# Leveraging Blockchain in Healthcare: Exploring Opportunities and Overcoming Challenges

***Dr. Saurabh Shandilya***[1]
[1]*General Manager Swasthya Kalyan Group of Institutions, Jaipur, India*
*Srb.shandilya84@gmail.com*

**ABSTRACT**

Patients and healthcare providers face significant challenges in accessing, managing, integrating, and securely sharing health records. Ideally, patients should be able to manage their medical records globally, track their medical history, grant data access, and securely share this information with healthcare professionals. Direct patient access to health data, coupled with a stronger data-sharing infrastructure, could enhance the healthcare system's ability to respond to public health emergencies, such as the COVID-19 outbreak. However, current healthcare technologies fall short in meeting these needs due to limitations in privacy, security, and comprehensive system interoperability. This paper reviews existing literature to explore how blockchain technology can address some of the critical challenges facing the healthcare industry. It identifies both the challenges and opportunities of implementing blockchain in healthcare and provides an overview of health-related blockchain solutions and key players across various applications. Our research builds upon and expands current studies on blockchain in healthcare.

**KEYWORDS:** Blockchain; Peer-to-Peer Network; Compliance Tracking; Healthcare Data; Cybersecurity; HIPAA Compliance; On-Chain Data Management

**DOINumber: 10.48047/nq.2022.20.2.NQ22381** **NeuroQuantology2022;20(2):819-832**



## 1. Introduction

The healthcare industry faces significant challenges in managing and securely retrieving the vast amounts of personal health data generated through routine operations and service delivery. Technologies such as healthcare monitoring devices and wearables also contribute to this data overload. However, health data remains largely inaccessible, non-standardized across systems, and difficult to interpret, use, and share. Data is collected from various sources and stored in centralized IT systems, making management and sharing a complex and resource-intensive process. Efficient management and secure retrieval of this data are essential for healthcare systems to gain a comprehensive view of patients, improve care quality, enhance communication, and ultimately achieve better health outcomes.

Another key challenge in healthcare is the lack of interoperability, inaccessible medical records, and the absence of comprehensive, secure population health data. Recent public health crises have underscored these gaps in healthcare system interoperability. In addition, safeguarding healthcare data is a critical issue. Many organizations store valuable health information in outdated, centralized IT infrastructures, making them prime targets for ransomware and other cyberattacks.

There has been growing momentum towards patient-driven interoperability, where patients take control of their own health data exchange. However, the industry is still in the early stages of developing the necessary infrastructure, software, and strategies to securely and reliably integrate various data sources. Existing systems face numerous challenges, including concerns about patient privacy, data integrity, quality, and accuracy. The healthcare sector is actively exploring innovative technologies to address these pressing issues. In this context, blockchain technology offers significant potential to address interoperability challenges and shift the focus to patient-centered care.

Research on the application of blockchain in healthcare is still emerging. Current literature provides limited insight into blockchain solutions that have been developed, tested, or deployed. As blockchain becomes more mainstream, it is essential to assess whether blockchain-enabled healthcare systems can improve health outcomes and reduce chronic disease risks in communities. The rest of this paper is structured as follows: Section two provides an overview of blockchain technology, describing its key components. Section three examines the challenges facing the healthcare industry and explores the potential benefits of blockchain in addressing critical issues like patient data accessibility and security. Section four outlines the technical, organizational, and behavioral challenges of implementing blockchain in healthcare, along with real-world use cases and emerging blockchain-based solutions. Lastly, section five summarizes the findings and presents conclusions.

## 2. Blockchain Technology Defined

Blockchain technology stands out as one of the most transformative innovations of this century. It offers not only operational and regulatory efficiencies but also enhances traceability and transparency across industries, including healthcare. Distributed ledger technology (DLT), often referred to as blockchain, has attracted significant attention in sectors beyond financial services. At its core, blockchain is a decentralized and continuously expanding series of records called 'blocks,' which are linked through a process known as mining. In this process, pending transactions are turned into complex mathematical puzzles that miners solve using computer systems. The result is a unique identifier called a hash, which secures the block and links it to the next in the chain. Each block contains a cryptographic hash of the previous block, a timestamp, and transaction data, creating a secure chain of information. Any change to the data in a block triggers a chain reaction that could compromise the entire blockchain. Once the information is processed, all computers in the network synchronize, creating a permanent and immutable digital record.

Blockchain technology allows data and transactions to be shared securely over a peer-to-peer (P2P) network, enhancing transparency and security. Though initially popularized for cryptocurrency and financial transactions, blockchain is now being adopted by industries like manufacturing, entertainment, and healthcare for its privacy and security features.

In India, blockchain holds immense potential for resolving critical challenges in healthcare, such as interoperability and data security, while placing patients at the center of the healthcare system. Blockchain enables secure access to medical records, supports mobile health applications and remote monitoring, and allows patients to retain control of their medical data. In the following section, we will explore how blockchain can address some of the major challenges faced by the Indian healthcare industry.

## 3. Critical Challenges and Blockchain Solutions

India's healthcare industry is vast and growing rapidly. It faces several critical challenges, including rising medical costs, uneven access to care, and complex regulatory requirements. The average expenditure on healthcare is increasing, and the government has been working towards making healthcare more accessible and affordable through various initiatives. However, with increasing healthcare demands, managing costs and improving care quality remain key concerns for the country.

In recent years, India has seen the entrance of tech giants and startups into the healthcare sector, aiming to tackle these challenges by leveraging advanced technologies like artificial intelligence (AI), wearables, and blockchain. While traditional healthcare models focus on treating illness after it occurs, there is a shift towards preventive healthcare, where wearable devices and other technologies continuously monitor individual health metrics such as heart rate, body temperature, and physical activity. These wearables, introduced by companies like Apple and Google, provide comprehensive data on health, which can be analyzed to give insights into lifestyle choices, sleep patterns, and other behaviors that influence overall health. By using this data, software applications aim to provide holistic preventive healthcare and improve patients' quality of life. This trend has been accelerated by the COVID-19 pandemic, which pushed for more remote and data-driven healthcare solutions [1].

Any technological solution aimed at improving healthcare in India must consider the diverse needs of consumers, healthcare providers, and regulatory bodies, while addressing the country’s unique challenges. Stakeholders in India are increasingly

looking at blockchain to optimize healthcare processes, reduce costs, improve patient outcomes, and ensure compliance with regulations such as the Health Data Management Policy under the National Digital Health Mission (NDHM). In a survey of life sciences executives, a large proportion of respondents indicated that blockchain could help overcome inefficient processes and legacy systems, which have been barriers to innovation in the healthcare sector. The potential for blockchain to streamline healthcare data management is significant, as highlighted by initiatives such as the National Health Stack (NHS) and its focus on integrating health records across public and private systems.

In 2020, several hospitals and healthcare providers in India began exploring blockchain-based solutions to store and manage patient data securely. For example, blockchain is being used in clinical trials to maintain transparency and data integrity, as well as in managing COVID-19 vaccination records.

Table 1 provides a summary of the potential applications of blockchain in India's healthcare and life sciences sectors. A detailed review of how blockchain can address healthcare data management challenges is presented in the following sections.

### 3.1. Data Collection and Storage

Healthcare monitoring technologies, such as wearables and mobile health applications, generate massive amounts of personal health data daily. The proper management and safe retrieval of this data are crucial for enabling data-driven decisions within our healthcare systems. Additionally, our existing healthcare system generates data through the normal activities of conducting business and providing various services. Throughout their lives, patients interact with numerous healthcare providers, leaving a trail of data that is often scattered across multiple systems. Consequently, providers frequently retain primary data stewardship, leading to a fragmented data trail and a decaying ease of access for patients.



Healthcare data is characterized by a large volume, heterogeneity, and speed. These datasets are non-uniform and encompass numerous variables, necessitating real-time data analysis to be actionable. Unfortunately, this data is often inaccessible, non-standardized across systems, and challenging to comprehend, utilize, and share effectively[4].

Table1.Blockchainpotentialsforhealthcareandlifesciences.

| Categories | Potential Use | Key Benefits |
|---|---|---|
| **Patient** | -Patient empowerment<br>-Track medical background<br>-Access latest medical prescriptions<br>-Share data securely across providers | Increases patient trust<br>Improves patient access to trusted data<br>Facilitates better collaboration<br>Enhances transparency<br>Personalizes patient experience<br>Reduces operational costs<br>Enables global access to health records<br>Provides access to latest prescriptions |
| **Regulation and Compliance** | Compliance tracking<br>Smart contract-based checks | Creates a trusted real-time audit trail<br>Automates privacy regulation enforcement<br>Monitors data sharing without revealing sensitive information |
| **Intercompany Process** | • Transfer of funds<br>• Medical device supply chain<br>• Temperature-controlledsupply chains<br>• Services | Facilitates automated payments with smart contracts<br>Speeds up payments<br>Offers full transparency of assets across the supply chain<br>Secure messaging between devices and service providers<br>Centralizes all transactions on a single platform |

| Categories | Potential Use | Key Benefits |
|---|---|---|
| **Administration and Back Offices** | - Revenue management | Increases tracking and tracing efficiency<br>Reduces administrative costs<br>Improves reliability and auditability<br>Speeds up financial transactions |
| **Pharmaceuticals** | Verifies drug provenance<br>Single source of aggregated information | Tracks and traces pharmaceuticals<br>Proof of authenticity to counter counterfeiting<br>Prevents counterfeit product transport and sale<br>Detects complications in pharmaceutical treatments |
| **Research & Development** | Securing clinical trials<br>Prevents intellectual property theft | Authenticates documents and ensures proof of existence<br>Access to large anonymous, authenticated patient databases |

### 3.1.1. Current Status of Healthcare Record-Keeping and Medical History

The characteristics of current healthcare record-keeping and data collection systems reveal several systemic issues[6, 14, 24]:

- **Patient-Provider Interaction Dependency:** Current systems heavily rely on direct interaction between patients and physicians, which can limit comprehensive data collection.
- **Underutilization of Data:** There is a significant failure to take advantage of the wealth of data generated, which hampers clinical decision-making and operational efficiency.
- **Cumbersome Healthcare Processes:** Patients often experience long and tedious processes to access healthcare services due to inefficiencies in data handling.
- **Fragmented Critical Patient Information:** Critical patient information is scattered across different systems, making it difficult for providers to access complete medical histories.
- **Lack of Data Availability:** The unavailability of essential data prevents many healthcare systems from providing timely and necessary treatments to patients.
- **Negative Impact on Management Systems:** The inefficiencies in data handling lead to management issues, as many healthcare players lack the right information for seamless operations.
- **Poor Data Security and Reliability:** The existing systems often provide inadequate healthcare data security, putting sensitive information at risk and affecting reliability.

The healthcare industry remains inefficient, with a significant portion of medical records still stored on paper and across disparate locations. This lack of digital integration prevents healthcare data from being used effectively to coordinate care, measure quality, or reduce medical errors[15]. Most healthcare data is digitally collected at various points, but it is crucial to extract the maximum benefits from this data without complicating existing processes. A significant challenge the healthcare industry faces is the ability to record, store, and share information easily and economically across disparate applications and systems[2]. Ensuring the portability of data and uniform compatibility across diverse systems is also essential[22].



### 3.1.2. Blockchain Solutions for Healthcare Record Keeping

Blockchain technology offers a promising solution for digital data management where authentication and consensus regarding data integrity are crucial. In healthcare, blockchain can be used to securely store critical medical data[25]. It addresses record-keeping issues by providing a reliable framework for continuous and steady growth of transactions in an environment that prioritizes consumer security. Blockchain technology is increasingly considered for securing DNA data, personal information, healthcare records, and vital medical history information.

With blockchain, healthcare providers can create an integrated health records system where patients are central to the process, holding the private key to their data. This empowers patients by giving them

control over who can access or use their data. The blockchain-powered integrated system not only helps in reconciling records and activities but also aids in curbing fraud. Patients can manage their health records securely and access their medical backgrounds—such as allergies, chronic diseases, and vaccinations—anywhere in the world[2].

Recent studies have proposed blockchain-based systems for preserving medical data, which ensure the authenticity and verifiability of stored information while maintaining user privacy. Such systems enable users to preserve important data perpetually and verify the originality of data if tampering is suspected[28]. Another study suggests a blockchain-based secure and privacy-preserving health information-sharing system aimed at improving diagnostic accuracy in e-health systems. Given blockchain's immutability, it can significantly enhance diagnosis accuracy, where security and privacy are critical[29].

**3.2. Data Sharing and Interoperability**

Inefficient interoperability within the healthcare sector creates two significant problems[5]:

1. **Patient Identification Difficulties:** The lack of universally recognized patient identifiers can complicate the accurate identification of patients.
2. **Information Blocking:** Healthcare providers may impose unreasonable constraints on the exchange of patient data or electronic health information, hindering timely access to vital information.

The lack of universally recognized patient identifiers and problematic information blocking practices presents substantial barriers to efficient healthcare delivery. The need for improved interoperability is especially evident in public health crises, such as the COVID-19 pandemic. The timing of such outbreaks underscores the dire need for a robust data-sharing infrastructure that facilitates seamless patient-provider communication and enhances the flow of information necessary for managing public health threats.

Patients should have straightforward access to their medical records, especially when consulting healthcare providers outside their primary care network. Furthermore, improving the flow of health data enables doctors to conduct remote monitoring and telemedicine consultations effectively. Such capabilities empower patients to keep their healthcare providers informed of their medical histories[3]. During public health crises, the need for expedient and transparent information becomes even more crucial, including guidance on assessing risk, identifying symptoms, and responding to treatment[3].

**3.2.1. Existing Data Sharing**

Medical records are frequently stored within centralized IT systems, which complicate the process of data sharing. The tasks of requesting, sending, receiving, and compiling patient data are often tedious, time-consuming, and costly. The development of technological solutions for medical data management has been slow due to regulatory challenges, incompatible backend systems, and fragmented shared medical information. The lack of collaboration and data sharing among healthcare storage systems severely limits the transmission, retrieval, and analysis of vital data. Consequently, a significant amount of data remains trapped in siloed databases, restricting patients' ability to engage effectively with their medical histories[2].



**3.2.2. Blockchain Solutions for Data Sharing**

Blockchain technology has the potential to simplify the sharing of healthcare data significantly and help overcome the interoperability challenges plaguing the healthcare sector. In a permissioned healthcare blockchain, patients can be identified using their unique hash ID, which ensures privacy and security. This hashing process makes the ID unique and protects the user's privacy. Patients would retain oversight of sharing the decryption key associated with their data blocks with their chosen healthcare providers, enhancing security, privacy, and interoperability while placing patients at the center of the healthcare ecosystem[14]. Both patients and providers would greatly benefit from accurate, up-to-date, and comprehensive medical records, leading to improved healthcare outcomes.

**3.3. Data Security and Identity Management**

Concerns regarding data security and patient privacy have intensified due to recent security breaches involving healthcare records. A report by the global cybersecurity insurance company Beazley indicated that 45% of ransomware attacks in 2017 targeted healthcare organizations[30]. The number of hacked healthcare records and medical data breaches is on the rise. For instance, the HIPPA Journal reported a surge in the number of breaches within the healthcare industry, rising from below 20 in 2009 to more than 350 in 2017[31]. According to the Department of Health and Human Services, healthcare breaches in 2018 exposed 13 million

healthcare records[32]. Data breaches averaged at least one per day, affecting over 27 million patient records in 2016[33]. Notably, in 2018, hackers exposed sensitive medical records of 1.4 million patients from the UnityPoint Health hospital network, marking it as one of the largest medical data breaches in the U.S. that year, compromising lab results, treatments, social security numbers, and insurance information[31].

**3.3.1. Existing Data Security Issues**

Many healthcare organizations store valuable health information in centralized locations utilizing aging legacy IT infrastructure, which makes them prime targets for ransomware and other cyberattacks[2]. Healthcare organizations are often the targets of sophisticated cyberattacks due to the extensive information they store. The loss of access to patient records and other critical information can severely cripple healthcare providers, costing victim organizations millions of dollars. In response, healthcare organizations are investing in advanced security technologies, including enhanced data backups, advanced encryption, AI, and real-time security platforms to preemptively address potential threats[30]. The growing concerns surrounding data security, patient privacy, and the rising number of cyberattacks underscore the urgent need for improved IT security.

**3.3.2. Blockchain Solutions for Data Security and Identity Management**

Blockchain offers several advantages for enhancing healthcare data security and identity management[34]. It can effectively curb threats and protect private data from unauthorized access. By encrypting data upon its addition to the blockchain, the information becomes immutable and virtually impossible to decipher without the appropriate permissions. Transactions can be authorized using a private identification key known solely to the individual. This contrasts with current healthcare data technologies, allowing healthcare providers to access a patient's medical data only with explicit access rights granted via the blockchain[22]. Improved data collaboration between providers can lead to higher diagnostic accuracy and more successful treatment outcomes, enabling healthcare facilities to deliver cost-effective care. Blockchain not only keeps patient information secure but also allows patients to share their data with any service providers they choose, providing proof of ownership and authenticity while combating counterfeiting[23].

A recent study by BIS Research projects that by 2025, the healthcare industry could save up to $100 billion annually through the adoption of blockchain technology. These savings would arise from reductions in costs related to data breaches, operational expenses, IT costs, counterfeit-related frauds, and insurance frauds. The growing demand for secure data storage solutions in the healthcare industry further underscores the potential of blockchain as a foundational technology for managing sensitive healthcare data[35].

## 4. Strategic Values and Implementation Challenges

Blockchain technology is still in its infancy and has not been widely adopted across all industries. The scarcity of successful blockchain implementation models creates uncertainty and influences decisions regarding the selection of blockchain technology for future growth. However, blockchain can be evaluated on its own merits as a foundational technology capable of addressing various innovation challenges. The following sections explore these aspects in detail.



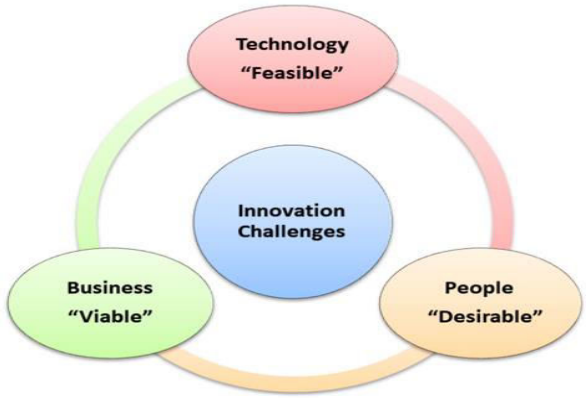


Figure 1. Innovation challenges.

### 4.1. Meeting Innovation Challenges and Offering Opportunities

According to the Massachusetts Institute of Technology (MIT), successful companies innovate by integrating the needs of people, leveraging technological possibilities, and fulfilling business success requirements. These companies adopt a systematic approach that merges marketing, design, and engineering perspectives to deliver innovation effectively【51】. Their products and services typically meet three essential criteria (Figure 1):

- **Technical:** Is there a better solution available? Does this solution provide a competitive advantage?

- **People:** Is there a genuine unmet need? How critical is this need?
- **Business:** Is the solution financially viable? Is it effective and cost-efficient?

Blockchain technology emerges as a robust solution for the healthcare sector, fulfilling all three innovation challenge requirements. It is technically feasible, desirable among patients, and offers viable benefits to healthcare providers. As highlighted throughout this paper, blockchain can lead to an integrated healthcare information system【22】. It maintains traceable records of distributed data and workflows, efficiently addressing diverse healthcare data challenges while maximizing the output from the collected data at various levels【52】.

Implementing blockchain in healthcare effectively addresses four major issues:

1. **Fragmented Data:** Consolidates patient information scattered across multiple systems into a unified format.
2. **Slow Access to Medical Data:** Enhances data retrieval speed, allowing healthcare providers to access critical patient information more quickly.
3. **System Interoperability:** Promotes seamless data exchange between different healthcare systems, improving communication and coordination.
4. **Patient Agency:** Empowers patients with control over their data, enhancing their involvement in their healthcare journey.

Moreover, the rapid advancements in blockchain technology and a strong industry-wide commitment to establishing standards and ensuring security indicate a promising future for blockchain in healthcare【22】. Figure 2 outlines the factors contributing to the increasing popularity of blockchain-based solutions in the healthcare market.

### 4.2. Emerging Blockchain-Based Healthcare Solutions

Several companies have embarked on the development and distribution of blockchain technologies tailored for the healthcare industry. The blockchain platforms and software provided by these organizations offer various solutions, including:

- **Secure Digital Record Storage:** Safeguarding sensitive health information against unauthorized access and breaches.
- **Improved Data Sharing and Utilization:** Streamlining the sharing of medical data between providers, thereby enhancing collaboration and patient care.
- **Integrity Protection for Health Records:** Ensuring that health records are accurate, tamper-proof, and up-to-date.
- **Drug Traceability and Counterfeiting Solutions:** Providing mechanisms to track pharmaceuticals throughout the supply chain, preventing counterfeit drugs from entering the market.



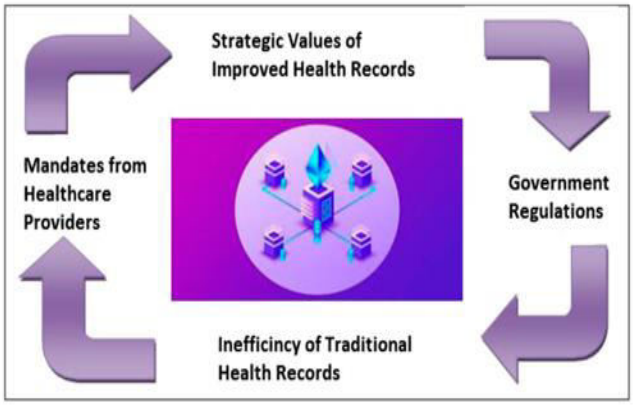


Figure 2. Strategic values of blockchain-based healthcare.

Table 2 summarizes various health-related blockchain products and key players offering proprietary blockchain solutions across different applications【54–56】.

| Company/Platform | Industry | Applications |
|---|---|---|
| **MEDREC** | Big Data | Cybersecurity, Software |
| | | Uses blockchain for electronic medical records, managing authentication, confidentiality, and data sharing. |
| **BURSTIQ** | Big Data | Cybersecurity, Software |
| | | Improves the way medical data is shared and used; HIPAA compliant platform for on-chain data management, complex data ownership, and granular consent. |

| Company/Platform | Industry | Applications |
|---|---|---|
| **FACTOM** | Enterprise Software | Information Technology |
| | | Helps the healthcare industry securely store digital records on the company's blockchain platform. |
| **MEDICALCHAIN** | Electronic Health Record | Medical |
| | | Protects the integrity of health records, maintains a record of origin, and protects patient identity. |
| **GUARDTIME** | Cybersecurity | Blockchain |
| | | Assists healthcare companies and governments in implementing blockchain into their cybersecurity methods. |
| **ROBOMED** | Blockchain | Medicine |
| | | Uses blockchain to securely gather patient information and share it with healthcare providers. |
| **PATIONTORY** | Blockchain | Cybersecurity, Healthcare, Information Technology |
| | | Offers solutions for secure storage and transfer of important medical information. |
| **BLOCKPHARMA** | Blockchain | Pharmaceuticals, Supply Chain |
| | | Provides solutions for drug traceability and counterfeiting using blockchain technology. |
| **NANOVISION** | Blockchain | Cybersecurity |
| | | Combines blockchain with AI to gather data from traditional data silos and incompatible records systems. |
| **TIERION** | Blockchain | SaaS |
| **CONECTINGCARE** | Cybersecurity | Blockchain |
| | | Uses blockchain to audit documents, records, and medicines, maintaining proof of ownership throughout the medical supply chain. |
| | | Tracks patient progress after hospital discharge. |
| **NEBULA GENOMICS** | Biotechnology | Genetics |
| | | Eliminates unnecessary spending and middlemen in the genetic studying process using blockchain. |



**4.3 Challenges of Blockchain Implementation in Healthcare**

The implementation of blockchain technology in healthcare faces several significant challenges. From a technical perspective, the technology is still in its early development stage, which requires ongoing improvements and may result in higher initial costs for healthcare institutions during the adoption phase. Scalability issues, lack of standardization, potential information decay, and the need for integration with existing legacy systems further complicate the situation. Additionally, the process of verifying new transactions on the blockchain can be time-consuming, and the computational requirements necessitate a network of interconnected computers to provide the necessary power for creating blocks. Concerns about the operational costs and efficiency of blockchain systems also arise, particularly due to the energy-intensive nature of transaction processing. Moreover, blockchain's limitations in handling data requiring high temporal resolution or complex data types, such as multi-dimensional data, images, and graphs, present further obstacles. On the organizational front, healthcare providers in India have already invested significantly in Electronic Health Records (EHR) systems, making a complete transition to blockchain economically unfeasible at

this stage. The lack of incentives for healthcare providers to adopt blockchain as a comprehensive framework for record-keeping, coupled with challenges in determining how to store existing record data and establishing a nationally recognized standard format for demographic information, complicates the adoption process. Furthermore, effective management of organizational changes related to employee adaptation during the transition to blockchain technology is essential for successful implementation. Regulatory and privacy challenges also exist, as government regulations concerning blockchain technology in healthcare remain unsettled, creating barriers to adoption. A significant cultural shift is needed within the Indian healthcare sector, requiring substantial buy-in from various stakeholders to foster acceptance of blockchain technology.

1. **Technical Challenges**
    - **Early Development Stage**: The blockchain software remains in its initial phases of development, necessitating ongoing improvements. Initial adoption may entail higher costs for healthcare institutions.
    - **Scalability Issues**: The technology faces hurdles regarding scalability, lack of standardization, potential information decay, and integration with existing legacy systems.
    - **Transaction Verification Delays**: The process of verifying new transactions on the blockchain can be time-consuming.
    - **Computational Requirements**: A network of interconnected computers (nodes) is essential to provide the computational power necessary for creating blocks.
    - **Unproven Systems**: Concerns arise regarding the operational costs and efficiency of blockchain systems, particularly due to the energy-intensive nature of transaction processing.
    - **Data Handling Limitations**: Blockchain is not particularly suitable for data requiring high temporal resolution or complex data types, such as multi-dimensional data, images, and graphs.
2. **Organizational Challenges**
    - **Existing Electronic Health Records (EHR)**: Healthcare providers in India have already made significant investments in EHR systems, rendering it economically unfeasible to transition entirely to blockchain technology at this stage.
    - **Incentives for Transition**: There is currently a lack of incentives for healthcare providers to adopt blockchain as a comprehensive framework for record-keeping.
    - **Data Storage Concerns**: Determining how to store existing record data on blockchain and establishing a nationally recognized standard format for demographic information are significant challenges.
    - **Management of Change**: Organizational issues related to employee management during the transition to blockchain technology must be effectively addressed to ensure successful implementation.
3. **Regulatory and Privacy Challenges**
    - **Regulatory Uncertainty**: Government regulations concerning blockchain technology in healthcare in India remain unsettled, creating barriers to adoption.
    - **Cultural Adoption**: There is a need for substantial buy-in from various stakeholders within the Indian healthcare sector to foster cultural acceptance of blockchain technology.



**4.4 Drivers for Adoption**

Despite the challenges, several drivers can promote the adoption of blockchain technology in healthcare. Uncertainties regarding operational costs and difficulties in determining the return on investment (ROI) hinder adoption efforts. Therefore, compelling incentives must be offered to healthcare providers in India, as the benefits of blockchain may not be immediately visible or quantifiable. Additionally, while blockchain may not address all existing medical record issues, it holds the potential to enhance efficiency in specific areas of the Indian healthcare system, paving the way for gradual improvements.

1. **Cost and ROI Uncertainty**: Uncertainties regarding the costs associated with operating blockchain and challenges in determining the return on investment (ROI) impede adoption.
2. **Incentives for Providers**: Compelling incentives must be offered to healthcare providers in India to adopt blockchain technology, as the benefits may not be immediately visible or quantifiable.
3. **Incremental Improvements**: Although blockchain may not resolve all existing medical record issues, it has the potential to enhance efficiency in specific areas of the Indian healthcare system.

**5. Summary and Conclusions**

The literature review reveals that research on blockchain technology in healthcare remains in its early stages, yet the number of proposed solutions is rapidly increasing. Blockchain has the potential to initiate a paradigm shift by providing a transformative approach that enhances decentralized management, security, and an immutable audit trail. Various use cases illustrate its capability to improve access control, interoperability, provenance, and data integrity within healthcare systems. Additionally, the distributed nature of blockchain, combined with its transparent information structure, presents opportunities for significant operational cost reductions. However, successful implementation of blockchain requires a redefinition of relationships among all stakeholders, including healthcare providers, patients, and the pharmaceutical industry. Therefore, there is a pressing need for further research into the real-world applications of blockchain technology in healthcare to fully realize its benefits and address the challenges it presents.

1. **Early Stage of Research**: The literature review indicates that research on blockchain in healthcare is still at an early stage, but the number of proposed solutions is rapidly increasing.
2. **Paradigm Change Potential**: Blockchain technology offers a transformative approach to decentralized management, enhanced security, and an immutable audit trail.
3. **Use Cases and Applications**: Various use cases demonstrate blockchain's potential to improve access control, interoperability, provenance, and data integrity within healthcare systems.
4. **Cost Reduction Opportunities**: Blockchain's distributed nature and transparent information structure can help reduce operational costs in healthcare.
5. **Integration Challenges**: Successful implementation necessitates redefining relationships among all stakeholders, including healthcare providers, patients, and the pharmaceutical industry.
6. **Ongoing Research Needs**: Further research into real-world applications of blockchain technology in healthcare is warranted.

**5.1 Implications for Practice**

1. **Limited Reporting of Benefits**: There are few documented instances of the business benefits of blockchain in healthcare, resulting in a lack of comprehensive data and understanding.
2. **Insights for Researchers**: This paper provides insights from a multidisciplinary group of practitioners, assisting researchers in identifying areas within the Indian healthcare system where blockchain can be effectively implemented.



**Research Limitations**

1. **Scarcity of Peer-Reviewed Papers**: There are few papers that explore the advantages and limitations of implementing blockchain in healthcare, with much of the discourse dominated by consultancy narratives.
2. **Focus on Terminology**: The results primarily relate to the mention of "blockchain in healthcare," rather than broader healthcare-related technologies.

**Practical Implications**

1. **Identification of Key Players**: This study identifies 12 products and key players offering proprietary blockchain solutions for healthcare.
2. **Business Applications**: Practitioners will gain insights into blockchain use cases, business potentials, strategic values, challenges, and areas of concern regarding its adaptation in healthcare organizations.

**References**

1. Saurabh shandilyaAn In-Depth Theoretical Exploration of Data Mining in the Healthcare Sector: Techniques, Challenges, and Future

Directionshttps://ijfans.org/uploads/paper/ba8f3069dac541849302936d781d4c70.pdf
2. Clim A, Zota RD, Tinica G. Big data in home health- care: A new frontier in personalized medicine. medical emergency services and prediction of hypertension risks. Int J Healthc Manag. Published online. 2018;28 Nov:241–249.
3. Bresnick J. Exploring the use of blockchain for EHRs, healthcare big data. ThinStock; 2017. [cited 2020 Jan 20]. Available from: https://healthitanalytics.com/ features/exploring-the-use-of-blockchain-for-ehrs- healthcare-big-data.
4. Postelnicu L. How the world of health and tech is looking at the coronavirus outbreak. 2020 Mar 11, Mobihealthnews. [cited 2020 Mar 22]. Available from:https://www.mobihealthnews.com/news/ europe/how-world-health-and-tech-looking- coronavirus-outbreak.
5. Kamble SS, Gunasekaran A, Goswami M, et al. A sys- tematic perspective on the applications of big data analytics in healthcare management. Int J Healthc Manag. 2018 Oct 05;12(3):226–240.
6. Gordon WJ, Catalini C. Blockchain technology for healthcare: facilitating the transition to patient-driven interoperability. Comput Struct Biotechnol J. 2018;16:224–230.
7. Pirtle C, Ehrenfeld JM. Blockchain for healthcare: the next generation of medical records? J Med Syst. 2018 Aug;42(9). Article 172.
8. Chen HS, Jarrell JT, Carpenter KA, et al. Blockchain in healthcare: a patient-centered model. Biomed J Sci Tech Res. 2019 Sep;20(3):15017–15022.
9. Attaran M, Gunasekaran A. Applications of block- chain technology in business: challenges and opportu- nities. Springer Briefs in Operations Management. Cham, Switzerland; 2019. ISBN 978-3-030-27797-0.
10. Iansiti M, Lakhani K. The truth about blockchain. Harvard Business Review; 2017 Jan–Feb.
11. Zheng Z, Xie S, Dai H, et al. An overview of block- chain technology: architecture, consensus, and future trends. IEEE 6th international congress on big data; 2017. [cited 2018 Jul 10]. Available from: https://
12. www.researchgate.net/publication/318131748_An_Overview_of_Blockchain_Technology_Architecture_Consensus_and_Future_Trends.
13. Lee Kuo Chuen D. Handbook of digital currency, 1st edn. Elsevier; 2015 [cited 2020 Jan 24]. Available from: http://EconPapers.repec.org/RePEc: eee:monogr:9780128021170.
14. Mougayar W, Buterin V. The business blockchain: promise, practice, and application of the next Internet technology. Hoboken (NJ): John Wiley & Sons, Inc; 2016.
15. Kuo TT, Kim HE, Ohno-Machado L. Blockchain dis- tributed ledger technologies for biomedical and health care applications. J Am Med Inform Assoc 2017 Nov;24(6):1211–1220.
16. Paranjape K, Parker M, Houlding D, et al. Implementation considerations for blockchain in healthcare institutions. Blockchain in Healthcare Today. Volume 2; 2019 Jul.
17. Hillestad R, Bigelow J, Bower A, et al. Can electronic medical record systems transform health care? poten- tial health benefits, savings, and costs. Health Aff. 2019;24(5):1103–1117.
18. Kamal R, McDermott D, Cox C. How has U.S. spend- ing on healthcare changed over time? Health System Tracker. 2019 [cited 2020 Apr 17]. Available from: https://www.healthsystemtracker.org/chart-collection/u-s-spending-healthcare-changed-time/ #item-start.
19. Sainz F. Apple and Google partner on COVID-19 con- tact tracing technology. Apple News. 2020 [cited 2020 Apr 17]. Available from: https://www.apple.com/ newsroom/2020/04/apple-and-google-partner-on- covid-19-contact-tracing-technology/.
20. Mackey TK, Kuo T, Gummadi B, et al. 'Fit-for-pur- pose?' - challenges and opportunities for applications of blockchain technology in the future of healthcare. BMC Med. 2019 Mar 27;17(1):68.
21. IBM Institute for Business Value. Team medicine: how life sciences can win with blockchain. IBM Corporation. 2018 [cited 2018 Mar 12]. Available from: https://public.dhe.ibm.com/common/ssi/ec

m/ 03/en/03013903usen/team-medicine.pdf.
22. Rosenbaum L. Anthem will use blockchain to secure medical data for its 40 million members in three years. Forbes. 2019 Dec 12. [cited 2020 Mar 17]. Available from: https://www.forbes.com/sites/ leahrosenbaum/2019/12/12/anthem-says-its-40- million-members-will-be-using-blockchain-to-
23. secure-patient-data-in-three-years/#305bc9be6837.
24. Hoy MB. An introduction to the blockchain and its implications for libraries and medicine. Med Ref Serv Q. 2017;36(3):273–279.
25. Yaeger K, Martini M, Rasouli J, et al. Emerging block- chain technology solutions for modern healthcare infrastructure. J Sci Innov Med. 2019;9(9):2–7.
26. Leon K. How is blockchain revolutionizing health- care? The Startup. 2018 Oct 23, [cited 2020 Jan 17]. Available from: https://medium.com/swlh/how-is-blockchain-revolutionizing-healthcare-d971d351528f.
27. Singh N. Blockchain for healthcare: use cases and applications. 101 Blockchains. 2019 Nov 21 [cited 2020 Jan 18]. Available from: https://101blockchains. com/blockchain-for-healthcare/.
28. Agbo C, Qusay HM, Eklund JM. Blockchain technol- ogy in healthcare: A systematic review. Healthcare. 2019 Apr 4;7(2):56.
29. Cheng EC, Leb Y, Zhoub J, et al. Healthcare services across China – on implementing an extensible univer- sally unique patient identifier system. Int J Healthc Manag. 2018;11(3):210–216.
30. Finasko. (2017). Blockchain analysis - applications of technology in different sectors. February 14. [cited 2018 March 12]. Available from: https://finasko.com/ t/blockchain-analysis-applications-of-the-technology- in-different-sectors/135.
31. Li H, Zhu L, Shen M, et al. Blockchain-based data preservation system for medical data. J Med Syst. 2018 Jul;42(8):141.
32. Zhang A, Lin X. Towards secure and privacy-preser- ving data sharing in e-Health systems via consortium blockchain. J Med Syst. 2018 Jul;42(8):140.
33. Duffy D. The 3 most important security statistics healthcare organizations need to know. Barkly; 2018 Wednesday, Mar 7 [cited 2020 Jan 27]. Available from: https://www.beckershospitalreview. com/ healthcare-information-technology/the-3-most- important-security-statistics-healthcare- organizations-need-to-know.html.
34. Davis J. 1.4 million patient records breached in UnityPoint Health phishing attack; 2018 [cited 2018 Mar15]. Available from: https://www. healthcareitnews.com/news/14-million-patient- records-breached-unitypoint-health-phishing-attack.
35. Journal H. Largest healthcare data breaches of 2018. HIPAA Journal; 2018 Dec 27. [cited 2020 Apr 17]. Available from: https://www.hipaajournal.com/ largest-healthcare-data-breaches-of-2018/.
36. Protenus, Inc. Breach barometer report: the year in review; 2017 [cited 2020 Jan 20]. Available from: https://cdn2.hubspot.net/hubfs/2331613/Breach_ Barometer/2016/2016%20Year%20in%20Review/ Protenus%20Breach%20Barometer-2016%20Year% 20in%20Review-%20final%20version.pdf.
37. Bouras MA, Lu Q, Zhang F, et al. Distributed ledger technology for eHealth identity privacy: state of the art and future perspective. Sensors. 2020 Jan 15;20 (2):E483.
38. BIS Research. Global Blockchain in Healthcare Market: Focus on Industry Analysisand Opportunity Matrix - Analysis and Forecast, 2018- 2025. 2018 [cited 2020 Jan 15]. Available from: https://bisresearch.com/industry-report/global- blockchain-in-healthcare-market-2025.html.
39. Duncam DT, Kawachi I. Neighborhood and health. 2nd Edition New York (NY): Oxford university Press; 2018.
40. Hughes LS, Phillips RL, DeVoe JE, et al. Community vital signs: taking the pulse of the community while caring for patients. J

Am Board Fam Med. 2016 May;29(3):419–422.
41. Giancaspro M. Is a 'smart contract' really a smart idea? insights from a legal perspective. Comp Law Secur Rev. 2017;33(6):825–835.
42. Luu L, Chu D, Olickel H, et al. Making smart contracts smarter. Proceedings of the 2016 ACM SIGSAC Conference on Computer and CommunicationsSecurity (CCS '16). ACM; 2016; New York, p. 254– 269.
43. Lorenz JT, Münstermann B, Higginson M, et al. Blockchain in insurance: opportunity or threat? 2016 Jul. [cited 2020 Mar 22]. Available from: https://www.mckinsey.com/~/media/McKinsey/Industries/Financial%20Services/Our%20Insights/Blockchain%20in%20insurance%20opportunity%20or%20threat/ Blockchain-in-insurance-opportunity-orthreat.ashx.
44. Zhou L, Wang L, Sub Y. MIStore: a blockchain-based medical insurance storage system. J Med Syst. 2018 July;42(8):149.
45. Haq J, Esuka OM. Blockchain technology in pharma- ceutical industry to prevent counterfeit drugs. Int J Comput Appl. 2018;180(25):8–12.
46. Bocek T, Rodrigues BB, Strasser T, et al. Blockchains everywhere-a use-case of blockchains in the pharma supply chain. In Integrated Network and Service Management (IM), IFIP/IEEE Symposium on, IEEE; 2017; p. 772–777.
47. Shanley A. Could blockchain improve pharmaceutical supplychainsecurity? Pharm Technol. 2017;41(8):34–39.
48. Vecchione A. Blockchain tech could track pharmacy supply chain. Drug Topics. 2017;161(11):21.
49. Modum. Modum website. 2019 [cited 2019 Apr 19]. Available from: https://modum.io/company/aboutus.
50. Rijmenam. Why blockchain is quickly becoming the gold standard for supply chain. 2018 November 21. [cited 2020 Jan 18]. Available from: https://medium.com/dataseries/why-blockchain-is-quickly-becoming- the-gold-standard-for-supply-chains-ec296bad305.
51. Nash DB. Trending in 2015: population health. J Healthcare Manage. 2015 July;60(4):246–248.
52. Organtree Website. 2019 [cited 2018 Mar 27]. Available from: https://www.indiegogo.com/projects/organtee-the-first-free-online-donor-registration#/.
53. Abdul Malak L. UAE first country in the world to use blockchain for organ donation. 2019 Feb 1 [cited May 05]. Available from: https://www.unlock-bc.com/ news/2019-02-01/uae-first-country-in-the-world-to- use-blockchain-for-organ-donation.
54. Eppinger SD. MIT's approach to design thinking. Online Course by Emeritus Institute of Management in collaboration with MIT Sloan School of Management. 2018 [cited 2020 Jan 15]. Available from:https://sg.emeritus.org/management-certificate-programs/innovation-design-thinking/.
55. Roehrs A, da Costa CA, da Rosa Righi R. OmniPHR: a distributed architecture model to integrate personal health records. J Biomed Inform. 2017;71:70–81.
56. Ekblaw A, Azaria A, Halamka JD, et al. A case study for blockchain in healthcare: "MedRec" prototype for electronic health records and medical research data. White Paper. MIT Media Lab, Beth Israel Deaconess Medical Center. 2018 Aug 16 [cited 2020 Jan 25]. Available from: https://static1.squarespace.com/static/59aae5e9a803bb10bedeb03e/t/5a6fd2f7e2c48387dff12676/1517278000381/ blockchain-medical-records-patient-data-medrec- eckblaw.pdf.
57. Marr B. 35 Amazing real-world examples of how Blockchain is changing your world. Forbes. 2018 Sep 25, [cited 2019 Mar 12]. Available from: https://bernardmarr.com/default.asp?contentID=1302.
58. Marr B. 30+ examples of Blockchain technology in practice. Forbes. 2018 Mar 14, [cited 2019 Mar 12]. Available from: https://www.forbes.com/sites/bernardmarr/2018/05/14/30-real-examples-of- blockchain-technology-in-practice/#616a3726740d.
59. Daley S. 15 examples of how blockchain is reviving healthcare. Builtin. 2019 Oct 3 [cited 2020 Jan 15 from May 5]. Available from:

https://builtin.com/ blockchain/blockchain-healthcare-applications- companies.

60. Alla S, Soltanisehat L, Tatar U, et al. Blockchain tech- nology in Electronic Healthcare Systems. Proceedings of the 2018 IISE Annual Conference; 2018; p. 1–6. [cited 2020 Jan 27]. Available from: https://www.researchgate.net/publication/325542378_Blockchain_Technology_in_Electronic_Healthcare_System.
61. Dubovitskaya A, Novotny P, Xu Z, et al. Applications of blockchain technology for data-sharing in oncol- ogy: results from a systematic literature review. Oncology. 2019 Dec 3: 1–9.
62. Peterson K, Deeduvanu R, Kanjamala P, et al. A block- chain-based approach to health information exchange networks. Mayo Clinic. 2016 [cited 2020 Jan 18]. Available from: https://pdfs.semanticscholar.org/c1b1/89c81b6fda71a471adec11cfe72f6067c1ad.pdf.
63. Ichikawa D, Kashiyama M, Ueno T. Tamper-resistant mobile health using blockchain technology. JMIR MhealthUhealth. 2017;5(7):1–10.
64. Angraal S, Krumholz HM, Schulz WL. Blockchain technology: applications in health care. Circulation: Cardiovasc Qual Outcomes. 2017;10(9):e003800.
65. Karafiloski E, Mishev A. Blockchain solutions for big data challenges: A literature review in Smart Technologies, IEEE EUROCON -17th International Conference; 2017.