Chapter 2
IoT-Based Environmental Monitoring to Reduce Healthcare Facilities' Environmental Impact:
Mitigating the Effects of Healthcare Infrastructure on Ecosystems and Public Health

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ABSTRACT

Healthcare facilities are vital to public health, but they also significantly impact the environment through energy and water consumption, medical waste, and pollutant emissions. This article explores the role of Internet of Things (IoT)-based environmental monitoring systems in minimizing hospitals' ecological footprint. IoT systems use real-time data from smart sensors to track air and water quality, energy usage, and waste volume. The analysis is framed by Cyber-Physical Systems (CPS), the One Health approach, and the Technology-Organization-Environment (TOE) model. A narrative literature review (2019–2024) highlights IoT's potential to improve pollution control, resource efficiency, and environmental compliance in healthcare settings. Despite clear benefits, implementation faces barriers such as high costs, cybersecurity risks, limited digital skills, and regulatory gaps. The article concludes that IoT offers a strategic path toward sustainable healthcare, aligned with Sustainable Development Goals (SDGs) 3, 6, 11, and 13.

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INTRODUCTION

Healthcare facilities—such as hospitals, clinics, and rehabilitation centers—strategically improve community wellbeing through promotive, preventive, curative, and rehabilitative functions. However, the operational activities of these institutions generate significant ecological impacts. The high energy demands required to operate heating, ventilation, air conditioning (HVAC) systems, lighting, and advanced medical equipment lead to substantial resource consumption and carbon emissions. Research shows that hospitals can achieve significant energy savings through conservation strategies, with an initial target of a 5% reduction in energy consumption in the first year and 2.5% in each subsequent year (González et al., 2018).

Sustainable architecture and design play a crucial role in reducing the ecological footprint of healthcare facilities. Guidelines such as the Green Guide for Health Care provide practical approaches for operational efficiency, energy and water conservation, and improved resource management (McGain & Naylor, 2014). Additionally, Moldovan et al. (2023) emphasize that integrating sustainability principles into healthcare service accreditation and quality systems is vital to balancing medical care with environmental preservation.

Beyond energy consumption, medical waste management poses a significant challenge. Hospitals produce approximately 0.5 to 2.5 kg of medical waste per patient daily, depending on infrastructure and healthcare management practices (Mominkhan et al., 2023). This waste includes sharps, chemicals, and other hazardous materials from laboratories, patient wards, and isolation units (Ibrahim et al., 2023; Wafula et al., 2019). Improper waste management can lead to soil and water contamination and increase the risk of infectious disease transmission (Han et al., 2024; Mishbahuddin et al., 2021).

The absence of an adequate waste management framework in many developing countries further exacerbates the situation. A study in Ethiopia revealed that most healthcare facilities lack structured waste management systems, resulting in substandard practices that pose health risks to communities (Wassie et al., 2022). Moreover, the global healthcare sector contributes nearly 5% of total carbon dioxide emissions, creating a paradox: institutions aimed at improving health simultaneously contribute to the factors that worsen disease (Mominkhan et al., 2023).

The rising trend in biomedical waste due to population growth, urbanization, and the use of disposable medical devices reinforces the urgency of re-evaluating waste management protocols. Efforts such as reducing single-use materials and transitioning to bioplastics and reusable medical tools have been proven to significantly lower greenhouse gas emissions (Ernawati, et al., 2025; Obubu et al., 2023). Visser et al. (2024) demonstrated that patients respond positively to healthcare institutions that prioritize environmental sustainability, without compromising service satisfaction.

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