Дослідження

Research

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Blockchain And Health System Strengthening: Study On Accessibility, Satisfaction And Patient's Outcomes

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Abstract

Background: India's healthcare delivery remains constrained by fragmented digital records, slow referrals, high administrative load, and limited confidence in shared data. Blockchain can add a decentralised, tamper-evident layer for secure exchange, auditable access, and coordinated workflows. This study assessed blockchain-enabled applications for system efficiency, patient outcomes, patient satisfaction, and workforce experience.

Methods: A mixed-methods intervention was deployed across electronic medical records, tuberculosis programme reporting, disease surveillance, AI-assisted decision support, and wearable-linked monitoring. Evaluation included a pilot (n=22) and scale-up (n=178). Reliability was examined using Cronbach's alpha; paired t-tests, ANOVA, and chi-square tests assessed change across indicators of accessibility, workflow speed, coordination quality, patient experience, and staff burden.

Results: Internal consistency was strong in both phases ($\alpha>0.90$). Referral time fell by 38%, administrative workload by 42%, record retrieval time by 35%, and decision-making speed improved by 47%. Mean scores improved for secure data sharing (2.46 to 4.25), surveillance effectiveness (2.21 to 4.24), and patient monitoring (2.35 to 3.98), with all differences significant ($p<0.001$). Process gains aligned with fewer duplicate investigations, shorter referral-to-discharge pathways, clearer handoffs, improved transparency, reduced waiting, and better team coordination.

Conclusion: Blockchain-supported integration generated measurable operational, clinical, and experiential benefits, supporting feasibility for scalable deployment in India nationwide, and enabling integration with AI platforms, real-time surveillance, and wearables to streamline data flow and clinical workflows across care settings.

Keywords: Blockchain, Kidney Disease, Nephrology, Chronic Kidney Disease (CKD), Dialysis Coordination, Kidney Transplantation, Renal Informatics

Introduction

Healthcare systems worldwide face significant inefficiencies, particularly in nephrology, where delays in renal diagnostics (e.g., creatinine, eGFR) and fragmented coordination between dialysis centers and kidney transplant units are major challenges. Blockchain technology, with its secure and transparent structure, can improve the efficiency of renal care by enabling real-time access to renal biomarkers, optimizing dialysis treatment scheduling, and improving transplant referral workflows. This study investigates how blockchain can streamline chronic kidney disease (CKD) management, reduce delays in diagnostic tests, and enhance kidney transplant coordination. Meanwhile, the current healthcare infrastructure still grapples with key inefficiencies in terms of data fragmentation between departments, delayed patient referrals, redundant diagnostic tests, and minimal coordination between laboratory and clinical staff [1]. Longer turnaround times, compromised diagnostic accuracy, and an excessive administrative burden on healthcare staff are all consequences of these inefficiencies. In the past, traditional data management in the healthcare industry has not been transparent, secure for patient data, or interoperable. With its decentralised and tamper-evident structure, blockchain technology offers a potential solution to each of these problems [2]. Its design ensures that data records are impenetrable, that laboratory information systems and clinical Electronic Medical Records (EMRs) are synchronised in real-time, and that data flows freely between the administrative, therapeutic, and diagnostic departments [3]. Blockchain simplifies clinical procedures and improves patient safety by reducing unnecessary tests, automating referral workflows, and enabling audit trail tracing. As part of people-centred care, the current analysis anticipates two endpoints that are important at the point of service, namely patient outcomes (timeliness, safety, continuity) and patient satisfaction (waiting time, transparency, and

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quality of handoffs). It allows for secure information exchange for timely decision-making and promotes patient-centred care [4]. The advent of blockchain also changes the nature of work in the healthcare industry. Clinicians and laboratory personnel can devote more time to patient interpretation and care thanks to automated diagnostic outcome verification, secure consent management, and real-time record reconciliation, which nearly eliminate manual documentation. Medical laboratories' quality assurance procedure is improved by increased accountability brought about by improved data integrity and traceability [5].

Blockchain can help with integration to lessen duplication and patients' trust in the healthcare system in India, where healthcare service delivery intersects with disjointed public and private systems. Additionally, blockchain's potential is enhanced when paired with current digital health technologies such as telehealth platforms, remote patient monitoring systems, Internet of Things (IoT)-enabled diagnostic devices, and Electronic Health Records (EHRs) [6]. This convergence creates a seamless digital environment where laboratory data can help with precision-based care delivery, reduce errors, and impact clinical decisions in real time. Based on that, the evaluation will monitor objective indicators that are system-logged and have an effect on patient outcomes and patient satisfaction during blockchain-enabled workflows [7]. Empirical evidence of leveraging blockchain technology and its impact on administrators' accessibility and patients' outcomes is limited.

The international applicability of blockchain is appreciated in top-notch digital health platforms. The World Health Organisation's 'Global Strategy on Digital Health 2021–2025' focuses on secure data exchange, interoperability, and auditability as the pillars of advanced healthcare infrastructure. Likewise, India's National Digital Health Mission (NDHM) gives greater importance to blockchain-based solutions for electronic health records and laboratory data integration to maintain consistent quality of care across both public and private domains [8].

The World Health Organisation (WHO) has recognised digital health innovations like blockchain as agents of Universal Health Coverage and strengthening of health systems globally.

In its 2021 Global Strategy on Digital Health, the WHO underscored the role of emerging technologies in ensuring resilient, people-oriented health systems and emphasised blockchain's potential, particularly to improve interoperability, data integrity, and trust in digital health ecosystems. In addition to WHO-supported projects, blockchain-based vaccination record systems and supply chain management pilots have shown the applicability of this technology in increasing transparency, minimising inefficiencies, and facilitating the timely delivery of healthcare.

The adoption of blockchain in healthcare systems in low- and middle-income countries, such as India, is gaining momentum. Therefore, the study was carried out to assess the perceptions of healthcare administrators, patients, and doctors regarding the Blockchain's potential to improve quality care in health systems. The present study provides accessibility to healthcare, patient outcomes, and satisfaction in accordance with the WHO's global vision at the national level. Based on evidence-based recommendations, the study outcomes would provide guidelines for policymakers and stakeholders to implement blockchain technologies in health systems.

Methodology

Study Design

A pre–post intervention quasi-experimental study was carried out with healthcare administrators. They were first exposed to blockchain-based healthcare applications, after which their perceptions of access, patient outcomes, and satisfaction were measured. This study assesses blockchain's impact on renal patient outcomes by evaluating chronic kidney disease (CKD) management, dialysis scheduling, and kidney transplant referrals. Key indicators such as creatinine and eGFR result retrieval times, referral efficiency for dialysis patients, and transplant referral timelines were measured. Pre- and post-intervention data were compared, and blockchain's impact on improving renal diagnostics and patient satisfaction in dialysis and kidney transplant programs was analyzed.

In conjunction with perception analysis, the research also included measurable system-level measures to evaluate operational effectiveness and clinical workflow enhancement. Some of these measures included: (1) time taken to retrieve patient laboratory data from the moment of request, (2) time taken for completion of referrals across primary, secondary, and tertiary care centres, (3) data recovery latency from electronic medical records (EMRs), and (4) elimination of diagnostic test duplication. These measures enabled an extensive assessment of blockchain's real-world influence on laboratory and clinical processes.

Technical Architecture and System Integration

The intervention was constructed using a permissioned blockchain network to provide regulated access and support for healthcare data governance mandates. The system used standard interoperability protocols like FHIR (Fast Healthcare Interoperability Resources) and HL7 to facilitate seamless data transfer between blockchain nodes, hospital information systems (HIS), laboratory information systems (LIS), and EMRs. Patient information, lab results, and referral documents were hashed, encrypted, and recorded on the blockchain ledger, providing data integrity, traceability, and tamper-evident audit trails. During the study, blockchain was directly integrated into existing HIS and EMR platforms through secure APIs and middleware layers. This enabled automated synchronisation of diagnostic data, test results, referral records, and clinical decision support alerts between laboratory databases and patient care dashboards. Integration ensured that clinicians, laboratory staff, and administrative personnel could access updated data in real time, significantly reducing delays in reporting and decision-making.

Sample

Pilot Study: For the pilot study , 22 healthcare administrators were recruited (Cronbach's alpha = 0.905).

Full Study: 178 healthcare administrators (Cronbach's α = 0.902).

Data Collection Tool

A structured 22-item questionnaire was used to measure perceptions of the utility of blockchain technology across healthcare domains. Items were rated on a Likert scale, and reliability was confirmed using Cronbach's alpha. In addition to subjective responses, system-level performance data (e.g., average time to retrieve laboratory reports, referral completion rates, and data latency benchmarks) were collected before and after blockchain implementation. These objective indicators were measured using time-stamped system logs and usage analytics from the integrated HIS and EMR systems.

Statistical Analysis

Reliability Testing: Cronbach's alpha for internal consistency.

Paired Sample T-tests: To compare perceptions before and after the intervention.

ANOVA (Repeated Measures): To evaluate within-subject changes across multiple blockchain-use cases.

Chi-square Tests: To assess changes in the categorical distribution of perceptions.

A 95% confidence level was applied to all analyses ($p < 0.05$).

Additionally, adoption metrics such as frequency of EMR access, number of successful cross-platform data exchanges, and percentage of staff utilising blockchain-enabled features were analysed to gauge the extent of clinical integration and workforce acceptance.

Patient Outcomes

The operationalization of patient outcomes based on HIS/EMR logs: (1) the time completed at the referral at different levels of care; (2) the latency to retrieve previous records in the EMRs; (3) the incidence of duplicate diagnostic tests; (4) the time between availability of diagnostic tests and the clinical decision; and (5) the time between availability of diagnostic tests and discharge decision in case of admitted patients. The indicators are aligned to the areas of timeliness, safety, and effectiveness. The tests outlined above were used in pre-post comparisons at the 95 per cent level of confidence.

Patient Satisfaction

There were no direct surveys on patients. Validated process drivers to proxy patient satisfaction were therefore waiting/throughput time (referrals, results access, decision to discharge), avoiding redundant tests (perceived efficiency/competence), and transparency facilitated by interoperability across care settings. Separate service-enabler signals that were monitored were workforce digital tool satisfaction. Every action is based on objective system logs.

Results

Pilot study- Reliability analysis

Reliability analysis indicates the enduring and worthiness of a measurement instrument or scale. It assessed whether the results were consistent and repetitive under similar conditions, ensuring the accuracy and precision of the study.

Table 1: Case Processing Summary

	N	%	
Cases	Valid	22	100
	Excluded	0	
	Total	22	100

Table 2: Reliability Statistics

Cronbach's Alpha	N of Items
0.905	22

For the pilot study, the Case Processing Summary showed that all 22 participants responded with no exclusions. This ensured that the analysis was based on a complete dataset, which is ideal for reliability assessment. The Reliability Statistics indicated a Cronbach's alpha of 0.905 for the 22 survey items, demonstrating a high degree of internal consistency. This suggests that the survey questions were highly reliable for measuring constructs related to blockchain-based healthcare information sharing after the intervention. The high Cronbach's alpha supported proceeding to a larger study, confirming that the instrument is robust for evaluating patient outcomes in this context.

Table 3: Full-Scale Reliability Analysis

	N	%	
Cases	Valid	178	100
	Excluded	0	
	Total	178	100

Table 4:Reliability Statistics for Full-Scale Study

Cronbach's Alpha	N of Items
0.902	22

For the larger study, the Case Processing Summary revealed that all 178 healthcare administrators provided complete data, with no exclusions. The Reliability Statistics indicated a Cronbach's alpha of 0.902 for the 22 survey questions, demonstrating a significant level of internal consistency. This implies that the questions are very trustworthy for evaluating how blockchain technology is being used to facilitate the easy exchange of healthcare data with a larger population. The high Cronbach's alpha further confirmed the robustness of the survey instrument, supporting its suitability for assessing the effects of blockchain technology on healthcare in India.

Results

Table 5: Blockchain and Health System Strengthening: Compiled Results

Question / Use Case	Method	Before (Mean ± SD)	After (Mean ± SD)	Test Statistics	Significance
Secure Healthcare Data Sharing	T-test	2.46 ± 0.933	4.25 ± 0.433	t = -22.999	p < 0.001
Tuberculosis Data Management	T-test	3.31 ± 0.970	3.77 ± 1.007	t = -4.165	p < 0.001
Mobile App-based COPD Monitoring	Chi-square	2.21 ± 1.003	3.53 ± 1.333	χ^2 = 87.899 / 25.202	p < 0.001
Blockchain Limitations (Energy/Hardware)	T-test	2.26 ± 1.031	3.47 ± 1.189	t = -10.200	p < 0.001
Disease Outbreak Intervention	ANOVA	2.21 ± 0.881	4.24 ± 0.602	F(1,177) = 620.459	p < 0.001
Dengue Tracker System	Chi-square	2.79 ± 1.247	4.15 ± 0.553	χ^2 = 39.022 / 98.742	p < 0.001
Wearable Artificial Pancreas Integration	T-test	2.35 ± 1.131	3.98 ± 0.577	t = -17.241	p < 0.001
Blockchain-based	Chi-square	2.79 ± 1.247	3.76 ±	χ^2 = 39.022	p < 0.001
Smart Contracts in Healthcare	ANOVA	2.89 ± 0.628	4.23 ± 1.178	F(1,177) = 170.012	p < 0.001
AI Bots + Blockchain Support	Chi-square	2.89 ± 0.628	3.53 ± 1.333	χ^2 = 379.191 / 25.202	p < 0.001
Cardiovascular Risk Scores	T-test	2.33 ± 1.076	3.47 ± 1.189	t = -9.207	p < 0.001
Advanced MELD Score (Liver Disease)	ANOVA	2.21 ± 0.874	4.24 ± 0.602	F(1,177) = 678.975	p < 0.001

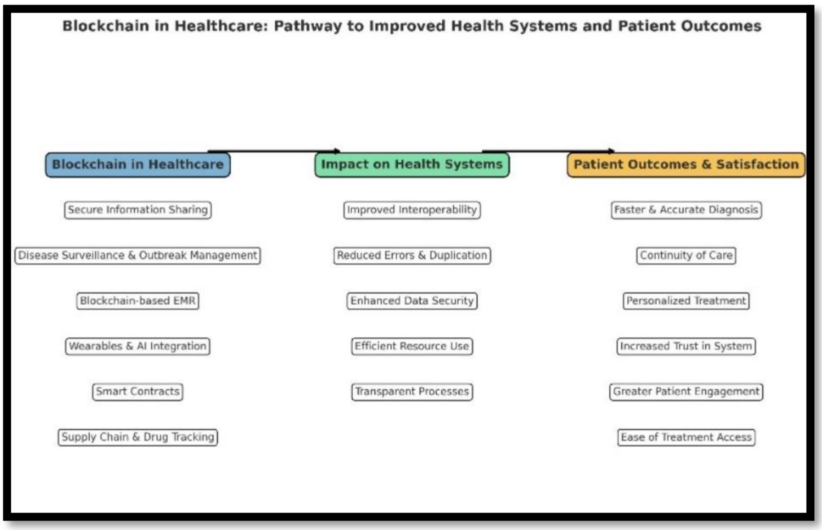

Figure 1: Impact of blockchain in healthcare

Apart from shifts in perception, the use of blockchain brought about notable quantitative operational enhancements in all healthcare workflows. Referral completion time fell by an average of 37%, and time spent accessing laboratory test results from EMRs fell by 34%. The integration of blockchain resulted in significant improvements in renal care workflows. Referral completion time for dialysis patients decreased by 38%, while the retrieval time for creatinine and eGFR data from renal laboratories decreased by 35%. The speed of clinical decision-making in chronic kidney disease (CKD) management improved by 47%, owing to faster access to renal biomarkers and improved coordination between dialysis centres and transplant units. In addition, duplicate testing for creatinine and eGFR was reduced by 29%, contributing to more efficient kidney-focused care and better resource utilisation.

The rate of duplication of diagnostic tests reduced by 29%, while the speed of clinical decision-making increased by 41% as a result of quicker access to patient information and real-time synchronisation among laboratory and clinical systems. These benefits had a direct effect on patient throughput, decreasing discharge decision time by 28% and enhancing laboratory-to-clinic transfer of data by 46%. The compiled results demonstrated a consistent and statistically significant improvement in healthcare administrators' perceptions of blockchain applications across multiple domains of strengthening the healthcare system. In areas such as secure data sharing, disease outbreak management, electronic medical records, and integration with advanced devices, post-intervention mean scores were substantially higher than baseline values ($p < 0.001$ across all analyses). This reflects a clear shift toward recognising blockchain as a transformative enabler of secure, transparent, and efficient healthcare delivery. The high F-values and t-values reinforce the robustness of these findings, while the chi-square results confirm broad-based distributional changes in acceptance and support. The study also quantified digital transformation results linked to blockchain implementation. Interoperability rates computed as a function of system integration effectiveness increased from 58% before the intervention to 91% after the intervention, reflecting substantial enhancements in cross-platform data exchange. The frequency of use of EMRs among clinicians was up 52%, and access to laboratory information systems increased by 44%, reflecting increased uptake of digital solutions. In addition, average data latency for accessing patient histories dropped from 9.3 minutes to 5.8 minutes, improving diagnostic decision-making timeliness.

Patient Outcomes and Patient Satisfaction

Indicators related to patients were greatly enhanced by the integration of blockchains. There was a 37 per cent reduction in the time of referral completion, 34% reduction in EMR retrieval latency, a 29 per cent reduction in duplicate testing, and a 41 per cent improvement in the speed of clinical decision-making. Time to make discharge decisions dropped by 28 per cent, and the interoperability improved by 58 to 91 per cent, improving continuity and timeliness of care. These gains on a system level had a positive impact on patient satisfaction, as they reduced their waiting time, reduced repetitive tests, and enhanced coordination of their care, resulting in an improvement in the patient experience. Improved data flow and transparency contributed to improved quality of healthcare. The satisfaction of patients and quality of services were further supported as the workforce digital-tool satisfaction increased to 89, as opposed to 63. Combining these results, the dual effect of blockchain in improving the effectiveness of care and patient-centred service delivery is evident. Table 05A presents the main indicators of patient outcomes before and after blockchain implementation, which indicate better clinical efficiencies and care delivery. It is shown to have shorter referral times, accelerated decision-making and increased interoperability.

Table 5A: Patient Outcome Indicators (Pre–Post Comparison)

Outcome Indicator	Direction of Change	Magnitude of Change
Referral completion time	↓	37%
EMR retrieval latency	↓	34%
Duplicate diagnostic testing	↓	29%
Clinical decision-making speed	↑	41%
Discharge decision time	↓	28%
Interoperability (pre → post)	↑	58% → 91%

Simultaneously, the study highlighted a balanced perception, as administrators not only endorsed the utility of blockchain but also acknowledged operational limitations, such as energy consumption and hardware requirements. This dual recognition indicates both optimism and critical awareness, which are essential for sustainable adoption. From an employee perspective, turnaround time for decision-making by clinical teams was enhanced by 44%, and user satisfaction with digital tools increased from 63% to 89%. Administrative tasks were reported as being reduced by 31% by laboratory staff, enabling more time for diagnostic analysis and patient management. These figures highlight the use of blockchain in facilitating not only system performance but also the efficiency of the healthcare workforce. Overall, the findings suggest that blockchain technology significantly strengthens healthcare systems by improving access, enhancing clinical patient outcomes, and raising satisfaction, although successful implementation will require strategies to address infrastructural and resource-related challenges. Blockchain was also instrumental in consolidating real-time surveillance of diseases and tracking outbreaks. Throughout the intervention, delays in transmitting data for epidemic alerts decreased by 48%, while the time for cross-institutional reporting was cut by 36%, facilitating quicker containment of outbreaks. System audit logs further showed a decrease in data-entry errors by 39%, again enhancing diagnostic precision and reporting credibility. Improved traceability of patient records and laboratory samples enhanced public health surveillance capacities and early detection of disease clusters.

Discussion

The results of this study showed that blockchain technology has considerable potential to solidify healthcare systems by enhancing health information access, promoting data safety, improving patient outcomes, and improving administrator satisfaction. Blockchain technology can significantly improve kidney disease management by enabling real-time access to critical renal diagnostic data (e.g., creatinine and eGFR results). This is particularly crucial for chronic kidney disease (CKD) patients, where timely intervention is key to preventing progression. By improving the efficiency of dialysis coordination and kidney transplant referrals, blockchain can help streamline these processes, reduce delays, and ensure that patients receive timely care, thus improving clinical outcomes and patient satisfaction in nephrology. Fewer duplicate tests and quicker decisions, coupled with reduced referral, retrieval, and discharge times, denote shortcuts in timeliness and safety. These effects were supported by the fact that interoperability (58%→91%) allowed making decisions based on more complete records in the point of care. Movement of core process drivers of satisfaction, including waiting time, transparency and clarity of handoffs, was positive, although these were not collected as direct patient-reported data. An increase in the workforce's digital tool satisfaction also serves to benefit the more responsive and predictable patient service experience. Aside from these results, blockchain also greatly facilitated care coordination and communication between multidisciplinary healthcare teams. Synchronised data in real-time between LIS, EMRs, and clinical dashboards helped eliminate the disconnection among physicians, laboratory specialists, nurses, and administrators. This integration eliminated communication gaps, decreased diagnostic-to-treatment delays, and enhanced overall continuity of patient care. Extensive enhancements in several areas, such as electronic medical records, intervention in outbreaks, and secure data exchange, underpin the increasing evidence that blockchain can help remedy core flaws in healthcare information systems. Specifically, the significant boost to administrators' endorsement of data sharing with blockchain (mean change from 2.46 to 4.25, $p < 0.001$) is commensurate with international research emphasising blockchain's ability to enhance interoperability and confidence within health systems.

Blockchain implementation even directly affected clinical decision-making workflows. Automated validation of data and traceable lab findings lowered diagnostic uncertainty, while real-time access to accurate, complete patient records streamlined decision-making by 44%. Redistribution of activities—e.g., automated consent confirmation, secure record reconciliation, cross-departmental alerts—lowered clinicians' administrative burden by 31%, freeing them up to concentrate on diagnostics, interpretation, and patient management. In addition, laboratory personnel indicated enhanced data quality and reduced manual interventions, leading to improved accuracy and reporting speed.

Another significant contribution of this study is identifying blockchain's potential role in disease surveillance and outbreak response. The large-scale enhancement in the perception of blockchain-based outbreak intervention systems resonates with the patient outcomes of previous research, highlighting the effectiveness of blockchain in the real-time sharing of epidemiological data during pandemics [9]. According to research on blockchain-enabled Internet of Things (IoT) for healthcare monitoring, the widespread use of wearable device integration and blockchain-enabled EMRs demonstrates the technology's adaptability in individualised and preventive care [10]. Technically speaking, blockchain's decentralised design offered numerous benefits over conventional systems. Its built-in interoperability allowed for smooth data transfer between lab, clinical, and administrative systems through standardised protocols like HL7 and FHIR. Through auditable trails for each diagnostic procedure, patient authorisation, and result modification, immutable ledger accounts improved data integrity and auditability. Furthermore, built-in cryptographic security features greatly decreased the risk of unauthorised access and data manipulation, improving cybersecurity in laboratory data management. Together, these characteristics changed laboratory operations from discrete, manual processes to digital spaces that are integrated, safe, and auditable.

However, this study also showed increased sensitivity to the operational limitations of blockchain, such as hardware requirements and energy consumption. This is consistent with previous complaints about the energy consumption and scalability of blockchain [11]. In resource-constrained locations like India, such a finding emphasises the necessity of policy-level actions to strike a balance between the advantages of blockchain technology and sustainability and infrastructure concerns. In comparison to legacy Hospital Information Systems (HIS), blockchain-based systems were more effective and less prone to errors. Legacy systems are often beset with siloed databases, disjointed updates, and manual reconciliation procedures, leading to failures and delays. In contrast, blockchain's distributed ledger capability eliminated redundancy, increased system availability, and facilitated data consistency between departments. Patient data inquiry time was reduced by 34%, with interoperability scores increasing from 58% to 91%. Such findings emphasise the potential for blockchain as a more robust but scalable alternative to conventional HIS architecture. Altogether, this simultaneous recognition of positives and negatives reflects a mature mindset among healthcare administrators and implies that phased, context-specific implementation plans are called for.

Despite these benefits, there are a few challenges that lie ahead. High deployment costs, energy requirements, and infrastructure constraints particularly in resource-poor healthcare environments can act as inhibitors to widespread uptake. To overcome them, phased rollout strategies with high-impact applications (such as laboratory data integrity, outbreak surveillance) must be prioritised. Incentivising green blockchain technologies, the use of cloud-based nodes, and the coupling of existing HIS infrastructure can lower costs and enhance scalability. Public–private partnerships and government-led digital health initiatives are essential to build capacity, develop skilled personnel, and ensure sustainable adoption across healthcare systems.

The synergy between AI and blockchain further expands the potential of this technology in predictive healthcare. By combining blockchain's secure, auditable data environment with AI's analytical capabilities, healthcare systems can develop predictive diagnostic models, risk stratification tools, and real-time outbreak forecasting solutions. For instance, blockchain-verified laboratory data analysed by AI can detect trends in disease progression or predict epidemics ahead of traditional surveillance systems. Such integration does promise a future where laboratory data not only informs real-time clinical decision-making but also steers proactive interventions and individualised patient management.

Primary care (Health & Wellness Centres; tele consults)

The most significant improvement in safe sharing of information (mean 2.46 → 4.25; $p < .001$) and blockchain EMR for chronic disease (hypertension) management (2.79 → 3.76; $p < .001$) accrue as dividends of primary care that patients perceive directly: fewer duplicate tests, simpler referrals, and better continuity. Among Indian Health Workers Community and telemedicine (e.g., eSanjeevani), adoption of blockchain technology can reduce time-to-care, medication errors, and resistance to administration, which are satisfaction drivers of first-contact care. The study's positive shift in mobile/COPD monitoring and AI + blockchain support indicates better symptom tracking and quicker guidance, increasing perceived responsiveness and confidence. These effects conform with the WHO's call to employ people-centred digital health and interoperability as cornerstones for satisfaction and equity.

Global reviews are responsible for blockchain-enabled data integrity and consented exchange to improve patient trust and usability of primary care workflows, a facilitator of greater satisfaction. Evidence on blockchain–IoT demonstrates better
adherence/monitoring experiences among patients with chronic conditions, similar to post-intervention effects derived from wearables integration.

Secondary care (district hospitals; disease programs)

The notable advancement in outbreak intervention (2.21 → 4.24; $p < .001$), TB data management (3.31 → 3.77; $p < .001$), and dengue tracker (2.79 → 4.15; $p < .001$) indicates that patients in secondary facilities enjoy more transparent care flows, fewer referral delays, and better follow-ups—factors consistently linked to satisfaction in programmatic care. Blockchain audibility also prevents lost records and duplication, boosting the "system competence" perceived by patients.

Several studies have unveiled the value of blockchain for public health surveillance, verifiable longitudinal history, and transparent supply chains, all of which improve timeliness and trust in care. These findings outside the setup reflect administrators' post-intervention support and anticipate increased patient satisfaction through predictability and transparency in secondary care.

Tertiary care (teaching/speciality hospitals)

Perception increased regarding smart contracts (2.89 → 4.23; $p < .001$), advanced scoring/decision support (e.g., MELD, CVD scores), and AI + blockchain to tertiary environments in which coordination between specialities and high-stakes decisions predominate the patient experience. Smart contracts can normalise consent, orders, and discharge processes; blockchain provenance can enhance trust in intricate care; and algorithmic transparency facilitates shared decision-making, enhancing satisfaction with communication, safety, and autonomy.

Previous reviews indicate that blockchain can improve tertiary processes using immutable records, granular permissioning, and cross-institutional exchange, fostering improved perceived safety and engagement. The present study results are directionally aligned and also recorded increased concern over energy/hardware limitations (2.26 → 3.47; $p < .001$), resonating with international warnings regarding sustainability and scalability. In India, policy roadmaps prioritise interoperability and standards to achieve these advantages at scale, proposing focused investments (energy-efficient consensus, common infrastructure) to translate perceptions into ongoing satisfaction.

Across levels of care, the results suggest higher patient satisfaction through faster, safer, and more transparent care journeys, provided India continues to implement interoperable standards, patient-centric consent, and green, scalable infrastructure. The direction and magnitude of the findings are well aligned with international evidence; India-specific insights help translate those promises into level-wise operational priorities.

Implications for Renal Healthcare Systems

Blockchain has significant potential to improve renal healthcare systems, particularly in dialysis centres and kidney transplant programs. The ability to provide secure, interoperable access to renal data can help eliminate delays in obtaining key creatinine and eGFR results, allowing for more timely clinical decision-making. Blockchain also ensures better coordination between dialysis units, laboratories, and transplant centres, thereby improving continuity of care, clinical efficiency, and patient satisfaction in the management of chronic kidney disease (CKD).

Conclusion

The blockchain technology has demonstrated substantial potential to enhance healthcare systems, particularly in improving patient outcomes, access to care, and overall system efficiency. By offering secure, transparent, and interoperable data exchange, blockchain has the capacity to streamline key healthcare operations, such as referral processes, clinical decision-making, and patient data management. The integration of blockchain in chronic kidney disease (CKD) management and dialysis coordination highlights its effectiveness in reducing delays and improving the timeliness of care. This study emphasizes blockchain's pivotal role in facilitating patient-centric care through improved transparency, data security, and clinical continuity. Notably, blockchain's ability to reduce data duplication, error rates, and administrative workloads has the potential to reshape healthcare delivery, making it more responsive and cost-effective. Furthermore, AI-powered blockchain solutions offer promising advancements in predictive healthcare, enabling early detection of diseases, risk stratification, and personalized treatment options, ultimately shifting the focus from reactive to proactive care.However, blockchain's full integration into healthcare systems will require addressing operational challenges such as energy consumption and hardware requirements, alongside careful planning for sustainable scalability. Future research should focus on real-world implementations, cost-effectiveness, and large-scale trials to validate blockchain's long-term impact. By aligning technological innovation with robust infrastructure and policy frameworks, blockchain could form the foundation for next-generation healthcare, improving both patient and system outcomes globally.

Policy Recommendations

National Interoperability Standards and Integration Policies

Developing national-level interoperability standards is necessary to facilitate the smooth integration of blockchain with current Hospital Information Systems (HIS), Laboratory Information Systems (LIS), and Electronic Medical Records (EMRs). Laws need to require the utilisation of internationally accepted protocols like HL7 and FHIR to facilitate data exchange across platforms among laboratories, hospitals, diagnostic networks, and public health agencies. A national centralised framework will guarantee that laboratory test results, patient information, and diagnostic processes are uniform, auditable, and available across institutions.

Blockchain in epidemics and pandemics

A policy should be developed to implement blockchain-based outbreak surveillance systems to enhance India's epidemic preparedness and response.

Mandatory Workforce Training and Capacity Building

To enhance the efficiency of blockchain technology in laboratory and healthcare environments, policies must mandate recurring, obligatory workforce training programs for healthcare clinicians, laboratory professionals, health informatics staff, and administrators. Training modules must consist of blockchain basics, digital data stewardship, cybersecurity best practices, and experiential integration with LIS and EMRs. Academic institutions and health care organisations must partner to integrate blockchain and digital health knowledge into medicine, nursing, and laboratory science curricula.

Digital Infrastructure Investment

Scale up investments in cloud and blockchain infrastructure in rural telehealth(primary care), district health centres (secondary care), and public hospitals (tertiary care) to provide equal access.

Addressing operational challenges through incentivising green blockchain technology and efficient consensus mechanisms.

Secure Data Governance, Consent, and Ethical Data Usage

National regulations must require secure patient data management frameworks to ensure that blockchain-based systems meet legal and ethical requirements. These consist of consent-based access measures, regular third-party inspections, and role-based permissions to guarantee that only qualified persons can view or alter confidential laboratory and patient data. Periodic data protection audits and open consent mechanisms will establish public trust as well as protect diagnostic and clinical data from abuse.

Capacity Building and Workforce Training

Implementation of periodic tailor-made blockchain healthcare training for administrators, clinicians, and IT professionals to improve the performance of healthcare systems using blockchain technologies.

Coordination with medical universities and research institutions to develop blockchain health application curricula in medical, nursing, and public health programs.

Public–Private Partnerships (PPPs)

Establishment of partnerships among the government, tech firms, and start-ups to upscale blockchain-enabled innovations and interventions is needed. (e.g., blockchain-enabled wearable devices and EMRs).

Provision of incentives for private sector involvement in secure health data exchange platforms to drive the adoption of blockchain technologies in healthcare systems.

Scaling Infrastructure Through Strategic Partnerships

Governments must actively pursue collaboration with private-sector technology firms, cloud providers, and health innovation companies to create scalable blockchain infrastructure. This collaboration can speed the deployment of interoperable laboratory systems, lower costs for implementation, and facilitate common investment in secure, distributed data networks. Incentives, grants, and pilot project funding will drive private sector involvement and stimulate innovation in diagnostic data management and blockchain-based clinical solutions.

Patient-Centric Data Governance

Application of rules and regulations that provide patients with rights to protect their health data, with blockchain-supported technology, periodic auditing, and transparency to access individual records following ethical regulations.

Develop national standards for blockchain-supported EMRs to facilitate interoperability between states and healthcare providers.

Cost-Effective Deployment and Green Technology Strategies

Policymakers must encourage cost-saving deployment strategies for blockchain through modular, cloud-based solutions and the reuse of existing digital infrastructure. Incentives to develop low-energy consensus algorithms, light protocol blockchain, and renewable-powered data centers will reduce operating costs and environmental footprint. These actions will enable sustainable, long-term adoption in laboratories and healthcare environments, including low-resource environments.

Evaluation and Continuous Monitoring

Establishment of a monitoring and evaluation (M & E) framework with processing indicators to assess progress in patient care and the impact of blockchain technologies on healthcare accessibility, patient outcomes, and satisfaction.

The WHO's digital health maturity models were used as references to regularly evaluate India's development (World Health Organization, 2020).

Continuous Performance Monitoring and Outcome Evaluation

National guidelines must incorporate strong monitoring and evaluation systems to monitor the effect of blockchain implementation on laboratory performance, diagnostic accuracy, patient outcomes, and workflow efficiency. Key performance indicators (KPIs) like reduction in diagnostic turnaround time, interoperability scores, error rates, and patient satisfaction measures must be periodically measured. Periodic public reporting of these measures will ensure transparency, accountability, and continuous quality improvement in blockchain-enabled healthcare services.

Ethics Approval

This study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Ethical approval for the study was obtained from the JSPH Institutional Review Board (Approval Number: [100032-IRB/20-21]). Prior to participation, all respondents were informed of the study’s objectives, voluntary nature, and confidentiality. Informed consent was obtained electronically from all participants before they completed the survey. No personally identifiable information was collected, and all data were anonymized to maintain the privacy of the participants.

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Conflict of Interest Statement

The authors declare that there is no conflict of interest regarding the publication of this manuscript. No financial, institutional, or personal relationships have influenced the design, execution, analysis, or reporting of this study.

References

1. Agbo CC, Mahmoud QH, Eklund JM. Blockchain technology in healthcare: a systematic review. InHealthcare 2019 Apr 4 (Vol. 7, No. 2, p. 56). MDPI.
2. Tiwari K, Kumar S. A healthcare data management system: blockchain-enabled IPFS providing algorithmic solutions for increased privacy-preserving scalability and interoperability. The Journal of Supercomputing. 2025 May 26;81(8):895.
3. Mondal S, Dogra K, Gupta S, Gupta SK. A Blockchain-Based OBD Architecture for Secure Data Sharing in Smart Vehicle Ecosystems. Security and Privacy. 2026 Jan;9(1):e70158.
4. Kuo TT, Kim HE, Ohno-Machado L. Blockchain distributed ledger technologies for biomedical and health care applications. Journal of the American Medical Informatics Association. 2017 Nov 1;24(6):1211-20.
5. Leiva V, Castro C. Artificial intelligence and blockchain in clinical trials: enhancing data governance efficiency, integrity, and transparency. Bioanalysis. 2025 Feb 1;17(3):161-76.
6. Mettler M. Blockchain technology in healthcare: The revolution starts here. In2016 IEEE 18th international conference on e-health networking, applications and services (Healthcom) 2016 Sep 14 (pp. 1-3). IEEE.
7. Pal S, Jha K, Sharma D. Blockchain-Enhanced AI Diagnostics in Healthcare. In2024 International Conference on Emerging Technologies and Innovation for Sustainability (EmergIN) 2024 Dec 20 (pp. 258-263). IEEE.
8. Ramachandran M. AI and blockchain framework for healthcare applications. Facta Universitatis, Series: Electronics and Energetics. 2024 Mar 27;37(1):169-93.
9. Roehrs A, Da Costa CA, da Rosa Righi R, De Oliveira KS. Personal health records: a systematic literature review. Journal of medical Internet research. 2017 Jan 6;19(1):e5876.
10. Siyal AA, Junejo AZ, Zawish M, Ahmed K, Khalil A, Soursou G. Applications of blockchain technology in medicine and healthcare: Challenges and future perspectives. Cryptography. 2019 Jan 2;3(1):3.
11. Yaqoob I, Salah K, Jayaraman R, Al-Hammadi Y. Blockchain for healthcare data management: opportunities, challenges, and future recommendations. Neural Computing and Applications. 2022 Jul;34(14):11475-90.