

Original Research Article

Innovative research on electronic health record (EHR) systems

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Abstract: This study systematically analyzes the development status of China's Electronic Health Record (EHR) systems, revealing core issues such as data fragmentation, inconsistent standards, limited cross-institutional collaboration, and insufficient intelligence. By applying large language models (LLMs) and integrating federated learning with blockchain technology, a new paradigm for medical data sharing is constructed. This research aims to provide theoretical support for EHR system optimization, promote efficient allocation of medical resources, foster medical research innovation, and ultimately achieve the dual objectives of improving healthcare service quality and optimizing medical costs.

Keywords: electronic health record (EHR) systems; data standardization; platform interoperability mechanisms

1. Introduction

1.1. Research background

In the modern healthcare sector, the innovative research on Electronic Health Record (EHR) systems holds significant importance. Rapid advancements in information technology have necessitated digital transformation in healthcare. Traditional paper-based medical records face challenges such as inconvenient storage, time-consuming retrieval, and limited information sharing, which hinder the demand for efficient, precise, and collaborative modern healthcare services.

EHR systems emerged to address these challenges. They electronically document patients' medical information—including medical histories, diagnostic results, and treatment plans—Substantially enhancing the management efficiency and utilization value of medical data. For instance, the successful application of 3D electronic manual online display technology in the electronics sector demonstrates the powerful capabilities of information technology in improving information interaction and utilization, providing a reference for EHR development.

Studies on innovation behaviors and system evolution in digital industry clusters emphasize that innovation relies on information technology. As a key component of healthcare digitalization, EHR systems not only improve service quality but also drive overall industry innovation. Additionally, research on secure electronic invoicing systems highlights the importance of information technology in ensuring security, offering critical insights for EHR systems to safeguard sensitive patient data.

Innovative research on EHR systems is an inevitable trend driven by technological and societal demands. It elevates healthcare service standards and accelerates digital transformation in the medical sector. By leveraging cross-domain technological experiences, EHR systems are poised to achieve more efficient, secure, and intelligent development, contributing significantly to global health initiatives.

1.2. Research significance

From the perspective of healthcare service quality improvement, EHR innovation enables rapid and accurate transmission and sharing of medical information. Physicians can easily access comprehensive patient histories and test results, facilitating precise diagnostic and therapeutic decisions. For example, in multidisciplinary consultations, doctors from different departments can review patient data in real time via EHR systems, reducing misdiagnoses and missed diagnoses caused by information asymmetry. This enhances patient care experiences and protects health rights.

In addressing aging population challenges, EHR innovation plays a pivotal role. With the increasing demand

for telemedicine and novel healthcare models, EHR systems serve as critical infrastructure for remote medical interactions. By integrating patient health data, physicians can remotely monitor conditions and provide timely recommendations, offering elderly patients convenient and efficient care while mitigating uneven distribution of medical resources.

Furthermore, EHR innovation strengthens medical information security. As digital storage and transmission of medical data grow, security concerns intensify. Drawing on automated detection technologies in electronic security systems, EHR innovation enhances system defenses to protect patient privacy and data integrity. This respects patient rights and maintains industry credibility.

In summary, EHR innovation demonstrates profound value in improving service quality, supporting aging populations, and ensuring data security. Its multifaceted benefits warrant further research and widespread adoption.

2. Analysis of China's EHR system status

2.1. Functional architecture

EHR system architecture focuses on data collection, storage, processing, and sharing. It integrates diverse medical information—Such as patient demographics, diagnostic records, and laboratory results—To create comprehensive health profiles. This architecture ensures data accuracy and accessibility, enabling healthcare professionals to retrieve information swiftly for informed decisions.

In practice, EHR architecture proves instrumental. For example, in managing self-limiting respiratory infections in primary care, electronic health records facilitate cohort studies to evaluate antibiotic prescription safety, providing scientific evidence for clinical practices. Amid the AI era, EHR architecture continues to evolve to address challenges from user-driven innovation in the healthcare industry, incorporating intelligent medical data analysis and decision-support functionalities^[1].

2.2. Industry value

EHR systems deliver multifaceted value to healthcare. From an innovation ecosystem perspective, they provide strong support for innovation and development in the healthcare industry. Wang Qimeng noted that embedded innovation ecosystems enhance innovation performance in non-core enterprises. In the healthcare sector, EHR adoption creates opportunities for institutions and tech firms to innovate around data-driven applications, driving sector-wide progress.

EHR systems dismantle traditional information barriers, enabling efficient data sharing across entities. This stimulates innovation in medical data applications, fostering industry advancement.

Additionally, they support digital transformation in healthcare financial management. Wang Hongli emphasized that smart financial systems are pivotal for enterprise development. EHR systems consolidate vast operational data, offering precise insights for cost control, resource allocation, and budget planning, thereby enhancing operational efficiency.

Moreover, EHR systems facilitate cross-sector innovation. Analogous to Zhao Yubo and Wang Yuhang's IoT-based smart grain monitoring system, EHR systems integrate with IoT, big data, and AI to enable hybrid innovation.

3. Core challenges

3.1. Data and collaboration issues

Despite widespread EHR adoption, challenges persist in data and collaboration.

Data Issues: EHR data quality varies due to inconsistent standards across institutions. For example, diagnostic descriptions differ in detail based on hospital protocols or physician preferences, compromising accuracy, completeness, and consistency. This undermines data utility and may misguide diagnoses. Data security is also critical, as breaches of sensitive patient information risk privacy violations and social repercussions.

Collaboration Issues: Inter-institutional EHR integration remains difficult due to disparate system architectures, data formats, and interface standards, hindering seamless data exchange. This fragments patient

histories across providers, affecting diagnostic accuracy and care continuity. Internal team collaboration also suffers from inefficient communication and inconsistent workflows among clinicians, nurses, and pharmacists, reducing efficiency and quality^[2].

Urgent solutions include establishing uniform data standards, enhancing audit mechanisms, and deploying advanced encryption for security. Inter-institutional collaboration requires system consolidation and standardized interfaces, while staff training and process standardization improve internal teamwork.

3.2. Intelligence deficiencies

EHR systems face limitations in intelligence. While designed to boost efficiency, current capabilities fall short of practical needs.

Data Processing: EHR systems struggle to efficiently analyze vast datasets—Such as patient records, diagnostics, and treatments—Leading to delayed information retrieval for clinicians. For instance, large hospitals generate massive daily data, overwhelming systems and forcing clinicians to manually sift through records.

Interactivity: Poor human-machine interaction design complicates system use, increasing error rates and reducing work efficiency among healthcare workers, particularly in resource-limited settings where staff may have limited technical proficiency.

Algorithmic Limitations: Existing algorithms struggle with complex medical logic and diverse clinical scenarios. For example, rare disease diagnosis may be hindered by insufficient feature recognition, increasing misdiagnosis risks.

Adaptability: Rapid advancements in treatments and drugs outpace EHR system updates, limiting their responsiveness to emerging medical needs. For instance, new cancer therapies may not be promptly integrated into EHR systems for diagnostic support.

These gaps hinder healthcare efficiency and digital transformation. Increased R&D investment, optimized system design, and enhanced algorithm accuracy are essential to advance EHR intelligence. Initiatives in China's Yangtze River Delta region, for example, focus on algorithm refinement to elevate system capabilities [3].

4. Innovative solutions

4.1. Large language model (LLM) applications

In digital healthcare, LLMs offer transformative potential for EHR systems. Their robust natural language processing capabilities enhance information extraction and integration. Medical records, often unstructured text, contain symptom descriptions, diagnoses, and treatment histories. LLMs trained on extensive medical corpora can identify key entities and relationships, structuring fragmented data for standardized management and analysis.

For instance, LLMs process patient histories to extract disease names, onset times, and medications, presenting clinicians with clear, comprehensive profiles for accurate diagnosis. In decision support, LLMs analyze patient data alongside medical guidelines and research to generate tailored recommendations, reducing errors and aiding less-experienced clinicians.

LLMs also improve patient communication by translating medical jargon into accessible language, facilitating dialogue, answering queries, and providing health guidance. This enhances patient engagement and satisfaction.

Overall, LLM integration in EHR systems offers novel pathways for digital and intelligent healthcare transformation, promising substantial improvements in service quality and efficiency.

4.2. Federated learning and blockchain integration

Federated learning (FL) and blockchain are pivotal in advancing EHR systems. FL, a distributed machine learning framework, enables collaborative model training across institutions without sharing raw data, preserving privacy while enhancing analysis efficiency and accuracy. This addresses traditional data-sharing privacy concerns, supporting broader EHR adoption.

Blockchain complements this with decentralized, tamper-proof, and traceable data storage. Each medical record becomes a block in a chronological chain, ensuring integrity and authenticity. This prevents

data tampering, provides reliable evidence in disputes, and enhances storage security through distributed architecture^[4].

Combining FL and blockchain creates secure, collaborative frameworks. Institutions leverage blockchain's security to conduct FL-driven data collaboration, optimizing models for precision medicine. For example, medical groups using these technologies have improved diagnostic outcomes for certain diseases.

As these technologies mature, FL- and blockchain-enabled EHR systems may achieve global adoption, advancing health initiatives.

5. Conclusion and outlook

EHR systems are increasingly integral to healthcare, highlighting the need for research on their evolution. Future EHR development will prioritize data integration, intelligence capabilities, and security. These development drive digital transformation, elevating service quality and patient experiences. Through continuous innovation, EHR systems promise to play a pivotal role in healthcare, contributing to global health goals.

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