INSTITUTE FOR HOMELAND SECURITY

Sam Houston State University

Healthcare System Responses to Blackouts and Natural Disasters

Institute for Homeland Security

Sam Houston State University

Peter S. Lehmann

Abstract

As natural disasters and extensive blackouts are poised to increase in frequency and severity, healthcare facilities must address the substantial disruptions to patient care that can occur during these incidents. Additionally, consistent growth in demand for electrical power has placed strains on the nation's aging electrical infrastructure, and experts have expressed concerns about the consequences of grid failure for essential services. The interdisciplinary literature on the effects of blackouts and disaster events on public health and safety is extensive, and the findings indicate that healthcare facilities often must confront surges of patients with a wide variety of physical and mental illnesses in the wake of long-term electrical outages. Moreover, the communities that are least resilient to power failures are typically those most in need of effective and responsive healthcare during disaster events. This report aims to (1) review the social science research on the consequences of power failures for the health and behavior of affected populations and (2) discuss the surge capacity challenges that hospital facilities face following natural disasters and power outages. In particular, this report highlights difficulties regarding shortages of trained staff, technological and supply chain breakdowns, the management of limited physical space, and communication disruptions.

Keywords: healthcare, natural disasters, power outages, electrical grid, technology

Introduction

The past century has seen a marked increase in the number of natural disasters in the U.S. as designated by the Federal Emergency Management Agency (FEMA), spiking from 500 events per year before the 1990s to more than 1,500 events annually since the early 2000s (Boustan et al., 2020; see also Bhola et al., 2023; Shukla & MacKenzie, 2024; Smith & Katz, 2013). When long-term electrical outages occur due to floods, earthquakes, hurricanes, tornadoes, excess heat, and winter storms, the impacts can be far-reaching and enduring (Noji, 2005; Tierney, 2019; Torche & Nobles, 2024), though patterns of social stratification can shape which individuals and communities are most affected (Arcaya et al., 2020; Blaikie et al., 2014; Bolin & Kurtz, 2018; Fothergill & Peek, 2015). Moreover, these trends have co-occurred alongside growing demand for electrical power across all sectors, and substantial strain on the country's aging infrastructure has sparked concerns that brownouts may become more common (e.g., Allen et al., 2016; Jabir et al., 2018; McFarland et al., 2015). As these events are projected to further increase in the years to come, resilience and preparedness are crucial.

The effects of blackouts—especially those precipitated by natural disasters—have well-documented harmful effects on public health (e.g., Culver et al., 2017; Leaning & Guha-Sapir, 2013; Noji, 2000, 2005). Even relatively short-lived power outages can increase rates of carbon monoxide poising, infectious and temperature-related illness, hospitalization, and mortality (Andresen et al., 2023; Bell et al., 2018; Casey et al., 2020; Lane et al., 2013; Makwana, 2020). Power outages are a particular concern for patients who rely on in-home electronic medical equipment (Molinari et al., 2017; Suran, 2023). Some scholarship also suggests that natural disasters can induce mental health crises, with research finding evidence of long-term posttraumatic stress disorder (PTSD) and depression in populations that experienced significant disaster events, especially among children and other vulnerable groups (Maclean et al., 2016; Neria et al., 2008; Norris et al., 2002, 2009; Shaw et al., 1996). These wide-ranging consequences of blackouts and natural disaster events have important implications for healthcare facilities, which must address influxes of patients and continue to function even in the presence of water loss, technological malfunctions, and outages that extend longer than backup generators can withstand (Klinger et al., 2014; Luke et al., 2021).

A large body of empirical research has emerged discussing the role of hospitals in disaster response and how these institutions can address barriers to effective functioning during prolonged power outages (e.g., Achour et al., 2014; Curtis et al., 2017; Melnychuk et al., 2022; Milsten, 2000; Moradi et al., 2021; Sheikhbardsiri et al., 2017; Tekeli-Yeşil, 2006). These scholarly contributions identify some key risks to public health posed by electrical outages and other cascading infrastructure failures, and they propose ways that hospitals can develop disaster resilience procedures to continue providing vital services. Healthcare systems' ability to take swift and effective action during these events is complex and multidimensional:

> Hospital infrastructure resilience can be described as the ability of hospitals to resist, absorb, and respond to the shock of disasters while maintaining and surging essential health services and to recover to an original state or adapt to a new one. Hospital resilience is far more than the protection of buildings and physical structures. It includes the development and maintenance of systems and processes to ensure the continuation of supply lines and the treatment of patients. Hospital resilience programs should incorporate workforce training and regular exercising of staff and systems to ensure that facilities remain operational during times of disaster. (Luke et al., 2021, p. 628)

Further, case studies of specific natural disasters and healthcare systems' responses to them can be highly informative as well, as they call attention to potential vulnerabilities and opportunities for additional development (Anderson & Bell, 2012; Espana-Schmidt et al., 2013; Freese et al., 2006; Glazer et al., 2021). Simulations and other assessments of hospital disaster preparedness likewise provide insights into ways that staff training, coordination, resource allocation, and other crisis response procedures may be enhanced to strengthen surge capacity (Basaglia et al., 2022; Paul & Batta, 2008; Sell et al., 2020; Vugrin et al., 2015).

Problem Statement and Research Objective

Experts have expressed concerns that recent increases in the frequency and intensity of natural disasters, combined with inadequate electrical infrastructure, represent a salient threat to the effective functioning of hospitals and healthcare facilities. In light of these trends, the aim of this report is twofold. First, I draw insights from social science research on the consequences of blackouts and natural disasters for public health and safety, which helps to contextualize the specific community needs that healthcare systems must address following disaster events. Second, I summarize existing scholarship on these issues as they relate to the functioning of hospitals, highlighting several case studies that illustrate how specific facilities and systems worked to provide continuity of care under highly unusual and challenging circumstances. By integrating multiple areas of research, this report is intended to provide an informational resource for policymakers, practitioners, and members of the public.

The Consequences of Blackouts and Natural Disasters

Experts have raised alarm that the effects of climate change are poised to worsen in the coming decades, increasing the incidence of extreme weather events that threaten critical infrastructure and harm communities (e.g., Bell et al., 2018; Bhola et al., 2023; Ebi et al., 2021; Smith & Katz, 2013). Though data from the U.S. Energy Information Administration (2024) reveal that the average American household was without power for approximately five and one-half hours in 2022, hurricanes and winter storms were responsible for weeks-long blackouts in some areas (see also Chakalian et al., 2019; Grineski et al., 2023; Mitsova et al., 2018). Indeed, extended power outages are a common feature of disaster events, and for this reason understanding the social costs associated with large-scale blackouts has emerged as a priority for researchers across many academic fields. Myriad interconnected services are impacted during blackouts (e.g., Arcaya et al., 2020; Auffhammer et al., 2017; Boustan et al., 2020; Noji, 2000, 2005; Shukla & MacKenzie, 2024), and thus it is challenging to provide a comprehensive discussion of disaster-related consequences. As Casey et al. (2020) note:

> Outages, particularly those related to weather, are almost always accompanied by intersecting and related phenomena that result in economic, social, and health damages. Economically, they interrupt business, cripple the internet, and halt many forms of transportation. The 2003 Northeast Blackout in Canada and the USA cost between $4 and 10 billion, and electricity infrastructure repairs alone cost $3.5 billion after Hurricane Sandy. Social costs include increased crime, motor vehicle crashes, psychosocial stress, and interrupted communication between emergency services, delivery of clean water, and waste removal. (p. 372)

Though research on the intersections between social structures and natural disasters has traditionally been disconnected from mainstream lines of inquiry in the social sciences (Tierney, 2007), scholarship on the origins and effects of disaster events has experienced much growth in recent years (see, e.g., Arcaya et al., 2020; Peek et al., 2021). From this vast literature, insights may be derived from the contributions of public health scholars, sociologists, and criminologists regarding how specific populations can be affected by natural disasters and how these events shape human behavior and affect the maintenance of social order (e.g., Berrebi et al., 2021; Frailing et al., 2015). While the health challenges faced by at-risk populations during and after blackouts and natural disasters are most central for the current focus, healthcare systems must operate within communities and thus are deeply affected by the social forces that emerge in the wake of a disaster, which include convergence behavior—that is, the "mass movement of people, messages, and supplies toward the disaster struck area" (Fritz & Mathewson, 1957, p. 1)—as well as collective action responses tied to panic, altruism, and conflict (Lemieux, 2014; Rodríguez et al., 2006; Rubin & Rogers, 2019).

Public Health Effects

Prior research has demonstrated that there are several key threats to public health that commonly stem from extended blackouts and natural disasters. A particular focus of scholars in this area is carbon monoxide (CO) poisoning (e.g., Cukor & Restuccia, 2007; Iqbal et al., 2012), which often increases during power outages due to indoor use of charcoal and gasoline-powered generators (Johnson-Arbor et al., 2014; Riddex & Dellgar, 2001; Van Sickle et al., 2007). Prolonged exposure to CO causes cellular hypoxia, ischemia, and death, and the symptoms of CO poisoning (i.e., headache, dizziness, nausea, and loss of consciousness) will lead people to seek out medical care—sometimes in numbers that strain emergency department capacities (Klinger et al., 2014). Similarly, the consumption of spoiled food and/or contaminated water can increase the incidence of gastrointestinal illness, which may become severe enough to warrant medical treatment among more vulnerable patients (Gehringer et al., 2018; Kosa et al., 2011; Marx et al., 2006). Blackouts and disaster events also may coincide with extreme temperatures, increasing rates of illness stemming from heat and cold exposure (e.g., Freese et al., 2006; Greenstein et al., 2016; Rand et al., 2005).

Prolonged blackouts can produce an influx of patients experiencing worsening symptoms of pre-existing cardiovascular, respiratory, and renal disease (Casey et al., 2020; Dominianni et al., 2018; Lin et al., 2011; Zhang et al., 2020). In many instances, emergency care visits for these conditions increase during extended power outages when electricity-dependent medical devices—including machines for dialysis, physiotherapy, and oxygen delivery—expend their battery backups and no longer function (Bean et al., 2020; Gotanda et al., 2015; Molinari et al., 2017; Suran, 2023). Further, as Rubin and Rogers (2019) note, many people who rely on in-home medical equipment seek out emergency care during blackouts to recharge these devices:

> Medical device failure patients accounted for 22% of all admissions within a 24-h period in New York following the 2003 blackout. Hospitals reported seeing many people who had “power emergencies” rather than “medical emergencies” and who were seeking to recharge medical equipment in Louisiana after Hurricane Isaac. Towards the end of the incident, libraries and Red Cross shelters began to be used to reduce the burden on hospitals by acting as “electricity shelters” for such people. (p. 376)

Patients who need regular medical treatments (e.g., those on dialysis; see Abir et al., 2013) are especially vulnerable during blackouts, as they may miss treatments due to inaccess to a facility with electricity. Some studies have shown that mortality increases sometimes can be attributed directly to extended power outages rather than to the underlying disaster event, with many such deaths caused by injury and CO poisoning (Anderson & Bell, 2012; Dominianni et al., 2018; Jani et al., 2006; Klinger et al., 2014).

The mental health outcomes associated with experiencing a disaster event have been studied extensively (e.g., Ebi et al., 2021; Maclean et al., 2016; Norris et al., 2002; Shaw et al., 1996). PTSD typically begins to manifest a few weeks following a traumatic event, and this condition is closely linked to major depression, generalized anxiety disorder, panic disorder, and substance abuse (Arnberg et al., 2013; Foa et al., 2006; North et al., 2004). However, medical facilities often must confront mental health crises that can be triggered or worsened in the immediate aftermath of a disaster event (Andresen et al., 2023; Gros et al., 2012; Vernberg et al., 2008), which can lead patients to seek out care in emergency departments (Rubin & Rogers, 2019). For example, Lin and colleagues (2016) observed increases in the number of people seeking mental healthcare treatment in the days following Hurricane Sandy in 2012, especially those who previously experienced trauma (see Bromet et al., 2017). However, these patterns are likely tied to the severity of the event; for relatively short-lived disaster events (e.g., the Northeast blackout of 2003), mental healthcare-seeking may decline slightly in the immediate aftermath (Freese et al., 2006).

Social-Psychological Responses

Although a comprehensive review of the literature on individual- and community-level responses to natural disasters and extensive power outages is beyond the current scope (for such reviews, see Arcaya et al., 2020; Reid, 2013; Tierney, 2007, 2019), several relevant insights from this body of work should be noted. First, the rapid convergence of people and resources to disaster-struck areas may provide a mix of "altruistic, prosocial, and highly adaptive behaviors among disaster survivors and first responders" (Peek et al., 2021, pp. 221-222) as well as exploitative behaviors such as looting and price-gouging (Fritz & Mathewson, 1957). Though acts of helpfulness motivated by solidarity and a shared sense of purpose generally far outnumber acts of exploitation and destruction (Berrebi et al., 2021; Lemieux, 2014; Rodríguez et al., 2006; Rubin & Rogers, 2019), instances of heightened person and property crime following disaster events have been reported in the literature (e.g., Frailing & Harper, 2020; Frailing et al., 2015; Gearhart et al., 2018; Genevie et al., 1987; Hoogesteyn et al., 2024; Varano et al., 2010) These behaviors are likely perpetrated by individuals who are already inclined to commit such acts under normal circumstances (Meldrum et al., 2021).

Another key theme that has emerged from this literature is that social stratification is a powerful predictor of public health and safety outcomes, and the effects of disasters and other social problems are often reciprocal and mutually reinforcing (Blaikie et al., 2014; Frailing & Harper, 2020; Prelog, 2016; Torche & Nobles, 2024). Indeed, the neighborhoods that are most susceptible to infrastructure collapse and spikes in criminal activity and medical emergencies are those which were economically disadvantaged before the disaster or blackout (e.g., Arcaya et al., 2020; Frailing et al., 2015; Grineski et al., 2023; Masozera et al., 2007; Weil et al., 2021; Wohlenberg, 1982). Moreover, while residents of vulnerable communities are those in greatest need of access to healthcare facilities during blackouts and natural disasters, hospitals in these contexts frequently are less resilient and, as a result, may experience noteworthy difficulties operating effectively (Bell et al., 2018; Lane et al., 2013). Given the growing uncertainty about the future of the country's electrical grid to handle extreme events (e.g., Allen et al., 2016; Jabir et al., 2018; McFarland et al., 2015), it is crucial to understand how healthcare facilities can best respond to these challenges moving forward.

Providing Healthcare in Disaster Events

Although widespread blackouts and extreme weather events have indirect effects on healthcare systems via their consequences for public health and safety, these incidents also directly compromise the complex hospitals' physical, institutional, and social infrastructures (Curtis et al., 2017; Holt, 2008; Milsten, 2000). Several noteworthy events—including the Northeast blackout of 2003 (Anderson & Bell, 2012; Brown, 2004; Freese et al., 2006; Kile et al., 2005; Prezant et al., 2005), Hurricane Sandy in 2012 (Espana-Schmidt et al., 2013; Lane et al., 2013), Winter Storm Uri in 2021 (Glazer et al., 2021), and others (e.g., Hassan & Mahmoud, 2021; Izumikawa, 2019; Kearns et al., 2014; Lichtenberger et al., 2010; Vugrin et al., 2015)—provide useful case studies that can help to identify these challenges and the lessons learned from responses to previous crises. The issues that healthcare facilities must confront during disaster events are variable but can include technological difficulties, inaccess to potable water, degradation of air quality, supply chain breakdowns, disruptions in communication within and between hospitals, challenges in medical record-keeping, staff shortages, and structural damage (Klinger et al., 2014; Luke et al., 2021; Melnychuk et al., 2022).

Healthcare system responses to blackouts and disasters fall within the general framework of "surge capacity resilience" (Kaji et al., 2006; Schultz & Koenig, 2006; Sheikhbardsiri et al.,

2017) through which natural disasters are sometimes linked with mass casualty events (Barten et al., 2021; Gill et al., 2021; Lomaglio et al., 2020; Milsten, 2000). Improving hospitals' ability to handle sudden influxes of patients, especially under strenuous circumstances, involves adopting a multidimensional approach that considers all facets of patient care:

> Hospital surge capacity can be defined as the capability to deal with the sudden influx of patients beyond the usual resulting from a disaster or emergency, and contributes to the effort to keep mortalities and morbidities as low as possible. It comprises mainly four components or domains: *staff*, *stuff*, *space*, and *system*. *Staff* refers to all the medical personnel, such as doctors, nurses, and technicians, who are essential to the functioning of the hospital. *Stuff* refers to every piece of equipment within a hospital. Consumable supplies, such as syringes, oxygen, intravenous medications, and medicine, can also be counted as stuff. *Space* mainly indicates the number of beds in a hospital and how many extra beds can be arranged during a surge. Lastly, the policies and procedures that link the departments within a hospital or connect the hospital to other facilities and services fall within the *system* domain. (Hasan et al., 2023, p. 13)

Importantly, the extent to which a given natural disaster event or power failure may compromise one or more of these dimensions can vary, and healthcare systems must consider and adapt to the unique features of the hazard itself as well as the geographical and social characteristics of the community (Curtis et al., 2017; Ebi et al., 2021; Hassan & Mahmoud, 2021; Lane et al., 2013; Tekeli-Yeşil, 2006). Past disaster events as well as the results from assessments and simulations can provide illustrative insights regarding how each of these four domains of surge capacity may be strengthened (e.g., Basaglia et al., 2022; Vugrin et al., 2015).

Staff: Personnel Shortages

One of the most effective ways that healthcare facilities can increase their effectiveness during a disaster event is by mobilizing additional staff, including local healthcare professionals, volunteers, and displaced staff from nearby facilities (Hasan et al., 2023; Toerper et al., 2018). If such a system is not already in place, preparation for these staff exchanges might involve the creation of a registry through which retired medical professionals and trained volunteers can be contacted when additional support is needed. Crucially, the number of available clinical and non-clinical staff typically declines in the immediate aftermath of a disaster due to illness, injury, or conflicting obligations that prevent staff members from reporting to work (Ghavami et al., 2022):

> Competing personal, family, and community demands and responsibilities might also impact staff availability. Problems related to staffing are often due to a need for child/elder care and supervision or lack of available public or personal transportation. Staff availability is often dependent on availability of childcare. One report noted that a hospital was able to temporarily maintain normal staffing without disruptions in patient care until the next group of staff arrived as relief. During Hurricane Hugo, preemptive steps were taken to ensure staffing before the hurricane made landfall by splitting available staff into two groups: one group remained at the hospital anticipating the storm, and after the storm passed, the second group arrived at the hospital to relieve the first group. (Melnychuk et al., 2022, p. 10)

Overcoming these challenges requires clear communication about staff schedules and roles as part of an effective disaster preparedness plan, as one Michigan hospital was able to do following the 2003 blackout (Brown, 2004). Further, the risk of staff burnout and fatigue is high due to the extended hours that staff must work (Andresen et al., 2023; Melnychuk et al., 2022). Finally, though staff shortages are a concern, healthcare facilities must be wary of the rapid convergence of well-intentioned but untrained and unlicensed volunteers and bystanders, which can create a significant administrative burden for hospitals (Milsten, 2000).

Stuff: Technological and Supply Chain Breakdowns

The breakdown of "stuff" in the wake of a blackout or natural disaster—medical devices, water, HVAC systems, and essential equipment—presents the most serious challenge to hospital functioning. Indeed, simulations reveal that hospital evacuations most likely occur following a chain of events that involves cascading infrastructure failures and a sequential degradation of hospital resources (Vugrin et al., 2015). Backup generators typically can function for 24 to 96 hours (Melnychuk et al., 2022); however, they can be plagued by weak performance (Achour et al., 2014), are prone to failure (Milsten, 2000), and can be vulnerable to flooding and storm damage (Barten et al., 2021; Norcross et al., 1993). Moreover, not all hospital services are connected to the generators, and auxiliary power may not be able to support computer-controlled equipment, diagnostic imaging scanners, laboratory devices, and fire alarm systems (Brown, 2004; Kile et al., 2005; Melnychuk et al., 2022). One immediate consequence of malfunctioning computer systems is a need to transition to paper charting, though Brown (2004) also describes satellite pharmacies throughout the building and the use of runners to carry samples and supplies to and from the laboratory as effective strategies amid power loss.

Hospitals require potable water and adequate water pressure to function effectively, and power failures can be accompanied by disruptions in water supply (Achour et al., 2014; Barten et al., 2021; Klinger et al., 2014), thus compromising the ability to wash hands, flush toilets, and sterilize instruments and equipment (Melnychuk et al., 2022). While water may be brought in by truck if backup water stores from wells and holding tanks are unavailable, these secondary resources may not arrive for several days if other infrastructure failures hinder transportation. Further, even if a supply of water is available, power loss can result in a breakdown of electricity-dependent filtration systems (Achour et al., 2014). Milsten (2000) notes that surgical services at the Medical Center of South Carolina encountered numerous difficulties due to the loss of water following Hurricane Hugo in 1989, as its power, temperature, and humidity control systems were cooled by water. Indeed, HVAC systems not only are beneficial for patient and staff comfort and safety, but they also help preserve biological specimens, ensure the proper functioning of life-saving technologies (e.g., ventilators, incubators, etc.), and help reduce the spread of illness (Melnychuk et al., 2022).

Supply chain disruptions represent another threat to effective surge capacity. Disasters and long-term outages can lead hospitals to expend stores of personal protective equipment, clean linens, and supplies for which a sizable stockpile may not exist (Heshmati, 2019; Polater & Demirdogen, 2018; Syahrir & Vanany, 2015). Supply chains for blood are likewise vulnerable to natural disasters, as these incidents can disrupt the delicate balance that must be maintained between the demand for blood transfusions and the number of blood donations (Fahimnia et al., 2017; Laermans et al., 2022; Vasconcelos et al., 2023). The ability for hospitals to acquire various essential goods likewise can inhibit their ability to provide continuity of care amid power and/or water loss, as Melnychuk et al. (2022) explain:

> Batteries are another "high-demand" item and supplies are frequently exhausted as they power communication devices, flashlights, exit lighting, emergency overhead lighting, and devices such as ventilators and medication pumps. In extreme cases, a lack of batteries can limit device-dependent therapies such as positive pressure ventilation. Other items such as suture kits, dressings, wheelchairs, and gurneys might also be in short supply. Loss of medications or access to medications can also create a significant burden on patients and medical relief teams and can result in ED visits for medication requests. A number of pieces of emergency clinical equipment and their quantities are considered to be very important or very important to be available during a sudden impact mass casualty incident. (p. 10)

Additionally, it must be noted that natural disasters can have consequences for the availability of supplies far outside the afflicted areas. For example, a saline shortage in mainland U.S. hospitals occurred when manufacturing factories in Puerto Rico shut down in the wake of Hurricane Maria in 2017 (Mazer-Amirshahi & Fox, 2018; Sacks et al., 2018).

Space: Patient Management

The effective use of physical space in hospitals under strained conditions emerged as a noteworthy challenge in past disaster events, including the 2003 Northeast blackout (Prezant et al., 2005) and Hurricane Sandy in 2012 (Adalja et al., 2014; Espana-Schmidt et al., 2013). Indeed, though healthcare professionals in New York had implemented additional preparedness measures following Hurricane Irene in 2011, the widespread flooding and power outages caused by Hurricane Sandy forced hospitals to absorb displaced patients from evacuated assisted living facilities, nursing homes, and other hospitals. Not only did staffing shortages and inaccess to electronic medical records hinder patient care, but hospitals also had to repurpose building lobbies and other empty spaces into treatment areas. Other case studies likewise have noted that the use of waiting rooms, corridors, and other non-clinical areas to treat patients was an effective way to quickly, albeit modestly, increase patient capacity (Esmailian et al., 2018; Kelen et al., 2017; Marcozzi et al., 2020; Sheikhbardsiri et al., 2017; Toerper et al., 2018). Prior knowledge of the hospital's existing capacity is essential (Hasan et al., 2023).

System: Communication Disruptions

When natural disasters and power failures occur, hospitals' internal and external means of communication are adversely affected, hindering the sharing of information both within and between hospitals (Melnychuk et al., 2022). Significant problems stemming from a loss of landline and cell phone service were observed following Tropical Storm Allison (Cocanour et al., 2002) and Hurricane Sandy (Uppal et al., 2013), though these intrahospital communication challenges may be mitigated through the use of battery-powered two-way radios (Kearns et al., 2014). However, the supply of these radios may be limited, and the deployment of a system of runners—a plausible alternative method of conveying information when electronic methods are unavailable (Brown, 2004)—poses additional difficulties (Melnychuk et al., 2022). Coordination with other hospitals and emergency medical services presents a more daunting challenge, and television and radio broadcasts have been used to share information regarding hospital capacity statuses and roadway conditions (Martchenke & Pointer, 1994). As previously mentioned, electronic health information allows hospital staff to track patients, document clinical orders, and share diagnostic and other test results; however, paper files may not follow patients when they are transferred to other facilities (Downey et al., 2013; Teperman, 2013).

Conclusion

Hospitals' resilience against natural disasters and power outages has emerged as a central concern for policymakers, medical practitioners, and members of the public, as continued access to healthcare technology and services must be provided amid electrical grid disruptions and infrastructure collapse (Luke et al., 2021; Sell et al., 2020). Given the numerous public health and social-psychological outcomes of disasters and extended outages (e.g., Andresen et al., 2023; Casey et al., 2020; Ebi et al., 2021), it is imperative that healthcare facilities assess and bolster their ability to effectively handle the climate-related weather events that are poised to intensify in the coming decades (Bell et al., 2018; Bhola et al., 2023). Further, these increases in the number and strength of disaster events are projected to occur in conjunction with a heightened risk of grid collapse due to inadequate infrastructure and growing consumer demand (Allen et al., 2016; Auffhammer et al., 2017; McFarland et al., 2015). Thus, while healthcare is just one of the many social systems that are vulnerable to electrical outages and natural disasters, evidence-based investment in surge capacity—informed by lessons learned—is needed for hospitals to prepare for future disasters and mitigate disruptions to patient care.

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Author Biography

Peter S. Lehmann, Ph.D., is an Assistant Professor in the Department of Criminal Justice and Criminology at Sam Houston State University. His research interests include juvenile justice and delinquency, criminal sentencing, racial and ethnic disparities in punishment, school discipline and safety, and public opinion on crime and criminal justice policy. His published work has appeared in *Justice Quarterly*, *Journal of Research in Crime and Delinquency*, *Crime & Delinquency*, *Punishment & Society*, and other journals.

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