Chapter 3
An Agentic Approach to Sustainable Environmental Monitoring Systems in Healthcare

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ABSTRACT

This chapter explores the transformative role of agentic AI in sustainable environmental monitoring for healthcare. The need for this shift arises from the sector's considerable environmental footprint and the challenge of ensuring contaminant-free spaces vital for patient safety and preventing Healthcare-Associated Infections (HAIs). The chapter introduces the theoretical foundations, architecture, and capabilities of AI agents, highlighting their contribution to "smart healthcare". A conceptual multi-agent system is then proposed to integrate intelligent agents into sustainable monitoring. The model covers functional requirements such as real-time monitoring and predictive analysis, as well as non-functional ones like scalability, security, and adherence to sustainability principles. The discussion concludes by addressing key technical, ethical, and regulatory challenges that must be overcome to fully harness agentic AI's potential in building proactive, personalized, and environmentally sustainable healthcare ecosystems.

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INTRODUCTION

The adverse impact of pollution and environmental change on health is now widely recognized (Landrigan et al., 2018; Watts et al., 2018), yet the health sector's own environmental impact has been less explored (Lenzen et al., 2020). Performance assessment in healthcare traditionally focuses on clinical outcomes and financial costs. However, providing healthcare services generates a wide range of air, water, and soil pollutants, with indirect and negative effects on health. Researchers estimate that healthcare is a major contributor to environmental degradation, generating between 4.4% and 5.2% of total global greenhouse-gas emissions (Pichler et al., 2019). Consequently, all stakeholders must be aware of these effects and assume the practical and ethical responsibility to integrate sustainability principles into performance evaluation and the management of healthcare organizations (Dolcini et al., 2025).

Healthcare - an inherently complex sector - faces significant challenges in delivering high-quality care under resource constraints (D. Sharma & Cotton, 2023; Holmér et al., 2023). For example, maintaining safe, contaminant-free environments in healthcare settings represents a significant, ongoing challenge for professionals. From operating rooms to blood banks and pharmacies, precise monitoring and control of parameters such as temperature, humidity, and air pressure are essential for patient safety and compliance with strict regulations (Montuori et al., 2024; Sehulster et al., 2003). Hospital environments - especially enclosed spaces frequently used by patients, staff, and visitors - can become both vectors for pathogen transmission and factors that affect clinical care quality (Tsang et al., 2024; Fonseca et al., 2022). For example, it is estimated that 1 in every 31 inpatients in United States (US) hospitals is expected to contract a Healthcare-Associated Infection (HAI). The US Centers for Disease Control and Prevention (CDC) reports nearly 2 million nosocomial infections and more than 90,000 deaths annually (Epicenters, 2024). According to the Agency for Healthcare Research and Quality, HAIs are the most common inpatient complications and rank among the top ten causes of death in the United States (Health Care-Associated Infections, n.d.). Globally, approximately 7% of inpatients in high-income countries and 10% in low- and middle-income countries acquire such infections (Danasekaran et al., 2014). Studies in high-income countries find that between 5% and 15% of inpatients develop HAI, while in intensive care units (ICUs), these infections can affect 9% to 37% of patients (Allegranzi et al., 2007; Vincent, 2003). In Europe, hospital-level HAI prevalence ranges from 4.6% to 9.3% (Haque et al., 2018).

Environmental monitoring contributes substantially to compliance with national and international hygiene and health-safety standards. Guidelines from organizations such as World Health Organization (WHO) and the CDC highlight the need