

Application of Integrated Big Data and Artificial Intelligence in Hospital Development

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Abstract: The digital transformation of the healthcare industry has entered a deep-water zone, where traditional single-data processing models and fragmented intelligent applications can no longer meet the demands of high-quality modern hospital development. The integrated fusion of big data and artificial intelligence has broken down data barriers and technological silos within hospitals, establishing an intelligent system that spans the entire process of data collection, governance, analysis, and application. This integration permeates critical areas such as clinical diagnosis and treatment, patient services, hospital management, and medical research. Based on practical hospital development scenarios, this paper analyzes from multiple perspectives the application logic, value proposition, and implementation pathways of integrated big data and AI solutions, clarifies major challenges encountered in current deployment, explores the digital and intelligent path toward modernization for public hospitals, and provides reference insights for hospital intelligent upgrades, improved quality and efficiency of medical services, and the realization of refined management.

Keywords: Big data; Artificial intelligence; Integrated convergence; Hospital construction smart medical care

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1. Introduction

As digital health strategies continue to advance, the development of smart hospitals has become a primary direction for the transformation and upgrading of public hospitals. Traditional hospital construction models face numerous challenges—including fragmented business processes, underutilized data resources, high manual operation and maintenance costs, and insufficient precision in diagnosis and treatment—which fail to meet the diverse healthcare needs of the public or support hospitals' refined operational development. Big data technologies enable the integration and in-depth analysis of massive datasets, while artificial intelligence offers intelligent analytics, autonomous judgment, and automated empowerment. The integrated fusion of these two technologies is not merely a simple superposition of capabilities, but rather a deep integration driven by a unified data foundation and intelligent models that reshapes the operational logic across various hospital business scenarios.

Currently, the integration of big data and artificial intelligence has evolved from conceptual exploration to real-world implementation, serving as a key driver to overcome bottlenecks in traditional healthcare development and promote comprehensive upgrades in clinical care, services, management, and research. It also represents a practical pathway toward building a modern, intelligent healthcare system.

2. Core logic of integrated hospital development with big data and artificial intelligence

2.1. Underlying logic of technological convergence

Integrated big data and artificial intelligence involve leveraging comprehensive medical data and utilizing intelligent algorithmic models to achieve a closed-loop transformation of data value. Traditional hospital information systems have primarily focused on building isolated business applications, resulting in fragmented data storage and inconsistent standards that fail to create effective data assets. The integrated approach establishes a unified data platform to consolidate multidimensional hospital data—including clinical care, patient services, administrative operations, and equipment performance—through processes such as data cleaning, normalization, anonymization, and standardization. This provides high-quality data support for AI model training and practical applications ^[1]. Furthermore, AI technologies reciprocally enhance big data governance by enabling intelligent classification, automated screening, and precise analysis, thereby improving the processing efficiency and utility of massive medical datasets. This creates a bidirectional feedback loop where data supports intelligent applications, and intelligent applications in turn optimize data quality.

2.2. Aligning with the development logic of hospital construction

The core goal of modern hospital development is to deliver high-quality medical services, achieve refined hospital management, foster innovative medical research, and ensure efficient operations. Integrated construction combining big data and artificial intelligence fully aligns with this objective, overcoming the shortcomings of traditional IT initiatives that emphasize hardware over applications and focus on infrastructure rather than empowerment. This model is grounded in the hospital's entire operational landscape, guided by real-world needs, and closely integrates technological capabilities with clinical workflows. Rather than merely accumulating intelligent devices superficially, it focuses on addressing key challenges in clinical care, patient access, hospital administration, and research innovation. By ensuring seamless alignment between technological empowerment and hospital advancement, it drives hospitals from digital infrastructure toward intelligent, deep-level operations ^[2].

3. Core application scenarios of integrated big data and artificial intelligence in hospital development

3.1. Intelligent clinical diagnosis and treatment applications to enhance the precision of medical services

Clinical diagnosis and treatment are the core business of hospitals and also a primary application scenario for integrated big data and artificial intelligence. It can compensate for the limitations of manual clinical practices, standardize treatment processes, and reduce diagnostic errors. The integrated system consolidates diverse patient information—including past medical history, test results, medication records, and clinical imaging—

and leverages deep learning algorithms to analyze case data. By comparing this data with standardized treatment guidelines and extensive clinical examples, it provides physicians with targeted diagnostic references and differential diagnostic insights. This approach is particularly effective in screening and assessing complex or early-stage, occult diseases, helping clinicians overcome limitations in clinical experience^[3].

An integrated intelligent system for standardized clinical workflows enables comprehensive intelligent monitoring throughout the entire treatment process. The system follows established clinical pathways, continuously comparing physicians' actions—such as diagnostic procedures, prescription writing, and test scheduling—with standard protocols. It issues intelligent alerts and proactive interventions when deviations occur, preventing over-treatment, missed diagnoses, misdiagnoses, and inappropriate medication use, thereby ensuring standardized and consistent clinical care. In postoperative rehabilitation and disease course management, the system uses dynamic data such as vital signs and recovery indicators to assess patients' progress, formulating personalized and scientifically grounded rehabilitation plans. This allows for intelligent, precise control across the entire disease trajectory, ultimately improving the quality of clinical diagnosis and enhancing patient safety.

3.2. Integrated patient services empower improved healthcare experience

Traditional healthcare models suffer from cumbersome procedures, long waiting times, and poor service coordination. The integration of big data and artificial intelligence has restructured the entire patient journey—before, during, and after hospital visits—enabling intelligent, convenient, and seamless upgrades in medical services. In the pre-hospital phase, natural language processing technologies are used to build an intelligent consultation and triage system that accurately interprets patients' symptom descriptions, automatically matching them with appropriate departments and available resources. This eliminates issues such as inappropriate registration or visiting the wrong department, streamlines outpatient preliminary screening, and increases outpatient department utilization^[4].

During the in-hospital phase, the integrated system consolidates internal resources including hospital beds, examination rooms, and diagnostic equipment, using intelligent scheduling algorithms to dynamically allocate resources. This optimizes patient workflows for appointments, tests, payments, and medication pickup, reducing unnecessary waiting and back-and-forth travel. Features such as smart navigation, automated reminders, and online consultations further enhance the patient experience, making healthcare more accessible and efficient.

In the post-hospital phase, leveraging comprehensive data from the entire care process, a personalized follow-up system is established. Based on patients' condition severity and follow-up needs, targeted services—including online follow-ups, health education, medication guidance, and appointment reminders—are provided. This breaks down the service barriers between inpatient treatment and outpatient rehabilitation, creating a closed-loop intelligent healthcare system that significantly improves patient satisfaction with medical services.

3.3. Refining hospital management to reduce in-hospital operational costs

Traditional hospital management models—such as administrative operations, logistics, and resource allocation—rely on manual statistics and subjective judgment, resulting in low efficiency, coarse control, and inadequate forecasting. An integrated big data and artificial intelligence system enables dynamic monitoring, intelligent analysis, and scientific assessment of comprehensive operational data across all hospital dimensions, transforming hospital management from experience-based to data-driven, refined, and

intelligent. The system integrates information related to staff scheduling, patient volume, workload, and performance, and applies intelligent models to optimize human resource allocation. This allows for precise adjustment and efficient dispatching of personnel, helping to avoid both underutilization and overwork, thereby enhancing overall team productivity^[5].

The integrated platform enables real-time monitoring of the usage, inventory levels, and operational status of medicines, consumables, and medical equipment. By analyzing data, it identifies patterns in material consumption, automatically generates requisition orders, issues alerts for shortages, and provides early warnings for issues such as material stockpiling or equipment damage. This helps reduce hospital operating costs.

3.4. Intelligent empowerment of medical research, stimulating innovation in healthcare

Medical research is the core driver of high-quality hospital development. Traditional research models suffer from difficulties in data acquisition, low efficiency in data integration, and long research cycles. The integrated construction of big data and artificial intelligence has introduced a new paradigm for medical research, establishing seamless data pathways between clinical practice and scientific innovation, enabling efficient transformation of clinical data into research data. By leveraging an integrated data platform, standardized clinical cases, imaging data, laboratory results, and follow-up information across the entire hospital can be rapidly consolidated, breaking down data silos between departments and building large-scale, high-quality medical research datasets that provide robust data support for clinical studies, new drug development, and exploration of innovative technologies. Meanwhile, AI algorithms can replace extensive repetitive research tasks—such as case screening, data statistics, literature comparison, and result analysis—through automation, significantly shortening research project timelines and reducing labor costs. Intelligent models can deeply uncover hidden medical patterns within vast clinical data, helping healthcare professionals discover novel diagnostic approaches, disease characteristics, and therapeutic targets, accelerating the translation of clinical experience into scientific outcomes. This continuously stimulates medical innovation within hospitals, advancing discipline development and enhancing institutional competitiveness.

4. Issues in the construction of integrated big data and artificial intelligence hospitals

4.1. Incomplete data governance system

Data serves as the foundation for integrated intelligent development, yet some hospitals currently face challenges with low levels of data standardization. Early-built business systems were developed under inconsistent standards, resulting in differences in data formats and statistical methodologies, which make data integration difficult. There is no routine mechanism for internal data governance, leading to common issues such as outdated data, redundancy, and missing information. As a result, high-quality data resources remain scarce, limiting the effectiveness of artificial intelligence models in analysis and decision-making, and hindering the deeper advancement of intelligent applications.

4.2. Insufficient depth of integration between technology and business

Some hospitals' digital and intelligent development tends to emphasize technology over actual business needs, resulting in superficial implementation of smart applications. Most intelligent systems merely achieve basic automation and data display, without customized development tailored to core challenges in clinical care, patient

services, and research management, leading to weak relevance in technological empowerment. The ability of medical staff and administrators to use intelligent systems varies significantly, with some individuals showing low acceptance and proficiency in adopting new technologies and systems. This limits the full utilization of high-quality technical resources and prevents the complete realization of integrated development outcomes.

4.3. The safety and compliance system has shortcomings

The hospital integrated platform aggregates vast amounts of patient privacy information, core clinical data, and hospital operational data, making data security and information compliance fundamental requirements for its development. Currently, some hospitals have relatively weak data security protection systems and lack comprehensive, routine, and end-to-end security control mechanisms, resulting in potential risks during data transmission, storage, sharing, and application. The medical data application compliance management system remains incomplete, with unclear standardized procedures for data authorization, privacy protection, and data sharing, which can easily lead to information leaks, data misuse, and other compliance issues, thereby hindering the standardized advancement of integrated platform construction.

5. Optimization path for integrated big data and artificial intelligence hospital development

5.1. Establishing a standardized data governance system

The hospital establishes unified data standards and specifications, comprehensively organizing, standardizing, and transforming various internal business data. It unifies data formats, statistical criteria, and entry protocols to completely eliminate data silos. A routine mechanism for data review, updating, and maintenance is established, with dedicated personnel responsible for data quality control, promptly removing redundant data, supplementing missing information, and correcting errors to continuously improve data completeness, accuracy, and consistency. A unified data middleware architecture is built to enable centralized storage, unified management, and seamless interconnectivity of all hospital data, laying a solid foundation for integrated artificial intelligence applications.

5.2. Deepening the integration of technology and healthcare operations

Focusing on the core business needs of the hospital, officials move beyond superficial smart development models and concentrate on addressing key challenges in clinical care, patient services, scientific research, and refined management. Officials develop customized, context-specific intelligent applications. Officials promote regular collaboration between technical teams and frontline clinical and administrative staff, continuously optimizing system functions based on real-world operational needs to ensure that intelligent technologies precisely align with medical workflows. At the same time, officials conduct ongoing training on intelligent system operations to enhance digital literacy across the entire hospital workforce, foster a data-driven and intelligent mindset, and advance the implementation of all related initiatives.

5.3. Strengthening data security and compliance defenses

Establish a comprehensive, end-to-end data security protection system by implementing security mechanisms throughout the entire lifecycle of data—collection, transmission, storage, application, and sharing. Employ technical measures such as role-based access control, data masking, encryption, and early risk warning to prevent

data breaches and misuse. Improve internal data compliance management systems by clearly defining standardized procedures for data usage, sharing, and openness, clarifying data security responsibilities across all positions, and strictly enforcing regulations on medical data privacy protection. Conduct regular security vulnerability assessments and emergency drills to enhance incident response capabilities, ensuring that the integrated development of big data and artificial intelligence proceeds in a compliant, secure, and stable manner.

6. Conclusion

The integration of big data and artificial intelligence is an inevitable trend in the development of modern hospitals and a key driver for high-quality advancement in the healthcare industry. By deeply combining technology with clinical operations, it empowers hospitals across clinical diagnosis and treatment, patient services, refined management, and medical research, effectively addressing various challenges in traditional hospital construction and operation, thereby enhancing service quality, improving operational efficiency, and accelerating scientific innovation. Currently, integrated digital and intelligent development in hospitals faces issues such as inadequate data governance, insufficient business integration, and incomplete security systems. Going forward, hospitals should, based on their specific circumstances, continuously optimize data governance frameworks, strengthen scenario-based intelligent applications, and establish a robust security and compliance defense. They must steadily advance the deep implementation of big data and AI integration, continually unlocking the potential of digital and intelligent technologies to transform hospitals toward standardization, precision, and intelligence.

Disclosure statement

The authors declare no conflict of interest.

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