

AI-driven Nurse Scheduling and Dynamic Task Allocation for ICUs: Optimizing Human Resource Allocation in Public Health Emergencies

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Abstract

Background: During public health emergencies, nursing demands in intensive care units (ICUs) surge dramatically. Traditional static scheduling fails to dynamically match tasks with personnel, resulting in declined care quality and elevated risks of nurse burnout. **Objective:** To develop a reinforcement-learning-based AI-powered scheduling and task allocation system to dynamically optimize ICU nurse staffing and improve the resilience of nursing systems amid large-scale public health emergencies. **Methods:** Retrospective data analysis and simulation modeling were adopted. Nursing scheduling records, patient data and workload assessment scales from the ICU of a tertiary hospital (2020–2025) were collected to construct a training dataset covering over 8,000 shifts. Patient severity levels, nurse qualification grades, consecutive working hours and prior workloads were set as system inputs. High-pressure public health emergency scenarios with bed occupancy rates $\geq 85\%$ were simulated. Indicators including nursing care quality scores, workload imbalance coefficients, critical patient response time, and burnout risk early-warning accuracy were used for comparison against conventional scheduling strategies. **Results:** The AI system raised care quality scores by 18% ($p < 0.05$), reduced the workload imbalance coefficient by 32%, and shortened critical patient response time by approximately 35 minutes. Its burnout risk prediction module achieved a 78% early-warning accuracy for high-risk shifts. **Conclusion:** This system substantially improves human resource allocation efficiency in ICUs, with sound clinical feasibility and promotion value. It serves as an effective AI decision-support tool for critical-care management under public health emergencies.

Keywords

Intensive Care Unit (ICU), Nursing Human Resource Management, Artificial Intelligence, Reinforcement Learning, Public Health Emergency