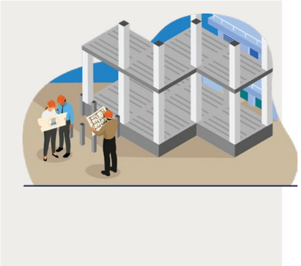
- **Integrate regular emergency preparedness employee training into the healthcare organization's continuing education program:** NYU Langone developed an emergency preparedness employee training and exercise program to increase awareness and responsiveness across its facilities.



3.3 Building and Campus: Design & Construction

- **Design facilities to promote both environmental sustainability and resilience:** After Superstorm Sandy (2012) NYU Langone updated renovation plans to incorporate principles of resilience, sustainability, and increased energy efficiency.
- **Increase resilience to power outages by installing cogeneration facilities on-site or in the medical district:** NYU Langone installed an on-site energy center that consists of a combined heat and power plant (capable of utilizing natural gas or fuel oil) as well as backup boilers and generators to reduce reliance on external sources.
- **Install energy efficient building equipment to extend the length of time during which the facility can function on backup power systems:** By conserving energy (e.g., choosing efficient equipment, utilizing automation to setback HVAC in areas that are not in use, providing training to optimize energy-efficient plant operations) and reducing reliance on the power grid, NYU Langone is better able to continue functioning during power outages and also reduce its contribution to climate change.
- **Install high efficiency air filtration systems to reduce the concentration of pollutants in indoor air:** Upgraded HEPA and MERV 13 air filters have reduced patient and staff exposure to disasters post-Superstorm Sandy (2012), such as toxic particulate matter during the ambient air quality crises caused by 2023 Canadian wildfires.
- **Place the healthcare organization's critical infrastructure above the level of projected flood risk:** Labs, building systems, and other equipment crucial to research, education, and patient care are located at an elevation above projected flood risk.
- **Install protective barriers and elevated walkways/driveways in areas at risk of flooding:** Stormwater management strategies (e.g., flood barriers equipped with crossover stairs to allow safe passage from one side to the other, flood pumps to remove water, perimeter barriers, flood doors) and green roofs contain and compartmentalize potential hazards (e.g., rising water), increase water retention, and slow overflow.

Element 3. Assessment and Remediation of Vulnerabilities in Infrastructure and Operations, continued



- **Place redundant IT systems off-site to increase the resilience of electronic medical records (EMRs):** Redundant IT systems are strategically positioned on opposite sides of the campus and elevated above the projected 500-year flood level.
- **Place EMR servers and equipment in climate-controlled spaces and above the flood line:** Medical equipment (e.g., magnetic resonance imaging (MRI) and computed tomography (CT) machines) are physically elevated above the level of projected flood risk to reduce the likelihood of care disruption during flooding events.

Element 4. Collaboration Between Healthcare Organizations

- **Share knowledge and lessons learned with other regional healthcare organizations:** NYU Langone openly shares its knowledge and experiences with peers and colleagues. The healthcare system is forging partnerships and sharing information and resources with healthcare organizations in New York City and across the country.

Element 5. Interdisciplinary Planning, Oversight, and Evaluation

- **Use the hazard vulnerability assessment process as an opportunity to build a culture of resilience within the healthcare organization:** NYU Langone's success is due to the culture of resiliency it has built, which includes its infrastructure and its people. NYU Langone conducts an annual hazard vulnerability analysis that has become a core foundation of preparedness strategy following Superstorm Sandy (2012).

Case Study:

Northern Light Health

CR4HC

Resilient Care for Rural Populations

Hospitals in Maine face unique healthcare delivery challenges because of the state's distinct population and geography. Maine is a largely forested state crossed by rivers and dotted with island communities. Forty percent of Maine's nearly 1.4 million residents are located within a single county, with the remainder dispersed across the expansive geography of the state (Maine Department of Health and Human Services, 2024). Additionally, Maine is recognized as the state with the oldest median population in the United States, with 22% of residents over age 65 (Population Reference Bureau, 2021). Maine's hospitals have large service areas and provide care to diverse populations (Maine Hospital Association, 2024). Patients in Maine's rural communities may need to travel long distances to access health care.

Northern Light Health's members include 10 of the 36 hospitals in Maine, including locations in urban Portland, remote Greenville, and coastal Blue Hill (Northern Light Health, 2023 a.). Northern Light understands that the communities it serves are already experiencing health effects from climate change (Northern Light Health, 2023 b.). The system signed the HHS Health Sector Climate Pledge in 2023 and began the process of developing a Climate Resiliency Plan, which describes the effect of climate change on the network's facilities and patients by identifying vulnerabilities and defining plans to enhance resiliency (Assistant Secretary for Health, 2022; Northern Light Health, 2023 b.).

Tailoring Resiliency to Meet Geographic and Community Needs

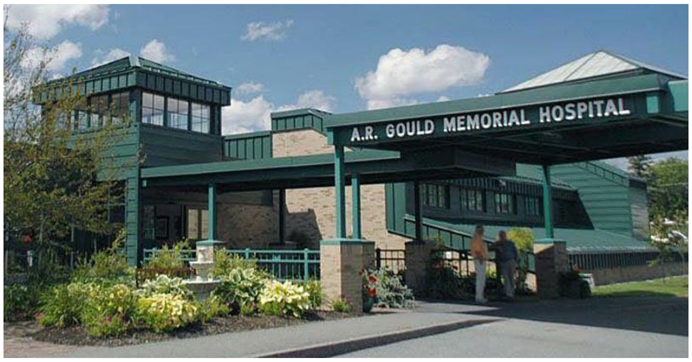
The planning effort kicked off with a prospective planning process to identify and address vulnerabilities to natural disasters, and other disruptions, across Northern Light's health delivery system. Signing the HHS Climate Pledge motivated Northern Light Health to consider these resiliency planning activities through a climate lens, which required broad interdisciplinary collaboration. Representatives from diverse disciplines, such as emergency preparedness, facilities management, food service, supply chain, community health, health equity, and more, convened to discuss various aspects of organizational resilience in the face of climate change. Drawing upon their professional experience, strategic partnerships, and climate and demographic models, the team identified critical areas for consideration, including infrastructure required to provide support to a variety of geographic locations and populations served (such as mitigating projected vulnerabilities in essential transportation systems). The system-wide climate resiliency plan was developed over a six-month period in 2023 and will continue to be revised as new data are identified. The team plans to revisit the document regularly and revise various components as new threats emerge.

The climate resiliency planning process has led Northern Light to incorporate prospective risk assessment into its infrastructure investment decisions, helping to ensure that it can continue to provide uninterrupted service during climate-related disasters and extreme weather events. The health system works alongside FM Global, a property and casualty insurance company, to identify and remediate such vulnerabilities across its facility portfolio. FM Global links climate vulnerability assessments with reductions in annual insurance premiums to encourage facilities to direct funds saved toward climate resiliency measures. The assessments for Northern Light Health identified campus-specific vulnerabilities, such as high winds and floods, and recommended specific remediation measures. The process highlighted the fact that many building standards and regulations are becoming obsolete, because they rely exclusively on historical weather trends. For example, requirements for HVAC (heating, ventilation, and air conditioning) units in hospitals are rapidly becoming obsolete in some parts of the country as temperature extremes and humidity increase. Prospective risk assessment has become increasingly necessary to future-proof building systems over the full lifespan of a new building.

Northern Light Health tailored the implementation of its new climate resiliency plan to each facility's unique geographic and demographic context. For example, a coastal facility such as Northern Light Mercy Hospital may prioritize improvements related to coastal storms and flooding. A facility serving remote rural populations, such as Northern Light AR Gould Hospital or Northern Light Sebasticook Valley Hospital, may focus on mitigating the risk of transportation infrastructure disruptions in the setting of severe weather events that could interrupt patients' access to care. The Northern Light Health service area includes remote islands whose residents must rely on boats or helicopters to access mainland healthcare services, impacting transit time for emergency responders and patients seeking care. Access to healthcare from remote areas such as these is especially susceptible to weather-related disruption. Prospective risk assessment that considers the effects of climate change on the geographic distribution, frequency, and severity of storms is increasingly important to ensure that Northern Light's healthcare facilities remain accessible.

Additionally, the priorities and cultural values of each of the communities served by Northern Light facilities are distinct – patients and employees represent diverse populations including immigrant groups, agricultural workers, urban and rural areas, and Indigenous communities.

One hospital that requires unique cultural considerations for its population and geography is Northern Light AR Gould Hospital. Located in Aroostook County, its service area includes Mi'kmaq Nation Tribal lands (Mi'kmaq Nation, 2024). The hospital incorporates culturally appropriate practices into its facility operations, including developing a first-in-the-nation policy to allow for sacred smudging ceremonies, while ensuring the safety of patients, visitors, and staff.



Resiliency Plan in Action

On December 18, 2023, shortly after Northern Light Health completed its initial resiliency plan, Maine experienced a devastating storm that was declared a federal disaster (FEMA, 2024). Following the storm, more than 400,000 people in Northern Light's catchment area experienced power outages and roadway closures, which both increased danger for patients dependent on electric-powered medical equipment and limited their access to care (Russell & Terhune, 2023, p. 2).

Northern Light Health personnel were able to tap into the recently strengthened interdisciplinary and inter-facility collaboration relationships they had developed through the resiliency planning process. As a result, emergency management personnel, facility operations staff, and clinicians were able to leverage emergency response resources and communication pathways described in the resiliency plan to provide continuous service to patients during the disaster and its aftermath. This experience proved the value of the health system's multi-disciplinary resilience planning process.

Establishing a Community of Resilience

Northern Light Health is committed to raising awareness about the impact of climate change on health and healthcare and to working with community partners and healthcare organizations across the state. The health system has developed a monthly speaker series and a quarterly newsletter for employees called the Climate Chronicles, which highlight climate resilience activities at Northern Light facilities, including collaborations with community partners, as well as general education on sustainability-related topics and opportunities for employees to take action.

Outward-facing communications activities include appearances on Healthy Living segments on local TV stations and a podcast miniseries produced by Northern Light Health, which seeks to inform the public about the population health effects of climate change and opportunities to increase community resilience.

The system has also convened a voluntary statewide healthcare learning collaborative, the Maine Healthcare Climate Collaborative. The Collaborative includes representatives from major health systems in the state (Northern Light Health, Maine Health, Central Maine Healthcare, and Covenant Health) and small independent hospitals, as well as nursing homes, rehabilitation centers, and other elements of Maine's healthcare network. The Collaborative meets monthly to discuss topics related to healthcare climate resilience protocols, processes, and policies. Northern Light Health shares information about partners such as FM Global with the Collaborative to provide practical examples of resources that healthcare organizations across the state can leverage to build resilience and better serve patients.

CR4HC Climate Resilience Strategies

The following section identifies specific climate resilience strategies from the Toolkit that are exemplified in this case study:

Element 1. Prospective Risk Assessment

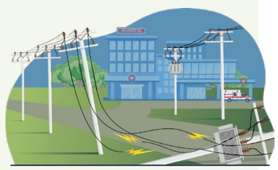
- **Consider both historical trends and climate projections to identify regional climate change-related hazards:** The climate resiliency planning process has led to Northern Light incorporating prospective risk assessment into infrastructure investment decisions, helping to ensure that it can continue to provide uninterrupted service during climate-related disasters and extreme weather events. The health system works alongside FM Global, a property and casualty insurance company, which links climate vulnerability assessments with reductions in annual insurance premiums to encourage facilities to direct funds saved toward climate resiliency measures.

Element 2. Health Equity and Community Engagement

2.1 Community Input

- **Regularly engage with community organizations in climate resilience education, communication, and integration sessions:** Northern Light Health has developed a monthly speaker series and a quarterly newsletter for employees called the Climate Chronicles, which highlight climate resilience activities at Northern Light facilities, including collaborations with community partners, as well as general education on sustainability-related topics and opportunities for employees to take action.
- **Integrate community input into conversations about the implications of regional climate projections on a healthcare organization's emergency planning process, future clinical needs, and opportunities to support community resilience:** The Northern Light resiliency plan is tailored to the varied priorities and cultural values of each of the communities served by its facilities. Patients and employees represent diverse populations including immigrant groups, agricultural workers, urban and rural areas, and Indigenous communities.

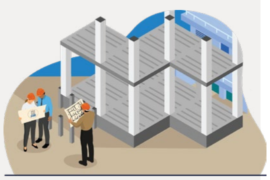
Element 2. Health Equity and Community Engagement, continued



2.2 Community Infrastructure

- **Work with local and regional partners to lower barriers to travel for patients and staff during climate change-related emergencies:** Northern Light Health tailored the implementation of its new climate resiliency plan to each facility's unique geographic and demographic context, such as the risk of transportation infrastructure disruptions in the setting of severe weather events that could interrupt patients' access to care.

Element 3. Assessment and Remediation of Vulnerabilities in Infrastructure and Operations



3.3 Building and Campus: Design & Construction

- **Design facilities to promote both environmental sustainability and resilience: 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:** The climate resiliency planning process has led to Northern Light incorporating prospective risk assessment into infrastructure investment decisions, helping to ensure that it can continue to provide uninterrupted service during climate-related disasters and extreme weather events. The process highlighted the fact that many building standards and regulations are becoming obsolete, because they rely exclusively on historical weather trends. Prospective risk assessment has become increasingly necessary to future-proof building systems over the full lifespan of a new building.

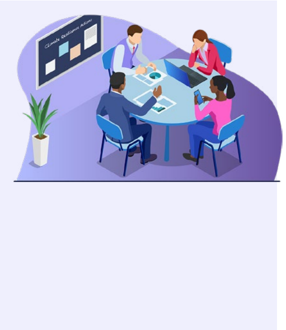
Element 4. Collaboration Between Healthcare Organizations

- **Share knowledge and lessons learned with other regional healthcare organizations:** The system has also convened a voluntary statewide healthcare learning collaborative, the Maine Healthcare Climate Collaborative, which discusses topics related to healthcare climate resilience protocols, processes, and policies. Northern Light Health shares information about partners to provide practical examples of resources that healthcare organizations across the state can leverage to build resilience and better serve patients.

Element 5. Interdisciplinary Planning, Oversight, and Evaluation

- **Integrate viewpoints from all segments of the healthcare organization, as well as outside partners, in climate resilience and emergency planning:** Signing the HHS Climate Pledge motivated Northern Light Health to consider these resiliency planning activities through a climate lens, which required broad interdisciplinary collaboration. Representatives from diverse disciplines such as emergency preparedness, facilities management, food service, supply chain, community health, health equity, and more convened to discuss various aspects of organizational resilience in the face of climate change. Drawing upon their professional experience, strategic partnerships, and climate and demographic models, the team identified critical areas for consideration including infrastructure required to provide support to a variety of geographic locations and populations served (such as mitigating projected vulnerabilities in essential transportation systems).

Element 5. Interdisciplinary Planning, Oversight, and Evaluation, continued



- **Use the hazard vulnerability assessment process as an opportunity to build a culture of resilience within the healthcare organization:** On December 18, 2023, shortly after Northern Light Health completed its initial resiliency plan, Northern Light Health personnel were able to tap into the recently strengthened interdisciplinary and inter-facility collaboration relationships they had developed through the resiliency planning process. As a result, emergency management personnel, facility operations staff, and clinicians were able to leverage emergency response resources and communication pathways described in the resiliency plan to provide continuous service to patients during the disaster and its aftermath.

Element 6. Communications & All-Hazards Approach

- **Collaborate with local partners to coordinate climate-related disaster messaging:** Outward-facing communications activities include appearances on Healthy Living segments on local TV stations and a podcast miniseries produced by Northern Light Health, which seeks to inform the public about the population health effects of climate change and opportunities to increase community resilience.

CASE STUDY:

Pueblo Community Health Center

CR4HC

Clean Energy for Community Health

Pueblo, Colorado is a city of just over 100,000 residents situated 100 miles south of Denver. Many residents experience severe economic hardship, with 17.6% of its population living below the federal poverty line (Census Bureau Profile, n.d.). Since 1983, the Pueblo Community Health Center (PCHC) has provided primary health care to city residents through its 10 community health clinics located in Pueblo and Huerfano Counties (Pueblo Community Health Center, n.d.a.). In 2020, PCHC began plans to build a state-of-the-art healthcare facility in Pueblo's underserved East Side neighborhood. During the planning phase, a physician Board member successfully advocated for the integration of sustainability and climate resilience into the building design. The business case demonstrated that incorporating renewable and energy saving measures at a 6–7% higher initial cost would pay off through lower utility expenses in 7–8 years, much less than the expected 50-year lifespan of the building. The East Side Clinic, which opened in January 2022, was the first healthcare center in North America to be identified by the New Buildings Institute as a net-zero facility, which generates renewable energy in a quantity equal to or exceeding the total amount of energy consumed on-site (New Buildings Institute, n.d.; Pueblo Community Health Center, n.d.b.). The clinic serves as a model for net-zero healthcare building design and contributes to the City and County of Pueblo's goal to operate on 100% renewable energy by 2035 (Pueblo, CO, n.d.).

Sustainability Through Innovative Design

The East Side Clinic was designed to work with – rather than against – the Pueblo environment. The proposed plan generated considerable interest from general contractors, allowing PCHC to select a company that was supportive of building the nation's first net-zero health clinic. The sustainable design also opened new funding pathways, such as tax credits from the U.S. Department of Treasury Community Development Financial Institutions Fund and renewable energy credits from the local utility Black Hills Energy, further reducing construction costs and accelerating the return on investment (Black Hills Energy, n.d.; Community Development Financial Institutions Fund, n.d.).

Examples of energy efficiency measures enabling the health center to achieve its net-zero goal include

- maximum insulation in the roof, ceilings, and walls beyond what is required by building codes;
- fiberglass framed windows and window shadings to offset the wide temperature fluctuations experienced in Pueblo;
- energy-efficient light emitting diode (LED) lighting system that maintains consistent indoor lighting in response to changes to daylight levels; and
- renewable energy systems (e.g., 280 kW solar panel array and geothermal heat pumps) that increase the clinic's resilience to climate hazards by reducing energy expenditure and minimizing reliance on the local energy grid.

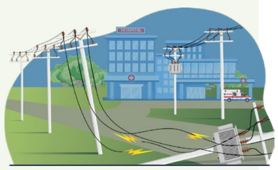
Community Impact

The Pueblo East Side Clinic's net-zero achievement inspired the local Urban Renewal Authority to designate an urban renewal district surrounding the health center (Pueblo Urban Renewal Authority, n.d.). The district includes a community center, city park, middle school, elementary school, library, church, and several mixed-use properties and is sparking much-needed revitalization in an underserved area of the city. The East Side Clinic enables PCHC to better serve its community by withstanding blackouts, heat waves, and other climate hazard-related events. Its energy conservation and resilience activities enable PCHC to channel utility cost savings into patient care and community support. Today, PCHC gives tours of the East Side Clinic to building designers and other groups interested in adopting sustainable building designs. The East Side Clinic serves as a testament to how a single environmentally conscious choice can positively influence an entire community, fostering a resilient future for all.

CR4HC Climate Resilience Strategies

The following section identifies specific climate resilience strategies from the Toolkit that are exemplified in this case study:

Element 2. Health Equity and Community Engagement



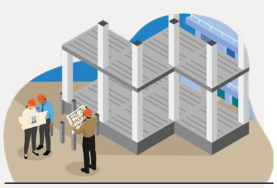
2.2 Community Infrastructure

- **Catalyze the development of resilient infrastructure at the neighborhood and community level:** The clinic serves as a model for net-zero healthcare building design and contributes to the City and County of Pueblo's goal to operate on 100% renewable energy by 2035. The Pueblo East Side Clinic's net-zero achievement inspired the local Urban Renewal Authority to designate an urban renewal district surrounding the health center.

2.3 Community Services

- **Fill gaps in local services to increase resilience, such as acting as a place of refuge during extreme weather events:** The East Side Clinic enables PCHC to better serve its community by withstanding blackouts, heat waves, and other climate hazard-related events.

Element 3. Assessment and Remediation of Vulnerabilities in Infrastructure and Operations



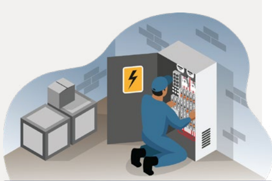
3.3 Building and Campus: Design & Construction

- **Establish a net-zero requirement for all new buildings and major renovations in the healthcare system:** The Pueblo Community Health Center East Side Clinic, which opened in January 2022, was the first healthcare center in North America to be identified by the New Buildings Institute as a net-zero facility, which generates renewable energy in a quantity equal to or exceeding the total amount of energy consumed on-site. The business case demonstrated that incorporating renewable and energy saving measures at a 6–7% higher initial cost would pay off through lower utility expenses in 7–8 years, much less than the expected 50-year lifespan of the building.

Element 3. Assessment and Remediation of Vulnerabilities in Infrastructure and Operations, continued

3.3 Building and Campus: Design & Construction, contined

- **Work with consultants who are familiar with climate-resilient design and construction techniques:** The East Side Clinic development plan generated considerable interest from general contractors, allowing PCHC to select a company that was supportive of building the nation's first net-zero health clinic.
- **Use building design strategies, like insulation and shading devices, to maintain safe temperatures inside the healthcare facility during extreme heat and cold events:** Examples of energy efficienc measures enabling the health center to achieve its net-zero goal include maximum insulation in the roof, ceilings, and walls beyond what is required by building codes; fiberglass framed windows and window shadings to offset the wide temperature fluctuations experienced in Pueblo; and, an energy-efficien LED lighting system that maintains consistent indoor lighting in response to changes to daylight levels.
- **Install energy-efficient building equipment to extend the length of time the facility can function on back-up power systems:** The combination of insulation and energy efficient mechanical and lighting systems, which reduce electricity demand, and on-site renewable power generation make it possible for the clinic to continue operations during power outages.



3.4 Building and Campus: Facility Operations

- **Generate renewable energy on the healthcare campus:** The East Side Clinic hosts a 280 kW solar panel array and geothermal heat pumps that increase the clinic's resilience to climate hazards by reducing energy expenditure and minimizing reliance on the local energy grid.

Case Study: Sacred Oaks Healing Center

CR4HC

Infrastructure Resilience to Deliver Culturally Responsive Care

In 2013, the California Indian Health Service (IHS) acquired 12 acres of land in Davis, California, to develop the Sacred Oaks Healing Center (Sacred Oaks) Youth Regional Treatment Center (YRTC) (Indian Health Service, n.d.a.). The location was selected for its proximity to healthcare professionals at the University of California Davis School of Medicine and its accessibility to local Tribal patient populations. IHS YRTC facilities provide residential care for American Indian and Alaska Native youth aged 12–17 who are struggling with substance use and co-occurring disorders (Indian Health Service, n.d.b.). Patients receive therapy, substance use counseling, access to cultural practices relevant to specific Tribes, and continuation of primary and secondary education throughout the duration of their stay, with additional assistance from ongoing care specialists who help discharged patients navigate outpatient services. Initially scheduled to open in 2020, the facility experienced construction and design setbacks affecting the building schedule, including storm-related floods in 2019 and the declaration of the COVID-19 Public Health Emergency in 2020 (Sacred Oaks Healing Center, 2022).

Flood Mitigation and Energy Resilience

Davis, California, is largely considered a low-risk area for storm-related flooding (City of Davis, California, 2024). However, during its construction in January 2019, Sacred Oaks experienced significant flooding following heavy rains that resulted in damage to its foundation and large swathes of deep mud that needed to be excavated before construction could continue.

After the flood, CWE, a civil engineering firm, was hired to perform a floodplain analysis of Sacred Oaks' property (CWE, n.d.). The analysis incorporated data from FEMA floodplain maps, the U.S. Army Corps of Engineers, NOAA, Yolo County drainage standards, and other hydrological sources to identify both short- and long-term recommendations to address flood risks at Sacred Oaks. Based on the recommendations, Sacred Oaks installed

- perimeter berms to mitigate flood damage during storms;
- landscaping improvements, such as flood channels and culverts, to direct excess floodwaters to a large detention pond; and
- a stormwater lift station to displace the detention pond's stormwater to adjacent properties (Romtech Utilities, 2021).

California Area IHS, which oversees Sacred Oaks, worked with national IHS to secure funding to incorporate these flood mitigation elements in the project. Although the mitigation elements cost nearly $3 million, cost savings analyses indicate that the facility could save more than $10 million in damages from future floods by reducing expenses incurred by patient and staff evacuations, structural damage, and equipment loss. Sacred Oaks intends to further increase its flood resiliency by constructing underground water retention chambers to collect rainfall (IHS, 2022). The use of collected rainwater for landscape irrigation is being studied as an option for the ongoing stormwater chambers project.

Sacred Oaks incorporates additional features of climate change resilience, beyond flood mitigation. The facility was initially designed and built with insulated structural panels to reduce energy costs related to cooling during hot summers and heating during cold winters, as well as American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) 135 energy efficient heating, ventilating, and air conditioning units. Following the flood, Sacred Oaks incorporated additional flood-resistance design measures, including

- incorporation of permeable walkways, driveways, and patio structures to reduce flood risk; and
- planting native flora across the property to reduce irrigation requirements and benefit native wildlife.

These resilience measures have reduced operating costs and mitigated structural damage during extreme weather events that have occurred post-occupancy.

The best time to identify high-risk weather hazards, such as the flood experienced by Sacred Oaks, is during the initial planning phase of a capital project, so that resiliency can be considered early in the design and development process. Although IHS maintains a library of up-to-date guidance documents, such as the IHS Architect/Engineer Design Guide, many of these best practice documents rely on historical data sets (Indian Health Service, n.d.c.). As global weather patterns continue to evolve in the setting of climate change, prospective risk assessments using climate models will likely become a foundational tool for future-proofing new construction/renovation projects and facility upgrades. In response to lessons learned from the Sacred Oaks flood, California Area IHS updated its land acquisition and building design procedures to include elements of prospective risk assessment, such as

- requiring an analysis of estimated changes to the 100- and 500-year floodplain under climate change scenarios,
- Climate Impacts Research Consortium (CIRC) toolkit (FEMA, 2024 a.),
- FEMA National Risk Index (FEMA, n.d.), and
- U.S. Climate Vulnerability Index (Environmental Defense Fund, 2024).

Culture as a Cornerstone of Health Care

Sacred Oaks is an example of a residential facility that incorporates weather hazard resiliency and environmental sustainability, as well as uplifting cultural practices, into its design and operations.

Treatment provided at Sacred Oaks connects patients to their culture with traditional and native healing services. Feedback provided by Tribal advisory groups and other stakeholders informed the building's architecture and landscape design, weaving in cultural and community practices throughout the healthcare facility. The landscape incorporates native plants, water and fire features, and outdoor areas to provide therapeutic environments. The facility's interior decor and artwork highlight traditional Tribal patterns and flow, and a Cultural Room enables patients to further focus on interacting with their cultural and Tribal histories. Furthermore, cultural specialists assist patients and healthcare providers in navigating cultural differences among different Tribes and weaving those elements into patient treatment plans (California Area Indian Health Service, n.d.).

As Sacred Oaks demonstrates, designing for climate resilience can be intertwined with cultural and historical practices while addressing health equity.

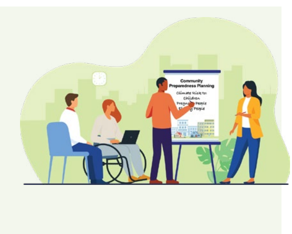
CR4HC Climate Resilience Strategies

The following section identifies specific climate resilience strategies from the Toolkit that are exemplified in this case study:

Element 1. Prospective Risk Assessment

- **Consider both historical trends and climate projections to identify regional climate change-related hazards:** California Area IHS requires capital projects to include elements of prospective risk assessment, such as an analysis of estimated changes to the 100- and 500-year floodplain under climate change scenarios, Climate Impacts Research Consortium toolkit, FEMA National Risk Index, and U.S. Climate Vulnerability Index.

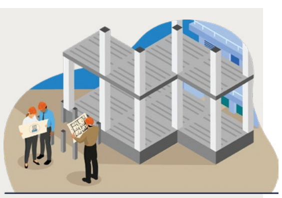
Element 2. Health Equity and Community Engagement



2.1 Community Input

- **Use the Justice, Equity, Diversity, and Inclusion (JEDI) framework to structure community input:** Treatment provided at Sacred Oaks connects patients to their culture with traditional and native healing services. Feedback provided by Tribal advisory groups and other stakeholders informed the building's architecture and landscape design by weaving in cultural and community practices throughout the healthcare facility.

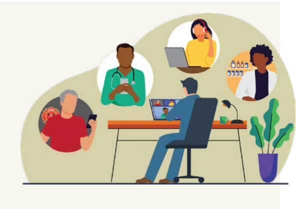
Element 3. Assessment and Remediation of Vulnerabilities in Infrastructure and Operations



3.3 Building and Campus: Design & Construction

- **Install protective barriers and elevated walkways/driveways in areas at risk of flooding:** The Sacred Oaks design included perimeter berms to mitigate flood damage during storms.
- **Use building design strategies like insulation and shading devices to maintain safe temperatures inside the healthcare facility during extreme heat and cold events:** Sacred Oaks installed insulated structural panels to reduce energy costs related to cooling during hot summers and heating during cold winters.
- **Install energy efficient building equipment to extend the length of time during which the facility can function on backup power systems:** The facility includes energy efficient heating, ventilating, and air conditioning units.
- **Use green infrastructure practices to absorb rainwater on-site and reduce flood risk:** Landscaping improvements reduce flood risk, such as permeable walkways, driveways, and patio structures; native, drought-resistant plants; flood channels and culverts, which direct excess floodwaters to a large detention pond; and, a stormwater lift station which displaces the detention pond's stormwater to adjacent properties. The facility is studying the possibility of constructing underground water retention chambers to store rainwater and supply landscape irrigation.

Element 4. Collaboration Between Healthcare Organizations



- **Share knowledge and lessons learned with other regional healthcare organizations:** California IHS updated its land acquisition and building design procedures in response to the lessons learned from the Sacred Oaks flood.

OASH | Office of Climate Change and Health Equity

Case Study:

Spaulding Rehabilitation Hospital

CR4HC

Designing for Climate Resilience Pays Dividends

This case study builds upon the findings of a previous Spaulding case study. This updated study delves deeper into the impacts of Spaulding's successes since its post-Superstorm Sandy (2012) construction in 2013.

Background

Superstorm Sandy (2012) swept up the East Coast in fall 2012, causing massive flooding and power outages and underlining the importance of resilient, standalone healthcare facilities. Although Boston was not severely impacted by the storm, models estimated that a direct hit would have put 6% of the city under water, damaging every waterfront neighborhood (Loth, 2013).

As sea levels rise and hurricanes increase in frequency and intensity, it becomes increasingly important to consider how power usage and reliability affect health center resilience (Sweet et al., 2022). In 2005, amid growing concerns about the vulnerability of Boston's healthcare infrastructure, the Mass General Brigham Hospital system (MGB) took a preemptive step and acquired a contaminated brownfield site in the Charlestown Navy Yard at the mouth of the Charles River. Its vision was to replace the existing Spaulding Rehabilitation Hospital (Spaulding) with a patient-centered, state-of-the-art facility that would be resilient in the face of climate change. In 2013, construction on Spaulding was completed. It stands today as an example of a healthcare facility designed to provide exemplary patient care and withstand the challenges posed by our changing climate.

Well-being Through Innovative Design

The plans for the new Spaulding facility were designed with the understanding that Boston's climate in 50 years will be significantly different than current conditions. MGB initiated a prospective risk assessment, strategically modeling the impact of extreme weather events and climate scenarios that could potentially occur over several decades. The decision to base the assessment on predictive data, rather than relying solely on retrospective data commonly used in risk assessments, underscores MGB's commitment to resilience and fortifies Spaulding and future MGB facilities against the impacts of climate change well into the 21st century.

Multiple innovations were employed to increase the reliability of Spaulding's power system. Its resilience activities include

- collaborating with the local utility provider to raise the electrical infrastructure above predicted flood levels,
- incorporating operable windows to provide access to energy efficient and refreshing harbor breezes and double as escape routes should an emergency occur, and
- utilizing triple-pane insulated windows to increase insulation and reduce energy expenditure.

The cost of implementing these nontraditional hospital design features was minimal. MGB was able to recover a portion of the additional costs directly through utility company rebates and incentives, and indirectly through funding for the brownfield site clean-up. Additional enhancements, such as a roof garden and planted seawalls, reduce the medical center's carbon footprint, increase its climate resilience, and provide significant benefits for the well-being of patients, families, staff, and visitors. A recent survey of MGB Spaulding residents indicated that an overwhelming 98% feel that the facility's outdoor spaces have a positive impact on surrounding communities (Hongbing et al., 2023).

Community Engagement and Collaboration

Community engagement inspired one of the great successes of Spaulding – the development of a playground for children with disabilities, designed by Spaulding pediatricians, on an adjacent site. The playground fosters community interaction and is an example of a healthcare facility investment designed to improve community health and resilience. To this day, the hospital playground remains an extremely active community site.

The success of Spaulding prompted MGB to consider delivery of care beyond its front doors. Hospitals can be thoughtfully designed to remain fully functional during natural disasters; however, patients' ability to receive care is contingent on facility access. Many of MGB's community health centers are the main healthcare providers for disadvantaged groups, which are particularly vulnerable during severe weather events. Engagement and cooperation across healthcare facilities in the network increases the overall system's accessibility to at-risk patients even when transportation infrastructure is temporarily disrupted. MGB also collaborates with the public agencies responsible for utilities, communications, and transportation to ensure that healthcare services remain accessible and functional community-wide during crises.

Since its unveiling in 2013, Spaulding has served as a proof-of-concept for many MGB projects. It successfully demonstrated that a hospital can operate without connection to the power grid for more than 96 hours in the event of extreme weather. Indeed, the novel approach used at Spaulding informed a 32-site resilience plan that includes all 14 of MGB's hospitals, administrative buildings, research facilities, and community health centers (The General Hospital Corporation, 2024 b.). Most recently, MGB has begun construction of a new hospital that draws inspiration from Spaulding's success. The new clinical care facility will be powered almost entirely with renewable energy sources and is designed to withstand disasters such as floods and high winds, enabling the building to continue operations during extreme weather events (The General Hospital Corporation, 2024 a.).

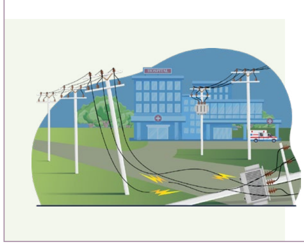
CR4HC Climate Resilience Strategies

The following section identifies specific climate resilience strategies from the Toolkit that are exemplified in this case study:

Element 1. Prospective Risk Assessment

- **Consider both historical trends and climate projections to identify regional climate change-related hazards:** The plans for the new Spaulding facility were designed with the understanding that Boston's climate in 50 years will be significantly different than current conditions. MGB initiated a prospective risk assessment, strategically modeling the impact of extreme weather events and climate scenarios that could potentially occur over several decades.

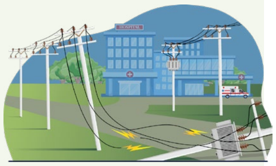
Element 2. Health Equity and Community Engagement



2.2 Community Infrastructure

- **Integrate regional climate projections into multiagency disaster protocols related to utilities, communications, and transportation:** MGB collaborates with the public agencies responsible for utilities, communications, and transportation to ensure that healthcare services remain accessible and functional community-wide during crises.

Element 2. Health Equity and Community Engagement, continued



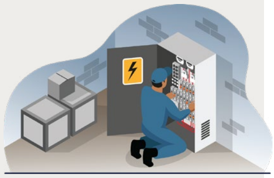
2.2 Community Infrastructure, continued

- **Enhance community resilience by remediating redeveloping contaminated sites for healthcare installations:** The new rehabilitation hospital is located on a formerly contaminated brownfield in Charlestown Navy Yard, Boston, Massachusetts.

Element 3. Assessment and Remediation of Vulnerabilities in Infrastructure and Operations

3.3 Building and Campus: Design & Construction

- **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:** The success of the Spaulding project and subsequent MBG resilience plan have led to future construction projects prioritizing design strategies that will future-proof the facility in a changing climate.
- **Design facilities to promote both environmental sustainability and resilience:** After successfully demonstrating that a hospital can operate without connection to the power grid for more than 96 hours in the event of extreme weather, Spaulding has been used as a proof-of-concept for future construction in the MGB network.
- **Install protective barriers and elevated walkways/driveways in areas at risk of flooding:** The entire facility was raised beyond code requirements to future-proof it from rising sea levels and flood risk. Planted bollards and a sea wall protect it on the water side of the site.
- **Place the healthcare organization's critical infrastructure above the level of projected flood risk:** Spaulding collaborated with the local utility provider to raise the electrical infrastructure above predicted flood levels.
- **Install operable windows with screens in non-clinical spaces to increase the healthcare facility's resilience during power outages:** The facility design incorporated operable windows which reduce energy demand, help patients and staff access fresh air, and double as escape routes should an emergency occur.
- **Use building design strategies, like insulation and shading devices, to maintain safe temperatures inside the healthcare facility during extreme heat and cold events:** One example of energy efficiency measures are Spaulding's triple-paned insulated windows, which reduce solar heat gain during summer months and heat loss during winter months.
- **Maximize green space on the ground level and facility roofs to reduce exposure to heat and flooding:** A roof garden and planted seawalls, in addition to maximizing green space on the site surrounding the hospital, reduce the medical center's carbon footprint, increase its climate resilience, and provide significant benefits for the well-being of patients, families, staff, and visitors.



3.4 Building and Campus: Facility Operations

- **Integrate pre-event resilience measures into healthcare facility operations preventive maintenance and emergency management plans:** MGB used the lessons learned from the rehabilitation hospital to enhance engagement and cooperations across facilities in its network, so that at-risk patients can access care during transportation disruptions.

Element 5. Interdisciplinary Planning, Oversight, and Evaluation

- **Develop a system-wide plan for coordinating care across all facility types under different disaster scenarios:** Establishing a protocol for coordinating care and opportunities to shelter in place during extreme weather events across all facility types in a healthcare system (from acute care to neighborhood clinic) can help direct at-risk populations to preventative services.

Case Study:

University of Nebraska Medical Center

CR4HC

Community-Centered Climate Resilience Planning

A Multidisciplinary, Collaborative Approach to Resilience Planning

The University of Nebraska Medical Center (UNMC) and Nebraska Medicine (NM), the largest healthcare system in Nebraska, employ a multi-stakeholder approach to climate resiliency planning that centers community health and health equity. The health system is preparing to face unpredictable disasters caused by climate change that will require adaptive preparation and response. UNMC/NM recognizes that sustainable operations, decarbonization, and all-hazard preparedness can positively affect community health, and is committed to increasing interdisciplinary collaborations across the system to enhance sustainability and climate resilience. The UNMC Office of Sustainability team uses prospective risk assessment tools to identify climate hazards and their risk profiles. The team uses this information alongside community input to identify and anticipate critical needs in emergency situations. This approach informs UNMC/NM's adaptation measures to build resilience in a changing climate.

Planning for Sustainability

For years, UNMC/NM clinics have been dedicated to increasing sustainability and minimizing their carbon footprint. In 2014, UNMC/NM published its first Sustainability Master Plan (University of Nebraska Medical Center & Nebraska Medicine, 2016). As of May 2023, UNMC/NM reports making strides toward reducing emissions of greenhouse gases, water usage, and waste; utilizing alternative transportation methods; and increasing engagement within their communities (University of Nebraska Medical Center & Nebraska Medicine, 2023). The need for expanding UNMC/NM's activities around resiliency was highlighted by the 2019 Winter Storm Ulmer, which caused $2.6 billion in damages and made one-third of Nebraska highway systems temporarily impassable (University of Nebraska–Lincoln, 2022). Although UNMC/NM was internally prepared to provide care to patients during this kind of disaster, the flood disrupted community infrastructure, including roads and public transportation, and prevented people from reaching UNMC/NM facilities. After the event, UMNC/NM reevaluated opportunities to align internal planning efforts with community emergency planning to better prepare for future weather-related hazards.

Prospective Assessment of Risk and Community Vulnerabilities

UNMC/NM campuses recognized the need to augment the system's emergency preparedness efforts with a forward-looking, community-centered approach to climate resilience. A member of the UNMC/NM sustainability team noted, "Climate impacts will touch every corner of the organization. Ensuring that … as many departments as possible are thinking about what specific, concrete impacts climate change will have on their work [is] essential." To this end, UNMC/UM gathered representatives of architecture and planning, business operations and finance, education, human resources, patient care, public safety, research, and supply chain management. To create a tailored Climate Vulnerability Assessment (CVA) process, these representatives used a combination of

- community engagement,
- [Climate Impacts Research Consortium (CIRC) toolkit](#) (FEMA, 2024 a.),

- FEMA National Risk Index (FEMA, 2024 n.d.),
- EPA's Environmental Justice Screening and Mapping Tool (EPA, 2014),
- U.S. Climate Vulnerability Index (Environmental Defense Fund, 2024), and
- local tools designed specifically for Nebraska (High Plains Regional Climate Center, n.d.), including tools developed for local Tribal communities (High Plains Regional Climate Center, 2024).

The resulting CVA measures institutional vulnerability by establishing climate projections and prospective risk levels and by assessing available evidence that connects climate and non-climate stressors and adaptive capacity throughout the health system. Special attention was paid to patient groups who are at high risk of negative health outcomes after exposure to climate change-related events and those who may benefit from increased support in accessing healthcare.

The CVA identified several areas of vulnerability, including

- power grid reliance,
- energy supply disruptions,
- barriers to safe travel, and
- supply chain interruptions.

The team recognized the need for crisis response planning to provide adequate community support during climate-related disruptions and stressors.

Understanding the strengths and vulnerabilities of the UNMC/NM health system and its relationship with community infrastructure resulted in a robust climate resilience strategy for future emergencies. For example, the medical center has increased resiliency in its power supply systems and cold-water supply systems for critical patient and research areas and is developing an emergency cooling plan to combat hot weather events. Furthermore, the UNMC/NM design guidelines are treated as living documents and are continually revised to incorporate best practices such as enhancing infrastructure; incorporating permeable surfaces for rainwater management; and contributing to multi-modal transportation infrastructure for public and private vehicles, bikes, and pedestrians.

Sustained Community Partnership

By involving the community in the development and implementation of the health system's resilience planning process, including incorporating information from trusted community sources, UNMC/NM is facilitating community connections and building trust. One member of the sustainability team noted, "We know that strength in strategy development and identifying tensions and barriers comes from a diverse set of perspectives." Thus, the health system seeks to integrate information from the High Plains Regional Climate Center as well as hazard plans developed by the Nebraska state government and local communities (High Plains Regional Climate Center, 2024, n.d.). UNMC/NM also plans to sustain and strengthen community engagement through its newly established Community Wellness Collaborative (CWC) in the Highlander development of North Omaha. The CWC is a non-clinical, community-serving space with a vision to provide support and resources through education, training, and building of career pathways. Climate resilience at the community level requires a community response that is fully integrated and well communicated to enable seamless action when hazardous weather events occur. UNMC/NM has leaned into its role as a key contributor to community climate resilience; its efforts to engage and connect beyond the walls of its facilities have paid dividends by fostering strategic partnerships and cooperation.

CR4HC Climate Resilience Strategies

The following section identifies specific climate resilience strategies from the Toolkit that are exemplified in this case study:

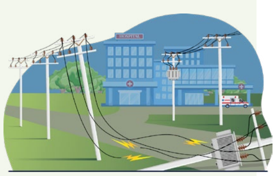
Element 1. Prospective Risk Assessment

- **Consider both historical trends and climate projections to identify regional climate change-related hazards:** The UNMC/NM health system Office of Sustainability team uses prospective risk assessment tools to identify climate hazards and their risk profiles. The team uses this information alongside community input to identify and anticipate critical needs in emergency situations. This approach informs UNMC/NM's adaptation measures to build resilience in a changing climate.

Element 2. Health Equity and Community Engagement

2.1 Community Input

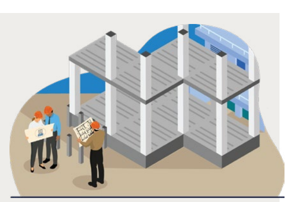
- **Integrate community input into conversations about the implications of regional climate projections on a healthcare organization's emergency planning process, future clinical needs, and opportunities to support community resilience:** The UNMC/NM health system prospective risk assessment and community vulnerability assessment centered community voices in the development of the climate vulnerability assessment and action plan.
- **Map patient populations who are sensitive to high-priority climate change-related hazards:** The UNMC/NM health system climate vulnerability assessment measures institutional vulnerability by establishing climate projections and prospective risk levels and by assessing available evidence that connects climate and non-climate stressors and adaptive capacity throughout the health system. Special attention was paid to patient groups who are at high risk of negative health outcomes after exposure to climate change-related events and those who may benefit from increased support in accessing health care.



2.2 Community Infrastructure

- **Work with local and regional partners to lower barriers to travel for patients and staff during climate change-related emergencies:** The UNMC/NM health system plans to sustain and strengthen community engagement through its newly established Community Wellness Collaborative (CWC) in the Highlander development of North Omaha. The CWC is a non-clinical, community-serving space with a vision to provide support and resources through education, training, and building of career pathways. Climate resilience at the community level requires a community response that is fully integrated and well communicated to enable seamless action when hazardous weather events occur.

Element 3. Assessment and Remediation of Vulnerabilities in Infrastructure and Operations



3.3 Building and Campus: Design & Construction

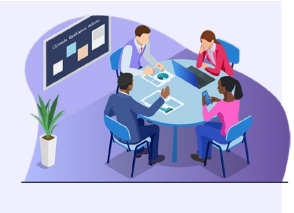
- **Design facilities to promote both environmental sustainability and resilience:** Understanding the strengths and vulnerabilities of the UNMC/NM health system and its relationship with community infrastructure resulted in a robust climate resilience strategy for future emergencies. For example, the medical center has increased resiliency in its power supply systems and cold-water supply systems for critical patient and research areas and is developing an emergency cooling plan to combat hot weather events.

Element 3. Assessment and Remediation of Vulnerabilities in Infrastructure and Operations, continued

3.5 Supply Chain

- **Integrate regional climate change projections into the healthcare organization's supply chain emergency planning process:** Supply chain vulnerabilities were included as a high priority in the UNMC/NM health system climate vulnerability assessment.

Element 5. Interdisciplinary Planning, Oversight, and Evaluation



- **Integrate viewpoints from all segments of the healthcare organization, as well as outside partners, in climate resilience and emergency planning:** UNMC/UM gathered representatives of architecture and planning, business operations and finance, education, human resources, patient care, public safety, research, and supply chain management to create a tailored Climate Vulnerability Assessment process.

Appendices

Appendix A: Climate Resilience Strategies Tools and Resources

Unless otherwise noted, these resources are relevant to all climate-related hazards covered in this toolkit. If they are specifically relevant to particular hazards, this is noted in the column on the right.

Element 1. Prospective Risk Assessment

Planning

Tools and Resources	Hazard Type
6-10 Day Min Temp Outlook: https://www.cpc.ncep.noaa.gov/products/predictions/short_range/cold/tmp_610.php	Extreme Winter Weather
AirNow: Air Quality Index (AQI) Monitoring and Forecasts: https://www.airnow.gov/wildfires/	Wildfire
ASHE Roadmap to Resiliency: https://www.poweredforpatients.org/wp-content/uploads/2017/03/Roadmap-to-Resiliency-ASHE-Powered-for-Patients-White-Paper.pdf	Extreme Heat
ASPR CIP: https://aspr.hhs.gov/cip/	
ASPR RISC Toolkit: https://aspr.hhs.gov/RISC/Pages/default.aspx	
ASPR TRACIE Healthcare System Recovery Timeline: A White Paper for Texas: https://files.asprtracie.hhs.gov/documents/aspr-tracie-ta-healthcare-facility-recovery-timeline-white-paper.pdf	Hurricanes
ASPR TRACIE Topic Collection Climate Change and Healthcare System Considerations: https://asprtracie.hhs.gov/technical-resources/158/climate-change-and-healthcare-system-considerations/0	
ASPR TRACIE Topic Collection EOPs/EMPs: https://asprtracie.hhs.gov/technical-resources/84/emncy-operations-plans-emncy-management-program/1	
ASPR TRACIE Topic Collection Natural Disasters: https://asprtracie.hhs.gov/technical-resources/36/natural-disasters/27	
Assessing Health Vulnerability to Climate Change: A Guide for Health Departments: https://stacks.cdc.gov/view/cdc/24906	
Billion-Dollar Weather and Climate Disasters: https://www.ncei.noaa.gov/access/billions/	
California's Groundwater Live: Groundwater Levels: https://storymaps.arcgis.com/stories/b3886b33b49c4fa8adf2ae8bdd8f16c3	Drought
CDC Heat & Health Tracker: https://ephtracking.cdc.gov/Applications/heatTracker/	Extreme Heat
CDC National Environmental Public Health Tracking Network: https://ephtracking.cdc.gov/DataExplorer/	

Tools and Resources	Hazard Type
CDC/ATSDR Social Vulnerability Index: https://www.atsdr.cdc.gov/placeandhealth/svi/index.html	
CISA Regional Resiliency Assessment Program: https://www.cisa.gov/resources-tools/programs/regional-resiliency-assessment-program	
Climate Change and Extreme Heat Events: https://catalyst.nejm.org/doi/full/10.1056/CAT.21.0454	Extreme Heat
Climate and Health Outlook Portal: https://storymaps.arcgis.com/stories/93ea47545cc944139e3fcefa919cb42b	
Climate Mapping for Resilience and Adaptation (CMRA) – Drought: https://storymaps.arcgis.com/stories/634ee231bb6743b88d23bda96fb838e9	Drought
CMRA – Flooding: https://storymaps.arcgis.com/stories/4ea811276aa641018f3a8d4e28585244	Flooding
CMRA – Wildfire: https://storymaps.arcgis.com/stories/ae2a8072429643f395f8f509df955ae6	Wildfire
ClimRR: https://climrr.anl.gov/	
ClimRR: Degree Day Explorer: https://disgeoportal.egs.anl.gov/portal/apps/webappviewer/index.html?id=ee49120fdd3640c6911e7bc17c027e0b	Extreme Heat, Extreme Winter Weather
ClimRR: Heat Index Explorer: https://disgeoportal.egs.anl.gov/portal/apps/webappviewer/index.html?id=06a52da514364cfab2eab106c247f6c3	Extreme Heat
ClimRR: Temperature Maximum Explorer: https://disgeoportal.egs.anl.gov/portal/apps/webappviewer/index.html?id=acfdc4c74086451cba23c1867f211b05	Extreme Heat
CMRA – Extreme Heat: https://storymaps.arcgis.com/stories/5e482f11d2514191bb89c20638d98b3c	Extreme Heat
CMRA: https://resilience.climate.gov/pages/hazards	Wildfire, Hurricanes, Flooding, Drought
Cumulative Drought Severity Index (CDSI) https://storymaps.arcgis.com/stories/451930a4f1b44147b5f110c5eee12b4f	Drought
Defining Extreme Heat as a Hazard: A Review of Current State Hazard Mitigation Plans: https://hdl.handle.net/10161/27339	Extreme Heat
DOE Rainwater Harvesting Tool: https://www.energy.gov/femp/rainwater-harvesting-tool	Drought
Drought Impact Reporter Dashboard: https://unldroughtcenter.maps.arcgis.com/apps/dashboards/46afe627bb60422f85944d70069c09cf	Drought
Drought Risk Atlas: https://droughtatlas.unl.edu/Home.aspx	Drought
Environmental Justice Index: https://www.atsdr.cdc.gov/placeandhealth/eji/index.html	
EPA Climate Change Indicators: Drought: https://www.epa.gov/climate-indicators/climate-change-indicators-drought	Drought

Tools and Resources	Hazard Type
FEMA Flood Map Service Center: https://msc.fema.gov/portal/home	Flooding
FEMA Risk MAP Program: https://www.fema.gov/flood-maps/tools-resources/risk-map	Hurricanes, Flooding, Thunderstorms & Tornadoes
FGI Surge Planning Tool: https://fgiguidelines.org/wp-content/uploads/2021/04/FGI_Guidance_for_Facilities_that_Respond_and_Adapt_to_Emergency_Conditions.pdf	
Flood Model Methodology: https://firststreet.org/risk-factor/flood-factor/	Flooding
InciWeb: https://inciweb.wildfire.gov/	Wildfire
Midwestern Regional Climate Center Tornado Tracks Tool: https://mrcc.purdue.edu/gismaps/cntytorn	Thunderstorms & Tornadoes
National Drought Mitigation Center: Drought Center Climographs: https://drought.unl.edu/Climographs.aspx	Drought
National Drought Mitigation Center: Drought Center Monitoring Tools: https://drought.unl.edu/Monitoring/DroughtMonitoringTools.aspx	Drought
National Integrated Drought Information System: Drought Early Warning Systems: https://www.drought.gov/about/drought-early-warning	Drought
NIHHIS: https://www.heat.gov/	Extreme Heat
NOAA Coastal Inundation Dashboard: https://tidesandcurrents.noaa.gov/inundationdb/	Hurricanes
NOAA Evaporative Demand Drought Index: https://psl.noaa.gov/eddi/	Drought
NOAA National Centers for Environmental Information (NCEI) Current Drought Reduction: https://www.ncei.noaa.gov/access/monitoring/drought-recovery/current/wmp/end-rain/4	Drought
NOAA NCEI Monthly Drought Report: https://www.ncei.noaa.gov/access/monitoring/monthly-report/drought	Drought
NOAA North American Drought Monitor: https://nadm-noaa.hub.arcgis.com/	Drought
NOAA Storm Events Database: https://www.ncdc.noaa.gov/stormevents/	Hurricanes, Flooding, Thunderstorms & Tornadoes, Extreme Winter Weather
NOAA Storm Prediction Center Fire Weather Outlooks: https://www.spc.noaa.gov/products/fire_wx/	Wildfire
North American Seasonal Fire Assessment and Outlook: https://www.nifc.gov/nicc-files/predictive/outlooks/NA_Outlook.pdf	Wildfire
National Risk Index (NRI): https://hazards.fema.gov/nri/	
NRI: Heat Wave: https://hazards.fema.gov/nri/heat-wave	Extreme Heat
NWS Climate Prediction Center: Drought Monitoring: https://www.cpc.ncep.noaa.gov/products/monitoring_and_data/drought.shtml	Drought

Tools and Resources	Hazard Type
NWS Hazards Map: https://www.weather.gov/	Wildfire, Hurricanes, Flooding, Thunderstorms & Tornadoes
NWS Hurricane Center Data Archive: https://www.nhc.noaa.gov/data/	Hurricanes
NWS National Hurricane Center Storm Surge Risk Maps: https://experience.arcgis.com/experience/203f772571cb48b1b8b50fdcc3272e2c	Hurricanes, Flooding, Thunderstorms & Tornadoes
NWS National Hurricane Center: https://www.nhc.noaa.gov/	Hurricanes
NWS Convective Storm Watch: https://www.spc.noaa.gov/products/watch/	Thunderstorms & Tornadoes
NWS SLOSH Model: https://www.nhc.noaa.gov/surge/slosh.php	Hurricanes
NYS Heat Vulnerability Index: https://www.health.ny.gov/environmental/weather/vulnerability_index/	Extreme Heat
Preparing for the Health Effects of Drought: A Resource Guide for Public Health Professionals: https://stacks.cdc.gov/view/cdc/61709	Drought
QuickDRI: https://quickdri.unl.edu/	Drought
Spatial Climate Analysis: https://hprcc.unl.edu/sca/	Extreme Winter Weather
U.S. Drought Monitor: https://droughtmonitor.unl.edu/	Drought
U.S. Drought Portal: https://www.drought.gov/	Drought
USFS Drought Summary Tool: https://usfs.maps.arcgis.com/apps/Cascade/index.html?appid=3b1396771b164dc4ae89885466a25116	Drought
USDA Forest Service Wildfire Risk to Communities: https://wildfirerisk.org/	Wildfire
USGS National Water Dashboard: https://dashboard.waterdata.usgs.gov/app/nwd/en/?aoi=default	
Vegetation Dynamics Viewer: https://vegdri.cr.usgs.gov/viewer/	Drought
WaterWatch: https://waterwatch.usgs.gov/index.php?id=ww	Drought, Flooding
Winter Storm Severity Index Web Display: https://www.wpc.ncep.noaa.gov/wwd/wssi/wssi.php	Extreme Winter Weather

People and Operations

Tools and Resources	Hazard Type
ASHE Hospital Disaster Preparedness: https://www.ashe.org/management_monographs/mg2009richter	
Building Community Resilience with Natural-Based Solutions (NBS): Strategies for Success: https://www.fema.gov/sites/default/files/documents/fema_nbs_community-resilience-strategies-success_102023.pdf	

Tools and Resources	Hazard Type
CDC NIOSH Occupational Exposure to Heat and Hot Environments: https://www.cdc.gov/niosh/docs/2016-106/	Extreme Heat
Climate Change and Extreme Heat Events: How Health Systems Should Prepare: https://catalyst.nejm.org/doi/full/10.1056/CAT.21.0454	Extreme Heat
Falling Dominoes: A Planner's Guide to Drought and Cascading Impacts: https://planning-org-uploaded-media.s3.amazonaws.com/publication/download_pdf/Falling-Dominoes-Planners-Guide-to-Drought-and-Cascading-Impacts.pdf	Drought
FEMA Create a Hazard Mitigation Plan: https://www.fema.gov/emergency-managers/risk-management/hazard-mitigation-planning/create-hazard-plan	
When Every Drop Counts: Protecting Public Health During Drought Conditions Counts -A Guide for Public Health Professionals: https://stacks.cdc.gov/view/cdc/5758	Drought

Physical Infrastructure

Tools and Resources	Hazard Type
ASHE Risk Assessment of Medical Equipment: https://www.ashe.org/medrisk	
NDMC: Drought Center Planning Tools: https://drought.unl.edu/Planning.aspx	Drought

Funding Opportunities

Tools and Resources	Hazard Type
ASPR Hospital Preparedness Program (HPP): https://aspr.hhs.gov/HealthCareReadiness/HPP/Pages/about-hpp.aspx	
Climate Ready Tribes: https://www.nihb.org/public_health/climate_resources.php#funding	
FEMA Building Resilient Infrastructure and Communities (BRIC): https://www.fema.gov/grants/mitigation/building-resilient-infrastructure-communities	
FEMA Emergency Management Baseline Assessment Grant Program: https://www.fema.gov/grants/preparedness/emergency-management-baseline-assessment	
FEMA Hazard Mitigation Grant Program (HMGP): https://www.fema.gov/grants/mitigation/hazard-mitigation	
FEMA Next Generation Warning System Grant Program (NGWSGP): https://www.fema.gov/emergency-managers/practitioners/integrated-public-alert-warning-system/broadcasters-wireless/ngwsp	
FEMA Pre-Disaster Mitigation (PDM) Grant Program: https://www.fema.gov/grants/mitigation/pre-disaster	
FEMA Safeguarding Tomorrow Revolving Loan Fund (RLF) Program: https://www.fema.gov/grants/mitigation/storm-rlf	

Tools and Resources	Hazard Type
HHS Compendium of Federal Resources for Health Sector Emissions Reduction and Resilience: https://www.hhs.gov/climate-change-health-equity-environmental-justice/climate-change-health-equity/actions/health-care-sector-pledge/federal-resources/index.html	
Inflation Reduction Act (IRA) Quickfinder for Health Care Sector Funding: https://www.hhs.gov/climate-change-health-equity-environmental-justice/climate-change-health-equity/quickfinder-ira/index.html	
NASA Solicitation and Proposal Integrated Review and Evaluation System (NSPIRES) Solicitation and Proposal System: https://nspires.nasaprs.com/	
National Integrated Heat Health Information System (NIIHHIS) Federal Funding Opportunities for Heat Resilience: https://www.heat.gov/pages/funding-opportunities	Extreme Heat
Tribal Climate Resilience (TCR) Annual Awards Program: https://www.bia.gov/bia/ots/tcr	
Tribal Climate Change Funding Guide: https://tribalclimateguide.uoregon.edu/	

Element 2.1 Community Input

Planning

Tools and Resources	Hazard Type
AirNow: AQI Monitoring and Forecasts: https://www.airnow.gov/wildfires/	Wildfire
AMA Center for Health Equity: https://www.ama-assn.org/about/ama-center-health-equity/embedding-equity-crisis-preparedness-and-response-health-systems	
ASPE Addressing SDOH: Examples of Successful Evidence-Based Strategies and Current Federal Efforts: https://aspe.hhs.gov/sites/default/files/documents/e2b650cd64cf84aae8ff0fae7474af82/SDOH-Evidence-Review.pdf	
ASPR TRACIE Topic Collection Disasters and Healthcare Disparity: https://asprtracie.hhs.gov/technical-resources/156/disasters-and-at-risk-populations/0	
Assessing Health Vulnerability to Climate Change: A Guide for Health Departments: https://stacks.cdc.gov/view/cdc/24906	
Disasters and Emergencies | Ready.gov: https://www.ready.gov/be-informed	
Extreme Cold: A Prevention Guide to Promote Your Personal Health and Safety: https://stacks.cdc.gov/view/cdc/5689	Extreme Winter Weather
FEMA Risk MAP Program: https://www.fema.gov/flood-maps/tools-resources/risk-map	Hurricanes, Flooding, Thunderstorms & Tornadoes
Heat Response Plans: Summary of Evidence and Strategies for Collaboration and Implementation: https://stacks.cdc.gov/view/cdc/93705	Extreme Heat
HHS emPOWER Map of Medicare Beneficiaries with Electricity-Dependent DME: https://empowerprogram.hhs.gov/empowermap	

Tools and Resources	Hazard Type
Natural Disasters and Severe Weather | Prevent Hypothermia & Frostbite: https://www.cdc.gov/natural-disasters/psa-toolkit/preventing-hypothermia-and-frostbite.html	Extreme Winter Weather
Preparing for the Health Effects of Drought: A Resource Guide for Public Health Professionals: https://stacks.cdc.gov/view/cdc/61709	Drought
Severe Weather Survival Tips | How to Stay Safe During Extreme Cold When You Live Outdoors: https://nhchc.org/wp-content/uploads/2019/08/Extreme_ColdV31.pdf	Extreme Winter Weather
SVI Interactive Map: https://www.atsdr.cdc.gov/place-health/php/svi/svi-interactive-map.html	

People and Operations

Tools and Resources	Hazard Type
AHA Community Health Needs Assessment: https://www.healthycommunities.org/resources/community-health-assessment-toolkit	
APHA Climate Change and Health Playbook: Adaptation Planning for Justice, Equity, Diversity and Inclusion: https://www.apha.org/Topics-and-Issues/Climate-Health-and-Equity/JEDI	
Beyond Health Care: The Role of Social Determinants in Promoting Health and Health Equity: https://www.kff.org/racial-equity-and-health-policy/issue-brief/beyond-health-care-the-role-of-social-determinants-in-promoting-health-and-health-equity/	
CDC Reentering Your Flooded Home: https://www.cdc.gov/floods/safety/reentering-your-flooded-home-safety.html	Flooding
Climate Change and Extreme Heat Events: How Health Systems Should Prepare: https://catalyst.nejm.org/doi/full/10.1056/CAT.21.0454	Extreme Heat
Community Wildfire Mitigation Best Practices Toolbox: https://co-co.org/community-wildfire-mitigation-best-practices-toolbox/	Wildfire
Developing an Equitable Wildfire Risk Mitigation Program: https://www.fireadapted-washington.org/wp-content/uploads/2023/07/Activity-1.-Equitable-Mitigation-Pro-gram-Report.pdf	Wildfire
Falling Dominoes: A Planner's Guide to Drought and Cascading Impacts: https://planning-org-uploaded-media.s3.amazonaws.com/publication/download_pdf/Falling-Dominoes-Planners-Guide-to-Drought-and-Cascading-Impacts.pdf	Drought
FEMA Wildfire and Outdoor Fire Safety Pictographs: https://www.usfa.fema.gov/gallery/pictographs/wildfire-and-outdoor.html	Wildfire
FEMA: A Whole Community Approach to Emergency Management: Principles, Themes, and Pathways for Action: https://www.fema.gov/sites/default/files/2020-07/whole_community_dec2011__2.pdf	
Floods and Your Safety | CDC: https://www.cdc.gov/healthywater/emergency/extreme-weather/floods.html	Flooding

Tools and Resources	Hazard Type
NAS Workshop on Communities, Climate Change, and Health Equity – Lessons Learned in Addressing Inequities in Heat-Related Climate Change Impacts: https://www.nationalacademies.org/event/06-20-2023/workshop-on-communities-climate-change-and-health-equity-lessons-learned-in-addressing-inequities-in-heat-related-climate-change-impacts	Extreme Heat

Funding Opportunities

Tools and Resources	Hazard Type
Climate Ready Tribes: https://www.nihb.org/public_health/climate_resources.php#funding	
Community Services Block Grant: https://www.acf.hhs.gov/ocs/programs/community-services-block-grant-csbg	Extreme Winter Weather
FEMA BRIC: https://www.fema.gov/grants/mitigation/building-resilient-infrastructure-communities	
FEMA National Flood Insurance Program: https://www.fema.gov/flood-insurance	Flooding
FEMA Floodplain Mangement: https://www.fema.gov/floodplain-management	Flooding
HHS Compendium of Federal Resources for Health Sector Emissions Reduction and Resilience: https://www.hhs.gov/climate-change-health-equity-environmental-justice/climate-change-health-equity/actions/health-care-sector-pledge/federal-resources/index.html	
IRA Quickfinder for Health Care Sector Funding: https://www.hhs.gov/climate-change-health-equity-environmental-justice/climate-change-health-equity/quickfinder-ira/index.html	
Tribal Climate Change Funding Guide: https://tribalclimateguide.uoregon.edu/	

Element 2.2 Community Infrastructure

Planning

Tools and Resources	Hazard Type
About Urban Heat Islands: https://www.heat.gov/pages/urban-heat-islands	Extreme Heat
City Resources for Adapting to Heat: https://www.epa.gov/heatislands/adapting-heat	Extreme Heat
Duke Energy Wildfire Emergency Preparedness: https://sustainablesolutions.duke-energy.com/solutions/energy-resilience/wildfire-emergency-preparedness/	Wildfire
EJSCREEN: https://ejscreen.epa.gov/mapper/	
EPA Heat Island Compendium: https://www.epa.gov/heatislands/heat-island-compendium	Extreme Heat

Tools and Resources	Hazard Type
EPA Heat Island Cooling Strategies: https://www.epa.gov/heatislands/heat-island-cooling-strategies	Extreme Heat
Disasters and Emergencies | Ready.gov: https://www.ready.gov/be-informed	
FEMA Risk MAP Program: https://www.fema.gov/flood-maps/tools-resources/risk-map	Hurricanes, Flooding, Thunderstorms & Tornadoes
Heat Response Plans: Summary of Evidence and Strategies for Collaboration and Implementation: https://stacks.cdc.gov/view/cdc/93705	Extreme Heat
i-Tree Species: https://species.itreetools.org	Extreme Heat
Masterclass: Understanding, Modeling, and Mitigating Urban Heat Islands: https://ghhin.org/masterclasses/masterclass-understanding-modeling-and-mitigating-urban-heat-islands/	Extreme Heat
National Center for Healthy Housing (NCHH) Cooling Centers by State: https://nchh.org/information-and-evidence/learn-about-healthy-housing/emergencies/extreme-heat/cooling-centers-by-state/	Extreme Heat
NCHH Cooling Centers by State: https://nchh.org/information-and-evidence/learn-about-healthy-housing/emergencies/extreme-heat/cooling-centers-by-state/	Extreme Heat
NIHHIS: https://www.heat.gov/	Extreme Heat
OSHA Flood Preparedness and Response: https://www.osha.gov/flood/preparedness	Flooding, Hurricanes, Thunderstorms & Tornadoes
Planning for Urban Heat Resilience – PAS Report 600: https://planning-org-uploaded-media.s3.amazonaws.com/publication/download_pdf/PAS-Report-600-r1.pdf	Extreme Heat
Planning Framework for Protecting Commercial Building Occupants from Smoke During Wildfire Events: https://www.ashrae.org/File%20Library/Technical%20Resources/COVID-19/Planning-Framework-for-Protecting-Commercial-Building-Occupants-from-Smoke-During-Wildfire-Events.pdf	Wildfire
Protecting Vulnerable Patient Populations from Climate Hazards: A Referral Guide for Health Professionals: https://www.hhs.gov/climate-change-health-equity-environmental-justice/climate-change-health-equity/health-sector-resource-hub/referral-guide/index.html	
Resources and Facilitation Toolkit: Before, During, and After a Wildfire: https://www.fireadaptedwashington.org/toolkit/#Smoke-Ready-Toolkit	Wildfire
Urban Forestry Toolkit: https://www.vibrantcitieslab.com/toolkit/	Extreme Heat
USDA Forest Service Wildfire Risk to Communities: https://wildfirerisk.org/	Wildfire
Urban Sustainability Directors Network (USDN) Resilience Hubs: What, Why, How: https://resilience-hub.org	
Vegetation Dynamics Viewer: https://vegdri.cr.usgs.gov/viewer/	Drought

People and Operations

Tools and Resources	Hazard Type
Building Community Resilience with NBS: Strategies for Success: https://www.fema.gov/sites/default/files/documents/fema_nbs_community-resilience-strategies-success_102023.pdf	
California Department of Water Resources: Conservation Tips: https://water.ca.gov/Water-Basics/Conservation-Tips	Drought
CDC Reentering Your Flooded Home: https://www.cdc.gov/floods/safety/reentering-your-flooded-home-safety.html?CDC_AAref_Val=https://www.cdc.gov/disasters/floods/after.html	Flooding
CDC Tornadoes: https://www.cdc.gov/tornadoes/	Thunderstorms & Tornadoes
Climate Change and Extreme Heat Events: How Health Systems Should Prepare: https://catalyst.nejm.org/doi/full/10.1056/CAT.21.0454	Extreme Heat
DHS Resilience Hub Finder: https://experience.arcgis.com/experience/7f7988a5b2df4543b9c6c73b2d8e18e1/	Hurricanes, Wildfire
EPA Drought Response and Recovery: A Basic Guide for Water Utilities: https://www.epa.gov/sites/default/files/2017-10/documents/drought_guide_final_508compliant_october2017.pdf	Drought
Falling Dominoes: A Planner's Guide to Drought and Cascading Impacts: https://planning-org-uploaded-media.s3.amazonaws.com/publication/download_pdf/Falling-Dominoes-Planners-Guide-to-Drought-and-Cascading-Impacts.pdf	Drought
FEMA Local Government Officials – Floodplain Management Resources: https://www.fema.gov/floodplain-management/manage-risk/local	Hurricanes, Flooding, Thunderstorms & Tornadoes
FEMA State and Tribal Government Officials – Floodplain Management Resources: https://www.fema.gov/floodplain-management/manage-risk/state-tribal	Hurricanes, Flooding, Thunderstorms & Tornadoes
Floods and Your Safety | CDC: https://www.cdc.gov/healthywater/emergency/extreme-weather/floods.html	Flooding
NIEHS Protecting Yourself While Removing Post-Disaster Debris from Your Home or Business: https://tools.niehs.nih.gov/wetp/public/hasl_get_blob.cfm?ID=9295	Flooding, Hurricanes, Thunderstorms & Tornadoes
NWS Flood Safety Tips and Resources: https://www.weather.gov/safety/flood	Flooding
NWS Social Media: Tornadoes: https://www.weather.gov/safety/thunderstorm	Thunderstorms & Tornadoes
NWS Tornado Safety: https://www.weather.gov/wrn/spring-tornado-sm	Thunderstorms & Tornadoes
OSHA Hurricane Preparedness and Response: https://www.osha.gov/hurricane	Hurricanes
OSHA Tornado Preparedness and Response: https://www.osha.gov/tornado	Thunderstorms & Tornadoes
Save our Water: https://saveourwater.com/	Drought
Disasters and Emergencies | Ready.gov: https://www.ready.gov/be-informed	

Physical Infrastructure

Tools and Resources	Hazard Type
Addressing Drought Across the West: https://experience.arcgis.com/experience/512cef7647fe42698dc05dd4e75d4343/page/Home/	Drought
CDC Private Wells After a Wildfire: https://www.cdc.gov/environmental-health-services/php/water/private-wells-after-a-wildfire.html	Wildfire
Chicago Climate Action Plan: https://www.chicago.gov/city/en/progs/env/climateaction.html	
Climate Ready DC Resilient Design Guidelines: https://doee.dc.gov/sites/default/files/dc/sites/ddoe/service_content/attachments/CRDC%20resilient%20design%20guidelines_FINALApproved.pdf	
Climate Resiliency Design Guidelines: https://climate.cityofnewyork.us/initiatives/climate-resiliency-design-guidelines/	
Condensation Control in Attics and Roofs in Cold Weather: https://basc.pnnl.gov/resource-guides/condensation-control-attics-and-roofs-cold-weather	Extreme Winter Weather
Curated Topical Reuse Resources: https://www.epa.gov/waterreuse/curated-topical-reuse-resources	Drought
DOE Efficient Design and Cool Roofs: https://www.energy.gov/energysaver/cool-roofs	Extreme Heat
DOE National Community Solar Partnership: https://www.energy.gov/communitysolar/community-solar	
DOE Zero Energy Buildings Resource Hub: https://www.energy.gov/eere/buildings/zero-energy-buildings-resource-hub	
Drought & WaterSense: https://www.epa.gov/watersense/drought-watersense	Drought
Drought and Infrastructure: A Planning Guide: https://www.cisa.gov/sites/default/files/publications/Drought-and-Infrastructure-A-Planning-Guide.pdf	Drought
EPA Flood Resilience: A Basic Guide for Water and Wastewater Utilities: https://www.epa.gov/waterutilityresponse/flood-resilience-basic-guide-water-and-wastewater-utilities	Flooding, Thunderstorms & Tornadoes
EPA Green Infrastructure for Climate Resiliency: https://www.epa.gov/green-infrastructure/green-infrastructure-climate-resiliency	
EPA Green Infrastructure Modeling Toolkit: https://www.epa.gov/water-research/green-infrastructure-modeling-toolkit	Hurricanes, Flooding, Drought, Thunderstorms & Tornadoes
EPA Green Stormwater Solutions for Congregations: https://www.epa.gov/sites/default/files/2020-06/documents/stormwatersolutionscongregations_508.pdf	Hurricanes, Thunderstorms & Tornadoes
EPA Incident Action Checklist: Wildfire: https://www.epa.gov/system/files/documents/2022-03/220218-incident-action-checklist-wildfires.pdf	Wildfire
EPA Technical information and resources to manage flood risk: https://www.epa.gov/green-infrastructure/manage-flood-risk	Flooding, Hurricanes, Thunderstorms & Tornadoes

Tools and Resources	Hazard Type
EPA Water Sector Utility Incident Action Checklist: https://www.epa.gov/waterutilityresponse/incident-action-checklists-water-utilities	
FEMA Building Codes Adoption Playbook for Authorities Having Jurisdiction: https://www.fema.gov/sites/default/files/documents/fema_building-codes-adoption-playbook-for-authorities-having-jurisdiction.pdf	Hurricanes, Flooding, Thunderstorms & Tornadoes
FEMA Elevator Installation for Buildings Located in Special Flood Hazard Areas: https://www.fema.gov/sites/default/files/2020-07/fema_tb4_elevator_installation.pdf	Hurricanes, Flooding
FEMA Emergency Power Systems for Critical Facilities: https://www.fema.gov/sites/default/files/2020-07/fema_p-1019_final_02-06-2015.pdf	Hurricanes, Flooding, Extreme Winter Weather, Thunderstorms & Tornadoes
FEMA Fact Sheet 3.0: Buildings, Systems and Equipment: https://www.fema.gov/sites/default/files/documents/fema_p-2181-fact-sheet-3-0-buildings.pdf	Hurricanes, Flooding, Thunderstorms & Tornadoes
FEMA Hurricane and Flood Mitigation Handbook for Public Facilities: https://www.wbdg.org/FFC/DHS/fema_p2181.pdf	Hurricanes, Flooding, Thunderstorms & Tornadoes, Extreme Winter Weather
FEMA Safe Rooms for Tornadoes and Hurricanes: https://www.fema.gov/sites/default/files/documents/fema_safe-rooms-for-tornadoes-and-hurricanes_p-361.pdf	Hurricanes, Flooding, Thunderstorms & Tornadoes
Firetopia Land Use Toolbox: https://cpaw.headwaterseconomics.org/apps/firetopia/	Wildfire
Flood Resilience Portal: https://floodresilience.net/how-to-build-resilience/	Flooding
Green Infrastructure – Build Resiliency to Drought: https://www.epa.gov/green-infrastructure/build-resiliency-drought	Drought
Healthcare Facilities and Power Outages: https://www.fema.gov/sites/default/files/2020-07/healthcare-facilities-and-power-outages.pdf	
International Plumbing Code (IPC) Storm Drainage Provisions: https://codes.iccsafe.org/content/IPC2018P5/chapter-11-storm-drainage	Hurricanes, Flooding, Thunderstorms & Tornadoes
Minimizing the Adverse Effects of Snow and Ice on Roofs: https://www.poa.usace.army.mil/Portals/34/docs/engineering/MP-01-5663,%20Minimizing%20the%20Adverse%20Effects%20of%20Snow%20and%20Ice%20on%20Roofs.pdf	Extreme Winter Weather
Natural and Structural Measures for Shoreline Stabilization: https://coast.noaa.gov/data/digitalcoast/pdf/living-shoreline.pdf	Flooding
Permeable pavement: https://www.epa.gov/system/files/documents/2021-11/bmp-permeable-pavements.pdf	Extreme Winter Weather
Resilience Strategies for Wildfire: https://www.c2es.org/wp-content/uploads/2018/11/resilience-strategies-for-wildfire.pdf	Wildfire
Sanitary Backflow Prevention Devices: https://www.edinamn.gov/DocumentCenter/View/8424/Sanitary-Backflow-Prevention-PDF	Hurricanes, Flooding, Thunderstorms & Tornadoes
Storm Wise South Florida Landscapes: https://www.sfwmd.gov/sites/default/files/documents/bts_stormwise_landscapes.pdf	Hurricanes

Tools and Resources	Hazard Type
Supporting Access to Health Care: Resilient Emergency Power for Florida Community Health Centers: https://fachc.org/wp-content/uploads/2023/05/Resilient-Emergency-Power-for-Community-Health-Centers_-MAY2023-1.pdf	
The Freeze-Thaw Cycle in Concrete and Brick Assemblies: https://orf.od.nih.gov/TechnicalResources/Documents/Technical%20Bulletins/19TB/The%20Freeze-Thaw%20Cycle%20in%20Concrete%20and%20Brick%20Assemblies%20January%202019-Technical%20Bulletin_508.pdf	Extreme Winter Weather
Water Reuse and Recycling: https://www.epa.gov/waterreuse	Drought
Water-Prepared Local Health Department Checklist: https://www.naccho.org/uploads/downloadable-resources/WASH-LHD-Factsheet-Final.pdf	Hurricanes, Flooding, Drought, Thunderstorms & Tornadoes
WaterSense: Outdoors: https://www.epa.gov/watersense/outdoors	Drought
Wildfire Resilience and the Role of Landscapes: https://www.facilitiesnet.com/groundsmanagement/article/Wildfire-Resilience-and-the-Role-of-Landscapes--19441	Wildfire
Wildfires and Safe Drinking Water: https://doh.wa.gov/community-and-environment/drinking-water/wildfires-and-safe-drinking-water#:~:text=Compile%20documentation%2C%20communicate%20with%20response%20partners%2C%20communicate%20with,of%20critical%20water%20infrastructure%20and%20locations.%20More%20items	Wildfire

Funding Opportunities

Tools and Resources	Hazard Type
Bureau of Reclamation WaterSMART: https://www.usbr.gov/watersmart/index.html	Drought, Wildfire
Climate Ready Tribes: https://www.nihb.org/public_health/climate_resources.php#funding	
Community Planning Assistance for Wildfires Implementation Resources: https://cpaw.headwaterseconomics.org/wp-content/uploads/2020/01/FINAL_CPAW-Implementation-Resources_2020.pdf	Wildfire
Community Services Block Grant: https://www.acf.hhs.gov/ocs/programs/community-services-block-grant-csbg	Extreme Winter Weather
DOE Weatherization Assistance Program: https://www.energy.gov/scep/wap/about-weatherization-assistance-program	Extreme Heat, Extreme Winter Weather
EPA Clean Water State Revolving Fund: https://www.epa.gov/cwsrf	Drought
EPA Drinking Water State Revolving Fund (DWSRF): https://www.epa.gov/dwsrf	Drought
EPA Environmental and Climate Justice Program: https://www.epa.gov/inflation-reduction-act/inflation-reduction-act-environmental-and-climate-justice-program	
FEMA BRIC: https://www.fema.gov/grants/mitigation/building-resilient-infrastructure-communities	

Tools and Resources	Hazard Type
FEMA Hazard Mitigation Grant Program Post Fire: https://www.fema.gov/grants/mitigation/post-fire	Wildfire
FEMA Hazard Mitigation Assistance (HMA) Program and Policy Guide: https://www.fema.gov/sites/default/files/documents/fema_hma_guide_08232023_v1.pdf	
FEMA HMGP: https://www.fema.gov/grants/mitigation/hazard-mitigation	
FEMA National Flood Insurance Program: https://www.fema.gov/flood-insurance	Flooding
FEMA Floodplain Mangement: https://www.fema.gov/floodplain-management	Hurricanes, Flooding, Thunderstorms & Tornadoes
FEMA PDM Grant Program: https://www.fema.gov/grants/mitigation/pre-disaster	
HHS Compendium of Federal Resources for Health Sector Emissions Reduction and Resilience: https://www.hhs.gov/climate-change-health-equity-environmental-justice/climate-change-health-equity/actions/health-care-sector-pledge/federal-resources/index.html	
Low Income Home Energy Assistance Program (LIHEAP): https://www.acf.hhs.gov/ocs/low-income-home-energy-assistance-program-liheap	
NIHHIS Federal Funding Opportunities for Heat Resilience: https://www.heat.gov/pages/funding-opportunities	Extreme Heat
NIHHIS - CAPA Strategies: Urban Heat Island Mapping Campaign Program: https://www.heat.gov/pages/mapping-campaigns	Extreme Heat
TCR Annual Awards Program: https://www.bia.gov/bia/ots/tcr	
Tribal Climate Change Funding Guide: https://tribalclimateguide.uoregon.edu/	
Water Reuse Infrastructure Funding Programs: https://www.epa.gov/waterreuse/water-reuse-infrastructure-funding-programs	Drought

Element 2.3 Community Services

Planning

Tools and Resources	Hazard Type
AirNow: AQI Monitoring and Forecasts: https://www.airnow.gov/wildfires/	Wildfire
ASPR TRACIE Durable Medical Equipment (DME) in Disasters: https://files.asprtracie.hhs.gov/documents/aspr-tracie-durable-medical-equipment-in-disasters.pdf	Flooding, Thunderstorms & Tornadoes, Extreme Winter Weather
CalEnviroScreen: https://oehha.ca.gov/calenviroscreen	
California Health Places Index (CHPI): https://www.healthyplacesindex.org/	

Tools and Resources	Hazard Type
CDC Emergency Planning, Training, and Response for Water, Sanitation, & Hygiene (WASH)-related Emergencies & Outbreaks: https://www.cdc.gov/healthywater/emergency/planning-training-response/index.html?CDC_AA_refVal=https%3A%2F%2Fwww.cdc.gov%2Fhealthywater%2Femergency%2Fplanning-training-response%2Fplanning-training-response.html	Flooding
CDC Protect Yourself From the Dangers of Extreme Heat: https://www.cdc.gov/climate-health/php/resources/protect-yourself-from-the-dangers-of-extreme-heat.html	Extreme Heat
City Resources for Adapting to Heat: https://www.epa.gov/heatislands/adapting-heat	Extreme Heat
EJSCREEN: https://ejscreen.epa.gov/mapper/	
Extreme Cold: A Prevention Guide to Promote Your Personal Health and Safety: https://stacks.cdc.gov/view/cdc/5689	Extreme Winter Weather
Disasters and Emergencies | Ready.gov: https://www.ready.gov/be-informed	
Heat Response Plans: Summary of Evidence and Strategies for Collaboration and Implementation: https://stacks.cdc.gov/view/cdc/93705	Extreme Heat
Heat-Related Emergency Medical Services (EMS) Activation Surveillance Dashboard: https://nemsis.org/heat-related-ems-activation-surveillance-dashboard/	Extreme Heat
HHS emPOWER Map of Medicare Beneficiaries with Electricity-Dependent DME: https://empowerprogram.hhs.gov/empowermap	
Natural Disasters and Severe Weather | Prevent Hypothermia & Frostbite: https://www.cdc.gov/natural-disasters/psa-toolkit/preventing-hypothermia-and-frostbite.html	Extreme Winter Weather
NCHH Cooling Centers by State: https://nchh.org/information-and-evidence/learn-about-healthy-housing/emergencies/extreme-heat/cooling-centers-by-state/	Extreme Heat
NOAA Storm Prediction Center Fire Weather Outlooks: https://www.spc.noaa.gov/products/fire_wx/	Wildfire
OSHA Flood Preparedness and Response: https://www.osha.gov/flood/preparedness	Flooding, Hurricanes, Thunderstorms & Tornadoes
Resources and Facilitation Toolkit: Before, During, and After a Wildfire: https://www.fireadaptedwashington.org/toolkit/#Smoke-Ready-Toolkit	Wildfire
Severe Weather Survival Tips | How to Stay Safe During Extreme Cold When You Live Outdoors: https://nhchc.org/wp-content/uploads/2019/08/Extreme_ColdV31.pdf	Extreme Winter Weather
SoCalGas: https://www.socalgas.com/	
Southern California Edison: https://www.sce.com/	
USDA Forest Service Wildfire Risk to Communities: https://wildfirerisk.org/	Wildfire
USDN Resilience Hubs: What, Why, How: https://resilience-hub.org	

People and Operations

Tools and Resources	Hazard Type
7 Tips to Prepare Your Hospital Before, During, and After a Hurricane Strikes: https://www.scphealth.com/blog/7-tips-to-prepare-your-hospital-before-during-and-after-a-hurricane-strikes/#:~:text=Plan%20for%20a%20Post-storm%20Patient%20Surge%20Hospitals%20should,optimizing%20your%20staffing%20mix%20and%20preparing%20your%20team.	Hurricanes, Flooding, Thunderstorms & Tornadoes
AgriSafe Network: https://www.agrisafe.org/	Flooding, Drought, Extreme Heat, Wildfire, Thunderstorms & Tornadoes
C40 Knowledge: https://www.c40knowledgehub.org	
California Department of Water Resources: Conservation Tips: https://water.ca.gov/Water-Basics/Conservation-Tips	Drought
CDC Drought Communication Toolkit: https://www.cdc.gov/drought-health/toolkit/index.html	Drought
CDC Heat and Medications – Guidance for Clinicians: https://www.cdc.gov/heat-health/hcp/clinical-guidance/heat-and-medications-guidance-for-clinicians.html	Extreme Heat
Climate Change and Extreme Heat Events: How Health Systems Should Prepare: https://catalyst.nejm.org/doi/full/10.1056/CAT.21.0454	Extreme Heat
Climate-Resilient Health Clinics Toolkit: https://www.americares.org/what-we-do/community-health/climate-resilient-health-clinics/#toolkit	
Disaster Supplemental Nutrition Assistance Program: https://www.disasterassistance.gov/get-assistance/forms-of-assistance/5769	
DHS Resilience Hub Finder: https://experience.arcgis.com/experience/7f7988a5b2df4543b9c6c73b2d8e18e1/	Hurricanes, Wildfire
Emergency Preparedness for The Homeless: https://nhchc.org/clinical-practice/homeless-services/emergency-preparedness/	
Falling Dominoes: A Planner's Guide to Drought and Cascading Impacts: https://planning-org-uploaded-media.s3.amazonaws.com/publication/download_pdf/Falling-Dominoes-Planners-Guide-to-Drought-and-Cascading-Impacts.pdf	Drought
Interagency Wildland Fire Air Quality Response Program: https://www.wildlandfiresmoke.net	Wildfire
Pediatric Environmental Health Specialty Units (PEHSU) Children's Health & Wildfires: https://www.pehsu.net/Children_s_Health_Wildfires.html	Wildfire
PEHSU Children's Health & Wildfires - Western States: https://wspehsu.ucsf.edu/projects/wildfires-and-childrens-health-2/	Wildfire
Save our Water: https://saveourwater.com/	Drought

Physical Infrastructure

Tools and Resources	Hazard Type
Climate Ready DC Resilient Design Guidelines: https://doee.dc.gov/sites/default/files/dc/sites/ddoe/service_content/attachments/CRDC%20resilient%20design%20guidelines_FINALApproved.pdf	
Condensation Control in Attics and Roofs in Cold Weather: https://basc.pnnl.gov/resource-guides/condensation-control-attics-and-roofs-cold-weather	Extreme Winter Weather
Curated Topical Reuse Resources: https://www.epa.gov/waterreuse/curated-topical-reuse-resources	Drought
Drought & WaterSense: https://www.epa.gov/watersense/drought-watersense	Drought
FEMA Hurricane and Flood Mitigation Handbook for Public Facilities: https://www.wbdg.org/FFC/DHS/fema_p2181.pdf	Hurricanes, Flooding, Thunderstorms & Tornadoes, Extreme Winter Weather
Minimizing the Adverse Effects of Snow and Ice on Roofs: https://www.poa.usace.army.mil/Portals/34/docs/engineering/MP-01-5663,%20Minimizing%20the%20Adverse%20Effects%20of%20Snow%20and%20Ice%20on%20Roofs.pdf	Extreme Winter Weather
NIHB Cooling Center Checklist for Tribes: https://www.nihb.org/resources/cooling-center-checklist-for-web.pdf	Extreme Heat
Permeable pavement: https://www.epa.gov/system/files/documents/2021-11/bmp-permeable-pavements.pdf	Extreme Winter Weather
The Freeze-Thaw Cycle in Concrete and Brick Assemblies: https://orf.od.nih.gov/TechnicalResources/Documents/Technical%20Bulletins/19TB/The%20Freeze-Thaw%20Cycle%20in%20Concrete%20and%20Brick%20Assemblies%20January%202019-Technical%20Bulletin_508.pdf	Extreme Winter Weather
Water Reuse and Recycling: https://www.epa.gov/waterreuse	Drought
Wildfire Response and Recovery: The Importance of Coordinated Care and Social Support: https://catalyst.nejm.org/doi/full/10.1056/CAT.22.0161	Wildfire

Funding Opportunities

Tools and Resources	Hazard Type
Cigna Extends Medicare Advantage Transportation Benefit Due to Heat: https://newsroom.cigna.com/2022-07-29-As-Temperatures-Rise,-Cigna-Offers-Medicare-Advantage-Customers-Rides-To-Cooling-Centers-at-No-Extra-Cost	Extreme Heat
Climate Ready Tribes: https://www.nihb.org/public_health/climate_resources.php#funding	
EPA Environmental and Climate Justice Program: https://www.epa.gov/inflation-reduction-act/inflation-reduction-act-environmental-and-climate-justice-program	
FEMA BRIC: https://www.fema.gov/grants/mitigation/building-resilient-infrastructure-communities	

Tools and Resources	Hazard Type
FEMA Emergency Food and Shelter Program: https://www.fema.gov/grants/emergency-food-and-shelter-program	
FEMA HMA Program and Policy Guide: https://www.fema.gov/sites/default/files/documents/fema_hma_guide_08232023_v1.pdf	
FEMA HMA: Warning Tools - Reverse 911: https://www.fema.gov/grants/mitigation/guide/part-12/b/12#:~:text=Reverse%20911%20systems%20allow%20safety,within%20a%20defined%20geographic%20area.	
HHS Compendium of Federal Resources for Health Sector Emissions Reduction and Resilience: https://www.hhs.gov/climate-change-health-equity-environmental-justice/climate-change-health-equity/actions/health-care-sector-pledge/federal-resources/index.html	
IRA Quickfinder for Health Care Sector Funding: https://www.hhs.gov/climate-change-health-equity-environmental-justice/climate-change-health-equity/quickfinder-ira/index.html	
Tribal Climate Change Funding Guide: https://tribalclimateguide.uoregon.edu/	

Element 2.4 Coordination with Local Office of Emergency Management

Planning

Tools and Resources	Hazard Type
AirNow: AQI Monitoring and Forecasts: https://www.airnow.gov/wildfires/	Wildfire
ASPR TRACIE Topic Collection Healthcare Facility Evacuation/Sheltering: https://asprtracie.hhs.gov/technical-resources/57/healthcare-facility-evacuation-sheltering/56	
ASPR TRACIE: Engaging Healthcare System Partners in Medical Surge: https://asprtracie.hhs.gov/surge-partners	
Assessing Health Vulnerability to Climate Change: A Guide for Health Departments: https://stacks.cdc.gov/view/cdc/24906	
California EMSA Hospital Incident Command System Current Guidebook and Appendices: https://emsa.ca.gov/disaster-medical-services-division-hospital-incident-command-system/	Wildfire
CDC Community Assessment for Public Health Emergency Response (CASPER): https://www.cdc.gov/casper/?CDC_AAref_Val=https://www.cdc.gov/nceh/casper/default.htm	
CDC/NWS HeatRisk Tool: https://www.wpc.ncep.noaa.gov/heatrisk/	Extreme Heat
CHCAMS Emergency Preparedness: https://chcams.org/emergency-preparedness/	Wildfire
City Resources for Adapting to Heat: https://www.epa.gov/heatislands/adapting-heat	Extreme Heat

Tools and Resources	Hazard Type
Climate Adaptation Planning for Emergency Management Course – AWR-347 Climate Adaptation Planning for Emergency Management: https://ndptc.hawaii.edu/training/catalog/35/#course-description	
CMRA – Wildfire: https://storymaps.arcgis.com/stories/ae2a8072429643f395f8f509df955ae6	Wildfire
Disasters and Emergencies | Ready.gov: https://www.ready.gov/be-informed	
FEMA Risk MAP Program: https://www.fema.gov/flood-maps/tools-resources/risk-map	Hurricanes, Flooding, Thunderstorms & Tornadoes
Heat Response Plans: Summary of Evidence and Strategies for Collaboration and Implementation: https://stacks.cdc.gov/view/cdc/93705	Extreme Heat
NASA Disaster Response Coordination System (DRCS): https://disasters-nasa.hub.arcgis.com/	Hurricanes
NOAA Coastal Inundation Dashboard: https://tidesandcurrents.noaa.gov/inundationdb/	Hurricanes
NOAA Storm Prediction Center Fire Weather Outlooks: https://www.spc.noaa.gov/products/fire_wx/	Wildfire
North American Seasonal Fire Assessment and Outlook: https://www.nifc.gov/nicc-files/predictive/outlooks/NA_Outlook.pdf	Wildfire
NWS Hazards Map: https://www.weather.gov/	Wildfire, Hurricanes, Flooding, Thunderstorms & Tornadoes
NWS National Hurricane Center: https://www.nhc.noaa.gov/	Hurricanes
OSHA Flood Preparedness and Response: https://www.osha.gov/flood/preparedness	Flooding, Hurricanes, Thunderstorms & Tornadoes
Preparing for the Health Effects of Drought: A Resource Guide for Public Health Professionals: https://stacks.cdc.gov/view/cdc/61709	Drought
USDA Forest Service Wildfire Risk to Communities: https://wildfirerisk.org/	Wildfire
WHO Checklist for assessing healthcare facilities in the context of storms: https://cdn.who.int/media/docs/default-source/climate-change/storm-checklists.pdf?sfvrsn=674ade9b_5	Hurricanes, Thunderstorms & Tornadoes
WHO Floods Checklist: https://cdn.who.int/media/docs/default-source/climate-change/flood-checklists.pdf?sfvrsn=730226ff_5	Flooding, Hurricanes, Thunderstorms & Tornadoes

People and Operations

Tools and Resources	Hazard Type
7 Tips to Prepare Your Hospital Before, During, and After a Hurricane Strikes: https://www.scphealth.com/blog/7-tips-to-prepare-your-hospital-before-during-and-after-a-hurricane-strikes/#:~:text=Plan%20for%20a%20Post-storm%20Patient%20Surge%20Hospitals%20should,optimizing%20your%20staffing%20mix%20and%20pre-paring%20your%20team	Hurricanes, Flooding, Thunderstorms & Tornadoes

Tools and Resources	Hazard Type
Building Community Resilience with NBS: Strategies for Success: https://www.fema.gov/sites/default/files/documents/fema_nbs_community-resilience-strategies-success_102023.pdf	
CDC Wildfires and Your Safety: https://www.cdc.gov/wildfires/about/?CDC_AAref_Val=https://www.cdc.gov/disasters/wildfires/index.html	Wildfire
Climate-Resilient Health Clinics Toolkit: https://www.americares.org/what-we-do/community-health/climate-resilient-health-clinics/#toolkit	
Falling Dominoes: A Planner's Guide to Drought and Cascading Impacts: https://planning-org-uploaded-media.s3.amazonaws.com/publication/download_pdf/Falling-Dominoes-Planners-Guide-to-Drought-and-Cascading-Impacts.pdf	Drought
FEMA | National Incident Management System: https://www.fema.gov/sites/default/files/documents/fema_guidance-extreme-temperatures-state-local-tribal-territorial-leaders.pdf	Extreme Winter Weather, Flooding, Thunderstorms & Tornadoes
FEMA Create a Hazard Mitigation Plan: https://www.fema.gov/emergency-managers/risk-management/hazard-mitigation-planning/create-hazard-plan	
Guidance on Extreme Temperatures for State, Local, Tribal and Territorial Leaders: https://www.fema.gov/sites/default/files/documents/fema_guidance-extreme-temperatures-state-local-tribal-territorial-leaders.pdf	Extreme Heat, Extreme Winter Weather
Healthcare Ready: Disaster Healthcare Supply Chain: https://healthcareready.org/wp-content/uploads/2020/02/HCR-FACTSHEET_disaster-supplychain_V2_021820.pdf	
Hurricane Preparedness Tabletop Exercise: https://www.setrac.org/wp-content/uploads/2022/06/Hurricane-TTX-2022-AAR.pdf	Hurricanes
Incident Response Guide: Wildland Fire: https://emsa.ca.gov/wp-content/uploads/sites/71/2017/07/Wildland-Fire-IRG.pdf	Wildfire
OSHA Hurricane Preparedness and Response: https://www.osha.gov/hurricane	Hurricanes
Strengthening Post-Hurricane Supply Chain Resilience: Observations from Hurricanes Harvey, Irma, and Maria: https://www.ncbi.nlm.nih.gov/books/NBK556360/	Hurricanes
When Every Drop Counts: Protecting Public Health During Drought Conditions Counts -A Guide for Public Health Professionals: https://stacks.cdc.gov/view/cdc/5758	Drought
WHO Checklist for assessing healthcare facilities in the context of sea level rise: https://cdn.who.int/media/docs/default-source/climate-change/sea-level-rise-checklists.pdf?sfvrsn=66f45cb2_5	Hurricanes, Flooding
Wildfire Preparedness: https://rise.articulate.com/share/iujqrMm1CFz3v7lVt5JYtVXLHWIHbyVq#/	Wildfire

Physical Infrastructure

Tools and Resources	Hazard Type
EPA Water Sector Utility Incident Action Checklist: https://www.epa.gov/waterutilityresponse/incident-action-checklists-water-utilities	

Tools and Resources	Hazard Type
Guidance for Health and Residential Facilities to Build Resilience to Emergency Conditions: https://fgiguidelines.org/wp-content/uploads/2021/04/FGI_Guidance_for_Facilities_that_Respond_and_Adapt_to_Emergency_Conditions.pdf	Flooding, Hurricanes Extreme Winter Weather, Thunderstorms & Tornadoes
Water-Prepared Local Health Department Checklist: https://www.naccho.org/uploads/downloadable-resources/WASH-LHD-Factsheet-Final.pdf	Hurricanes, Flooding, Drought, Thunderstorms & Tornadoes
Wildfire Response and Recovery: The Importance of Coordinated Care and Social Support: https://catalyst.nejm.org/doi/full/10.1056/CAT.22.0161	Wildfire

Funding Opportunities

Tools and Resources	Hazard Type
ASPR HPP: https://aspr.hhs.gov/HealthCareReadiness/HPP/Pages/about-hpp.aspx	
CDC Public Health Emergency Preparedness (PHEP) Program and Guidance: https://www.cdc.gov/readiness/php/phep/index.html	
Cigna Extends Medicare Advantage Transportation Benefit Due to Heat: https://newsroom.cigna.com/2022-07-29-As-Temperatures-Rise,-Cigna-Offers-Medicare-Advantage-Customers-Rides-To-Cooling-Centers-at-No-Extra-Cost	Extreme Heat
FEMA NGWSGP: https://www.fema.gov/emergency-managers/practitioners/integrated-public-alert-warning-system/broadcasters-wireless/ngwsp	

Element 3.1 Staff Support

Planning

Tools and Resources	Hazard Type
ASPR TRACIE Topic Collection Healthcare Facility Evacuation/Sheltering: https://asprtracie.hhs.gov/technical-resources/57/healthcare-facility-evacuation-sheltering/56	
Disasters and Emergencies | Ready.gov: https://www.ready.gov/be-informed	
NOAA Coastal Inundation Dashboard: https://tidesandcurrents.noaa.gov/inundationdb/	Hurricanes
Pandemic Preparedness Guides: https://www.cdc.gov/pandemic-flu/hcp/healthcare-preparedness-response/index.html	
WHO Checklist for assessing healthcare facilities in the context of storms: https://cdn.who.int/media/docs/default-source/climate-change/storm-checklists.pdf?sfvrsn=674ade9b_5	Hurricanes, Thunderstorms & Tornadoes
WHO Floods Checklist: https://cdn.who.int/media/docs/default-source/climate-change/flood-checklists.pdf?sfvrsn=730226ff_5	Flooding, Hurricanes, Thunderstorms & Tornadoes

People and Operations

Tools and Resources	Hazard Type
Agency for Healthcare Research and Quality Care for the Caregiver: https://www.ahrq.gov/patient-safety/settings/hospital/candor/modules/notes6.html	
American Industrial Hygiene Association (AIHA) Tornado Recovery Resources: https://www.aiha.org/public-resources/consumer-resources/disaster-response-resource-center/health-and-safety-issues-in-natural-disasters/tornado-recovery-hazards	Thunderstorms & Tornadoes
American Red Cross Tornado Safety Resources: https://www.redcross.org/get-help/how-to-prepare-for-emergencies/types-of-emergencies/tornado.html	Thunderstorms & Tornadoes
ASPR TRACIE Technical Resources: https://asprtracie.hhs.gov/technical-resources	
C40 Knowledge: https://www.c40knowledgehub.org	
California OSHA Heat Prevention for Indoor Working Environments: https://www.cahf.org/Portals/29/DisasterPreparedness/extreme%20temps/cal_OSHA_Indoor_environments.pdf	Extreme Heat
CDC National Institute for Occupational Safety and Health (NIOSH): https://www.cdc.gov/niosh	Thunderstorms & Tornadoes, Hurricanes, Extreme Heat
CDC Reentering Your Flooded Home: https://www.cdc.gov/floods/safety/reentering-your-flooded-home-safety.html?CDC_AAref_Val=https://www.cdc.gov/disasters/floods/after.html	Flooding
CDC Tornadoes: https://www.cdc.gov/tornadoes/	Thunderstorms & Tornadoes
Cold Stress Guide: https://www.osha.gov/emergency-preparedness/guides/cold-stress	Extreme Winter Weather
Cold Weather Safety: https://www.weather.gov/safety/cold	Extreme Winter Weather
Creating a Resilient Organization: Caring for Health Care Workers During a Crisis: https://www.ama-assn.org/system/files/2020-05/caring-for-health-care-workers-covid-19.pdf	
FEMA Tornado Resources: https://community.fema.gov/ProtectiveActions/s/article/Tornado	Thunderstorms & Tornadoes
Flooding Advice for Managers of Healthcare Facilities: https://www.hpsc.ie/a-z/environmentandhealth/severeweatherevents/flooding/floodingadviceforthegeneralpublic/floodinghealthcarefacilityadvice/	Flooding
Floods and Your Safety | CDC: https://www.cdc.gov/healthywater/emergency/extreme-weather/floods.html	Flooding
Health Facilities Preparation for Extreme Heat: https://www.canada.ca/en/health-canada/services/environmental-workplace-health/reports-publications/climate-change-health/health-facilities-preparation-extreme-heat-recommendations-retirement-care-facility-managers-health-canada-2011.html	Extreme Heat
HHS Public Health Emergency System for Advance Registration of Volunteer Health Professionals: https://www.phe.gov/esarvhp/	

Tools and Resources	Hazard Type
Hurricane Preparedness Tabletop Exercise: https://www.setrac.org/wp-content/uploads/2022/06/Hurricane-TTX-2022-AAR.pdf	Hurricanes
OSHA Evacuation Plans and Procedures eTool: https://www.osha.gov/etools/evacuation-plans-procedures/eap/elements	
OSHA Flood Cleanup Factsheet: https://www.osha.gov/sites/default/files/publications/OSHA3471.pdf	Flooding
U.S. DOL Worker Safety After Storms: https://www.youtube.com/watch?v=rLOlXazP3Qs	Flooding, Thunderstorms & Tornadoes
WHO Checklist for assessing healthcare facilities in the context of sea level rise: https://cdn.who.int/media/docs/default-source/climate-change/sea-level-rise-check-lists.pdf?sfvrsn=66f45cb2_5	Hurricanes, Flooding

Physical Infrastructure

Tools and Resources	Hazard Type
Federal medical shelters: https://aspr.hhs.gov/SNS/Pages/Federal-Medical-Stations.aspx	
WHO Drought Checklists: https://cdn.who.int/media/docs/default-source/climate-change/drought-checklists.pdf?sfvrsn=bcff4453_5	Drought

Element 3.2 Clinical Considerations

Planning

Tools and Resources	Hazard Type
AirNow: AQI Monitoring and Forecasts: https://www.airnow.gov/wildfires/	Wildfire
ASHE Weathering the Storm: Health care facilities on the front lines of climate change response and recovery: https://www.ashe.org/sustainability/weathering-the-storm-climate-change	
ASPR TRACIE: Engaging Healthcare System Partners in Medical Surge: https://asprtracie.hhs.gov/surge-partners	
CDC Emergency Planning, Training, and Response for WASH-related Emergencies & Outbreaks: https://www.cdc.gov/water-emergency/php/training/index.html	Flooding
CDC Heat & Health Tracker: https://ephtracking.cdc.gov/Applications/heatTracker/	Extreme Heat
CDC National Environmental Public Health Tracking Network: https://ephtracking.cdc.gov/DataExplorer/	
CDC/NWS HeatRisk Tool: https://www.wpc.ncep.noaa.gov/heatrisk/	Extreme Heat
Disasters and Emergencies | Ready.gov: https://www.ready.gov/be-informed	

Tools and Resources	Hazard Type
Extreme Cold: A Prevention Guide to Promote Your Personal Health and Safety: https://stacks.cdc.gov/view/cdc/5689	Extreme Winter Weather
FEMA Flood Map Service Center: https://msc.fema.gov/portal/home	Flooding
FEMA Risk MAP Program: https://www.fema.gov/flood-maps/tools-resources/risk-map	Hurricanes, Flooding, Thunderstorms & Tornadoes
Heat Response Plans: Summary of Evidence and Strategies for Collaboration and Implementation: https://stacks.cdc.gov/view/cdc/93705	Extreme Heat
Heat-Related EMS Activation Surveillance Dashboard: https://nemsis.org/heat-related-ems-activation-surveillance-dashboard/	Extreme Heat
HHS emPOWER Map of Medicare Beneficiaries with Electricity-Dependent DME: https://empowerprogram.hhs.gov/empowermap	
Natural Disasters and Severe Weather | Prevent Hypothermia & Frostbite: https://www.cdc.gov/natural-disasters/psa-toolkit/preventing-hypothermia-and-frostbite.html	Extreme Winter Weather
NOAA Storm Prediction Center Fire Weather Outlooks: https://www.spc.noaa.gov/products/fire_wx/	Wildfire
Planning Framework for Protecting Commercial Building Occupants from Smoke During Wildfire Events: https://www.ashrae.org/File%20Library/Technical%20Resources/COVID-19/Planning-Framework-for-Protecting-Commercial-Building-Occupants-from-Smoke-During-Wildfire-Events.pdf	Wildfire
Severe Weather Survival Tips | How to Stay Safe During Extreme Cold When You Live Outdoors: https://nhchc.org/wp-content/uploads/2019/08/Extreme_ColdV31.pdf	Extreme Winter Weather
USDA Forest Service Wildfire Risk to Communities: https://wildfirerisk.org/	Wildfire

People and Operations

Tools and Resources	Hazard Type
AgriSafe Network: https://www.agrisafe.org/	Drought, Extreme Heat, Wildfire, Flooding, Thunderstorms & Tornadoes
AIHA Tornado Recovery Resources: https://www.aiha.org/public-resources/consumer-resources/disaster-response-resource-center/health-and-safety-issues-in-natural-disasters/tornado-recovery-hazards	Thunderstorms & Tornadoes
ASHE Hospital Incident Command System (HICS): https://www.ashe.org/management_monographs/mg2008richter	
C40 Knowledge: https://www.c40knowledgehub.org	
California Association of Health Facilities' (CAHF) Disaster Preparedness Program: Extreme Temperatures: https://www.cahfdisasterprep.com/extremetemp	Extreme Heat, Extreme Winter Weather

Tools and Resources	Hazard Type
CDC Drought Communication Toolkit: https://www.cdc.gov/drought-health/toolkit/index.html	Drought
CDC Tornadoes: https://www.cdc.gov/tornadoes/	Thunderstorms & Tornadoes
Checklist for assessing climate hazards | Cold Waves: https://cdn.who.int/media/docs/default-source/climate-change/cold-wave-checklists.pdf?sfvrsn=a0a7f2db_5	Extreme Winter Weather
Climate Change and Extreme Heat Events: How Health Systems Should Prepare: https://catalyst.nejm.org/doi/full/10.1056/CAT.21.0454	Extreme Heat
Climate-Resilient Health Clinics Toolkit: https://www.americares.org/what-we-do/community-health/climate-resilient-health-clinics/#toolkit	
Cold Stress Guide: https://www.osha.gov/emergency-preparedness/guides/cold-stress	Extreme Winter Weather
Cold Weather Safety: https://www.weather.gov/safety/cold	Extreme Winter Weather
Cold-Related Illnesses: https://www.cdc.gov/niosh/topics/coldstress/coldrelatedillnesses.html	Extreme Winter Weather
Disaster Crash Cart Charting for Emergency Shelters: https://disastercrashcart.org/chartingemergencyshelter.php	Wildfire
Disasters and Emergencies | Ready.gov: https://www.ready.gov/be-informed	
Emergency Preparedness for The Homeless: https://nhchc.org/clinical-practice/homeless-services/emergency-preparedness/	
FEMA Tornado Resources: https://community.fema.gov/ProtectiveActions/s/article/Tornado	Thunderstorms & Tornadoes
Floods and Your Safety | CDC: https://www.cdc.gov/water-emergency/?CDC_AAref_Val=https://www.cdc.gov/healthywater/emergency/extreme-weather/floods.html	Flooding
Floods Create Health Risks: What to LookOout For and How to Avoid Them: https://www.preventionweb.net/news/floods-create-health-risks-what-look-out-and-how-avoid-them	Flooding
Health Facility Wildfire Preparedness: https://cdphe.colorado.gov/health-facility-wildfire-preparedness	Wildfire
Incident Response Guide: Wildland Fire: https://emsa.ca.gov/wp-content/uploads/sites/71/2017/07/Wildland-Fire-IRG.pdf	Wildfire
When Every Drop Counts: Protecting Public Health During Drought Conditions Counts -A Guide for Public Health Professionals: https://stacks.cdc.gov/view/cdc/5758	Drought
Wildfire Preparedness: https://rise.articulate.com/share/iujqrMm1CFz3v7lVt5JYtVXLHWIHbyVq#/	Wildfire
WHO Floods: https://www.who.int/health-topics/floods#tab=tab_1	Flooding, Thunderstorms & Tornadoes

Tools and Resources	Hazard Type
WHO guidance for climate resilient and environmentally sustainable health care facilities: https://www.who.int/publications/i/item/9789240012226	

Funding Opportunities

Tools and Resources	Hazard Type
FEMA BRIC: https://www.fema.gov/grants/mitigation/building-resilient-infrastructure-communities	
FEMA Fact Sheet 3.0: Buildings, Systems and Equipment: https://www.fema.gov/sites/default/files/documents/fema_p-2181-fact-sheet-3-0-buildings.pdf	Hurricanes, Flooding, Thunderstorms & Tornadoes
Guidance for Health and Residential Facilities to Build Resilience to Emergency Conditions: https://fgiguidelines.org/wp-content/uploads/2021/04/FGI_Guidance_for_Facilities_that_Respond_and_Adapt_to_Emergency_Conditions.pdf	Flooding, Hurricanes, Extreme Winter Weather, Thunderstorms & Tornadoes
HHS Compendium of Federal Resources for Health Sector Emissions Reduction and Resilience: https://www.hhs.gov/climate-change-health-equity-environmental-justice/climate-change-health-equity/actions/health-care-sector-pledge/federal-resources/index.html	

Element 3.3 Building and Campus: Design & Construction

Planning

Tools and Resources	Hazard Type
ASHE Best Practices in Business Planning for Energy Resiliency: https://www.ashe.org/bestpractices	
Climate Resilience for Frontline Clinics Toolkit: https://www.americares.org/what-we-do/community-health/climate-resilient-health-clinics/	
i-Tree Species: https://species.itreetools.org	Extreme Heat
NIST Contingency Planning Guide for Information Systems: https://nvlpubs.nist.gov/nistpubs/Legacy/SP/nistspecialpublication800-34r1.pdf	
Planning for Urban Heat Resilience – PAS Report 600: https://planning-org-uploaded-media.s3.amazonaws.com/publication/download_pdf/PAS-Report-600-r1.pdf	Extreme Heat
TCR Annual Awards Program: https://www.bia.gov/bia/ots/tcr	
Tree Campus USA: https://www.arborday.org/our-work/tree-campus-higher-education/standards	Extreme Heat
WHO Checklist for assessing healthcare facilities in the context of storms: https://cdn.who.int/media/docs/default-source/climate-change/storm-checklists.pdf?sfvrsn=674ade9b_5	Hurricanes, Thunderstorms & Tornadoes
WHO Floods Checklist: https://cdn.who.int/media/docs/default-source/climate-change/flood-checklists.pdf?sfvrsn=730226ff_5	Flooding, Hurricanes, Thunderstorms & Tornadoes

People and Operations

Tools and Resources	Hazard Type
C40 Knowledge: https://www.c40knowledgehub.org	
CAHF Ready, Set, Go! for Extreme Cold: https://www.cahf.org/Portals/29/DisasterPreparedness/extreme%20temps/RSG-ExtremeCold.pdf	Extreme Winter Weather
Climate-Resilient Health Clinics Toolkit: https://www.americares.org/what-we-do/community-health/climate-resilient-health-clinics/#toolkit	
Hospital Fire Prevention and Evacuation Guide: https://iris.paho.org/bitstream/handle/10665.2/34976/hospitalsdontburn_eng.pdf?sequence=1&isAllowed=y	Wildfire
OSHA Evacuation Plans and Procedures eTool: https://www.osha.gov/etools/evacuation-plans-procedures/eap/elements	
Save our Water: https://saveourwater.com/	Drought
Storm Preparedness and Response Tools and Checklists for Healthcare Facilities: https://www.urmc.rochester.edu/emergency-preparedness/preparedness-and-response-tools-resources/winter-weather-preparedness.aspx	Extreme Winter Weather
Tip Sheet: Extreme Cold Weather for Alternative Care Sites: https://files.asprtracie.hhs.gov/documents/hcw-training-resources-extreme-cold-weather-government-resources-and-tip-sheet.pdf	Extreme Winter Weather
WHO Checklist for assessing healthcare facilities in the context of sea level rise: https://cdn.who.int/media/docs/default-source/climate-change/sea-level-rise-checklists.pdf?sfvrsn=66f45cb2_5	Hurricanes, Flooding

Physical Infrastructure

Tools and Resources	Hazard Type
ASPR Topic Collection on Alternate Care Sites: https://asprtracie.hhs.gov/technical-resources/48/alternate-care-sites-including-shelter-medical-care/47	
Building Community Resilience with NBS: A Guide for Local Officials: https://www.fema.gov/sites/default/files/documents/fema_riskmap-nature-based-solutions-guide_2021.pdf	
CDC Emergency Water Supply Planning Guide for Hospitals and Healthcare Facilities: https://www.cdc.gov/healthywater/emergency/ewsp.html	
Climate Ready DC Resilient Design Guidelines: https://doee.dc.gov/sites/default/files/dc/sites/ddoe/service_content/attachments/CRDC%20resilient%20design%20guidelines_FINALApproved.pdf	
Climate Resilience for Frontline Clinics Toolkit: https://www.americares.org/what-we-do/community-health/climate-resilient-health-clinics/	
CMS Categorical Waiver: https://www.cms.gov/files/document/qso-23-11-lsc.pdf	

Tools and Resources	Hazard Type
Cold climate impact on runoff management: https://stormwater.pca.state.mn.us/images/5/50/Cold_climate_impact_on_runoff_management.pdf	Extreme Winter Weather
Condensation Control in Attics and Roofs in Cold Weather: https://basc.pnnl.gov/resource-guides/condensation-control-attics-and-roofs-cold-weather	Extreme Winter Weather
Curated Topical Reuse Resources: https://www.epa.gov/waterreuse/curated-topical-reuse-resources	Drought
EPA Flood Resilience: A Basic Guide for Water and Wastewater Utilities: https://www.epa.gov/waterutilityresponse/flood-resilience-basic-guide-water-and-wastewater-utilities	Flooding, Thunderstorms & Tornadoes
EPA Green Infrastructure for Climate Resiliency: https://www.epa.gov/green-infrastructure/green-infrastructure-climate-resiliency	
EPA Green Infrastructure Modeling Toolkit: https://www.epa.gov/water-research/green-infrastructure-modeling-toolkit	Hurricanes, Flooding, Drought, Thunderstorms & Tornadoes
EPA Green Stormwater Solutions for Congregations: https://www.epa.gov/sites/default/files/2020-06/documents/stormwatersolutionscongregations_508.pdf	Hurricanes, Thunderstorms & Tornadoes
EPA Technical information and resources to manage flood risk: https://www.epa.gov/green-infrastructure/manage-flood-risk	Flooding, Hurricanes Thunderstorms & Tornadoes
FEMA Building Codes Adoption Playbook for Authorities Having Jurisdiction: https://www.fema.gov/sites/default/files/documents/fema_building-codes-adoption-playbook-for-authorities-having-jurisdiction.pdf	Hurricanes, Flooding, Thunderstorms & Tornadoes
FEMA Elevator Installation for Buildings Located in Special Flood Hazard Areas: https://www.fema.gov/sites/default/files/2020-07/fema_tb4_elevator_installation.pdf	Hurricanes, Flooding
FEMA Emergency Power Systems for Critical Facilities: https://www.fema.gov/sites/default/files/2020-07/fema_p-1019_final_02-06-2015.pdf	Hurricanes, Flooding, Extreme Winter Weather, Thunderstorms & Tornadoes
FEMA Fact Sheet 3.0: Buildings, Systems and Equipment: https://www.fema.gov/sites/default/files/documents/fema_p-2181-fact-sheet-3-0-buildings.pdf	Hurricanes, Flooding, Thunderstorms & Tornadoes
FEMA Hurricane and Flood Mitigation Handbook for Public Facilities: https://www.wbdg.org/FFC/DHS/fema_p2181.pdf	Hurricanes, Flooding, Thunderstorms & Tornadoes, Extreme Winter Weather
FEMA Safe Rooms for Tornadoes and Hurricanes: https://www.fema.gov/sites/default/files/documents/fema_safe-rooms-for-tornadoes-and-hurricanes_p-361.pdf	Hurricanes, Flooding, Thunderstorms & Tornadoes
Flood Resilience Portal: https://floodresilience.net/how-to-build-resilience/	Flooding
Green Infrastructure - Build Resiliency to Drought: https://www.epa.gov/green-infrastructure/build-resiliency-drought	Drought
Guidance for Health and Residential Facilities to Build Resilience to Emergency Conditions: https://fgiguidelines.org/wp-content/uploads/2021/04/FGI_Guidance_for_Facilities_that_Respond_and_Adapt_to_Emergency_Conditions.pdf	Flooding, Hurricanes, Extreme Winter Weather, Thunderstorms & Tornadoes

Tools and Resources	Hazard Type
Healthcare Facilities and Power Outages: https://www.fema.gov/sites/default/files/2020-07/healthcare-facilities-and-power-outages.pdf	
Hospitals weather cold temps with proven practices: https://www.hfmmagazine.com/articles/4391-hospitals-weather-cold-temps-with-proven-practices	Extreme Winter Weather
IPC Storm Drainage Provisions: https://codes.iccsafe.org/content/IPC2018P5/chapter-11-storm-drainage	Hurricanes, Flooding, Thunderstorms & Tornadoes
Minimizing the Adverse Effects of Snow and Ice on Roofs: https://www.poa.usace.army.mil/Portals/34/docs/engineering/MP-01-5663,%20Minimizing%20the%20Adverse%20Effects%20of%20Snow%20and%20Ice%20on%20Roofs.pdf	Extreme Winter Weather
Mitigating the Effects of Extreme Heat: https://www.csemag.com/articles/mitigating-the-effects-of-extreme-heat/	Extreme Heat
NOAA NIDIS Building a More Drought-Resilient Urban Forest Ecosystem: https://www.drought.gov/drought-research/building-more-drought-resilient-urban-forest-ecosystem	Drought
NYSUFC: The Urban Heat Island and Extreme Heat: https://nysufc.org/the-urban-heat-island-and-extreme-heat-eight-guidelines-for-trees-in-the-urban-landscape/2023/08/29/	Extreme Heat
Permeable pavement: https://www.epa.gov/system/files/documents/2021-11/bmp-permeable-pavements.pdf	Extreme Winter Weather
Sanitary Backflow Prevention Devices: https://www.edinamn.gov/DocumentCenter/View/8424/Sanitary-Backflow-Prevention-PDF	Hurricanes, Flooding, Thunderstorms & Tornadoes
Smart Hospitals – Rainwater Harvesting for Smart Health Care Facilities: https://www.paho.org/en/documents/smart-hospitals-rainwater-harvesting-smart-health-care-facilities	Drought
The Freeze-Thaw Cycle in Concrete and Brick Assemblies: https://orf.od.nih.gov/TechnicalResources/Documents/Technical%20Bulletins/19TB/The%20Freeze-Thaw%20Cycle%20in%20Concrete%20and%20Brick%20Assemblies%20January%20 2019-Technical%20Bulletin_508.pdf	Extreme Winter Weather
Water Reuse and Recycling: https://www.epa.gov/waterreuse	Drought
WaterSense – Commercial Buildings: https://www.epa.gov/watersense/commercial-buildings	Drought
WaterSense Simple Water Assessment Checklist for Commercial and Institutional Facilities: https://www.epa.gov/sites/default/files/2017-01/documents/ws-commercial-water-assessment-checklist.pdf	Drought
WaterSense: Outdoors: https://www.epa.gov/watersense/outdoors	Drought
WHO Drought Checklists: https://cdn.who.int/media/docs/default-source/climate-change/drought-checklists.pdf?sfvrsn=bcff4453_5	Drought

Funding Opportunities

Tools and Resources	Hazard Type
EPA Community Change Grant: https://www.epa.gov/system/files/documents/2024-03/overview-of-the-community-change-grants-program.pdf	Extreme Heat
FEMA BRIC: https://www.fema.gov/grants/mitigation/building-resilient-infrastructure-communities	
FEMA Hazard Mitigation Grant Program Post Fire: https://www.fema.gov/grants/mitigation/post-fire	Wildfire
FEMA HMGP: https://www.fema.gov/grants/mitigation/hazard-mitigation	
FEMA PDM Grant Program: https://www.fema.gov/grants/mitigation/pre-disaster	
HHS Compendium of Federal Resources for Health Sector Emissions Reduction and Resilience: https://www.hhs.gov/climate-change-health-equity-environmental-justice/climate-change-health-equity/actions/health-care-sector-pledge/federal-resources/index.html	
IRA Quickfinder for Health Care Sector Funding: https://www.hhs.gov/climate-change-health-equity-environmental-justice/climate-change-health-equity/quickfinder-ira/index.html	
NIHHIS Federal Funding Opportunities for Heat Resilience: https://www.heat.gov/pages/funding-opportunities	Extreme Heat
NIHHIS-CAPA Strategies: Urban Heat Island Mapping Campaign Program: https://www.heat.gov/pages/mapping-campaigns	Extreme Heat
TCR Annual Awards Program: https://www.bia.gov/bia/ots/tcr	

Element 3.4 Building and Campus: Facility Operations

Planning

Tools and Resources	Hazard Type
AHA Health Care Leader's Guide to Sustainability and Decarbonization: https://www.aha.org/sustainability/health-care-leaders-guide	
ASPR TRACIE Healthcare System Recovery Timeline: A White Paper for Texas: https://files.asprtracie.hhs.gov/documents/aspr-tracie-ta-healthcare-facility-recovery-timeline-white-paper.pdf	Hurricanes
CISA Resilient Power Best Practices for Critical Facilities and Sites: https://www.cisa.gov/resources-tools/resources/cisa-resilient-power-best-practices-critical-facilities-and-sites	
Disasters and Emergencies | Ready.gov: https://www.ready.gov/be-informed	
Duke Energy Wildfire Emergency Preparedness: https://sustainablesolutions.duke-energy.com/solutions/energy-resilience/wildfire-emergency-preparedness/	Wildfire

Tools and Resources	Hazard Type
OSHA Flood Preparedness and Response: https://www.osha.gov/flood/preparedness	Flooding, Hurricanes, Thunderstorms & Tornadoes
Planning for Urban Heat Resilience – PAS Report 600: https://planning-org-uploaded-media.s3.amazonaws.com/publication/download_pdf/PAS-Report-600-r1.pdf	Extreme Heat
Planning Framework for Protecting Commercial Building Occupants from Smoke During Wildfire Events: https://www.ashrae.org/File%20Library/Technical%20Resources/COVID-19/Planning-Framework-for-Protecting-Commercial-Building-Occupants-from-Smoke-During-Wildfire-Events.pdf	Wildfire
The Joint Commission, Sustainable Healthcare: https://www.jointcommission.org/our-priorities/sustainable-healthcare/	
WHO Checklist for assessing healthcare facilities in the context of storms: https://cdn.who.int/media/docs/default-source/climate-change/storm-checklists.pdf?sfvrsn=674ade9b_5	Hurricanes, Thunderstorms & Tornadoes
WHO Floods Checklist: https://cdn.who.int/media/docs/default-source/climate-change/flood-checklists.pdf?sfvrsn=730226ff_5	Flooding, Hurricanes, Thunderstorms & Tornadoes

People and Operations

Tools and Resources	Hazard Type
ASPR TRACIE Technical Resources: https://asprtracie.hhs.gov/technical-resources	
C40 Knowledge: https://www.c40knowledgehub.org	
CAHF Disaster Preparedness Program: Extreme Temperatures: https://www.cahfdisasterprep.com/extremetemp	Extreme Heat, Extreme Winter Weather
Climate-Resilient Health Clinics Toolkit: https://www.americares.org/what-we-do/community-health/climate-resilient-health-clinics/#toolkit	
Health Facilities Preparation for Extreme Heat: https://www.canada.ca/en/health-canada/services/environmental-workplace-health/reports-publications/climate-change-health/health-facilities-preparation-extreme-heat-recommendations-retirement-care-facility-managers-health-canada-2011.html	Extreme Heat
OSHA Evacuation Plans and Procedures eTool: https://www.osha.gov/etools/evacuation-plans-procedures/eap/elements	
Prioritizing Resilience: Best Practices on Energy Resilience for Healthcare Facilities: https://www.nga.org/publications/prioritizing-resilience-best-practices-on-energy-resilience-for-healthcare-facilities/	
Save our Water: https://saveourwater.com/	Drought
Storm Preparedness and Response Tools and Checklists for Healthcare Facilities: https://www.urmc.rochester.edu/emergency-preparedness/preparedness-and-response-tools-resources/winter-weather-preparedness.aspx	Extreme Winter Weather

Tools and Resources	Hazard Type
Tip Sheet: Extreme Cold Weather for Alternative Care Sites: https://files.asprtracie.hhs.gov/documents/hcw-training-resources-extreme-cold-weather-government-resources-and-tip-sheet.pdf	Extreme Winter Weather
WHO Checklist for assessing healthcare facilities in the context of sea level rise: https://cdn.who.int/media/docs/default-source/climate-change/sea-level-rise-checklists.pdf?sfvrsn=66f45cb2_5	Hurricanes, Flooding

Physical Infrastructure

Tools and Resources	Hazard Type
ASHE Roadmap to Resiliency: https://www.ashe.org/resiliency	
ASPR Topic Collection on Alternate Care Sites: https://asprtracie.hhs.gov/technical-resources/48/alternate-care-sites-including-shelter-medical-care/47	
CDC Rapid Assessment Form for Wells Affected by Wildfire: https://www.cdc.gov/environmental-health-services/php/water/assessment-form-wells-wildfires.html?CDC_AAref_Val=https://www.cdc.gov/nceh/ehs/water/private-wells/rapid-assessment-form-wells-after-wildfire.html	Wildfire
Climate Ready DC Resilient Design Guidelines: https://doee.dc.gov/sites/default/files/dc/sites/ddoe/service_content/attachments/CRDC%20resilient%20design%20guidelines_FINALApproved.pdf	
Climate Resilience for Frontline Clinics Toolkit https://www.americares.org/what-we-do/community-health/climate-resilient-health-clinics/	
CMS Categorical Waiver: https://www.cms.gov/files/document/qso-23-11-lsc.pdf	
Cold Climate Impact on Runoff Management: https://stormwater.pca.state.mn.us/images/5/50/Cold_climate_impact_on_runoff_management.pdf	Extreme Winter Weather
Condensation Control in Attics and Roofs in Cold Weather: https://basc.pnnl.gov/resource-guides/condensation-control-attics-and-roofs-cold-weather	Extreme Winter Weather
Emergency Response: 2021 Wildfire Season, Template & Checklists: https://insights-north-america.aon.com/mtcor/aon-wildfire-emergency-response-2020-template-checklists-report	Wildfire
EPA Flood Resilience: A Basic Guide for Water and Wastewater Utilities: https://www.epa.gov/waterutilityresponse/flood-resilience-basic-guide-water-and-wastewater-utilities	Flooding, Thunderstorms & Tornadoes
EPA Incident Action Checklist: Wildfire: https://www.epa.gov/system/files/documents/2022-03/220218-incident-action-checklist-wildfires.pdf	Wildfire
EPA Technical information and resources to manage flood risk: https://www.epa.gov/green-infrastructure/manage-flood-risk	Flooding, Hurricanes, Thunderstorms & Tornadoes
FEMA Elevator Installation for Buildings Located in Special Flood Hazard: Areas: https://www.fema.gov/sites/default/files/2020-07/fema_tb4_elevator_installation.pdf	Hurricanes, Flooding

Tools and Resources	Hazard Type
FEMA Emergency Power Systems for Critical Facilities: https://www.fema.gov/sites/default/files/2020-07/fema_p-1019_final_02-06-2015.pdf	Hurricanes, Flooding, Extreme Winter Weather, Thunderstorms & Tornadoes
FEMA Fact Sheet 3.0: Buildings, Systems and Equipment: https://www.fema.gov/sites/default/files/documents/fema_p-2181-fact-sheet-3-0-buildings.pdf	Hurricanes, Flooding, Thunderstorms & Tornadoes
FEMA Hurricane and Flood Mitigation Handbook for Public Facilities: https://www.wbdg.org/FFC/DHS/fema_p2181.pdf	Hurricanes, Flooding, Thunderstorms & Tornadoes, Extreme Winter Weather
FEMA Safe Rooms for Tornadoes and Hurricanes: https://www.fema.gov/sites/default/files/documents/fema_safe-rooms-for-tornadoes-and-hurricanes_p-361.pdf	Hurricanes, Flooding, Thunderstorms & Tornadoes
Guidance for Health and Residential Facilities to Build Resilience to Emergency Conditions: https://fgiguidelines.org/wp-content/uploads/2021/04/FGI_Guidance_for_Facilities_that_Respond_and_Adapt_to_Emergency_Conditions.pdf	Flooding, Hurricanes, Extreme Winter Weather, Thunderstorms & Tornadoes
Healthcare Facilities and Power Outages: https://www.fema.gov/sites/default/files/2020-07/healthcare-facilities-and-power-outages.pdf	
Hospitals weather cold temps with proven practices: https://www.hfmmagazine.com/articles/4391-hospitals-weather-cold-temps-with-proven-practices	Extreme Winter Weather
IPC Storm Drainage Provisions: https://codes.iccsafe.org/content/IPC2018P5/chapter-11-storm-drainage	Hurricanes, Flooding, Thunderstorms & Tornadoes
Minimizing the Adverse Effects of Snow and Ice on Roofs: https://www.poa.usace.army.mil/Portals/34/docs/engineering/MP-01-5663,%20Minimizing%20the%20Adverse%20Effects%20of%20Snow%20and%20Ice%20on%20Roofs.pdf	Extreme Winter Weather
Permeable pavement: https://www.epa.gov/system/files/documents/2021-11/bmp-permeable-pavements.pdf	Extreme Winter Weather
Smart Hospitals - Rainwater Harvesting for Smart Health Care Facilities: https://www.paho.org/en/documents/smart-hospitals-rainwater-harvesting-smart-health-care-facilities	Drought
Sustainable Landscape Guidelines: https://www.hennepin.us/-/media/hennepinus/business/conservation/facility-services.pdf	Drought, Flooding
Sustainable Landscapes in California: A Guidebook for Commercial and Industrial Site Managers: https://pacinst.org/wp-content/uploads/2020/08/Sustainable-Landscapes-in-California-Pacific-Institute-2020.pdf	Drought, Flooding
The Freeze–Thaw Cycle in Concrete and Brick Assemblies: https://orf.od.nih.gov/TechnicalResources/Documents/Technical%20Bulletins/19TB/The%20Freeze-Thaw%20Cycle%20in%20Concrete%20and%20Brick%20Assemblies%20January%202019-Technical%20Bulletin_508.pdf	Extreme Winter Weather
Water Reuse and Recycling: https://www.epa.gov/waterreuse	Drought
WaterSense – Commercial Buildings: https://www.epa.gov/watersense/commercial-buildings	Drought

Tools and Resources	Hazard Type
WaterSense Simple Water Assessment Checklist for Commercial and Institutional Facilities: https://www.epa.gov/sites/default/files/2017-01/documents/ws-commercial-water-assessment-checklist.pdf	Drought
WHO Drought Checklists: https://cdn.who.int/media/docs/default-source/climate-change/drought-checklists.pdf?sfvrsn=bcff4453_5	Drought
Wildfires and Safe Drinking Water: https://doh.wa.gov/community-and-environment/drinking-water/wildfires-and-safe-drinking-water#:~:text=Compile%20documentation%2C%20communicate%20with%20response%20partners%2C%20communicate%20with,of%20critical%20water%20infrastructure%20and%20locations.%20More%20items	Wildfire

Funding Opportunities

Tools and Resources	Hazard Type
CISA RRAP: https://www.cisa.gov/resources-tools/programs/regional-resiliency-assessment-program	
EPA DWSRF: https://www.epa.gov/dwsrf	Drought
FEMA BRIC: https://www.fema.gov/grants/mitigation/building-resilient-infrastructure-communities	
FEMA Hazard Mitigation Grant Program Post Fire: https://www.fema.gov/grants/mitigation/post-fire	Wildfire
FEMA HMGP: https://www.fema.gov/grants/mitigation/hazard-mitigation	
FEMA PDM Grant Program: https://www.fema.gov/grants/mitigation/pre-disaster	
HHS Compendium of Federal Resources for Health Sector Emissions Reduction and Resilience: https://www.hhs.gov/climate-change-health-equity-environmental-justice/climate-change-health-equity/actions/health-care-sector-pledge/federal-resources/index.html	
IRA Quickfinder for Health Care Sector Funding: https://www.hhs.gov/climate-change-health-equity-environmental-justice/climate-change-health-equity/quickfinder-ira/index.html	

Element 3.5 Supply Chain

Planning

Tools and Resources	Hazard Type
Climate Resilience for Frontline Clinics Toolkit: https://www.americares.org/what-we-do/community-health/climate-resilient-health-clinics/	
Heat Response Plans: Summary of Evidence and Strategies for Collaboration and Implementation: https://stacks.cdc.gov/view/cdc/93705	Extreme Heat

Tools and Resources	Hazard Type
PGH Climate Excellence Standard: https://practicegreenhealth.org/climate-excellence-standard	
Practice Greenhealth: https://practicegreenhealth.org/	
Practice Greenhealth Climate Resilience Planning: https://practicegreenhealth.org/topics/climate-and-health/climate-resilience-planning	
Roundtable Report: Supply Chain Risk Mitigation for Scientific Facilities and Tools: https://science.osti.gov/-/media/hep/pdf/Reports/Supply-chain-risk-mitigation-for-scientific-facilities-and-tools.pdf	Extreme Heat
Supply Chain Climate Risk Management Framework: https://sftool.gov/plan/556/supply-chain-climate-risk-management-framework	
WHO Checklist for assessing healthcare facilities in the context of storms: https://cdn.who.int/media/docs/default-source/climate-change/storm-checklists.pdf?sfvrsn=674ade9b_5	Hurricanes, Thunderstorms & Tornadoes
WHO Floods Checklist: https://cdn.who.int/media/docs/default-source/climate-change/flood-checklists.pdf?sfvrsn=730226ff_5	Flooding, Hurricanes, Thunderstorms & Tornadoes

People and Operations

Tools and Resources	Hazard Type
4 Ways One Hospital Provided Care Through a Wildfire: https://newsroom.medline.com/supply-chain/4-ways-one-hospital-provided-care-through-a-wildfire/	Wildfire
ASPR TRACIE Technical Resources: https://asprtracie.hhs.gov/technical-resources	
CAHF Disaster Preparedness Program: Extreme Temperatures: https://www.cahfdisasterprep.com/extremetemp	Extreme Heat, Extreme Winter Weather
Climate-Resilient Health Clinics Toolkit: https://www.americares.org/what-we-do/community-health/climate-resilient-health-clinics/#toolkit	
Health Facilities Preparation for Extreme Heat: https://www.canada.ca/en/health-canada/services/environmental-workplace-health/reports-publications/climate-change-health/health-facilities-preparation-extreme-heat-recommendations-retirement-care-facility-managers-health-canada-2011.html	Extreme Heat
Healthcare Ready: Disaster Healthcare Supply Chain: https://healthcareready.org/wp-content/uploads/2020/02/HCR-FACTSHEET_disaster-supplychain_V2_021820.pdf	
Storm Preparedness and Response Tools and Checklists for Healthcare Facilities: https://www.urmc.rochester.edu/emergency-preparedness/preparedness-and-response-tools-resources/winter-weather-preparedness.aspx	Extreme Winter Weather
Storm Preparedness and Response Tools and Checklists for Healthcare: https://www.urmc.rochester.edu/emergency-preparedness/preparedness-and-response-tools-resources/winter-weather-preparedness.aspx	Extreme Winter Weather

Tools and Resources	Hazard Type
Strengthening Post-Hurricane Supply Chain Resilience: Observations from Hurricanes Harvey, Irma, and Maria: https://www.ncbi.nlm.nih.gov/books/NBK556360/	Hurricanes
WHO Checklist for assessing healthcare facilities in the context of sea level rise: https://cdn.who.int/media/docs/default-source/climate-change/sea-level-rise-checklists.pdf?sfvrsn=66f45cb2_5	Hurricanes, Flooding

Physical Infrastructure

Tools and Resources	Hazard Type
Climate Resilience for Frontline Clinics Toolkit: https://www.americares.org/what-we-do/community-health/climate-resilient-health-clinics/	
EPA Water Sector Utility Incident Action Checklist: https://www.epa.gov/waterutilityresponse/incident-action-checklists-water-utilities	
FEMA Emergency Power Systems for Critical Facilities: https://www.fema.gov/sites/default/files/2020-07/fema_p-1019_final_02-06-2015.pdf	Hurricanes, Flooding, Extreme Winter Weather, Thunderstorms & Tornadoes
FEMA Hurricane and Flood Mitigation Handbook for Public Facilities: https://www.wbdg.org/FFC/DHS/fema_p2181.pdf	Hurricanes, Flooding, Thunderstorms & Tornadoes, Extreme Winter Weather
Guidance for Health and Residential Facilities to Build Resilience to Emergency Conditions: https://fgiguidelines.org/wp-content/uploads/2021/04/FGI_Guidance_for_Facilities_that_Respond_and_Adapt_to_Emergency_Conditions.pdf	Flooding, Extreme Winter Weather, Hurricanes, Thunderstorms & Tornadoes
Hospitals weather cold temps with proven practices: https://www.hfmmagazine.com/articles/4391-hospitals-weather-cold-temps-with-proven-practices	Extreme Winter Weather
WHO Drought Checklists: https://cdn.who.int/media/docs/default-source/climate-change/drought-checklists.pdf?sfvrsn=bcff4453_5	Drought

Funding Opportunities

Tools and Resources	Hazard Type
FEMA BRIC: https://www.fema.gov/grants/mitigation/building-resilient-infrastructure-communities	
HHS Compendium of Federal Resources for Health Sector Emissions Reduction and Resilience: https://www.hhs.gov/climate-change-health-equity-environmental-justice/climate-change-health-equity/actions/health-care-sector-pledge/federal-resources/index.html	
IRA Quickfinder for Health Care Sector Funding: https://www.hhs.gov/climate-change-health-equity-environmental-justice/climate-change-health-equity/quickfinder-ira/index.html	

Element 4. Collaboration Between Healthcare Organizations

Planning

Tools and Resources	Hazard Type
ASPR CIP: https://aspr.hhs.gov/cip/	
ASPR TRACIE: Engaging Healthcare System Partners in Medical Surge: https://asprtracie.hhs.gov/surge-partners	
Climate and Health: A Guide for Cross-Sector Collaboration: https://www.cdc.gov/climateandhealth/docs/crosssectorclimateandhealth.pdf	
Disasters and Emergencies | Ready.gov: https://www.ready.gov/be-informed	
Heat Response Plans: Summary of Evidence and Strategies for Collaboration and Implementation: https://stacks.cdc.gov/view/cdc/93705	Extreme Heat
OSHA Flood Preparedness and Response: https://www.osha.gov/flood/preparedness	Flooding, Hurricanes, Thunderstorms & Tornadoes
Preparing for the Health Effects of Drought: A Resource Guide for Public Health Professionals: https://stacks.cdc.gov/view/cdc/61709	Drought

People and Operations

Tools and Resources	Hazard Type
APHA Climate Change and Health Playbook: Adaptation Planning for Justice, Equity, Diversity and Inclusion: https://www.apha.org/Topics-and-Issues/Climate-Health-and-Equity/JEDI	
Building Resilience Against Climate Effects (BRACE) Framework: https://www.cdc.gov/climate-health/php/brace/index.html	Extreme Winter Weather, Flooding, Thunderstorms & Tornadoes
Climate Change and Extreme Heat Events: How Health Systems Should Prepare: https://catalyst.nejm.org/doi/full/10.1056/CAT.21.0454	Extreme Heat
Climate Change Resilience and Healthcare System Considerations: https://files.asprtracie.hhs.gov/documents/aspr-tracie-climate-change-resilience-and-healthcare-system-considerations-508.pdf	Flooding
Climate-Resilient Health Clinics Toolkit: https://www.americares.org/what-we-do/community-health/climate-resilient-health-clinics/#toolkit	
Disasters and Emergencies | Ready.gov: https://www.ready.gov/be-informed	
Incident Response Guide: Wildland Fire: https://emsa.ca.gov/wp-content/uploads/sites/71/2017/07/Wildland-Fire-IRG.pdf	Wildfire
Interagency Wildland Fire Air Quality Response Program: https://www.wildlandfiresmoke.net	Wildfire
OSHA Hurricane Preparedness and Response: https://www.osha.gov/hurricane	Hurricanes

Tools and Resources	Hazard Type
When Every Drop Counts: Protecting Public Health During Drought Conditions Counts – A Guide for Public Health Professionals: https://stacks.cdc.gov/view/cdc/5758	Drought
Wildfire Smoke: A guide for public health officials: https://www.airnow.gov/sites/default/files/2021-09/wildfire-smoke-guide_0.pdf	Wildfire
Wildfire Smoke: Considerations for California's Public Health Officials 2022: https://www.cdph.ca.gov/Programs/EPO/CDPH%20Document%20Library/EOM%20Documents/Wildfire-Smoke-Considerations-CA-PHO_08-2022.pdf	Wildfire

Funding Opportunities

Tools and Resources	Hazard Type
ASPR HPP: https://aspr.hhs.gov/HealthCareReadiness/HPP/Pages/about-hpp.aspx	
FEMA BRIC: https://www.fema.gov/grants/mitigation/building-resilient-infrastructure-communities	
HHS Compendium of Federal Resources for Health Sector Emissions Reduction and Resilience: https://www.hhs.gov/climate-change-health-equity-environmental-justice/climate-change-health-equity/actions/health-care-sector-pledge/federal-resources/index.html	
IRA Quickfinder for Health Care Sector Funding: https://www.hhs.gov/climate-change-health-equity-environmental-justice/climate-change-health-equity/quickfinder-ira/index.html	

Element 5. Interdisciplinary Planning, Oversight, and Evaluation

Planning

Tools and Resources	Hazard Type
6-10 Day Min Temp Outlook: https://www.cpc.ncep.noaa.gov/products/predictions/short_range/cold/tmp_610.php	Extreme Winter Weather
CDC CASPER: https://www.cdc.gov/casper/?CDC_AAref_Val=https://www.cdc.gov/nceh/casper/default.htm	
City Resources for Adapting to Heat: https://www.epa.gov/heatislands/adapting-heat	Extreme Heat
Climate Resilience for Frontline Clinics Toolkit: https://www.americares.org/what-we-do/community-health/climate-resilient-health-clinics/	
FEMA Risk MAP Program: https://www.fema.gov/flood-maps/tools-resources/risk-map	Hurricanes, Flooding, Thunderstorms & Tornadoes
Heat Response Plans: Summary of Evidence and Strategies for Collaboration and Implementation: https://stacks.cdc.gov/view/cdc/93705	Extreme Heat

Tools and Resources	Hazard Type
National Drought Mitigation Center: Drought Center Climographs: https://drought.unl.edu/Climographs.aspx	Drought
National Drought Mitigation Center: Drought Center Monitoring Tools: https://drought.unl.edu/Monitoring/DroughtMonitoringTools.aspx	Drought
NWS Hazards Map: https://www.weather.gov/	Wildfire, Hurricanes, Flooding, Thunderstorms & Tornadoes
WHO Checklist for assessing healthcare facilities in the context of storms: https://cdn.who.int/media/docs/default-source/climate-change/storm-checklists.pdf?sfvrsn=674ade9b_5	Hurricanes, Thunderstorms & Tornadoes
WHO Checklists to assess vulnerabilities in healthcare facilities in the context of climate change: https://www.who.int/publications/i/item/9789240022904	
WHO Floods Checklist: https://cdn.who.int/media/docs/default-source/climate-change/flood-checklists.pdf?sfvrsn=730226ff_5	Flooding, Hurricanes, Thunderstorms & Tornadoes
Winter Storm Severity Index (WSSI): http://www.wpc.ncep.noaa.gov/wwd/wssi/wssi.php	Extreme Winter Weather

People and Operations

Tools and Resources	Hazard Type
AIHA Tornado Recovery Resources: https://www.aiha.org/public-resources/consumer-resources/disaster-response-resource-center/health-and-safety-issues-in-natural-disasters/tornado-recovery-hazards	Thunderstorms & Tornadoes
APHA Climate Change and Health Playbook: Adaptation Planning for Justice, Equity, Diversity and Inclusion: https://www.apha.org/Topics-and-Issues/Climate-Health-and-Equity/JEDI	
Climate Change and Extreme Heat Events: How Health Systems Should Prepare: https://catalyst.nejm.org/doi/full/10.1056/CAT.21.0454	Extreme Heat
Climate Change Resilience and Healthcare System Considerations: https://files.asprtracie.hhs.gov/documents/aspr-tracie-climate-change-resilience-and-healthcare-system-considerations-508.pdf	Flooding
Climate-Resilient Health Clinics Toolkit: https://www.americares.org/what-we-do/community-health/climate-resilient-health-clinics/#toolkit	
FEMA Tornado Resources: https://community.fema.gov/ProtectiveActions/s/article/Tornado	Thunderstorms & Tornadoes
Incident Response Guide: Wildland Fire: https://emsa.ca.gov/wp-content/uploads/sites/71/2017/07/Wildland-Fire-IRG.pdf	Wildfire
OSHA Evacuation Plans and Procedures eTool: https://www.osha.gov/etools/evacuation-plans-procedures/eap/elements	

Tools and Resources	Hazard Type
Storm Preparedness and Response Tools and Checklists for Healthcare Facilities: https://www.urmc.rochester.edu/emergency-preparedness/preparedness-and-response-tools-resources/winter-weather-preparedness.aspx	Extreme Winter Weather
Tip Sheet: Extreme Cold Weather for Alternative Care Sites: https://files.asprtracie.hhs.gov/documents/hcw-training-resources-extreme-cold-weather-government-resources-and-tip-sheet.pdf	Extreme Winter Weather
When Every Drop Counts: Protecting Public Health During Drought Conditions Counts – A Guide for Public Health Professionals: https://stacks.cdc.gov/view/cdc/5758	Drought

Physical Infrastructure

Tools and Resources	Hazard Type
Climate Ready DC Resilient Design Guidelines: https://doee.dc.gov/sites/default/files/dc/sites/ddoe/service_content/attachments/CRDC%20resilient%20design%20guidelines_FINALApproved.pdf	
Climate Resilience for Frontline Clinics Toolkit: https://www.americares.org/what-we-do/community-health/climate-resilient-health-clinics/	
Cold climate impact on runoff management: https://stormwater.pca.state.mn.us/images/5/50/Cold_climate_impact_on_runoff_management.pdf	Extreme Winter Weather
Condensation Control in Attics and Roofs in Cold Weather: https://basc.pnnl.gov/resource-guides/condensation-control-attics-and-roofs-cold-weather	Extreme Winter Weather
EPA Water Sector Utility Incident Action Checklist: https://www.epa.gov/waterutilityresponse/incident-action-checklists-water-utilities	
FEMA Emergency Power Systems for Critical Facilities: https://www.fema.gov/sites/default/files/2020-07/fema_p-1019_final_02-06-2015.pdf	Hurricanes, Flooding, Extreme Winter Weather, Thunderstorms & Tornadoes
FEMA Fact Sheet 3.0: Buildings, Systems and Equipment: https://www.fema.gov/sites/default/files/documents/fema_p-2181-fact-sheet-3-0-buildings.pdf	Hurricanes, Flooding, Thunderstorms & Tornadoes
FEMA Hurricane and Flood Mitigation Handbook for Public Facilities: https://www.wbdg.org/FFC/DHS/fema_p2181.pdf	Hurricanes, Flooding, Thunderstorms & Tornadoes, Extreme Winter Weather
Flood Resilience Portal: https://floodresilience.net/how-to-build-resilience/	Flooding
Guidance for Health and Residential Facilities to Build Resilience to Emergency Conditions: https://fgiguidelines.org/wp-content/uploads/2021/04/FGI_Guidance_for_Facilities_that_Respond_and_Adapt_to_Emergency_Conditions.pdf	Flooding, Hurricanes, Extreme Winter Weather, Thunderstorms & Tornadoes
Hospitals weather cold temps with proven practices: https://www.hfmmagazine.com/articles/4391-hospitals-weather-cold-temps-with-proven-practices	Extreme Winter Weather
Minimizing the Adverse Effects of Snow and Ice on Roofs: https://www.poa.usace.army.mil/Portals/34/docs/engineering/MP-01-5663,%20Minimizing%20the%20Adverse%20Effects%20of%20Snow%20and%20Ice%20on%20Roofs.pdf	Extreme Winter Weather

Tools and Resources	Hazard Type
National Drought Mitigation Center: Drought Center Planning Tools: https://drought.unl.edu/Planning.aspx	Drought
Permeable pavement: https://www.epa.gov/system/files/documents/2021-11/bmp-permeable-pavements.pdf	Extreme Winter Weather
The Freeze-Thaw Cycle in Concrete and Brick Assemblies: https://orf.od.nih.gov/TechnicalResources/Documents/Technical%20Bulletins/19TB/The%20Freeze-Thaw%20Cycle%20in%20Concrete%20and%20Brick%20Assemblies%20January%202019-Technical%20Bulletin_508.pdf	Extreme Winter Weather
Water-Prepared Local Health Department Checklist: https://www.naccho.org/uploads/downloadable-resources/WASH-LHD-Factsheet-Final.pdf	Hurricanes, Flooding, Drought, Thunderstorms & Tornadoes

Funding Opportunities

Tools and Resources	Hazard Type
ASPR HPP: https://aspr.hhs.gov/HealthCareReadiness/HPP/Pages/about-hpp.aspx	
CDC PHEP Program and Guidance: https://www.cdc.gov/readiness/php/phep/index.html	

Element 6. Communications & All-Hazards Approach

Planning

Tools and Resources	Hazard Type
6-10 Day Min Temp Outlook: https://www.cpc.ncep.noaa.gov/products/predictions/short_range/cold/tmp_610.php	Extreme Winter Weather
About Heat and Your Health: https://www.cdc.gov/heat-health/about-heat-and-your-health.html	Extreme Heat
About Urban Heat Islands: https://www.heat.gov/pages/urban-heat-islands	Extreme Heat
Billion-Dollar Weather and Climate Disasters: https://www.ncei.noaa.gov/access/billions/	
CDC CASPER: https://www.cdc.gov/casper/?CDC_AAref_Val=https://www.cdc.gov/nceh/casper/default.htm	
City Resources for Adapting to Heat: https://www.epa.gov/heatislands/adapting-heat	Extreme Heat
Cool Your Community Social Media Toolkit: https://www.epa.gov/heatislands/cool-your-community-social-media-toolkit	Extreme Heat
Disasters and Emergencies | Ready.gov: https://www.ready.gov/be-informed	
Extreme Heat | Ready.gov: https://www.ready.gov/heat	Extreme Heat
Florida AHCA Emergency Preparedness Resources: https://ahca.myflorida.com/health-care-policy-and-oversight/emergency-preparedness-resources	Extreme Heat

Tools and Resources	Hazard Type
Heat Response Plans: Summary of Evidence and Strategies for Collaboration and Implementation: https://stacks.cdc.gov/view/cdc/93705	Extreme Heat
NHTSA Child Heatstroke Prevention Social Media Playbook: https://www.trafficsafetymarketing.gov/sites/tsm.gov/files/2024-04/child-heatstroke-social-media-playbook-en-2024-16260-v3-tag.pdf	Extreme Heat
NIHHIS: https://www.heat.gov/	Extreme Heat
NWS Hazards Map: https://www.weather.gov/	Wildfire, Hurricanes, Flooding, Thunderstorms & Tornadoes
OSHA Flood Preparedness and Response: https://www.osha.gov/flood/preparedness	Flooding, Hurricanes, Thunderstorms & Tornadoes
WHO Floods Checklist: https://cdn.who.int/media/docs/default-source/climate-change/flood-checklists.pdf?sfvrsn=730226ff_5	Flooding, Hurricanes, Thunderstorms & Tornadoes
Who is Most At Risk to Extreme Heat?: https://www.heat.gov/pages/who-is-at-risk-to-extreme-heat	Extreme Heat
Winter Storm Severity Index (WSSI): http://www.wpc.ncep.noaa.gov/wwd/wssi/wssi.php	Extreme Winter Weather

People and Operations

Tools and Resources	Hazard Type
AIHA Tornado Recovery Resources: https://www.aiha.org/public-resources/consumer-resources/disaster-response-resource-center/health-and-safety-issues-in-natural-disasters/tornado-recovery-hazards	Thunderstorms & Tornadoes
American Red Cross Tornado Safety Resources: https://www.redcross.org/get-help/how-to-prepare-for-emergencies/types-of-emergencies/tornado.html	Thunderstorms & Tornadoes
Building Community Resilience with NBS: Strategies for Success: https://www.fema.gov/sites/default/files/documents/fema_nbs_community-resilience-strategies-success_102023.pdf	
CDC Drought Communication Toolkit: https://www.cdc.gov/drought-health/toolkit/index.html	Drought
CDC NIOSH: https://www.cdc.gov/niosh	
CDC Tornadoes: https://www.cdc.gov/tornadoes/	Thunderstorms & Tornadoes
Climate Change and Extreme Heat Events: How Health Systems Should Prepare: https://catalyst.nejm.org/doi/full/10.1056/CAT.21.0454	Extreme Heat
Climate-Resilient Health Clinics Toolkit: https://www.americares.org/what-we-do/community-health/climate-resilient-health-clinics/#toolkit	
Disasters and Emergencies | Ready.gov: https://www.ready.gov/be-informed	

Tools and Resources	Hazard Type
EPA Smoke-Ready Toolbox for Wildfires: https://www.epa.gov/air-research/smoke-ready-toolbox-wildfires	Wildfire
Falling Dominoes: A Planner's Guide to Drought and Cascading Impacts: https://planning-org-uploaded-media.s3.amazonaws.com/publication/download_pdf/Falling-Dominoes-Planners-Guide-to-Drought-and-Cascading-Impacts.pdf	Drought
FEMA Create a Hazard Mitigation Plan: https://www.fema.gov/emergency-managers/risk-management/hazard-mitigation-planning/create-hazard-plan	
FEMA Tornado Resources: https://community.fema.gov/ProtectiveActions/s/article/Tornado	Thunderstorms & Tornadoes
FEMA Wildfire and Outdoor Fire Safety Pictographs: https://www.usfa.fema.gov/gallery/pictographs/wildfire-and-outdoor.html	Wildfire
Interagency Wildland Fire Air Quality Response Program: https://www.wildlandfiresmoke.net	Wildfire
OSHA Hurricane Preparedness and Response: https://www.osha.gov/hurricane	Hurricanes
PEHSU Children's Health & Wildfires: https://www.pehsu.net/Children_s_Health_Wildfires.html	Wildfire
Storm Preparedness and Response Tools and Checklists for Healthcare Facilities: https://www.urmc.rochester.edu/emergency-preparedness/preparedness-and-response-tools-resources/winter-weather-preparedness.aspx	Extreme Winter Weather
Tip Sheet: Extreme Cold Weather for Alternative Care Sites: https://files.asprtracie.hhs.gov/documents/hcw-training-resources-extreme-cold-weather-government-resources-and-tip-sheet.pdf	Extreme Winter Weather
When Every Drop Counts: Protecting Public Health During Drought Conditions Counts – A Guide for Public Health Professionals: https://stacks.cdc.gov/view/cdc/5758	Drought

Physical Infrastructure

Tools and Resources	Hazard Type
Climate Ready DC Resilient Design Guidelines: https://doee.dc.gov/sites/default/files/dc/sites/ddoe/service_content/attachments/CRDC%20resilient%20design%20guidelines_FINALApproved.pdf	
Cold climate impact on runoff management: https://stormwater.pca.state.mn.us/images/5/50/Cold_climate_impact_on_runoff_management.pdf	Extreme Winter Weather
Condensation Control in Attics and Roofs in Cold Weather: https://basc.pnnl.gov/resource-guides/condensation-control-attics-and-roofs-cold-weather	Extreme Winter Weather
FEMA Emergency Power Systems for Critical Facilities: https://www.fema.gov/sites/default/files/2020-07/fema_p-1019_final_02-06-2015.pdf	Hurricanes, Flooding, Extreme Winter Weather, Thunderstorms & Tornadoes

Tools and Resources	Hazard Type
FEMA Hurricane and Flood Mitigation Handbook for Public Facilities: https://www.wbdg.org/FFC/DHS/fema_p2181.pdf	Hurricanes, Flooding, Thunderstorms & Tornadoes, Extreme Winter Weather
Hospitals weather cold temps with proven practices: https://www.hfmmagazine.com/articles/4391-hospitals-weather-cold-temps-with-proven-practices	Extreme Winter Weather
Minimizing the Adverse Effects of Snow and Ice on Roofs: https://www.poa.usace.army.mil/Portals/34/docs/engineering/MP-01-5663,%20Minimizing%20the%20Adverse%20Effects%20of%20Snow%20and%20Ice%20on%20Roofs.pdf	Extreme Winter Weather
Permeable pavement: https://www.epa.gov/system/files/documents/2021-11/bmp-permeable-pavements.pdf	Extreme Winter Weather
The Freeze-Thaw Cycle in Concrete and Brick Assemblies: https://orf.od.nih.gov/TechnicalResources/Documents/Technical%20Bulletins/19TB/The%20Freeze-Thaw%20Cycle%20in%20Concrete%20and%20Brick%20Assemblies%20January%202019-Technical%20Bulletin_508.pdf	Extreme Winter Weather

Funding Opportunities

Tools and Resources	Hazard Type
Cigna Extends Medicare Advantage Transportation Benefit Due to Heat: https://newsroom.cigna.com/2022-07-29-As-Temperatures-Rise,-Cigna-Offers-Medicare-Advantage-Customers-Rides-To-Cooling-Centers-at-No-Extra-Cost	Extreme Heat
FEMA BRIC: https://www.fema.gov/grants/mitigation/building-resilient-infrastructure-communities	
HHS Compendium of Federal Resources for Health Sector Emissions Reduction and Resilience: https://www.hhs.gov/climate-change-health-equity-environmental-justice/climate-change-health-equity/actions/health-care-sector-pledge/federal-resources/index.html	
IRA Quickfinder for Health Care Sector Funding: https://www.hhs.gov/climate-change-health-equity-environmental-justice/climate-change-health-equity/quickfinder-ira/index.html	
Tribal Climate Change Funding Guide: https://tribalclimateguide.uoregon.edu/	

Appendix B: Climate Resilience for Health Care (CR4HC) References

In some cases, hazard-specific citations for resilience strategies are not available. However, many resilience strategies are relevant to multiple hazards. Therefore, when citations specific to a particular hazard are not available, the toolkit references evidence-based resources focused on different hazards that are broadly relevant and applicable.

Abraham, S., Kammeyer, C., & Cooley, H. (2020). Sustainable landscapes in California: A guidebook for commercial and industrial site managers. *Pacific Institute.* https://pacinst.org/wp-content/uploads/2020/08/Sustainable-Landscapes-in-California-Pacific-Institute-2020.pdf

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Appendix C: Federal Organization Acronyms

These acronyms and abbreviations are commonly used to refer to federal agencies and are used throughout this Toolkit. Other acronyms and abbreviations are spelled out the first time they are used in every section of the Toolkit.

ASPR: Administration for Strategic Preparedness and Response

ASPR TRACIE: Administration for Strategic Preparedness and Response – Technical Resources, Assistance Center, and Information Exchange

CDC: Centers for Disease Control and Prevention

CISA: Cybersecurity & Infrastructure Security Agency

CMS: Centers for Medicare & Medicaid Services

DOE: Department of Energy

EIA: Energy Information Administration

EPA: U.S. Environmental Protection Agency

FEMA: Federal Emergency Management Agency

HRSA: Health Resources and Services Administration

HHS: U.S. Department of Health and Human Services

NACCHO: National Association of County and City Health Officials

NIST: National Institute of Standards & Technology

NOAA: National Oceanic and Atmospheric Administration

OASH: Office of the Assistant Secretary for Health

OCCHE: Office of Climate Change and Health Equity

SAMHSA: Substance Abuse and Mental Health Services Administration

USDA: U.S. Department of Agriculture

VA: U.S. Department of Veterans Affairs

WHO: World Health Organization