



Hospital Resilience and Continuity of Medical Care in the Face of Extreme Weather Events



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Keywords

*continuity of care;
critical infrastructure;
extreme weather events;
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public health;*

Abstract

Currently, extreme weather events are occurring globally, posing a threat to critical public health infrastructure. Prolonged disruptions to basic services, especially electricity and drinking water, directly compromise the continuity of medical care in critical areas such as intensive care units, operating rooms, and cold chains for biological products. The objective of this study was to analyze the current evidence on hospital resilience strategies, evaluating both operational vulnerability and the integration of infrastructure and governance solutions to mitigate the impact of climate crises. A qualitative approach was used as the review methodology, based on a search of scientific literature in indexed databases. The results indicate that the transition to adapted healthcare buildings, the use of decentralized energy systems (such as microgrids and renewable backup sources), and the updating of hospital emergency plans are critical determinants for preventing avoidable morbidity and mortality during disasters. Hospital resilience must cease to be a reactive approach and become a structural necessity in healthcare planning. Extreme weather events are currently occurring worldwide, endangering critical public health infrastructure. Prolonged disruptions to essential services, especially the supply of electricity and drinking water, pose an immediate threat to maintaining healthcare in critical areas such as intensive care units, operating rooms, and cold chains for biological products. The objective of this study was to analyze updated data on hospital resilience strategies, evaluating both operational vulnerability and the incorporation of infrastructure and governance solutions to mitigate the effects of climate crises. A review methodology based on searching scientific literature in indexed databases and a qualitative approach was used. The results indicate that the transition to adapted healthcare buildings, the use of decentralized energy systems (such as microgrids and backup renewable sources), and the updating of hospital emergency plans are critical determinants for preventing avoidable morbidity and mortality during disasters. Hospital resilience must cease to be a reactive approach and become a structural necessity in healthcare planning.

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Introduction

Climate change is causing a global increase in the frequency, intensity, and predictability of extreme weather events. Phenomena such as flash floods, tropical cyclones, prolonged droughts, and extreme heat waves not only affect ecosystems and local economies but also place unprecedented pressure on public health systems. (Or & Seppänen, 2024). In this context, hospitals and health institutions play a fundamental role as essential critical infrastructure; their operational capacity is indispensable not only for the immediate response to major disasters, but also to ensure the continuity of treatment for chronic diseases and the normal functioning of clinical activities in the affected areas, as well as in the reduction of emissions (Olawade et al., 2025).

Historically, the relationship between health and the environment has been approached from an epidemiological perspective, focusing on the proliferation of infectious vectors or on pathologies associated with heat stress. However, there is a critical gap in the literature regarding the structural and operational vulnerability of healthcare facilities to external systemic failures (*Strengthening healthcare system resilience : a comprehensive framework for tropical cyclone Preparedness and response - The Lancet Regional Health – Americas* , 2025) . Massive blackouts and physical damage to utility networks cause the paralysis of essential medical equipment, the disruption of the cold chain for vaccines and medicines, and the disruption of sanitation and information systems (Etkho, 2023).

The relationship between health and the environment has traditionally been addressed from an epidemiological perspective (Moreno Sánchez, 2022), paying special attention to the expansion of disease vector distribution areas or to conditions related to heat stress. However, it is important to note that there is a significant gap in the scientific literature regarding the structural and operational vulnerability of healthcare facilities to external systemic failures (Mitra et al., 2024). Large-scale power outages and physical damage to basic service infrastructure lead to the failure of critical medical equipment and the disruption of the cold chain for vaccine and medication storage (Rivera, 2020), as well as dysfunctions in hygiene and information systems.

The reality is that hospital resilience must exist globally. This is defined as the capacity of a healthcare facility to resist, absorb, adapt to, and recover from the effects of a hazard in a timely and efficient manner (Burnett et al., 2023), while maintaining operational continuity. This can now be achieved using distributed generation and smart grids, which can be incorporated into traditional architectural design and integrated into technological, logistical, and administrative governance dimensions. By incorporating a new vision to address the vulnerability of healthcare infrastructure to climate crises and implementing adaptation strategies, resilience could be guaranteed to ensure the continuity of medical care in hospitals (Rodríguez et al., 2026).

Methodology

The review methodology used was based on searching scientific literature in indexed databases such as PubMed, Scopus, and Web of Science, covering publications preferably from the period 2020–2026, and a qualitative approach, in addition to a narrative aimed at synthesizing the available scientific and technical literature on hospital resilience and climate change, as well as highlighting the possible uses of distributed generation and smart grids to achieve resilience in hospital centers.

Analysis and Discussion of the Results

Operational and clinical vulnerability to climatic events

The evidence analyzed demonstrates that the failure of primary support services (electricity, water, and telecommunications) triggers a chain reaction within hospital facilities. Interruptions in the conventional power supply pose an immediate risk to patients dependent on mechanical ventilation in Intensive Care Units (ICUs), neonatology, and surgical areas (Loor et al., 2022).

Furthermore, the loss of adequate climate control during extreme heat waves exacerbates physiological stress in vulnerable patients and compromises the thermal stability of laboratories and blood banks. A common finding in the literature is that traditional diesel generators, considered the backup standard for decades, have critical limitations during prolonged events (Holzbach et al., 2025). In this context, there is a dependence on fuel supply chains blocked by impassable roads, mechanical failures due to overload, and limited response times that jeopardize continuity of care within hours of a disaster.

Infrastructure and technological mitigation solutions

To counteract these vulnerabilities, current trends in hospital engineering point towards energy decentralization and structural reinforcement (Villamizar et al., 2023). The integration of **hospital microgrids** that combine renewable energy sources (such as photovoltaic panels) with advanced battery storage systems and smart controllers is positioned as a highly effective alternative (Lagrange et al., 2020).

Unlike traditional fossil fuel generators, microgrids allow for a seamless and uninterrupted transition ("zero-second blackout") for critical loads, as well as ensuring energy autonomy for weeks in scenarios where public grids completely collapse. Similarly, the literature highlights the need to implement bioclimatic designs, perimeter physical barriers against flooding, and redundant potable water storage systems that guarantee hygiene and sterilization for at least 72 hours after an extreme event (Zabala-Fuertes et al., 2026).

Governance, emergency plans and risk management

Infrastructure alone is insufficient without a robust operational governance framework. The reviewed studies agree that Hospital Emergency Plans (HEPs) frequently lack simulations based on multi-hazard climate change scenarios. Continuity of healthcare requires close interagency coordination among hospitals, electricity grid operators, civil protection services, and local health authorities.

Training clinical and administrative staff in energy crisis management and prioritizing patient flow in the face of temporary operational capacity reductions are key to minimizing preventable mortality. Resilience, therefore, is as much a matter of physical engineering as it is of organizational resilience and decision-making under pressure. (*Climate-resilient and environmentally sustainable health facilities. WHO - PAHO/WHO guidelines / Pan American Health Organization, 2021*).

Factors involved in disaster resilience in hospital infrastructure

There are different factors involved in disaster resilience in hospital infrastructure, as shown in Figure 1.



Figure 1. Factors involved in resilience to extreme weather events. Source: Author's own elaboration and AI assistance

Based on knowledge of the potential climatic difficulties that can occur in a territory, buildings must be designed to be safe, have good operational and functional capacity, and be energy sustainable, as well as have a reliable water supply; both are fundamental in the event of any natural disaster. Finally, programs must be in place to prepare people to adapt to any of these phenomena, making training essential in these resilience processes against natural phenomena. The results show that with adequate infrastructure to address natural disasters, continuity of medical care and good patient safety can be achieved.

Conclusions

It became evident that to achieve hospital resilience, strategies must be developed that allow the sustainable operation of the facilities in the face of any natural disaster, in addition to evaluating both operational vulnerability and the integration of infrastructure and governance solutions.

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