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Blockchain in Health Care, Evolutionary or Revolutionary – An Evidence Based Review

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Abstract

There has been an increasing interest in blockchain technology from the health care sector in the last couple of years. The value proposition for using blockchain technology in the health care sector is to share sensitive patient data among health care entities securely and to empower patients. Blockchain technology allows patients to have an active role in developing and updating their own patient data. However, is blockchain technology really the silver bullet it seems to be?

With this paper, we aim to understand the benefits and challenges of blockchain technology in the health care sector. We discuss innovation and security implications concerning blockchain technology in health care. Furthermore, we show that there is a need for more use cases to ensure the secure sharing of data within the health care sector. In our opinion, blockchain technology will not solve the issues encountered by the health care sector; in fact, it may raise more issues than it will solve.

Keywords: Blockchain, Health Care, Innovation, Security, Implications

INTRODUCTION

The evolution of new technologies, such as Internet and data sciences, has promoted the development and innovation of healthcare and improved the construction of the smart healthcare system.

Smart health is a system with medical data as the core, which combines electronic medical record, electronic health archive, and medical Internet of things by using Internet, data transmission, and exchange technologies to build medical and health services and optimal management.

Currently, the smart healthcare industry has made a progress, but there are still problems of data security and system security.

Blockchain has the characteristics of decentralization, anonymity, tamper proof, and auditability. It was introduced in the fintech industry, Bitcoin was the first electronic payment system to truly exploit the

power of blockchain technology. Since then, blockchain technology has been infiltrating various fields of Information Technology (IT). Blockchain is beginning to shape the way information/value is exchanged in the financial sector, supply chain, healthcare system, and reputation system1.

Healthcare is considered as one of the application areas of blockchain technology. But the technology adoption in the healthcare industry is relatively slow. In many scenarios, the technology available in health care is not sufficient to capture all forms of care being catered. This is mainly due to use of old age technology to transfer information between relevant parties1.

Also, when it comes to patient-doctor interaction in India, paper-based prescription is still persistent. When someone gets ill and visits the doctor, the prescription for medicine is given in a piece of paper. This paper needs to be taken to a chemist to receive the medicines. In case of the loss of the paper containing prescription, the patient has to revisit the doctor.

In this review, we try to find the impact blockchain technology can have in the domain of healthcare. On the other hand, we will also look into the current state of blockchain technology and healthcare industry. We will then try to break healthcare into various subdomains (e.g Health Information Exchange (HIE), claims adjudication and patient billing management, drug supply chain integrity, pharmaceutical clinical trials, etc.) and explore how each section can be improved through blockchain.

OBJECTIVES OF THE REVIEW

1. What is blockchain technology and what are its implications?
2. What are the application areas of blockchain?
3. What is the current state of healthcare systems?
4. What is current state of blockchain in regards to healthcare industry?
5. Which fields within healthcare sector can make use of blockchain technology?
6. What solution concerning blockchain technology can be implemented in the healthcare sector to tackle current problems?
7. What open issues exists and what are area for future research?

BACKGROUND

The need for a decentralized or a distributed system over a centralized system was highlighted by Paul Baran in his memorandum [Baran, 1964].

Decentralized systems, on the other hand, consists of multiple central coordinators rather than a single central node. The coordinators coordinate with each other and non-coordinators communicate by coordinators. Here, one point of failure is solved by introducing various coordinating nodes. In case of a failure of one coordinating nodes, message communication can go through via other available coordinating nodes. Multiple failures can be tolerated in this architecture until the network is disconnected1.

A distributed system is a collection of independent entities that cooperate to solve a problem that cannot be individually solved. The concept of a centralized coordinator is eradicated in distributed systems and, all the nodes take part in computation and information sharing collectively. A computer system can be classified as distributed if the participating nodes do have common physical clock, do not have shared memory, are geographically separated, and are autonomous and heterogenous1.

Modern day blockchain technology derives this notion. A blockchain is "an open, distributed ledger that can record transactions between two parties efficiently in a verifiable and permanent way. From this definition, it can be inferred that blockchain provides a platform that is accessible to everyone(open), not controlled by a single authority(distributed or decentralized), fast and scalable(efficient), provides validity of information(verifiable) and, is persistent(permanent) and tamper proof 2,3.

BLOCKCHAIN ARCHITECTURE

The variants of blockchain are still evolving and maturing. There are no set of rules that break the blockchain in various layers but glancing through the bird's eye view, the blockchain can be divided into five fundamental layers:

1. Application
2. Execution
3. Semantic
4. Propagation

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5. consensus layer

APPLICATION LAYER

In this layer desired functionality for the end-user is coded. The technology stack can consist of client-side tooling, APIs, development tooling, etc. An ideal blockchain application would not follow the client-server model and no centralized server that a client would access, like bitcoin4.

EXECUTION LAYER

The instructions ordered by the application layer are executed in this layer. The instruction could be as simple as transferring an asset from owner 'X' to receiver 'Y' or could be complex ones in the form of smart contract execution which can contain multiple conditional operations4.

SEMANTIC LAYER

This layer can also be referred to as a logical layer. Transaction to be carried out and written in blocks as well as block generation happens in order4.

PROPAGATION LAYER

Propagation layer can be considered as a communication layer that enables peer to be discovered and message to be relayed. Every node in the system needs to have the latest state of the network4.

CONSENSUS LAYER

Consensus layer's primary job is to get all the nodes to agree on one consistent state of the 15 ledger. There are various ways for consensus to be achieved. Bitcoin's consensus mechanism Proof-of-Work (POW) depends upon the amount of computing power put to solve a puzzle [Jakobsson and Juels, 1999].4.

TYPES OF BLOCKCHAIN

It is crucial to know and understand different types of blockchain that exists. A solution to an existing problem might be solved in efficient way by a blockchain implementation where requires trust among involved parties and, demands involved parties to have an identity unlike bitcoin implementation. Similarly, a blockchain that was specifically built for healthcare system may not fit into blockchain for financial systems[5].

PERMISSIONLESS BLOCKCHAINS

where anyone can become a node taking part in consensus and contribute their computing power in return for a monetary reward.

HYBRID BLOCKCHAINS

where information in the block can be read, but only preselected enterprise/entities can take part in the consensus process.

PERMISSIONED BLOCKCHAINS

where information reading as well as becoming a node that takes part in consensus requires authorization and verification.

However, different categorisation can be found, where the blockchains are divided into public, consortium, and fully private blockchains:

PUBLIC BLOCKCHAINS

where anyone can read, send transaction and take part in consensus.

CONSORTIUM BLOCKCHAINS

are the ones where nodes involved in consensus are pre-selected, whereas the right to read may be public.

FULLY PRIVATE BLOCKCHAINS

where the permission to write in limited to one centralized organization, and read permission maybe public or private[5].

BLOCKCHAIN IN HEALTHCARE

One of the biggest, frequently occurring, and most damaging security incidents is health-related data breaches. "Healthcare is the only industry in which internal actors are the biggest threat to an organization. Healthcare industry is heavily fragmented. This results in inefficiency in the system and is also major hurdle as of now7.

The principal perk of using blockchain in the healthcare industry is that it provides a platform for storing health-related data by maintaining privacy and immutability. Following domains could profit from the introduction of blockchain7.

PERSONAL HEALTH RECORD STORAGE

Another benefit of having EMR that are standardized and have universal data format is that they can contribute to research. Furthermore, public health data commons could also be established, "Blockchain

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technology could provide a model for establishing a cost-effective public-health data commons.

Many individuals would like to contribute personal health data—like personal genomic data from 23 and Me, quantified-self tracking device data (FitBit), and health and fitness app data (MapMyRun)—to data research commons, in varying levels of openness/privacy, but there has not been a venue for this8.

BLOCKCHAIN HEALTH NOTARY

Providing proof-of-existence documents which are usually carried out by notaries can also be incorporated in the blockchain. For example, during the visa process, city registration and many other safety-related issues require us to provide the documents such as proof of insurance, conditions, physician referrals, treatment, status and many more[8]..

DOCTOR VENDOR RFP SERVICES AND ASSURANCE CONTRACTS

Services such as Uber where drivers bid for assignments with customers could be easily realised in the blockchain where a doctor can be assigned to a patient creating a two-way market for all health services. This could also help facilitate the price transparency between doctor and patient treatment process.

BLOCKCHAIN IN HEALTHCARE DATA MANAGEMENT

One of the biggest impact blockchain can have in the healthcare industry is data management. Different approaches and tools are being used by health care organizations and health care personnel to exchange the patient's health information. People move from one place to another due to multiple reasons, therefore they usually seek health care services from different providers in different regions[9].

EXISTING PROJECTS

Guardtime and Estonian biobank announced partnership to deploy blockchain based data access and governance tool for medical data

Philips Research is working on "verifiable data exchange", which enables researchers in a network of hospitals and universities to request data that match their need for research[10].

COUNTERFEIT DRUGS DISCOVERY AND SUPPLY CHAIN

There is no denying that when it comes to curing a disease, drugs need to be genuine. There should be no compromise from raw materials and production, to stages of storage and distribution, monitoring and tracking. Re-labelling the expired drugs with new expiry date, and counterfeit drugs that put the quality of the intended drug in jeopardy[10].

EXISTING PROJECTS

1. Accenture and DHL experimented with their proof of concept of tracking and tracing of pharmaceutical products from manufacturing to patients successfully successfully.
2. Medi ledger, was also developed with the vision to meet the demands of DSCSA. The project's blockchain network consists of look-up directory which can be accessed through permissioned messaging network that allows companies to securely request and respond to product identifier verification requests.

PRESCRIPTION MANAGEMENT

Paper-based prescription is still prevalent in developed countries like Germany. This form of prescription has many flaws: paper-based prescription can be destroyed by natural phenomenon like rain, can be tore, and be easily misunderstood by a pharmacist. Prescription misuse has been on the rise in recent years leading to large-scale problems like Opioid crisis[11].

EXISTING PROJECTS

1. BlockMedx has three core focus: prescription fraud, abuse and nonadherence. They focus on tackling prescription fraud with proprietary prescribing and prescription monitoring capabilities using blockchain technology
2. Project Heisenberg is an open source project available in Github. It is a decentralized identity management and ERP system which is built on top of permissioned Ethereum consortium network.

CLAIM AND BILLING MANAGEMENT

Claim and billing involves finance, and this section of healthcare can encounter inefficiencies and controversies. These issues mainly occur due to lack of trust and transparency in the system. Blockchain

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provides an excellent opportunity to tackle these obstacles that are prevalent in current practice.12.

EXISTING PROJECTS

1. Change healthcare's blockchain platform can process 30 million transaction per day using the hyperledger fabric framework. The company helps in claims settlement and payment through the blockchain platform.
2. HSBlox combines machine learning and blockchain to provide secure, realtime information sharing and interventions. Smart contracts automate multiparty transactions.

MEDICINE RESEARCH

One of the domains that play a huge role in the overall development of the healthcare facility and cannot be understated is research. Blockchain can help in clinical research by helping in structuring transparent checkable methodology, and it can help check clinical trial integrity given that a set of core metadata is defined. Finally, it can lead to community-driven Internet of health data, gathering researchers and patient communities, social networks and IoT data flows, at a global dimension, with granularity and transparency and decentralisation[13].

INNOVATION AND SECURITY IMPLICATIONS OF BLOCKCHAIN IN HEALTH CARE

Whether blockchain is a blessing or a curse, in terms of innovation and security, it is a matter of what it adds to a no-blockchain situation. It can add information technology (IT) or business costs or complexity[14].

Blockchain technology emerged with the promise to address this challenge; it enables innovation by implementing a modern decentralized information infrastructure. The health care sector has a long history of heavy regulation and bureaucratic inefficiency that has decelerated its innovation and an increasing number of data breaches have been reported in recent years. It is claimed that innovating with blockchain ensures the privacy and security of highly vulnerable and sensitive patient data in the cyber world. However, there are more experiments of proposed blockchain solutions than full implementations in the health care sector[15].

SECURITY IMPLICATIONS OF BLOCKCHAIN IN HEALTH CARE

It is claimed that private permissioned blockchain deployment brings the most benefits for health care applications, however, it brings security risks at the same time. Private permissioned blockchains are limited to trusted and predefined participants, and a central authority manages the rights to read and write operations of the blockchain[16]..

Private permissioned blockchain can also enable the availability of audit trails and progress traceability. In the case of using patient-generated health data for research purposes, smart contracts enable patients to give consent and permission for researchers to access their health data[17].

However, data integrity can be compromised, as the patient data entry point, which is the patient's device, can be used to impersonate the patient. Sharing patient health data with researchers poses a threat to the privacy of the patient; even if the data are pseudonymized, there is a risk of reidentification[18].

Additionally, validating a block of a large data size consumes much power and entails further operational costs. In either case, the service availability, which is critical for health care services, would be compromised. The security of patient health data with blockchain technology is still in its proof-of-concept phase, and security and privacy are not fully guaranteed so far[21]. The attempts to address security and privacy of blockchain in health care appear to be at the expense of other important features of blockchain technology itself or the needs of the health care sector[19-22].

DISCUSSION

In this viewpoint paper, we have examined the various innovation and security implications of using blockchain technology in the health care sector. Based on that, we revisit our research question: What implications may blockchain technology bring to the health care sector?

Blockchain technology is not new; however, exploring the feasibility of blockchain applications for the health care sector is in its infancy. The current state of innovating with blockchain in health care is in the proof-of-concept phase. Blockchain is a technological innovation that brings benefits and

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challenges[23]. The health care sector is expected to benefit from blockchain in terms of empowering patients and increasing immutability and traceability[23].

The needs of the health care sector include sharing vast amounts of patient health data across involved entities (ie, interoperability), regulatory compliance (eg, GDPR), data confidentiality, data integrity, privacy, and data and service availability. The feasibility of using blockchain in health care is dependent on the capability of storing and processing vast amounts of patient health data, ensuring privacy, and reducing operating costs[24].

On the other hand, if the blockchain is designed to process large data, it will cause extra operating costs due to the performance overhead, and it will expose the network to DDoS attacks. We see the need to distinguish between the benefits and challenges that are unique to blockchain and those that are common across other technological innovations. For example interoperability is not a challenge specific to blockchain per se; rather, it is a common challenge when adopting any technological innovation[25].

We argue that blockchain technology is surrounded by a controversy between marketing hype and realistic criticism. The marketing hype has manifested in the claim that blockchain is immune to common security attacks that threaten data confidentiality, integrity, and availability[25]. Meanwhile, there are realistic criticisms that show that blockchains are hackable in many ways. A comprehensive list of security threats in blockchain and their causes has already been rendered. This serves as an incentive for research on security improvements for blockchain in general as well as in health care[26-30].

Future research efforts can aid health care providers in developing the required Based on the topics and views debated in this paper, we summarize the implications of blockchain for health care in terms of both the patients and the health care providers (Table 1).

GROUP	BENEFITS	CHALLENGES
PATIENTS	• Patients are empowered with self-sovereignty through self managing personal patient-generated health data.	• Some patients may not be interested in self-managing their health data
	• The identity of the patients is anonymized.	
HEALTH CARE PROVIDERS	• Providing a decentralized database with identical copies of the same complete health information, which is made accessible to all parties in the health care chain •	• Blockchain can be resource consuming when all entities in the chain have to approve a large-sized data block
	• Facilitating collaboration and data sharing	• Compliance issues with GDPR
	• Claimed immutability of a transaction's history	• Interoperability is a challenge, and complex systems are not the best use cases for blockchain
	DDoS: distributed denial-of-service. ***GDPR: General Data Protection***	• A 51% attack, specific to blockchain, affects

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	Regulation	the integrity of transactions' data and consumes the network resource

Table 1 – Benefits & Challenges in Block chain

CONCLUSION

Throughout this paper, we have presented and discussed various views on blockchain technology and the positive and negative issues related to it. Blockchain technology is regarded as a promising technology for securely sharing health data. Throughout this work, we have highlighted the myths and important challenges concerning blockchain technology.

Further, we have questioned the applicability of blockchain technology to the health care sector. Governments may want to examine feasible scenarios in which to use blockchain in the health care sector as well as the challenges associated with the traditionalism of such a sector and the immaturity of blockchain.

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