World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(REVIEW ARTICLE)

# Blockchain-based solutions for medical data sharing and patient privacy protection in India

Seema Babusing Rathod *

*Department of Computer Science and Engineering, Sipna College of Engineering and Technology, Amravati, Maharashtra, India.*

World Journal of Advanced Research and Reviews, 2025, 28(02), 1444–1450

Publication history: Received on 04 October 2025; revised on 10 November 2025; accepted on 13 November 2025

Article DOI: https://doi.org/10.30574/wjarr.2025.28.2.3787

## Abstract

The growing digitization of healthcare in India has led to an urgent need for secure, transparent, and patient-centric data management systems. Traditional centralized databases are vulnerable to breaches and unauthorized access, posing serious risks to patient privacy. This study explores blockchain-based solutions for secure medical data sharing and privacy protection within India's healthcare ecosystem. Blockchain's decentralized and immutable structure ensures data integrity, transparency, and confidentiality while enabling patient-controlled access through smart contracts. By integrating blockchain with initiatives such as the National Digital Health Mission (NDHM), healthcare institutions can achieve interoperability and secure exchange of electronic health records (EHRs). The proposed approach enhances trust, reduces data misuse, and strengthens the foundation for a secure digital healthcare infrastructure in India.

**Keywords:** Blockchain Technology; Medical Data Security; Patient Privacy Protection; Electronic Health Records (EHR); National Digital Health Mission (NDHM); Decentralized Data Management; Smart Contracts

## 1. Introduction

The digitization of healthcare in India has led to massive volumes of sensitive medical data, including electronic health records, diagnostic reports, and personal health information. While digital systems improve accessibility and efficiency, they also pose significant risks to data privacy, security, and integrity.(Gohar et al., 2022) Blockchain technology provides a decentralized, tamper-proof solution for secure medical data sharing, enabling patient-controlled access through smart contracts. (Bai and Sarkis, 2013)By ensuring transparency, interoperability, and auditability, blockchain enhances trust between patients, healthcare providers, and institutions.(Bhatia and Srivastava, 2018) Implementing blockchain in India can strengthen privacy protection, prevent unauthorized access, and support the country's evolving digital health ecosystem.(Haleem et al., 2021)

## 2. History of Blockchain

The concept of blockchain originated in 2008 when Satoshi Nakamoto introduced it as the underlying technology for Bitcoin, the first cryptocurrency.(Kosasih et al., 2024) Initially designed to enable secure, decentralized financial transactions, blockchain quickly gained attention for its potential beyond digital currencies.(Varshney et al., 2021) The technology's foundation lies in distributed ledgers, cryptographic hashing, and consensus mechanisms, ensuring transparency and immutability.(Govindan et al., 2014)

* Corresponding author: Seema Babusing Rathod

Over the years, blockchain has evolved into multiple generations.(Angelis and Ribeiro Da Silva, 2019) Blockchain 1.0 was focused on cryptocurrencies; Blockchain 2.0 introduced smart contracts with Ethereum, enabling programmable transactions; and Blockchain 3.0 expanded applications to sectors such as supply chain, governance, healthcare, and the Internet of Things.(Andoni et al., 2019) Today, blockchain is recognized as a disruptive technology with immense potential for secure data management across industries.(Saini et al., 2022)

## 3. Description of Blockchain

Blockchain is a decentralized and distributed digital ledger that records transactions across multiple computers in a secure, transparent, and immutable manner. (Anandaraj et al., 2025) Unlike traditional centralized databases, blockchain stores data in blocks that are linked chronologically to form a chain, ensuring data integrity and preventing unauthorized alterations.(Wu et al., 2022) Each block contains a cryptographic hash of the previous block, transaction details, and a timestamp, making the system tamper-resistant.(Zala et al., 2022). The technology operates on consensus mechanisms such as Proof of Work (PoW) or Proof of Stake (PoS) to validate transactions without a central authority.(Nimmy et al., 2022) Blockchain also supports smart contracts, self-executing digital agreements that automate processes based on predefined rules.(Zala et al., 2022)By combining transparency, security, and decentralization, blockchain is widely applied beyond cryptocurrency, including healthcare, supply chain, finance, and governance, offering trusted data sharing and improved accountability.(Meng et al., 2021)

**Table 1** Identified Research Gaps and Proposed Solutions for Blockchain-Based Medical Data Sharing in India

| Sr. No. | Identified Research Gap | Proposed Solution |
|---|---|---|
| 1 | Centralized healthcare databases are prone to breaches and unauthorized access. | Implement decentralized blockchain storage to eliminate single points of failure and enhance data security. |
| 2 | Patients lack control and ownership of their electronic health records (EHRs). | Introduce smart contracts to provide patient-controlled data access and consent-based sharing. |
| 3 | Poor interoperability among healthcare institutions and systems. | Integrate blockchain with the National Digital Health Mission (NDHM) for standardized and secure data exchange. |
| 4 | Limited transparency in how medical data is stored, shared, and accessed. | Use blockchain's immutable ledger to record every transaction, ensuring transparency and auditability. |
| 5 | Traditional systems cannot guarantee data integrity once information is stored. | Employ cryptographic hashing to ensure stored data remains tamper-proof and verifiable. |
| 6 | Weak mechanisms for compliance with healthcare data privacy regulations. | Develop blockchain-based frameworks aligned with Indian data protection laws and healthcare standards. |
| 7 | Lack of practical implementation of emerging technologies in healthcare data management. | Combine Blockchain, AI, and IoT for secure data sharing, analytics, and intelligent healthcare decision-making. |

**Table 1** summarizes the key research gaps in India's digital healthcare ecosystem and presents blockchain-based solutions to address them. By employing decentralized storage, smart contracts, and integration with NDHM, the proposed approach enhances data security, patient control, interoperability, transparency, and regulatory compliance, thereby strengthening trust and credibility in medical data management.

## 4. Pros and Cons of Blockchain

### 4.1. Pros

- **Security:** Data stored on blockchain is encrypted and tamper-proof, reducing risks of hacking and fraud.(Ahl et al., 2020)
- **Transparency:** All participants can verify transactions, enhancing trust and accountability.
- **Decentralization:** Eliminates the need for a central authority, preventing single-point failures.
- **Immutability:** Once recorded, data cannot be altered or deleted, ensuring record integrity.(Ramachandran, 2025)

- **Efficiency:** Automates transactions through smart contracts, reducing manual processes and intermediaries.(Ramachandran, 2025)
- **Cons:**
- **Scalability Issues:** Processing a large number of transactions can be slow and resource-intensive.(Economides, 1996)
- **High Energy Consumption:** Consensus algorithms like Proof of Work require significant computational power.(Ball and Craig, 2010)
- **Complex Integration:** Integrating blockchain with existing healthcare systems is technically challenging.(Economides, 1996)
- **Regulatory Uncertainty:** Lack of clear legal frameworks affects adoption in countries like India.(Ahl et al., 2020)
- **Data Privacy Concerns:** While data is secure, public visibility of transactions may raise confidentiality issues.(Govindan et al., 2014)

## 5. Blockchain Algorithms and Models

Blockchain technology operates through a combination of algorithms and models that ensure security, transparency, and decentralization.(Desai and Ambali, 2024) The core of blockchain lies in its consensus algorithms, which allow network participants to agree on the validity of transactions without a central authority.(Moona et al., 2019) Common mechanisms include Proof of Work (PoW), which requires solving complex puzzles to verify blocks; Proof of Stake (PoS), where validators are selected based on their stake, offering better energy efficiency; and Practical Byzantine Fault Tolerance (PBFT), which provides reliability even when some nodes act maliciously, making it suitable for private healthcare blockchains.(Usharani and Attigeri, 2022)In addition, blockchain employs cryptographic algorithms such as SHA-256, which generates secure hashes for data integrity, and Elliptic Curve Digital Signature Algorithm (ECDSA) for authentication and transaction verification. Based on accessibility and control, blockchain models are classified as public, private, and consortium. Public blockchains like Bitcoin are open to all users, private blockchains are restricted to specific organizations, and consortium blockchains are jointly managed by multiple entities, balancing privacy and transparency. Together, these algorithms and models form the foundation of blockchain, ensuring secure, efficient, and trustworthy data management in healthcare and other sectors.

### 5.1. Some Applications on Blockchain

Blockchain technology has found diverse applications across multiple sectors due to its ability to provide transparency, security, and decentralization. In healthcare, blockchain is used for secure electronic health record (EHR) management, drug supply chain tracking, and patient consent management, ensuring data privacy and authenticity. In finance, it supports cryptocurrency transactions, cross-border payments, and smart contracts for automated, trustless operations. Supply chain management benefits from blockchain through real-time tracking of goods, fraud prevention, and improved traceability. In education, blockchain enables digital certificate verification, reducing credential fraud. Additionally, government services utilize blockchain for land record management, identity verification, and voting systems, enhancing transparency and reducing corruption. Overall, blockchain's applications continue to expand, promoting trust and efficiency across industries.

## 6. Proposed theory

The proposed theory suggests implementing a blockchain-based decentralized healthcare data management system to ensure secure, transparent, and patient-controlled medical data sharing in India. In this model, all patient health records are stored in encrypted blocks distributed across a secure network of healthcare institutions. Each transaction or data access request is verified through a consensus mechanism, ensuring only authorized entities can view or update information.

Smart contracts are employed to automate data access permissions patients can grant, revoke, or modify access rights without intermediaries. This enhances privacy and prevents unauthorized sharing. By integrating blockchain with the National Digital Health Mission (NDHM) framework, interoperability between hospitals, clinics, and laboratories can be achieved while maintaining compliance with privacy regulations. This proposed system ensures data immutability, transparency, and accountability, reducing risks of breaches and fostering patient trust in India's digital healthcare ecosystem.

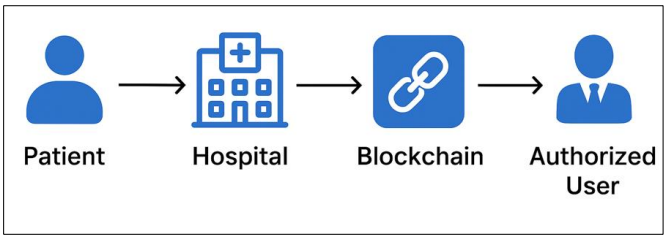


**Figure 1** Flow of Data in the Proposed Blockchain Healthcare System

## 7. Example: Blockchain Integration in India's National Digital Health Mission (NDHM)

The National Digital Health Mission (NDHM), launched by the Government of India, aims to create a unified digital health ecosystem where every citizen has a unique Health ID for accessing medical records across hospitals and clinics. (Li et al., 2025)To ensure data security, privacy, and interoperability, researchers and startups have proposed integrating blockchain technology into the NDHM framework.For instance, Apollo Hospitals and Oracle collaborated on a blockchain-based health records pilot project, enabling secure data exchange between hospitals and diagnostic centers. In this system, patient data is encrypted and stored on a blockchain ledger, and only authorized healthcare providers can access it through patient consent managed via smart contracts.This approach enhances data integrity, traceability, and patient control, reducing medical errors and preventing data breaches. (Anandaraj et al., 2025)It demonstrates how blockchain can strengthen healthcare privacy and interoperability in India's digital health ecosystem.

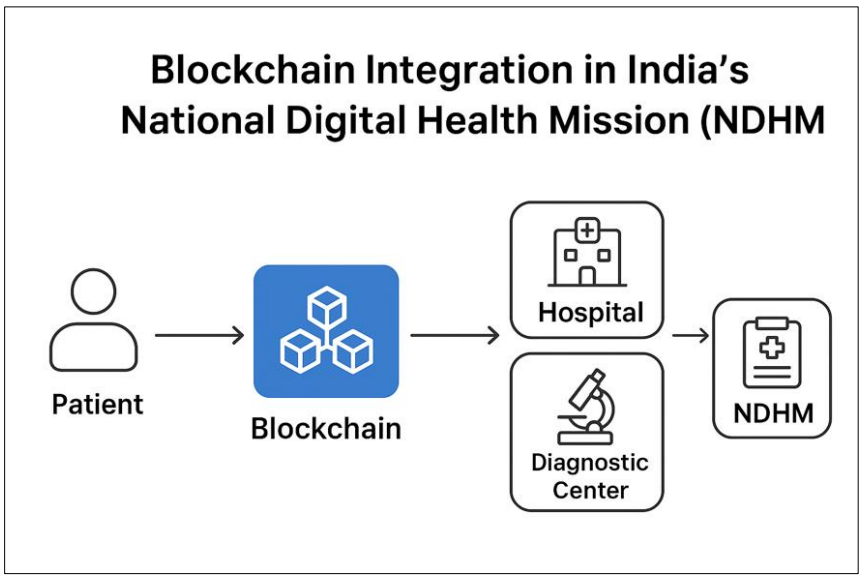


**Figure 2** Block Diagram of NDHM Blockchain-Based Healthcare System

**Table 2** Trust and Credibility in Online Healthcare Environments Using Blockchain-Based Solutions

| Aspect | Traditional Online Healthcare Systems | Blockchain-Based Healthcare Systems | Impact on Trust and Credibility |
|---|---|---|---|
| Data Storage | Centralized databases managed by a single authority | Decentralized, distributed ledger across multiple nodes | Eliminates single point of failure; increases transparency |
| Data Integrity | High risk of unauthorized modification or data tampering | An immutable ledger ensures data cannot be altered once recorded | Builds confidence in data authenticity |
| Access Control | Controlled by hospitals or third-party servers | Smart contracts enable patient-controlled access permissions | Empowers patients; enhances credibility of access control |
| Transparency | Limited visibility into data handling processes | All transactions are recorded and auditable on the blockchain | Strengthens accountability and trustworthiness |
| Privacy Protection | Vulnerable to breaches and insider misuse | Encryption and pseudonymization ensure confidentiality | Protects patient identity; improves trust in data privacy |
| Interoperability | Often lacks standardized frameworks for data exchange | Facilitates secure interoperability across healthcare systems | Promotes collaboration with reliability |
| Regulatory Compliance | Difficult to monitor compliance and audit trails | Provides verifiable audit logs for authorities | Increases credibility in legal and ethical compliance |
| Patient Trust | Patients depend on institutional goodwill | Patients control their own health records via blockchain | Enhances patient empowerment and trust in digital systems |

Table 2 illustrates how blockchain technology enhances trust and credibility in online healthcare environments by ensuring data integrity, transparency, and patient-controlled access compared to traditional centralized systems. The decentralized and immutable nature of blockchain fosters greater reliability and confidence in medical data management within India's digital healthcare ecosystem.

## 8. Conclusion

Blockchain technology offers a transformative solution for secure and transparent medical data sharing in India's healthcare system. By integrating blockchain with the National Digital Health Mission (NDHM), patient data can be stored and accessed with enhanced privacy, integrity, and control. The decentralized nature of blockchain minimizes data breaches, ensures accountability, and promotes interoperability among healthcare providers. Implementing blockchain-based systems empowers patients to manage their health information effectively, fosters trust in digital healthcare services, and supports India's vision of a robust, secure, and efficient digital health ecosystem.

## Compliance with ethical standards

### *Disclosure of conflict of interest*

No conflict of interest to be disclosed.

## References

[1] Ahl, A., Yarime, M., Goto, M., Chopra, S. S., Kumar, N. Manoj., Tanaka, K., and Sagawa, D. (2020). Exploring blockchain for the energy transition: Opportunities and challenges based on a case study in Japan. Renewable and Sustainable Energy Reviews, 117, 109488. https://doi.org/10.1016/j.rser.2019.109488

[2] Anandaraj, M., Ganeshkumar, P., Naganandhini, S., and Selvaraj, K. (2025). Blockchain-powered healthcare in the metaverse: Advancing security, interoperability, and patient empowerment. In Leveraging Metaverse and Analytics of Things (AoT) in Medical Systems (pp. 101–123). Elsevier. https://doi.org/10.1016/B978-0-443-24049-2.00007-8

[3] Andoni, M., Robu, V., Flynn, D., Abram, S., Geach, D., Jenkins, D., McCallum, P., and Peacock, A. (2019). Blockchain technology in the energy sector: A systematic review of challenges and opportunities. Renewable and Sustainable Energy Reviews, 100, 143–174. https://doi.org/10.1016/j.rser.2018.10.014

[4] Angelis, J., and Ribeiro Da Silva, E. (2019). Blockchain adoption: A value driver perspective. Business Horizons, 62(3), 307–314. https://doi.org/10.1016/j.bushor.2018.12.001

[5] Bai, C., and Sarkis, J. (2013). A grey-based DEMATEL model for evaluating business process management critical success factors. International Journal of Production Economics, 146(1), 281–292. https://doi.org/10.1016/j.ijpe.2013.07.011

[6] Ball, A., and Craig, R. (2010). Using neo-institutionalism to advance social and environmental accounting. Critical Perspectives on Accounting, 21(4), 283–293. https://doi.org/10.1016/j.cpa.2009.11.006

[7] Bhatia, M. S., and Srivastava, R. K. (2018). Analysis of external barriers to remanufacturing using grey-DEMATEL approach: An Indian perspective. Resources, Conservation and Recycling, 136, 79–87. https://doi.org/10.1016/j.resconrec.2018.03.021

[8] Desai, S., and Ambali, B. (2024). HEALTHCARE SECURITY WITH BLOCKCHAIN IN INDIA. ShodhAI: Journal of Artificial Intelligence, 1(1). https://doi.org/10.29121/shodhai.v1.i1.2024.6

[9] Economides, N. (1996). The economics of networks. International Journal of Industrial Organization, 14(6), 673–699. https://doi.org/10.1016/0167-7187(96)01015-6

[10] Gohar, A. N., Abdelmawgoud, S. A., and Farhan, M. S. (2022). A Patient-Centric Healthcare Framework Reference Architecture for Better Semantic Interoperability Based on Blockchain, Cloud, and IoT. IEEE Access, 10, 92137–92157. https://doi.org/10.1109/ACCESS.2022.3202902

[11] Govindan, K., Kaliyan, M., Kannan, D., and Haq, A. N. (2014). Barriers analysis for green supply chain management implementation in Indian industries using analytic hierarchy process. International Journal of Production Economics, 147, 555–568. https://doi.org/10.1016/j.ijpe.2013.08.018

[12] Haleem, A., Javaid, M., Singh, R. P., Suman, R., and Rab, S. (2021). Blockchain technology applications in healthcare: An overview. International Journal of Intelligent Networks, 2, 130–139. https://doi.org/10.1016/j.ijin.2021.09.005

[13] Kosasih, E. E., Papadakis, E., Baryannis, G., and Brintrup, A. (2024). A review of explainable Artificial Intelligence in supply chain management using neurosymbolic approaches. International Journal of Production Research, 62(4), 1510–1540. https://doi.org/10.1080/00207543.2023.2281663

[14] Li, K., Lohachab, A., Dumontier, M., and Urovi, V. (2025). Privacy preservation in blockchain-based healthcare data sharing: A systematic review. Peer-to-Peer Networking and Applications, 18(6), 302. https://doi.org/10.1007/s12083-025-02148-9

[15] Meng, Y., Speier, W., Ong, M., and Arnold, C. W. (2021). HCET: Hierarchical Clinical Embedding With Topic Modeling on Electronic Health Records for Predicting Future Depression. IEEE Journal of Biomedical and Health Informatics, 25(4), 1265–1272. https://doi.org/10.1109/JBHI.2020.3004072

[16] Moona, G., Jewariya, M., and Sharma, R. (2019). Relevance of Dimensional Metrology in Manufacturing Industries. MAPAN, 34(1), 97–104. https://doi.org/10.1007/s12647-018-0291-3

[17] Nimmy, S. F., Hussain, O. K., Chakrabortty, R. K., Hussain, F. K., and Saberi, M. (2022). Explainability in supply chain operational risk management: A systematic literature review. Knowledge-Based Systems, 235, 107587. https://doi.org/10.1016/j.knosys.2021.107587

[18] Ramachandran, M. (2025). Introduction to Blockchain Concepts. In M. Ramachandran, Blockchain Engineering (pp. 3–33). Springer Nature Singapore. https://doi.org/10.1007/978-981-96-4360-8_1

[19] Saini, A., Wijaya, D., Kaur, N., Xiang, Y., and Gao, L. (2022). LSP: Lightweight Smart-Contract-Based Transaction Prioritization Scheme for Smart Healthcare. IEEE Internet of Things Journal, 9(15), 14005–14017. https://doi.org/10.1109/JIOT.2022.3145406

[20] Usharani, A. V., and Attigeri, G. (2022). Secure EMR Classification and Deduplication Using MapReduce. IEEE Access, 10, 34404–34414. https://doi.org/10.1109/ACCESS.2022.3161439

[21] Varshney, A., Garg, N., Nagla, K. S., Nair, T. S., Jaiswal, S. K., Yadav, S., and Aswal, D. K. (2021). Challenges in Sensors Technology for Industry 4.0 for Futuristic Metrological Applications. MAPAN, 36(2), 215–226. https://doi.org/10.1007/s12647-021-00453-1

[22] Wu, G., Wang, S., Ning, Z., and Zhu, B. (2022). Privacy-Preserved Electronic Medical Record Exchanging and Sharing: A Blockchain-Based Smart Healthcare System. IEEE Journal of Biomedical and Health Informatics, 26(5), 1917–1927. https://doi.org/10.1109/JBHI.2021.3123643

[23] Zala, K., Thakkar, H. K., Jadeja, R., Singh, P., Kotecha, K., and Shukla, M. (2022). PRMS: Design and Development of Patients' E-Healthcare Records Management System for Privacy Preservation in Third Party Cloud Platforms. IEEE Access, 10, 85777–85791. https://doi.org/10.1109/ACCESS.2022.3198094