Journal of Organizational and End User Computing
Volume 38 • Issue 1 • January-December 2026

AI-Driven Public Health Information Management and Emergency Decision-Making:
A Case Study of Hospital Information Systems

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Received: December 30th, 2025 | **Accepted:** April 3rd, 2026

ABSTRACT

The increasing complexity of healthcare systems and the rapid growth of heterogeneous medical data pose significant challenges to effective decision-making in public health and clinical practice. Existing data-driven approaches often struggle to balance predictive accuracy, robustness, and interpretability, particularly under dynamic and uncertain conditions. To address these challenges, this study proposes an AI-driven Emergency Decision-Making framework (AIM-EDM) that integrates multi-source health data, temporal modeling, and causal reasoning into a unified decision-support architecture. The proposed framework leverages deep representation learning to capture complex temporal patterns, incorporates knowledge-guided causal inference to enhance interpretability, and employs decision optimization to support reliable and actionable outcomes.

KEYWORDS

Emergency Decision-Making, Healthcare Analytics, Causal Reasoning, Knowledge-Enhanced Learning, Clinical Decision Support Systems

INTRODUCTION

The rapid digitalization of healthcare systems has led to an unprecedented growth in the volume, diversity, and complexity of medical data (Kartskhia, 2021). Electronic health records (EHRs), real-time monitoring systems, and large-scale public health databases have created new opportunities

DOI: 10.4018/JOEUC.407232

for data-driven decision-making in clinical and emergency management scenarios (Munagandla et al., 2024; Patel, 2024; Sudharson et al., 2025). Similar trends can be observed in other intelligent decision-support systems, where artificial intelligence techniques are increasingly used to optimize service processes and improve system efficiency (Kumar & Rajaram, 2024; Z. Wu et al., 2024). At the same time, the increasing frequency of public health emergencies and the rising complexity of patient conditions have placed significant pressure on traditional decision-support systems (Jiang, 2024), which often struggle to provide timely, reliable, and interpretable recommendations in dynamic and uncertain environments (Ezeji et al., 2024).

In recent years, artificial intelligence (AI) methods have shown considerable promise in supporting complex decision-making processes across domains, including healthcare and organizational management (Ali & Simmou, 2025; Fahim et al., 2025). Deep learning and representation learning techniques, including transfer learning and large-scale neural architectures, have demonstrated strong predictive performance across a wide range of data-intensive tasks (M. M. Li et al., 2022; Morid et al., 2023; Shua, 2025). However, existing approaches often exhibit several critical limitations. Many models focus primarily on predictive accuracy while overlooking causal relationships among clinical variables, leading to limited interpretability and reduced reliability under distribution shifts (Mesinovic et al., 2023). In addition, most existing systems are designed for isolated prediction tasks and lack the ability to integrate heterogeneous data sources or to support decision-making under uncertainty, thereby restricting their applicability in real-world emergency and public health scenarios.

In this study, emergency decision-making refers to the process of generating timely, reliable, and actionable recommendations for high-stakes healthcare situations under dynamic, uncertain, and resource-constrained conditions. In the context of hospital information systems and public health management, this process includes early risk identification, patient state assessment, intervention prioritization, and uncertainty-aware support for clinical or operational response. Unlike conventional predictive modeling, which primarily focuses on estimating future outcomes, emergency decision-making emphasizes translating predictive and causal insights into concrete actions that support rapid, informed responses in evolving healthcare environments.

To address these challenges, this study aims to develop a unified framework for intelligent emergency decision-making that combines predictive modeling, causal reasoning, and knowledge-driven analysis. The core objective is to construct a robust and interpretable system that leverages heterogeneous clinical data, captures complex temporal dependencies, and supports informed decision-making under dynamic and uncertain conditions. By integrating multi-source data and explicitly modeling causal relationships, the proposed approach seeks to overcome the limitations of purely data-driven models and enhance both the reliability and transparency of decision outcomes.

Specifically, this work proposes an AI-enabled information management and emergency decision-making (AIM-EDM) framework that integrates temporal representation learning, knowledge-guided reasoning, and decision optimization within a unified architecture. The framework is designed to jointly model patient states, clinical interventions, and outcome trajectories, enabling more accurate risk assessment and actionable decision support. Unlike conventional models that treat prediction and decision-making as separate processes, the proposed approach tightly couples these components to enable more coherent, context-aware inference.

The main contributions of this study can be summarized as follows. We propose a unified decision-making framework that integrates heterogeneous healthcare data with causal and temporal modeling. Additionally, we develop a scalable and interpretable architecture capable of supporting complex clinical and public health decision tasks. Finally, we conduct extensive experimental evaluations on multiple real-world datasets to demonstrate the effectiveness, robustness, and generalizability of the proposed approach. Collectively, these contributions advance the state of the art in intelligent healthcare decision support and provide a practical foundation for next-generation data-driven health systems.

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