

A Study on the Architecture Design of Intelligent Public Health Prevention and Control Platforms

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Abstract: With the increasing complexity of infectious disease prevention and control and critical care emergency work, the traditional manual monitoring and early warning system has been difficult to meet the needs of modern public health management and regional medical coordination. To cope with this challenge, this paper constructs a whole-process medical intelligence optimization platform, based on cutting-edge technologies such as Internet of Things (IoT), 5G communication, artificial intelligence (AI) and blockchain, to realize the full-cycle medical management of pre-hospital emergency care, in-hospital treatment and post-hospital rehabilitation. The platform adopts a five-layer architecture of data collection, transmission, analysis, decision support and user interaction, and integrates edge computing, federated learning and deep learning algorithms to ensure safe data sharing and real-time processing. This paper elaborates the system architecture and key technologies of the platform, and discusses its application value in public health emergency response and personalized rehabilitation management, which provides a feasible path for the construction of a smart healthcare ecosystem.

Keywords: Intelligent public health; 5G communication; regional collaborative treatment; edge computing; dynamic resource scheduling.

1. Introduction

With the convergence of technologies such as the Internet of Things (IoT), 5G communications, artificial intelligence (AI), and blockchain, smart health platforms have become a core vehicle for the digital transformation of public health management. Existing studies have shown that such platforms significantly improve the accuracy of remote monitoring, resource scheduling, and disease prediction by collecting vital signs, environmental parameters, and patient behavioral data in real time [1, 2], combined with the high throughput and low latency characteristics of 5G networks [3–5]. At the level of architectural innovation, the introduction of federated learning and blockchain technology [6, 7] effectively solves the privacy paradox in cross-institutional data sharing and provides a technological paradigm for the construction of decentralized healthcare collaboration networks. However, current research mostly focuses on single-scenario optimization, such as chronic disease management [8] or emergency response [9], with structural shortcomings such as health monitoring–intervention–recovery full-cycle synergy disconnection [10] and insufficient interoperability of heterogeneous systems [11]. Recent research trends suggest that building an intelligent middle office that balances privacy security with dynamic resource provisioning [3, 6] will be a key path to break through the bottleneck of fragmentation of existing platforms.

This research constructs a whole-process medical intelligent optimization platform, which adopts a five-layer architecture, including data acquisition layer, data transmission layer, data analysis layer, decision support layer and user interaction layer, and its core mechanisms include data sharing, intelligent decision making and dynamic optimisation. The system achieves intelligent management of the whole process of medical treatment and rescue, improves

the efficiency of medical resources utilisation, and optimises the patient's treatment and rehabilitation experience through technologies such as edge computing, AI intelligent analysis, and federated learning.

2. Research Plan and System Architecture Design

2.1. Data Acquisition Layer (Perception Layer)

As the basic layer of the system, the data acquisition layer undertakes the monitoring, automatic acquisition and intelligent fusion of key information such as vital signs, environmental parameters, patient flow and other key information in pre-hospital, in-hospital and post-hospital phases, to ensure the comprehensiveness, timeliness and reliability of the data, and to provide accurate support for real-time decision-making.

The data sources of this layer includes: patient's vital signs, health status; medical environment (beds, ICU resources, patient flow), emergency and treatment scenarios (ambulance, operating rooms, rehabilitation centres), external environment (air quality, temperature and humidity, urban traffic), and combination of historical and dynamic data (EHR, intelligent prediction), all of which are captured through sensors, wearable devices, and video/audio capture, intelligent diagnostic devices, etc., and combined with edge computing and AI intelligent analysis to ensure the accuracy and effectiveness of the data. In terms of data sharing mechanism, the system integrates multi-source data from ambulance, hospital HIS systems, wearable devices, etc. through the federal health data lake to achieve cross-agency medical data collaboration. Meanwhile, in order to ensure patient privacy and security, it adopts federated learning and decentralised storage technology to ensure that the data is available without leaking personal privacy. In terms of intelligent decision-making mechanism, the AI Decision

Center optimises medical resource scheduling and patient flow through LSTM demand prediction and Deep Reinforcement Learning (DRL) scheduling algorithms, while combining with AI-assisted diagnostic system to provide accurate diagnosis and treatment recommendations for doctors. The dynamic optimisation mechanism covers pre-hospital, in-hospital and post-hospital processes, such as

optimising ambulance scheduling with real-time traffic data and ICU bed status, optimising bed utilisation through the ICU intelligent allocation module, and providing personalised rehabilitation programmes with the help of wearable devices and the AI health management system to reduce the risk of chronic diseases.

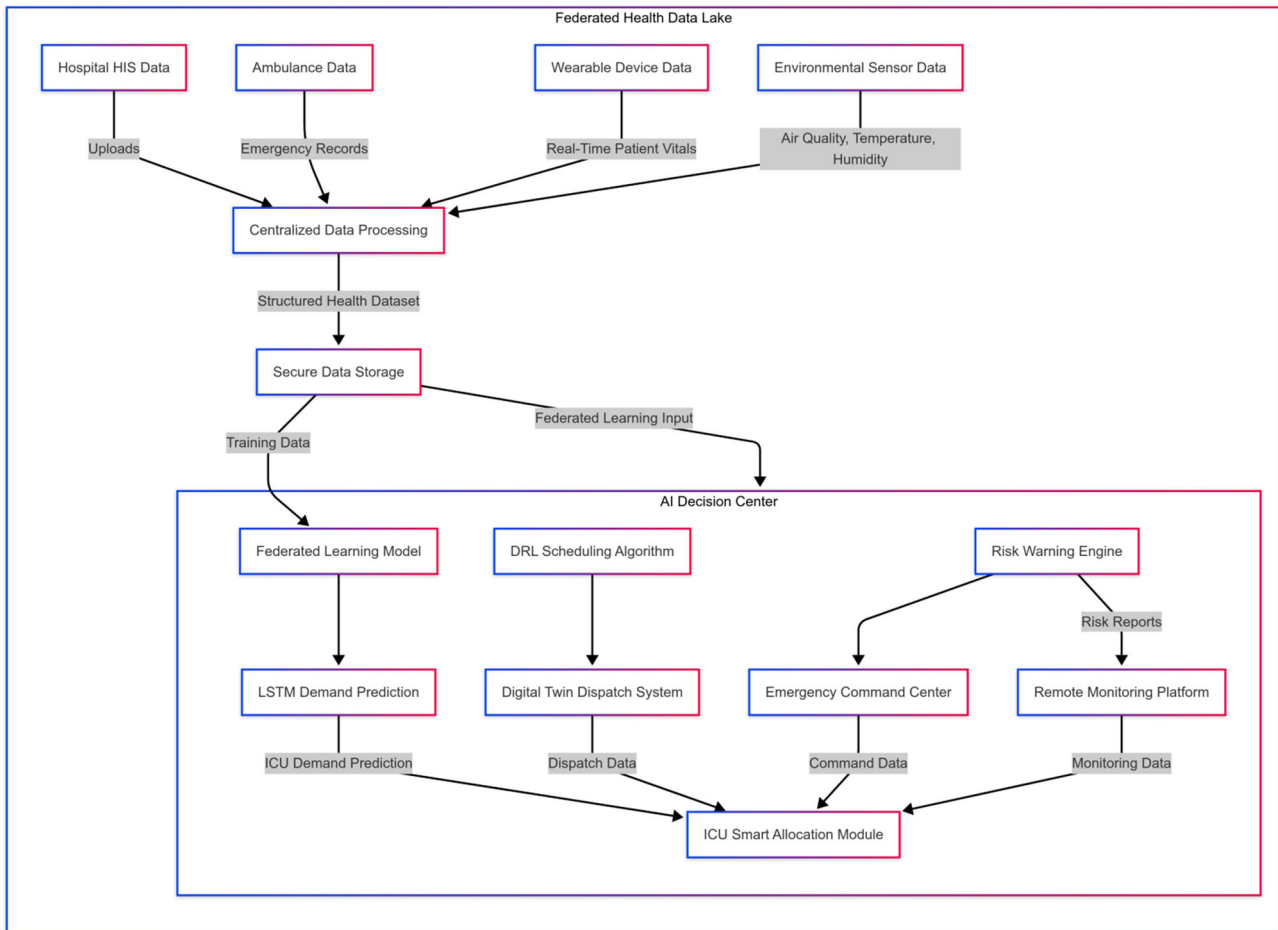


Figure 1. Flowchart of data sharing and analysis in the Smart Healthcare Federal Health Data Lake

2.1.1. Pre-hospital Multimodal Data Acquisition and Precise Positioning

The pre-hospital stage realises the intelligence of the whole process of first aid through multimodal data fusion and accurate positioning technology. Firstly, real-time patient location data is collected by BeiDou Navigation Satellite System (BDS)/GIS positioning systems, and combined with dynamic scheduling algorithms to optimise the first aid path to ensure that the ambulance arrives at the scene quickly. Simultaneously, the 5G ambulance terminal synchronously monitors vital signs such as ECG, oxygen saturation, blood pressure, etc., and constructs panoramic data of the emergency scene through multi-modal fusion (4K video streaming, audio help information, electronic health record). On this basis, the edge computing processing unit is deployed at the ambulance end, integrating positioning, video and sensor data in real time, and using AI multimodal fusion algorithms to improve the accuracy of patient status recognition. Synchronously, the AI-assisted diagnostic system generates a preliminary condition assessment to provide decision support for in-hospital treatment. In addition, the risk warning engine combines the AI early prediction model to analyse the patient's condition, push high-risk

warning signals to the emergency command centre, and prioritise the scheduling of treatment resources. Finally, the LSTM time-series prediction model dynamically analyses the availability of regional ICU beds, intelligently matches patients with target hospitals, and achieves optimal allocation of medical resources.

2.1.2. In-hospital multi-source data acquisition and intelligent flow optimisation

The data collection in the in-hospital stage takes accurate patient flow and intelligent ward monitoring as the core goal, and optimises medical resource allocation and treatment efficiency through data collection and intelligent analysis covering the whole hospital. Firstly, the ultra-wideband (UWB) positioning technology tracks the patient flow path in real time, and combined with the digital twin scheduling system simulates the allocation of resources within the hospital to improve the efficiency of beds and medical equipment. Second, the ICU intelligent allocation module uses the LSTM demand prediction model to dynamically dispatch beds and ensure that critically ill patients are prioritised to ICUs or emergency wards based on bed status, ICU capacity and the severity of the patient's condition. Meanwhile, the smart ward monitoring system deploys IoT

sensors (Internet of Things) in ICU and emergency department to collect patients' vital signs data (e.g., heart rate, blood oxygen, temperature, blood pressure, etc.) in real time and automatically warns of abnormalities through AI intelligent analysis. Furthermore, the Electronic Health Record (EHR) system synchronises patient data and combines with the AI-assisted diagnosis system to achieve intelligent disease identification, thus improving doctors' decision-making efficiency. The telemedicine and central data processing module uploads patient monitoring data to the central data centre to support doctors' remote consultation and provide intelligent decision-making support for complex conditions, while optimising patient allocation and reducing retention time by combining with the dynamic planning system of the emergency department. Finally, the edge computing node inside the ICU processes high-priority vital signs data, performs local early warning analysis of the patient's status, and uploads abnormalities to the central data centre to reduce data transmission delays and improve real-time response capabilities.

2.1.3. Post-hospital Multi-dimensional Data Collection and Personalised Rehabilitation Management

In the post-hospital phase, the platform achieves multi-dimensional long-term rehabilitation data collection and analysis through the remote health monitoring and personalised rehabilitation management module, providing support for AI precision assessment and early intervention. Firstly, the flexible wearable device continuously monitors the patient's vital signs such as heart rate, blood oxygen, activity level and sleep status, while combining with environmental monitoring sensors to collect air quality, temperature and humidity, and noise level to dynamically optimise the patient's rehabilitation environment. Secondly, the remote monitoring platform uploads real-time data to the central processing system, so that abnormal indicators during the rehabilitation process can be detected in a timely manner through collaborative analysis. Apart from that, the platform integrates health status analysis and chronic disease management functions, combining personalised rehabilitation systems to optimise post-operative recovery and chronic disease intervention strategies. On the foundation of this, AI algorithms generate personalised rehabilitation plans based on patients' health trends, covering exercise recommendations, diet plans and medication adjustments, and continuously optimise interventions through an intelligent health management system. In the meantime, the platform's built-in risk warning engine monitors patient data in real time and automatically pushes early warning information to medical institutions after analysing the risk of deterioration of chronic diseases to ensure rapid response to emergencies. Finally, the federal health data lake ensures the safe sharing of multi-source information by integrating hospital HIS data, ambulance records, wearable devices and environmental sensor data. In the process, Federated Learning technology trains health prediction models under the premise of protecting data privacy, which significantly improves the accuracy of medical decisions.

2.2. Data transmission layer (network layer)

This layer guarantees real-time data transmission, safe sharing and cross-platform interconnection through multiple communication technologies to ensure seamless data docking in pre-hospital, in-hospital and post-hospital phases, optimise the emergency response speed and medical resource

scheduling efficiency, and improve the overall quality of treatment.

2.2.1. Wireless communication: multi-level data transmission architecture

The data transmission layer ensures real-time and priority management of medical data by building a multi-level wireless communication architecture. First of all, 5G, Wi-Fi 6 and NB-IoT technologies are used to realise large-scale device networking, and the data is transmitted in layers according to the degree of urgency, ensuring that key vital signs such as ECG and oxygen saturation are transmitted to the hospital system in priority, significantly reducing the time delay and improving the response speed of first aid. On this basis, the 5G emergency gateway deployed at the ambulance end can upload the patient's vital signs to the ICU and emergency department in real time, enabling the medical team to formulate a rescue plan in advance, and synchronise the key health information to the EHR system, strengthening the efficiency of the data connection between the pre-hospital and in-hospital areas. Moreover, the in-hospital UWB technology accurately tracks the patient's location, and combined with AI analysis of the movement trajectory, dynamically optimises the flow paths between the emergency department, ICU and general wards, thus reducing the number of patients stranded and increasing the turnover rate of hospital beds. In order to further improve the quality of treatment, the ambulance side also supports 4K HD video and voice transmission, enabling remote experts to intervene in the emergency scene in real time and provide resuscitation guidance, which ultimately improves the survival rate of critically ill patients.

2.2.2. Edge Computing: High Real-time Data Processing

Edge computing nodes are deployed at the ambulance end, hospital ICU, emergency department, and post-hospital rehabilitation and monitoring centre for high-priority data processing to optimize emergency response and medical resource scheduling. According to different stages of the medical process, edge computing nodes play different core roles in pre-hospital emergency response, in-hospital treatment and post-hospital rehabilitation management to optimise emergency response, medical resource scheduling and rehabilitation monitoring respectively. The intelligent analysis and medical scheduling process of edge computing nodes is shown in the following figure:

(1) Pre-hospital emergency care: real-time analysis and early warning

The core of the data transmission layer is to achieve high real-time data processing through edge computing, so as to optimise the efficiency of medical response. In the pre-hospital emergency scenario, edge computing nodes are deployed at the ambulance end to directly process vital signs data (e.g., ECG, oxygen, blood pressure), quickly assess the severity of the condition using AI algorithms, and synchronise critical data to the hospital in milliseconds via 5G and Wi-Fi 6 networks. This mechanism will avoid transmission delays that rely on cloud-based computing and enable emergency department doctors to grasp the patient's status in advance. Concurrently, edge computing combined with LSTM models predicts ICU bed demand and dynamically optimises bed scheduling strategies to ensure priority admission of critical patients. Based on this, the AI risk warning engine can analyse emergency video streams and vital signs data in real time, identify the risk of deterioration such as acute respiratory failure in advance, and push alerts to the hospital to fight for golden time for rescue.

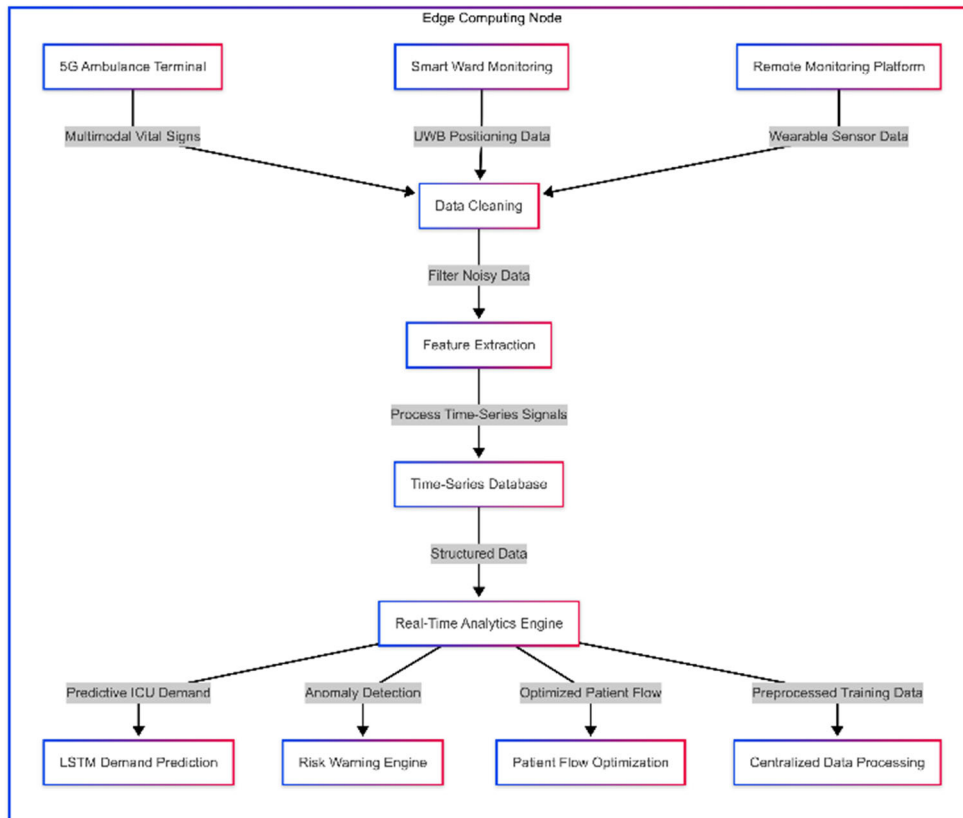


Figure 2. Flowchart of data processing in edge computing nodes

(2) In-hospital rescue: ICU/emergency data sharing and real-time optimisation

In the in-hospital stage, the high real-time characteristics of edge computing further support data collaboration between ICU and emergency department. IoT sensors deployed in ICU continuously collect data such as patients' heart rate, blood oxygen, etc., which are instantly analysed by edge computing nodes to analyse abnormal indicators and uploaded to the scheduling centre, reducing the processing burden on the central server. Based on real-time vital signs data, the AI risk alert engine automatically detects high-risk patients (e.g., sepsis, acute respiratory failure) and pushes alerts to healthcare workers in advance, gaining a critical window of time for resuscitation. Meanwhile, the Deep Reinforcement Learning (DRL) scheduling algorithm dynamically optimises the medical resource allocation plan by combining the resource status of the emergency department and ICU, the patient's condition, and the medical and nursing scheduling data. For example, when the system identifies a patient with acute heart failure, the DRL algorithm can link with the emergency command centre to prioritise the deployment of ECMO equipment and specialist healthcare teams to ensure that the critically ill patient receives optimal treatment. In addition, the ultra-wideband (UWB) positioning technology tracks the in-hospital flow path of patients in real time, and dynamically adjusts bed allocation through AI algorithms to shorten the detention time in ICUs and emergency departments. This localised processing mechanism not only avoids delays in cross-level data transmission, but also improves the efficiency of inter-hospital collaborative treatment of complex cases through the linkage of the electronic health record (EHR) system and the remote consultation platform.

(3) Post-hospital rehabilitation: remote monitoring and

health management

In post-hospital rehabilitation management, data such as post-operative recovery and chronic disease health management are continuously monitored by deploying edge computing nodes in post-hospital rehabilitation centres, patients' homes, and telemedicine platforms. Edge computing balances real-time and privacy security with a layered data transmission mechanism. Edge nodes deployed in rehabilitation centres and patients' homes continuously monitor post-operative recovery data, but only upload abnormal indicators (e.g., sudden changes in heart rate, abnormal blood oxygenation) to the cloud to reduce redundant data transmission. This design reduces network load and protects patient privacy through localised storage. Synchronously, edge computing synergises with the federal health data lake to integrate long-term health trends for chronic disease management model training without the need to share raw data. For instance, sleep and activity data collected by wearable devices complete the initial analysis locally, and only upload the characteristic parameters to the federated learning platform, which not only safeguards data security, but also supports the dynamic optimisation of personalised rehabilitation programmes.

2.2.3. Data Security

The data transmission layer safeguards the security of the whole process of medical data by means of hybrid storage architecture and decentralised technology. In the design of data storage architecture, real-time data and long-term data adopt a hierarchical management model. vital signs data from ICU and emergency department are stored in local edge computing nodes as a priority to avoid the interference of network latency on the assessment of medical conditions. Long-term analysis data is stored in the federal health data lake to support cross-hospital collaborative research and

chronic disease trend analysis. Building on this, the federated health data lake achieves cross-institutional data sharing by leveraging federated learning technology, which ensures that sensitive patient information is not leaked to complete multi-party collaboration. In addition, the data transmission layer adopts the ‘on-chain index + off-chain storage’ mode to strengthen data integrity. The on-chain index guarantees the tamperability of medical data, while the off-chain storage supports dynamic updating and correction, taking into account both data security and system flexibility.

2.3. Data Analysis Layer (Computing Layer)

As the core of intelligent decision-making, the data

analysis layer relies on cloud computing, artificial intelligence (AI), digital twins, and other technologies to deeply analyse pre-hospital, in-hospital, and post-hospital medical data for intelligent scheduling, resource optimisation, accurate diagnosis, and health prediction, so as to improve the overall efficiency of the medical process. Figure 3 shows the overall data flow of pre-hospital prevention and control, in-hospital treatment and post-hospital monitoring, and highlights the central role of the Federal Health Data Lake and AI Decision Centre in the healthcare process.

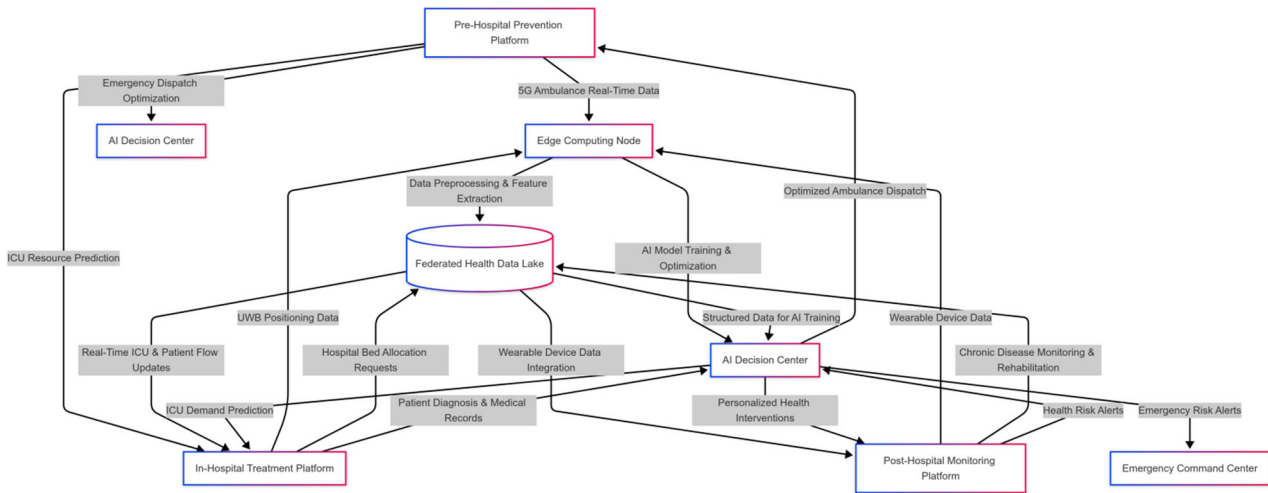


Figure 3. Smart Healthcare Data Analytics and Decision Making Architecture Diagram

2.3.1. Pre-hospital: Intelligent EMS Decision Making and Resource Prediction

(1) AI Intelligent Decision Aid System Optimises Rescue Paths

The platform's AI intelligent decision-making assistance system calculates the optimal rescue path by combining real-time traffic data, weather information, ambulance distribution and emergency department congestion, and continuously optimises the ambulance dispatch strategy by means of reinforcement learning scheduling algorithms to improve the efficiency of regional collaborative rescue. In addition, the system can predict ICU resource demand based on historical data and current condition analysis, and pre-allocate resources in advance to reduce the risk of overloaded hospitals.

(2) First aid vital signs analysis and risk warning

Edge computing nodes analyse patients' vital signs data in real time at the ambulance side, eliminate abnormal data, and only upload key abnormalities to the hospital to ensure that the first aid command centre and the emergency department of the hospital can grasp the information of critically ill patients in the first time. Meanwhile, the AI intelligent analysis assistance system combines sepsis, acute organ failure and other risk assessment models to trigger the risk warning engine as soon as a high-risk condition is detected, notify the hospital's emergency department, and prepare the appropriate treatment plan in advance.

(3) ICU Demand Prediction and Resource Pre-allocation

Based on the LSTM time-series analysis model, the system uses hospital HIS data, regional ICU resource distribution, and emergency admission trends to dynamically predict ICU beds. Different hospitals share ICU resource usage trends

through federated learning to optimise ICU resource scheduling without sharing the original data and improve the efficiency of medical resource matching.

2.3.2. In-hospital: Intelligent Patient Flow and Resource Scheduling

(1) Digital twin scheduling system

In the in-hospital stage, the digital twin model simulates the occupancy of hospital beds, the use of medical equipment and the state of patient flow in real time to achieve accurate scheduling. The ICU intelligent allocation module automatically adjusts the beds in ICUs and emergency wards according to the severity of the disease and the availability of medical resources to ensure that critically ill patients are admitted and treated with priority and to improve the utilisation rate of medical resources.

(2) Patient flow optimisation

With the help of UWB high-precision positioning system, the system accurately monitors the flow path of patients in the hospital and combines with AI-assisted analysis to predict the point of patient retention and automatically adjust the path of patient admission to improve the efficiency of treatment. Combined with the dynamic planning of the emergency department, the system can optimise the emergency admission process based on real-time bed availability, patient flow, and healthcare resource allocation to reduce stranding and improve the turnover rate.

(3) ICU Resource Prediction and Optimisation

The LSTM demand prediction model combines ICU resources and disease trends to predict ICU demand, plan bed allocation in advance, and improve resource utilisation. Concurrently, smart ward IoT sensors monitor the vital signs of patients in ICU and emergency ward in real time, and

combine with AI to intelligently analyse changes in condition and optimize ward management.

Edge computing nodes inside the ICU perform local calculations on patients' vital signs data, and combined with LSTM ICU demand prediction, dynamically adjust ICU resource allocation to ensure optimal resource utilisation and reduce ICU resource vacancy or overload.

(4) AI-assisted diagnosis and telemedicine support

Combined with electronic health records (EHR), AI uses multimodal data analysis (medical images, laboratory data, vital signs) to automatically identify disease patterns and improve doctors' diagnostic efficiency. At the same time, AI diagnostic data is used for model training to continuously optimise algorithms and improve the accuracy of diagnosis and treatment.

The telemedicine platform supports doctors to remotely access patients' electronic medical records and provides remote diagnostic advice in conjunction with the AI-assisted diagnostic system, which improves the diagnostic level of primary hospitals and reduces delays in the referral of critically ill patients.

(5) Central data processing and risk warning

ICU and emergency ward patient data in the in-hospital stage is uploaded to the central data processing system in real time, and AI combines ICU and emergency resource data to optimise bed flow, dynamically adjust beds, medical equipment, and healthcare resources to improve resource utilisation and reduce resource waste.

In addition, the system will combine with the AI-assisted diagnosis system to identify high-risk conditions such as sepsis, acute organ failure, respiratory failure, etc., trigger the emergency treatment warning, notify the ICU medical and nursing staff, and improve the success rate of rescue.

2.3.3. Post-hospital: personalised rehabilitation management and chronic disease warning

(1) AI personalised rehabilitation management

Based on the patient's health data, AI generates a personalised rehabilitation plan, including remote monitoring, exercise plan, nutritional advice, and medication guidance, to ensure that the rehabilitation process is scientific and reasonable. The rehabilitation training plan is dynamically adjusted in combination with the patient's physical state to reduce the risk of secondary injuries during the recovery period.

(2) Intelligent Health Management System

By implementing AI combined with the patient's history and real-time health data, it can identify the risk of recurrence of chronic diseases in advance and provide personalised intervention suggestions. Remote monitoring + AI intelligently analyses health data collected by wearable devices, predicts disease deterioration trends, and pushes early warning information to doctors and patients in advance to reduce the risk of sudden illness.

(3) Federated Learning Personalised Health Management

Through federated learning, different hospitals, rehabilitation institutions and health management platforms can jointly train AI chronic disease prediction models without sharing raw data, improving the accuracy of personalised rehabilitation programmes while ensuring patient privacy and security.

The data analytics layer plays a central role in intelligent decision-making for the entire medical process, ensuring efficient use of medical resources, improving the quality of patient care, and optimising long-term health management solutions, providing strong support for the intelligent medical system.

2.4. Decision support layer (application layer)

The decision support layer is the core of the intelligent decision-making system, which generates the optimal medical decision-making scheme based on the raw data provided by the data collection layer, the real-time communication guaranteed by the data transmission layer, and the AI calculation results of the data analysis layer. Its main core functions include: optimal allocation of medical resources, dynamic scheduling of emergency resources, hospital beds, medical equipment, healthcare personnel, etc.. The intelligent risk assessment and early warning: identifying high-risk patients in advance, reducing the incidence of critical situations, and improving the success rate of resuscitation. The assistance in medical decision-making: providing doctors with intelligent auxiliary support for diagnosis, treatment, and rehabilitation management. As well as personalised health management: providing personalised rehabilitation, chronic disease, and medical care based on AI analysis to provide personalised rehabilitation, chronic disease management, and telemedicine solutions. Figure 4 below shows the operational flow of the AI Decision Centre.

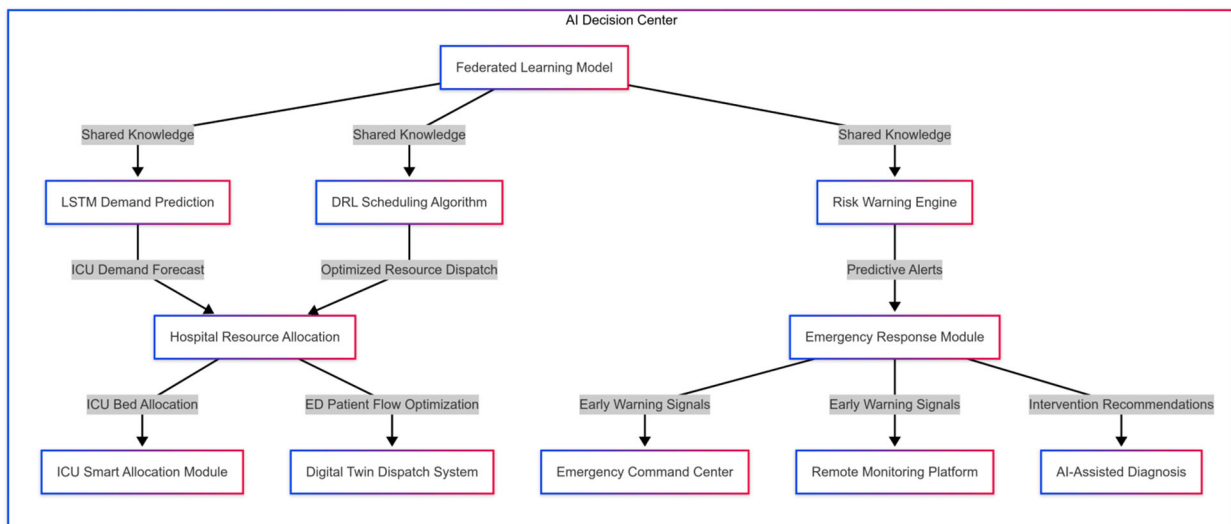


Figure 4: Intelligent scheduling and early warning process of AI decision centre

2.4.1. Pre-hospital: emergency dispatch optimisation and resource matching

(1) Intelligent scheduling optimisation: based on LSTM demand prediction and reinforcement learning scheduling algorithm, it optimises ambulance allocation, improves the response capability of the emergency system, and combines with GIS and traffic data to dynamically calculate the optimal driving path to avoid traffic congestion affecting the rescue speed.

(2) Priority allocation of high-risk patients: Combined with AI wind control model, it automatically identifies critical patients and matches them in advance to hospitals with corresponding treatment capacity, improving the success rate of treatment, ensuring that critically ill patients can get the fastest way to treatment, and reducing the time of transferring to hospitals and waiting.

(3) Medical resource linkage decision-making: Combined with ICU bed usage rate prediction, it sends bed warning to target hospitals in advance to ensure seamless transfer of critically ill patients, and at the same time, it dynamically matches medical teams with the help of AI-assisted system to ensure synchronous scheduling of doctors, equipment, and ward resources to improve treatment efficiency.

2.4.2. In-hospital: Intelligent Diagnosis and Medical Resource Scheduling

(1) Intelligent allocation of ICU and emergency beds: Dynamically adjust medical resources based on bed status, severity of patient's condition, doctor load, etc., to avoid waste of bed resources. It also combines with ultra-wideband (UWB) positioning technology to track the flow of patients in real time, optimise the in-hospital transfer path, and improve the turnover rate of hospital beds.

(2) Intelligent Assisted Diagnosis and Treatment: Combining multi-modal data such as patients' medical records, medical images, and vital signs, it provides doctors with intelligent diagnostic suggestions and improves decision-making efficiency. Moreover, it leverages digital twin technology to simulate the development trend of patients' conditions in real-time and assists doctors in formulating more accurate treatment plans.

(3) Surgery and treatment planning: Optimise surgical scheduling, reduce waiting time and improve the overall medical efficiency of the hospital. It also combines with the surgical risk assessment system to predict post-operative recovery and provide post-operative care advice to ensure more accurate post-operative management of patients.

2.4.3. Post-hospital: remote health management and intelligent rehabilitation decision-making

(1) Personalised rehabilitation programme: based on AI analysis, personalised rehabilitation management strategies such as exercise, diet and medication are formulated to improve the quality of patient recovery. At the same time, combined with intelligent wearable devices, remote rehabilitation monitoring is realised and the rehabilitation plan is dynamically adjusted.

(2) Intelligent monitoring of chronic diseases: Combine with remote monitoring data to optimise chronic disease management plans, improve the accuracy of disease prediction, reduce the risk of recurrence of chronic diseases, and use intelligent data analysis to assess patients' health trends, intervene in advance for possible health risks, and reduce the occurrence of complications.

(3) Telemedicine decision-making: provide remote consultation support for long-term rehabilitation patients, reduce unnecessary hospital visits and improve the efficiency of medical resources utilisation.

2.5. User Interaction Layer (Terminal Layer)

As the front-end interaction interface of the system, the user interaction layer mainly serves different groups such as first responders, hospital administrators, patients and family members, aiming to provide efficient, intuitive and intelligent medical interaction experience. By integrating visual management, intelligent voice interaction, telemedicine, and personalised health assistants, this layer enhances the user's ability to access, manipulate, and feedback on medical data, ensuring the accuracy and timeliness of information transfer, thus realising a seamless integration of medical processes. Figure 5 below shows the interaction flow of the system platform.

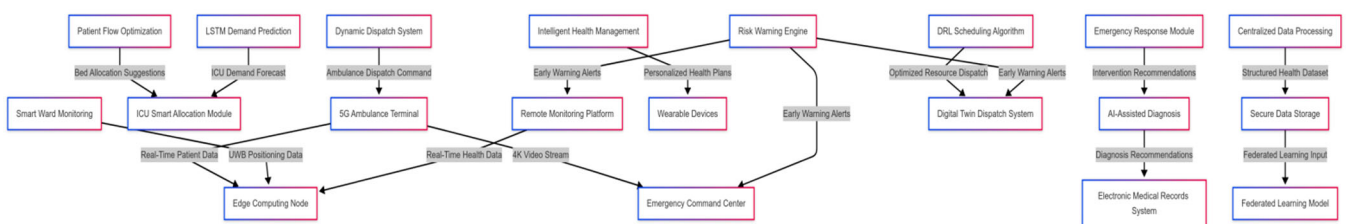


Figure 5: Schematic diagram of the system interaction flow

2.5.1. Pre-hospital: Emergency personnel interaction

(1) Ambulance Intelligent Terminal: Emergency personnel can view the patient's condition summary, receive instructions for optimising the emergency route, and upload the patient's vital signs data to the hospital system in real time via the vehicle-mounted intelligent terminal. The terminal interface adopts an intuitive graphical interaction design to ensure that emergency personnel can quickly access key information in emergency situations and submit real-time medical records by voice or touch.

(2) Dynamic task assignment system: The emergency command centre can view the real-time location of ambulance

and the receiving capacity of hospitals through the visual interface, and dynamically assign emergency tasks. The system is equipped with interactive functions such as task priority labelling and real-time path adjustment to ensure that the commanders can flexibly manage the emergency resources, and it supports multi-party collaborative interface to synchronise and update the information of the first aiders and the hospitals at once.

(3) Voice assistant assisted first aid: Combined with natural language processing (NLP), first aiders can quickly retrieve patients' medical history and obtain first aid guidance through voice input, thus improving the efficiency of resuscitation.

The voice assistant supports keyword triggering modes, such as ‘first aid measures for hypertension’ or ‘CPR guidelines’, to provide concise medical advice, and can be linked with the electronic health record (EHR) system to realise rapid medical record search.

2.5.2. In-hospital: Interaction between medical staff and hospital administrators

(1) ICU/Emergency Visual Management Platform: Hospital managers can view the status of hospital-wide medical resources in the digital twin scheduling system, including ICU bed usage, emergency patient flow, and surgical scheduling, in order to optimize hospital operational decisions. The platform supports data visualisation interaction modes, such as dynamic charts, heat maps, patient flow animations, etc., enabling managers to make data-driven decisions quickly. Synchronously, the platform supports personalised interface customisation to adjust the data display content according to different management needs.

(2) AI-assisted decision-making interface: Doctors can view AI-assisted diagnostic recommendations and patient history analysis results in the electronic health record system (EHR) to improve the accuracy of clinical decision-making. The interface is optimised to support multi-level interactions, allowing doctors to adjust diagnostic recommendations through filtering criteria (e.g., medical history, lab results, imaging data) and to use interactive analysis tools (e.g., case comparison, condition prediction) to explore treatment options in depth.

(3) Remote Consultation and Collaboration: Doctors can use the AR/VR remote collaboration system to conduct cross-institutional and cross-departmental consultations to improve the diagnostic efficiency of difficult cases. The system provides an immersive interactive experience, allowing doctors to mark medical images, share surgical plans and conduct remote diagnosis and treatment demonstrations through gesture control in the virtual consultation room, improving the accuracy and convenience of remote collaboration.

2.5.3. Post-hospital: patient and family health management interaction

(1) Health monitoring APP: patients can view real-time vital signs, rehabilitation plans, personalised health advice, and receive AI intelligent reminders (e.g. medication, follow-up consultation, rehabilitation training, etc.) in the APP. The APP supports data visualisation function, where patients can view their health trend graph and receive dynamic health feedback. Meanwhile, users can customise the notification priority to ensure that critical health reminders (e.g. blood pressure abnormality alerts) are pushed with high priority.

(2) Remote Health Consultation: Patients can communicate with doctors online through the telemedicine system to reduce unnecessary offline visits and improve the convenience of medical treatment. The system provides an intelligent consultation interactive interface, where patients can choose to describe their symptoms by voice or text, and the AI assistant can automatically collate a summary of their condition and recommend a suitable doctor. The interface on the doctor's side supports multi-dimensional medical record browsing and remote video calls to ensure efficient communication.

(4) Personalised health assistant: Combined with the intelligent voice assistant, patients can voice query their health status and get AI rehabilitation guidance, which improves the user experience. The assistant has the ability to

sense the situation, for example, when it detects that the patient has been sitting for too long, it actively pushes the reminder of ‘please get up and move’. At the same time, the assistant can be linked with smart home devices, such as automatically adjusting the sleep environment, playing relaxation music, etc., to enhance the rehabilitation experience.

3. Conclusion

This study presents an intelligent public health prevention and control platform that comprising five core layers—data acquisition, data transmission, data analysis, decision support, and user interaction—ensures comprehensive health monitoring, optimized medical workflows, and personalized rehabilitation management. This system achieves optimised results in several aspects. In the first place, in terms of medical data sharing, the federal health data lake effectively solves the problem of data silos and achieves cross-agency data collaboration. Subsequently, the AI decision centre uses distributed computing + edge computing technology to ensure the high efficiency of the data flow while safeguarding patient privacy. The platform demonstrates significant potential to transform public health management, improve healthcare outcomes, and promote more efficient resource utilization. Through multimodal data fusion, intelligent scheduling algorithms, and AI-driven decision support, the platform enhances the efficiency of emergency response, hospital operations, and post-discharge health monitoring. While addressing key challenges such as data interoperability and privacy, the platform demonstrates significant potential to transform public health management, improve healthcare outcomes, and promote more efficient resource utilization. Future research will focus on further refining cross-platform interoperability, enhancing predictive analytics, and expanding the system's application to broader healthcare ecosystems.

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