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Designing a Practical Blockchain-Based Model for Electronic Health Records (EHR) in Iraqi Medical Institutions

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ABSTRACT

In Iraq, the fragmented systems within the healthcare sector struggle to protect patient-sensitive data, maintain data integrity, and enable interoperability, as highlighted. This review will focus on how blockchain technology can overcome these earlier challenges by improving the security and efficiency of information systems. Health Information Systems (HIS) are challenged with data breaches, cyber-attacks, and an interoperability gap in their healthcare information infrastructure due to blockchain decentralized, immutable transparency qualities. It creates a safe place for medical records storage and operation that can improve data integrity, security, privacy, and ease of use, eventually decreasing administrative inefficiency. This paper discusses the current situation of HIS in Iraq, which is faced with a lack of resources, poor standardization, and little technology uptake due to resistance. It analyses blockchain-enabled solutions to secure e-health records (EHR) and health information exchange HIE or clinical decision support systems (CDSS) to improve health delivery. Primary interventions implemented at the community level (e.g., identified key strengths of blockchain, including data security, patient outcomes, and process streamlining). The model of the blockchain-based EHR system in the Iraqi healthcare system is proposed and demonstrated, thus highlighting the need for technical development, regulatory basis, and stakeholder collaboration. We will discuss some challenges like scaling, regulatory burden, and technical specialty. The paper comes to an end by suggesting pragmatic solutions, which are implementation-phased, capability-building, and embracing standards. With blockchain, Iraqi medical establishments will enhance the quality of care by creating an encrypted, patient-centered, and efficient health system that secures information on sensitive medical matters. This review outlines the transformative capability of blockchain in Iraq's healthcare challenges and suggests a pathway towards practical usage.

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1. INTRODUCTION

Blockchain is a decentralized digital ledger that stores transaction data in a secure and tamper proof manner. Abstract Over the last few years, this technology has been in high demand to boost security and ensure privacy, transparency within different industries-healthcare included. Healthcare sector is one of the most data-intensive sectors, data is something that flows from patients between the provider electronic medical records and mutually to other stakeholders [1][2]. Protection of healthcare information systems (HIS), for preserving data privacy, prevention from data breaches and ensuring medical records are accurate is an important epidemiological issue [3]. One of the transformative answers to many significant healthcare related challenges in which healthcare systems reside across regions such as Iraq (where data security and interoperability are compounded issues) is blockchain technology. Healthcare institutions are able to do all of the following by using blockchain:

- Data Integritity : Blockchain also keeps a tamper-evident record of every transactions thus medical records are secure through blockchain. There are no delays in visible traceability for changes to the data and it becomes very difficult to change records unnoticed [4].
- Privacy: Patients can use their private keys to take control over who sees what in the medical record and data is encrypted for storage and transmission on blockchain These make it very hard for any non authorized entities to get sensitive information, directly helping in data privacy [5].
- Enhanced Interoperability: Blockchain serves as a common ground where various systems can communicate with each other on the basis of shared platform that increases healthcare information interoperability. There improvement minimizes the number of errors and duplications in records of patient result in better care [6].
- Enhanced Security: In secured and distributed data storage, healthcare information systems are made secure with the use of blockchain as a robustness. A method to prevent cyberattacks, data breaches, and patient privacy protection in confidentiality [7].
- Decentralized Data Management: Blockchain offers a secure and distributed mode of storage/ sharing of information which lessens dependence on centralized systems that are by nature single point of failures.

In Iraq, where healthcare systems are constrained by resources, standardization and the resistance to innovation in technology blockchain technology could be very impactful. In this paper we investigate how blockchain can get these challenges achieved by suggesting a feasible architecture for a blockchain based EHR model of Iraq to healthcare system. Critical to this model is the technical infrastructure, regulatory environment and stakeholder participation in order for an effective implementation. As an outcome, Iraqi medical centers will be able to have a more safe and functional healthcare system that helps improve the quality of care and assure sensitive patient information with the application of blockchain.

2. Background

2.1 Blockchain Technology

A distributed digital ledger, the first 2008 original theoretical implementation of blockchain as a basis for the digital currency Bitcoin [8] It is a distributed digital ledger, wherein blocks data are strung together using cryptographic techniques and this is how the blockchain maintained by each computer (or node) on the computer network. A block contains different transactions each; impossible to change or delete after the block is added on blockchain. A tamper proof, secure log of everything that has been transacted on the blockchain [9]. See Figure 1, the blockchain operates on top of a set of nodes that validate, validate and verify transactions on the network.

Each node has its copies of blockchain and when a new transaction happen, nodes collectively work to validate & integrate it into the blockchain [1]. This distributed verification process makes sure the blockchain is precise and real [10] Blockchain the emergence of Blockchain as an interest topic in recent years primarily due to its capabilities to increase security, privacy and transparency across industrial sectors such as banking [9], healthcare etc., blockchain meets the interests of some other entities like supply chain management [11].

Because of this secure and decentralized nature of data storage, mitigation to data breaches and cyberattacks as well as an increase in efficiency and transparency of company operationsBlockchain technology offers a way to store and share data [12] successfully.

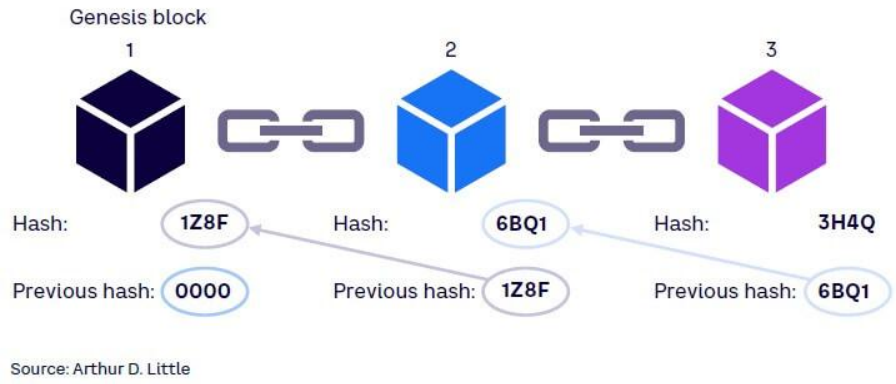


Figure 1. The Basic Blockchain Technology structure

Blockchain technology addresses the requirement for a data safe, decentralized storage and distributing architecture. As future projections predict, blockchain is supposed to grow and be adopted more widely in the next couple years especially for places that require a lot of integrity of data [13].

2.2 Healthcare Information System

Hospital Information System (HIS) computer-based platforms to process and integrate healthcare data. These are the systems with software and hardware to get, store, communicate patient information, medical record data, and other healthcare-related data. The increasingly important: The exponential increase in data created and processed [13] has made health Information Systems (HIS) to be more useful in the sector of health care, withιο· Red IS HIS is used to help healthcare practitioner maintain treatment for patients with accuracy and efficiency, bringing up the service quality process administration undertakings HIS can be classified as fundamental components for Health Information Systems (HIS) into:

- Electronic health records (EHR): Digitized version of the patients' medical history; contain an all-encompassing health record including personal demographics and clinical records · Electronic Health Records(EHRs) enable seamless interprofessional data exchange which complements care and improves coordination and continuity of care [14].
- Picture Archiving and Communication Systems (PACS): This is used to constantly store medical images (like CT, MRI, Ultrasound etc. They allow for the capture, storing, retrieval and sharing of medical images electronically is meant to improve the diagnostic accuracy, efficiency [15].
- Clinical Decision Support Systems (CDSS) Clinical Decision support systems (CDSS) assist providers w/in making informed clinical decisions by providing immediate access to the up-to-date & relevant clinical information, evidence-based guidelines & treatment recommendation. These systems lower the likelihood of medical errors & increase patient outcome [4]

Health Information Systems (HIS) support various healthcare activities patient registration, appointment making, billing and medication prescriptions. Automation of these functions help HIS release the pressure of administration, bring reduced errors and increase efficiencies in the systems. HIS also enhances the quality of care as it provides immediate access to accurate and complete patient data for healthcare providers. .

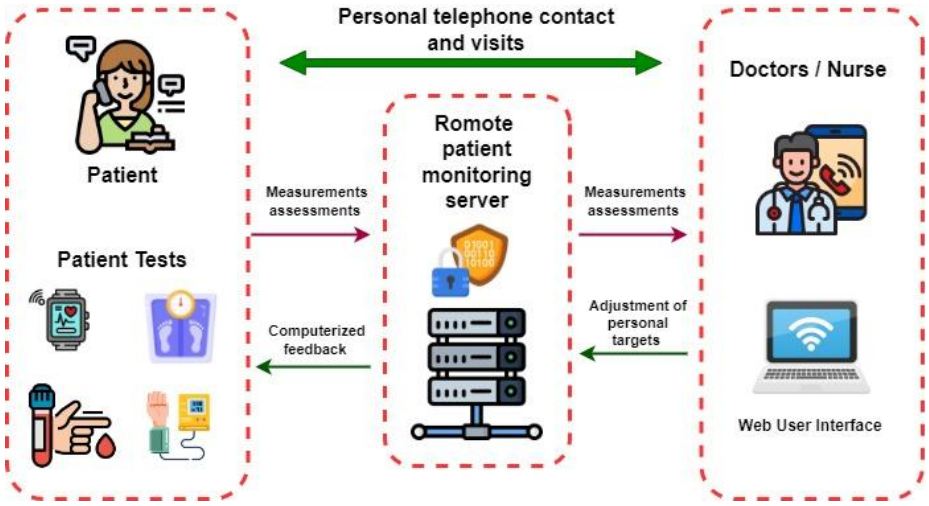


Figure 2. Healthcare Information System

Health Information Systems (HIS) has been reported to decrease medical errors, enhance patient safety and also improve healthcare delivery. While there are still formidable hurdles in terms of data security, interoperability and need to prescribe protocols severely limiting the far-reaching implementation of Health Information Systems (HIS) [5].

3. Contribution

Risks of blockchain technology and influence on the shield health information systems are very subjectively can be a lot of implications in vaccine adverse event reporting: better care, faster, more secure and private data sharing, faster clinical trials / drug approvals, making telemedicine/remote care more practical have certain costs etc The blockchain can significantly impact better patient outcomes, trust and privacy in the security of healthcare information systems including accuracy; integrity security for health care providers to make more appropriate decisions and personalized-level treatment [11]. Reduced errors and redundancies in medical records by blockchain promises to increase the effectiveness of healthcare information systems resulting in less time and resource wastage for the healthcare players as well hence improves quality care [12]. One of the most important advantages of blockchain is to increase the privacy and security in data with the use of robust cryptographic techniques as well as decentralized storage, very hard on cyberattacks and potention data breaches [13]. Blockchain facilitates data sharing through a medium where various systems can share and communicate information with each other smoothly, thereby taking away administrative burdens to ensure that a complete, accurate view of the care of a patient is available to all care providers [14]. Blockchain helps in accurate and trustworthy of clinical trial data that speeds up drug development, expedite regulatory approvals, while improving patient safety [15].

Blockchain also enables telemedicine and remote care by offering a patient data sharing platform that will help providers to deliver good quality care remotely especially in the areas which are under served [16]. More broadly, blockchain technology can lower health care costs substantially through error reduction, process streamlining and improved data sharing which frees up resources to improve care delivery, quality and infrastructure [17]. In sum, blockchain contributions to the healthcare industry are revolutionary and change the industry into more patient-centred, efficient and secure one.

4. Prior Reviews

Many past reviews are available about blockchain technology in healthcare with the help of which we could be able to convert its potentials from dreams into reality along with its threats. Summary of some of the key reviews from 2019 to 2023, their conclusions and contributions are given below:

Ghazal et al. Another study conducted by [11] in the year of 2021 is concerned with the possible advantages from blockchain technology in pharmaceutical and biomedical research data secure management on IoT platforms. This field importance of data security and privacy with the authors highlights that blockchain-enabled IoT platforms may be the answer to secure decentralized offer configurations. They also mused on the difficulties and limitations with blockchain in this respect, scalability,and regulatory roadblock, and suggested more research and initiative on all these. Sultana et al. 12 A secure medical image-sharing system using blockchain, Zero trust approach was proposed in publication year of 2020 Have observed that traditional medical image sharing systems are relatively fragile to different types of security breaches and hence he concluded that a blockchain based decentralized trustless system is more secure [1] The authors introduced zero-trust model, cryptography and smart contract for increased security and privacy in their proposed system. The research appreciates the possibility of blockchain implementation in medical imaging such as data security and privacy advantages and urges further studies. Agbo et al. Systematic review of blockchain technology applications and benefits to healthcare Agbo et al. [13] 2019 Cited:481 PeerReviewed systematicsreview those authors further elaborated on how the blockchain could revolutionize the security and privacy of healthcare systems interoperability between systems for new models of care delivery and research. They also articulated issues like regulatory constraints, technology challenges and uniformity. The review highlighted that although blockchain is very promising in healthcare, this needs more research and development stage to harness its inherent value.

In 2021, Attaran [14] analyzed potential for blockchain and health care, concentrating on how it might be used to increase data, administrative simplicity and the security of interoperability. The regulatory and legal impediments as well as data privacy issues/ethical considerations noted this is an early study. The author finally states that dose need for stakeholder collaboration and more research in order for blockchain to have its full effects to deliver health care. Merlo et al. [15], 2022 Systematic review on blockchain technology in healthcare out the literature The authors described a few of the advantages that could include better security for data, interoperability, and patient empowerment. This examines both categories of use cases EHRs (electronic health records), clinical trials as well as supply chain management. Nevertheless, the review also detailed scalability and technical limitations, regulatory infrastructure, as well as the requirement for commonality. The following emphasis was that of the collaboration and knowledge sharing between stakeholders in order to harvest blockchain fully for healthcare purpose.

Hussien et al. [16] conducted systematic review 2019 on blockchain technology possible applications in healthcare. The authors created a blockchain application taxonomy for healthcare, they analyzed the reasons for using a blockchain and put forward challenges that are to be tackled.

Finally, the paper proposed recommendations for future research and development as well as necessity of support from the standardization process and stakeholder's collaboration. 2023, Fiore et al. [17] systematic literature review on blockchain applications for healthcare supply chain In respective work, the authors assessed 47 articles and concluded that blockchain as a technology has four main applications to healthcare supply chain: traceability, transparency, efficiency but not security. This paper further addressed regulatory, interoperability and scalability issues The authors finalized that blockchain in health care supply chain has the potential to transform the ecosystem but with more research and development on various challenges. In [7] Baysal et al. [18] Discuss multivocal literature review 2023 on Blockchain in the healthcare domain The authors reviewed 55 articles and defined six broad realms where blockchain can be utilized- electronic health records, supply chain management, clinical trials telemedicine medical record sharing (health-data), health insurance. The paper specifically covered the issues and advantages in incorporating blockchain into healthcare such as data privacy/security, interoperability, regulation compliance or scalability. The authors expressed hope that blockchain has the ability to revolutionize the health space by bringing secure an open-platform for data sharing and increasing efficiency but more research and development is required to resolve existing hurdles.

Table 1: The summary of the prominent research

Reference	Year	Key Focus	Benefits	Challenges
Ghazal et al. [11]	2021	Blockchain in pharmaceutical and biomedical research (IoT platforms)	- Secure and decentralized data management - Enhanced data security and privacy	- Scalability issues - Regulatory barriers
Sultana et al. [12]	2020	Secure medical image sharing using zero-trust principles and blockchain	- Increased security and privacy for medical images - Decentralized and trustless system	- Implementation complexity - Need for further research
Agbo et al. [13]	2019	A systematic review of blockchain applications in healthcare	- Improved security, privacy, and interoperability - New forms of healthcare delivery	- Regulatory barriers - Technical limitations - Need for standardization
Attaran [14]	2021	Blockchain for data security, interoperability, and administrative efficiency	- Enhanced data security and interoperability - Streamlined administrative processes	- Regulatory and legal hurdles - Data privacy concerns - Ethical considerations
Merlo et al. [15]	2022	A systematic review of blockchain in healthcare	- Increased data security and interoperability - Patient empowerment	- Regulatory and legal frameworks - Technical limitations - Need for standardization
Hussien et al. [16]	2019	Taxonomy of blockchain applications in healthcare	- Improved data security and privacy - Enhanced patient control over data	- Scalability issues - Regulatory challenges - Need for standardized approaches
Fiore et al. [17]	2023	Blockchain in the healthcare supply chain	- Improved traceability, transparency, efficiency, and security in the supply chain	- Regulatory issues - Interoperability challenges - Scalability limitations
Baysal et al. [18]	2023	Multifocal literature review on blockchain in health	- Secure and transparent data sharing - Improved efficiency in various healthcare areas	- Data privacy and security concerns - Interoperability issues - Regulatory compliance

5. Healthcare Information Systems for Iraqi Medical Institutions

Healthcare Information Systems (HIS) in Iraqi hospitals has traditional root to the early 2000s, when the Iraq health system was recovering from Gulf War and pangs of economic sanctions in its body [19]. The health system at that time was struggling with the lack of medical supplies, equipment and personnel in Iraq. The challenges lead The Iraqi Ministry of Health (MOH) to take initiatives in the reform of all health care delivery system including introducing HIS [21]. Aim: These reforms were to improve the delivery of healthcare and eliminate the administrative procedures in Iraqi medical facilities [20].

The first HIS implementations in the Iraqi medical institutions emphasized administrative automation i.e. patient registration, scheduling appointments and billing. This in-turn help to relieve administrative load and improve the throughput for healthcare delivery. Since then, HIS in Iraqi medical institutions has grown and developed over time. MOH has launched electronic health records (EHR) and picture archiving and communication systems (PACS) that better manage patient data management, patient data quality serving as much efficient care delivery.

The MOH also introduced clinical decision support systems (CDSS), where healthcare providers were granted for instance immediate access to clinical guidelines in which certain medical information. Despite that, HIS in Iraqi medical institutions challenges the interoperability among systems, resource weakness and security holes[20]. There are efforts to combat these issues in practice, including standards adoption for HIS internationally and using blockchain to provide confidentiality and privacy of patient data [13][17].

5.1. Application of Healthcare Systems in Iraq

This part will elaborate some studies of healthcare in Iraq; Mohammed and Abdulwahid [21] In 2022, the study attempts by Mohammed Abdulwahid (2022) aimed at discover the clients' perception about family centered care and health services delivered by the Family Health Services Provider Partnership (FHSP) in Iraq. The cross-sectional study design was based on a sample with randomly selected 400 patients of out two of primary healthcare centers. The evaluation questionnaire showed satisfaction of family-centered care (communication and respect among other aspects). According to the study, clients are satisfied with family centered care especially provider communication and respect. Clients also felt more supported and included in the decision making. Family-centered care services are effective in increasing client satisfaction and participation of clients in the health care decision, but community level promotion of these services must be implemented.

In the elderly healthcare system, [22] priya and jinny (2021) Machine learning techniques were reviewed for chronic diseases. The review covered the application of machine learning across multiple studies in the fields of diagnosis, prediction and prognosis of chronic diseases like diabetes, cardiovascular diseases and osteoporosis. Interest in the article was on what potential machine learning might offer, namely accurate diagnosis leading to better treatment pathways and less expensive health care outcomes. Nevertheless, issues related to the review included data privacy and the necessity for deep validation and testing with machine learning models. Authors concluded that machine learning can change elderly patient-centered healthcare but this would require further investigation and improvement for its existing limitations.

Lafta et al. [23], evaluating the status of healthcare and care-seeking behaviors in Mosul-Iraq one year after liberation from ISIS However, there were still wide disparities on access and use driven by various vulnerable population groups like women and children The study showed a change in care seeking from trying to access care in neighboring country/ISIS regions or Mosul city to seeking care within Mosul. However, barriers like financial constraints and shortage of reliable transportation were still there. The research concluded that focused efforts are required to enhance availability and accessibility of health care services for Mosul targeting vulnerable populations.

Al-Taha et al Study The quality of primary healthcare services [24] in Al-Ramadi City, West of Iraq was assessed by Al-Taha et al. Reasoned in 2017 [24] studied the quality of primary healthcare in Al-Ramadi City (West of Iraq) a cross-sectional study with total of 350 purposively selected from primary healthcare centers recruited centrally. Evaluation was done based on the Donabedian model which comprises of structure process outcome The structure of primary health centers was found satisfactory in study had few deficiencies related to availability of medical equipments and supplies. The care process (access, continuity, comprehensiveness), and patient satisfaction was evaluated. Access and continuity of care were good but comprehensiveness Less well and patient satisfaction worse Health status of patients is good enough but patient compliance and cost-effectiveness were low. Findings: This study concluded that primary health care services in Al-Ramadi city should be increased in effectiveness as well as patient satisfaction.

Jordan et al in the current article [25][26] a systematic review of studies evaluating health system quality in humanitarian contexts (conflict areas, natural disasters and refugee camps) A total of 25 articles were included in the systematic review based on eligibility criteria and concluded that health systems in humanitarian settings are rarely well funded, resourced, nor coordinated/collaborative. The review highlighted a paucity of the evidence itself; including the absence of standardization in quality assessment methodologies and minimal timing of effect interventions have on health outcomes. As authors noted that to achieve effective and sustainable humanitarian response a more holistic and structured quality assessment of health systems in these settings is required. Results highlighting the necessity for quality in crisis, especially to ensure that the most vulnerable population is able to access the best healthcare facilities provided.

Table 2: Summary of Healthcare Information Systems in Iraqi Medical Institutions

Aspect	Details	References
Historical Context	- HIS implementation began in the early 2000s as part of healthcare reforms. - Aimed to improve healthcare delivery and streamline administrative processes. - Challenges included shortages of medical supplies, equipment, and personnel.	[20], [21]
Initial HIS Implementations	- Focused on automating administrative processes (e.g., patient registration, appointment scheduling, billing). - Reduced administrative burdens and improved efficiency.	[21]
Evolution of HIS in Iraq	- The introduction of Electronic Health Records (EHRs), Picture Archiving and Communication Systems (PACS), and Clinical Decision-Support Systems (CDSS) to manage patient data and improve care quality. - Continued challenges: lack of interoperability, limited resources, and security vulnerabilities.	[21], [22], [23]
Recent Efforts	- Adoption of international standards for HIS. - Blockchain technology is used to enhance data security and privacy.	[22], [23]
Family-Centered Care (2022)	A study by Mohammed and Abdulwahid found positive client perspectives toward family-centered care. - Clients satisfied with communication, respect, and involvement in decision-making.	[24]
Machine Learning in Elderly Care (2021)	A review by Priya and Jinny highlighted the potential of machine learning for diagnosing and managing chronic ailments in the elderly. - Challenges include data privacy and model validation.	[25]
Healthcare in Mosul Post-ISIS (2022)	A study by Lafta et al. found improved healthcare availability in Mosul but gaps in access for vulnerable populations. - Barriers included financial constraints and inadequate transportation.	[26]
Primary Healthcare in Al-Ramadi (2017)	A study by Al-Taha et al. evaluated primary healthcare quality using the Donabedian model. - Found deficiencies in medical equipment, comprehensiveness, and patient satisfaction.	[27]
Health Systems in Humanitarian Settings (2021)	- Systematic review by Jordan et al. identified challenges in healthcare quality in conflict-affected areas. - Emphasized the need for standardized quality assessment methodologies.	[28]

Previous Table 2 studies have given us an idea of how the health sector in Iraq faces challenges and what can be done to increase healthcare access and quality, improve financing from individuals. Progress in HIS and health services delivery has been substantial, but obstacles like constrained budgetary resources, threats to security and disparities in access and quality still exist. The enhancement of healthcare system in Iraq needs reinforcement of international standards, use of innovative tools and technologies (such as blockchain, machine learning etc.) as well efforts to break down systemic barriers.

5.2 Challenges Facing Healthcare Information Systems in Iraq

Healthcare Information Systems (HIS) in Iraqi medical-surgical institutions have a lot of obstacles that prevent them from being efficiently implemented and operationalized. These difficulties come from the lack of resources, technology silos and breaches, and difficulties in regard to change and quickly affect the quality of care that healthcare institutions are providing. The lack of necessary funds, health professionals, and infrastructure space is a significant concern. This phase is highly challenging to healthcare institutions that face financial restraints because of high HIS costs, such as infrastructure (hardware and software) and building and implementing training, which incur enormous burdens [29][30]. This absence of resources hinders the development of resilient and substantial systems, which in turn cannot significantly contribute to improved quality of healthcare.

Interoperability is a significant sticking point. In Iraq, many of the health facilities offer HIS systems on their own and communicate with each other very little. This fragmentation leads to isolated "silos" of patient data that create barriers to a thorough clinical evaluation and efficient care delivery. This inability to fully disseminate information leads to errors, duplicates, and inefficiencies, creating a degradation of healthcare quality.

Dark notes that security weaknesses only add to the problem. Hackings and breaches risk the protection and integrity of patient records. In reality, many medical institutions in Iraq do not have the infrastructure or knowledge to implement untested sophisticated cyber security measures. While securing patient information and institutions is hard, we need to defend all our cyber defenses. In addition, the lack of standard data formats and protocols creates additional hurdles.

Data from institution to institution cannot be studied or compared similarly because of a lack of standardization, which prevents research and improvement in healthcare quality efforts. Uniform Data Profiling is Needed to Perform Monitoring, Evaluations and Improvement Efficiencies Change resistance is another major hindrance to HIS adoption in many countries. Given the level of familiarity most healthcare providers in Iraq have with paper systems, concerns over the obsolescence of jobs, and the lack of traditional technology integration. Conquering this resistance will require systemic training, ongoing support and advocacy to show the value added by HIS for better healthcare.

That notwithstanding, the HIS in Iraq is a future that has hope despite those difficulties. Iraq can use resource and capacity constraints to strengthen system interoperability, improve security, and standardize data practice for a patient-centered healthcare system. To bring this vision to life, collective action among the national/state governments, healthcare providers, and international partners will be required to break the existing barriers and pave the way to an innovative healthcare ecosystem.

6. Design of the Blockchain-Based EHR Model

6.1 Healthcare Technology Solutions Implemented in Iraq

Iraq is embracing new healthcare technology solutions to improve healthcare services' quality and support patient outcomes. These efforts individually target broad systemic issues, employing new technologies to improve national health through accessibility, efficiency, and affordable care. Telemedicine is rapidly becoming the standard for bringing healthcare closer and accessible to underserved rural areas.

The Iraqi Ministry of Health initiated a program that connects peripheral healthcare providers with urban experts in medical networks. The results of this initiative have significantly increased access to healthcare for people in high-risk areas with poor medical infrastructure. This has been instrumental in overcoming the challenges of accurate display and timely availability of patient medical records through implementing electronic health records (EHRs). Now, in the Najaf Health Directorate, healthcare providers can view all patient information without fragmenting care management and prevent or reduce medical errors through incomplete records. Mobile health (mHealth) applications are revolutionizing patient engagement by providing self-care information, health data, and remote monitoring. In addition to enabling the self-management of patients, apps not only provide healthcare providers with great ways to communicate remotely with patients, eliminating the need for office visits and improving healthcare efficiency.

Electronic health information exchange (HIE) systems have been introduced to enhance health information exchange between healthcare providers. The Ministry of Health has launched a nationwide electronic health information exchange system that allows healthcare professionals to view each other’s patient records from anywhere within the government healthcare network. This advancement has created and improved collaboration and care coordination between providers. Artificial intelligence (AI) is a game changer in data analytics and clinical decision support. AI can help identify patterns within large data sets to accelerate more accurate diagnoses and personalized care plans that improve patient outcomes while reducing healthcare spending.

Clinical decision support systems (CDSS) have also improved decision-making accuracy with diagnostic and treatment guidelines provided based on publicly available evidence-based disease databases. These systems, developed and implemented by the Iraqi Ministry of Health, are used across healthcare settings with the goal of improving the quality of care and reducing medical errors. The example of these technological developments illustrates Iraq’s commitment to modernizing healthcare technologies for a better, patient-centered healthcare system that meets the demands of a rapidly growing and safe population.

a. Proposed Framework for a Blockchain-Based System to Protect Electronic Health Records (EHR)

A practical blockchain-based model for the Security of Electronic Health Records (EHR) in a system results from a design driven by a holistic framework that tackles some of the major issues facing the Iraqi health sector (e.g., data weak security, absent interoperability, and insufficient resources).

The framework (Figure 3) starts with a deep dive into needs in the healthcare industry today; tools and technologies that can be used have been reviewed to surface any issues with regard to security, etc. Then, the objectives for the new system (e.g., better data security, patient privacy, and efficiency in administrative processes) will be articulated. After going through the planning phase, the technical implementation of the system is designed next. A secure and private blockchain platform like Hyperledger Fabric or Ethereum is picked there. Blockchain nodes are put to work in any hospitals or medical institutions that will render the hardware and the software to facilitate these nodes. Moreover, APIs are developed for integration purposes from the blockchain system with available systems for a seamless connection and reduced distractions. Patient data is protected while stored and being transmitted securely through strong end-to-end encryption; AES-256 is used for this purpose.

A Public Key Infrastructure (PKI) is also used to govern the identities of patients and healthcare professionals so that only parties with allowed access can have data inflow. The blockchain keeps a permanent audit trail of any from inside or outside changes to the records, making the system transparent and auditable. From a regulatory standpoint, a robust law is formed that clarifies data ownership and patient consent about sharing data. The consent tracking is stored on the blockchain as a form of transparency, and Role Based Access Control (RBAC) restrictions are set up for access to sensitive data. In addition, it has to be a system compliant with international standards such as HL7 FHIR for the exchange of data and GDPR for security.

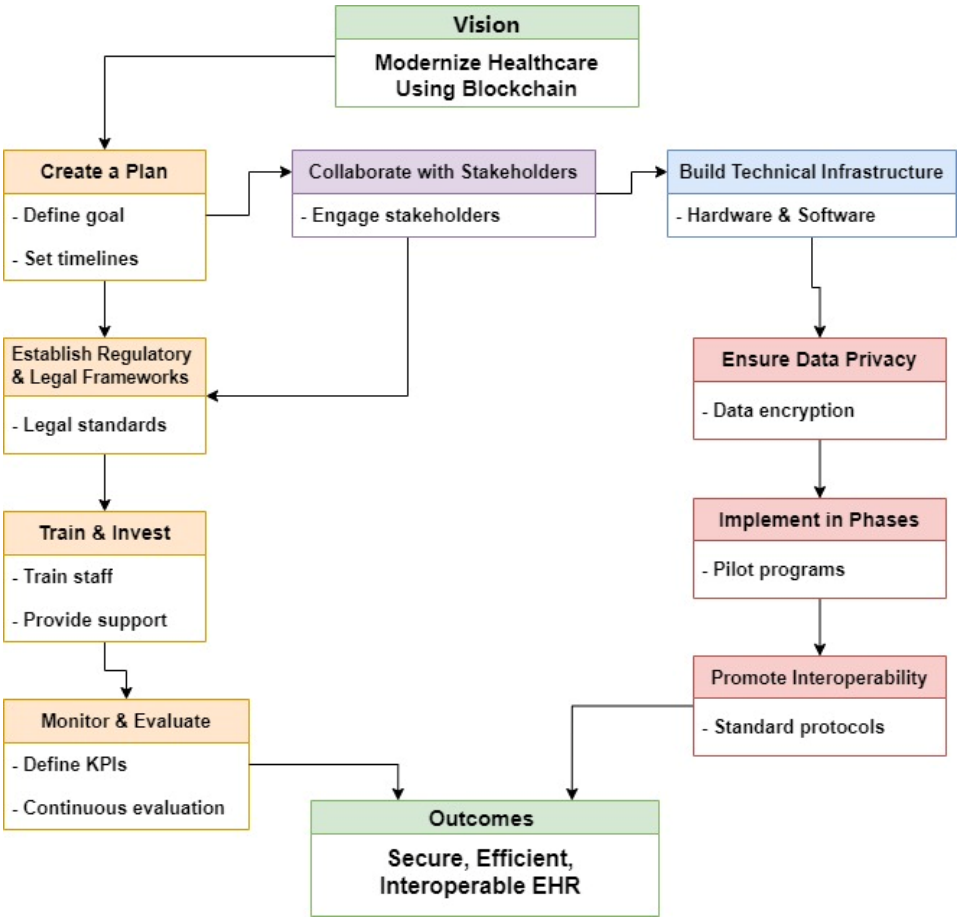


Figure 3. Steps to Modernize Healthcare in Iraq Using Blockchain Technology

A unique digital identity for patients and providers is a patient (system) that will verify their User Key via cryptographic keys and biometrics of both. Security of Data Access Smart contracts governs data access according to constraints, thus ensuring all the data is secure and monitored. For interoperability, Organizations start off by implementing standardized data formats (for example, HL7 FHIR) to make the exchange of data between various systems easy.

Note: APIs are made to integrate the blockchain system with existing systems, and then data conversions are used to match formats to make the old and new compatible.

At the end of the design phase (Figure 4), it is piloted with a single selected hospital or health institution. The Bio signals system is iteratively refined based on feedback from patients and healthcare providers before scaling it. It also includes training sessions for healthcare professionals to use the system best. Next, monitoring and evaluation are in place to measure system performance using Key Performance Indicators (KPIs) such as data access time, error rate, or patient satisfaction. Regular audits are performed for data integrity and efficiency, and then, based on the evaluation results, continuous improvement.

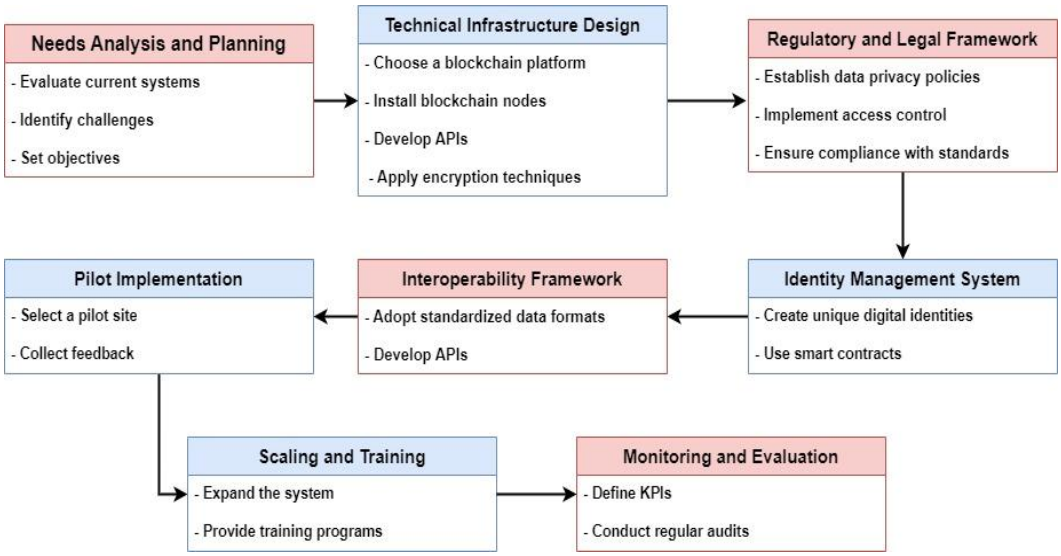


Figure 4. The logical sequence for designing and implementing the blockchain-based system

7. Results and Discussion

Drawing on the examination of methods and technologies in Iraqi medical facilities and findings of the costs to establish health information systems in Iraq, this paper presents several recommendations to revamp and promote health blockchain storage of medical records within health systems. The success of deploying a blockchain-based EHR system hinges on an effective implementation strategy. This strategy should have well-defined targets in Iraq, such as objectives and dates. The underlying technical structure, regulations, legal norms, and data privacy provisions must be clarified. A methodology can be developed, which helps lay out the steps for implementation more efficiently and aligns objectives with the healthcare system. The successful adoption of a blockchain EHR system requires collaboration with stakeholders. Blockchain technology is no more than theoretical without the contribution of a wide range of stakeholders, such as healthcare organizations, government bodies, technologists, and trailblazers. If you engage early and early, you are more likely to see widespread use and a system that does what everyone needs. Addressing the issues and thus gaining trust means you must be open for correspondence to keep updating and facilitating feedback loops throughout the long game.

Another major piece is establishing the technical groundwork. Proper hardware, software, and network systems that must be compatible with blockchain are sorely needed to make the advent of funding feasible. Iraq's healthcare system, as currently constituted, requires that healthcare providers build secure, scalable, and interoperable infrastructure as soon as possible. The future of blockchain in healthcare adoption lies with rules that enforce and save the data, don’t leak personal patient data no matter what, and promote interoperability. These frameworks should include data governance, patient consent, and protection requirements. Healthcare providers must work with the government to facilitate blockchain adoption while protecting patient privacy. Data privacy in a blockchain-EHR system should be the most important thing for patients to have proper rights over their data. Best practices for patient privacy should be implemented to lock down patient data from unauthorized access and attacks on the cyber front. Patients must be told who can look at their records and where their information is kept. The system should be developed to include encryption and access controls to keep important data safe. An incremental system install is a sound way to avoid system-level risks. A pilot designed to test the system in a select hospital allows healthcare providers to discover any required problems or tweaks before a national launch.

It also favors healthcare providers and patients who want to roll out the new system in phases. However, adopting blockchain technology requires fundamental training and human resources investment. This training has to be given to healthcare providers, administrators, and IT staff on the new system and its perks. However, technical support is also needed for the challenges and to operate without glitches. Among the most significant benefits blockchain technology offers in healthcare, interoperability must be first and foremost. To fully benefit from the opportunity, Iraq should employ standardized protocols and standard data formats that permit institutions to inter-connect freely. That reduces error rates, improves processes, and, just as significantly, improves the end-of-care quality. Continuous monitoring and evaluation must be done to sustain the effectiveness of a system.

The system's effect on healthcare delivery, patient outcomes and data security needs to be monitored through Key Performance Indicators (KPIs). An audit and user feedback will fine-tune audits, highlighting flaws that needs to be addressed. Transition from paper to EHR in Iraq getting a major overhaul of the healthcare system since it's vision would be blockchain based EHR system. It enhances data security, privacy, and interoperability but only if implemented with strategy & execution. By implementing the right vision, utilizing technology and paying great attention over patient Data Security, healthcare providers in Iraq will actually be able to introduce a system for better patient outcomes with minimum privacy issues of medical data. Such endeavor calls for commitment of stakeholders and full compliance, along with sustained trainings and/or more of the same. From creating a roadmap, working with Stakeholders and creating an adequate technical infrastructure to enforce data privacy – we start with this roadmap. Phased launch, pilot programs to begin and then the full roll-out nationwide Interoperability is enabled and performance is measured by KPIs. With those steps, Iraq can make considerable progress in modernizing its healthcare and providing high quality care while breaking down barriers for patient security data.

8. Conclusion

The incorporation of blockchain technology within Iraq's healthcare sector represents a significant opportunity to tackle persistent issues pertaining to data security, interoperability, and administrative inefficiencies. This research highlights the capacity of blockchain to transform the management of Electronic Health Records (EHR) by utilizing its decentralized, immutable, and transparent attributes. By facilitating secure data storage, enabling patient-controlled access, and promoting seamless interoperability among diverse systems, blockchain can greatly improve the integrity and privacy of sensitive medical data while minimizing errors and redundancies.

The proposed blockchain-based EHR framework is designed specifically for the Iraqi healthcare environment, focusing on technical viability, adherence to regulations, and collaboration among stakeholders. Essential elements such as cryptographic encryption, smart contracts, and decentralized identity management are employed to address significant vulnerabilities inherent in current Health Information Systems (HIS), thereby fostering trust between patients and healthcare providers. Nevertheless, challenges including limitations on scalability, regulatory uncertainties, and the necessity for technical proficiency must be recognized. To achieve this vision, a phased implementation strategy, capacity-building programs, and compliance with international standards (e.g., HL7 FHIR, GDPR) are crucial. Collaboration among policymakers, healthcare organizations, and technology providers will be essential for overcoming regulatory obstacles and ensuring fair adoption of the technology.

Moreover, ongoing monitoring and iterative enhancements driven by pilot initiatives can further optimize the system's effectiveness. In summary, the adoption of blockchain holds the promise of establishing a patient-centered, efficient, and resilient healthcare ecosystem in Iraq, in alignment with global advancements in digital health. By emphasizing innovation, investing in infrastructure, and engaging stakeholders, Iraqi medical institutions can harness the full capabilities of blockchain to enhance care quality, protect data, and create a sustainable framework for addressing future healthcare challenges.

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