



Using Blockchain Integration Patterns to Ensure Data Integrity in the Health Care Industry

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Authors' contributions

This work was carried out in collaboration among all authors. Author KG designed the study proposal, conducted the study and involved in every stage of the study. Author AK involved in data collection and data refining of the study. Author BS involved in statistical analysis and literature searches in the study and authors PM, SAA and ZEA reviewed and managed the analysis of the study and approved the final manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Security is crucial in the healthcare industry. Between 2012 and 2019, almost 179 million health records were exposed to data breaches. The intruders got into homes and companies to take credit card and banking information, as well as health and genetic research data. Blockchain is a fantastic

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technology for applications in the area of protection because it can keep an incorruptible, decentralized, and open record of all patient data. It is, nevertheless, secure and keeps any person's identity hidden. When dealing with decentralized technology, patients, doctors, and hospital personnel may all share the same information. On a blockchain, the cost of verifying a single transaction is negligible. You can audit a single piece of data in real time, and it's entirely visible to everyone. As a result, costless verification is economically possible. Recent audits of healthcare data, for example, have necessitated the time-consuming and costly examination of tiny units of transactions. This procedure had to be interrupted and redone on a frequent basis prior to blockchains in order to comply with regulations. Compared to traditional healthcare information management solutions, blockchain provides five potential benefits. Blockchains are ideal for decentralized administration applications, such as when hospitals, consumers, and payers want to work together without the need for a middleman. The second advantage of blockchains is that they may offer immutable archives of sensitive data, which makes them ideal for static databases (e.g., insurance claim records). Blockchains are very useful for tracing the origins and histories of digital artifacts (e.g., patient consent in clinical trials). According to cryptographic protocols, changing the ownership of an item can only be done by the person who owns it. Furthermore, the attributes' origins may be traced, making previously confirmed evidence considerably more reusable. The fourth advantage of blockchains is that they ensure the longevity, consistency, and accessibility of records. As a result, they're perfect for long-term records storage and availability (e.g., the electronic health records of patients). Patients' personal keys encrypt the data, which is only accessible with their consent, making it safer and more private. There is no method to access personal information even if the network is hacked by a hostile entity.

Keywords: Blockchain; blockchain in health data; blockchain in health care; security; data integrity.

1. INTRODUCTION

Blockchain technology is built on the foundation of the principle of a secure, distributed ledger mechanism. The system facilitates the auditable transfer of virtually every form of transaction between parties. All knowledge relating to blockchain transactions is both autonomously verifiable and impregnable for individuals without prior authorisation from both stakeholders (even externally). The first and perhaps most well-known use of blockchain technology is Bitcoin, but since the original Bitcoin release there has been a huge proliferation of blockchain applications [1].

While a landmark study or argument for blockchain technology still needs to be produced in healthcare, there is a lot of possible avenues to apply the blockchain in the existing healthcare framework. Any list is probably incomplete, but these examples reflect some of the literature written and accessible on the application of blockchain in health [2].

2. IMPLEMENTATION SEGMENTS

One big area that blockchains can promote is safe access to and contact between individuals and organisations with patient health information. Many White Papers have been released, including groups from the Mayo Clinic and MIT that define a patient information sharing system based on blockchain technologies which will enable patient-controlled access to records through institutions using HL7 Fast Healthcare Interoperability Resources (FHIR), JSON, or any other encoding system. Instead of encoding the real health care records, the models use simple comparisons, such as institutions or data lakes, to point to where the actual data is stored. The following citation describes an app that functions similarly to the Healthcare Data Gateway, but it is created by people from China, and its main feature is that it enables patients to monitor and directly manage rule-based access to their health information via a smartphone interface and authentication enabled by a blockchain network. Those proposals promote the principle of medical evidence held by patients which will have the effect of decentralising medical information in a manner that is still undetermined [3].



Fig.1. Health Data Analytics

The corporate research is a major driver of progress in health care, but serious questions about the integrity of studies have been posed with insufficient funds and publishing pressures. Organizations such as ClinicalTrials.gov and others were created to help patients identify endpoints and analyses before clinical trials and other tests were conducted. Because of its permanent, verifiable record, the blockchain was proposed as a possible digital resource for the credibility of biomedical science. In 2014, Benjamin Carlisle, followed by many UK researchers, suggested that researchers could use blockchain in order to document the predefined aspects of their experiments, such as the architecture of the sample, the analysis strategy and the data structure, and later on tested by literature consumers in order to lessen the prejudice that can be introduced in post-hoc analysis. The Blockchain also provides the opportunity to validate the completeness of current scientific results and analysis by external observers, even though the evidence itself is not made public. These kinds of implementations will strengthen the integrity of scientific science and build public confidence in medical research [4].

3. RESEARCH STATEMENT

For personal EHR administration, Blockchain technology is also a feasible option. Patients may be remunerated with tokens for their sharing of health data and research findings with medical practitioners and their research partners, if so-called 'smart contracts' are used. One global blockchain may serve as the foundation for a worldwide electronic health record that keeps patient information safe, stores it in a verifiable way, and is publicly available in real-time by

anybody in the healthcare service provider chain. While blockchain is a developing industry that eliminates dangers of middlemen, it is based on a digital distributed ledger and consensus algorithm that is still being developed. Prior to the early 2000s, research applications focused on the financial industry. However, the notion of decentralisation has been applied to a wide range of domains, including education, the Internet of Things, banking, supply chain, defence, governance, healthcare, and many more. Stakeholders (provider, patient, payer, research organisations, and supply chain carriers) want the health care system to be interoperable, secure, genuine, transparent, and quick.

4. REVIEW OF LITERATURE

Tandon, A. et al., underlined that Blockchain has earned widespread recognition for its capacity to improve current business models and frameworks by inducing both innovation and change. Consequently, the management domain and its processes have seen increased academic and business attention as a result of this technology. Even though a great deal of study has been done about the application of blockchain in management, this topic gives a jumbled, fragmented perspective of the existing breadth and boundaries of knowledge around the subject. This work deals with this missing piece by reviewing the existing literature using bibliometric methods to compile it.

Tanwar, S. et al., presented that due to their complexity and expense, modern healthcare systems are described as complex and pricey. Still, with enhanced health record management,

utilising insurance companies, and utilising blockchain technology, this can be lessened.

While blockchain was originally designed to offer decentralised records of financial transactions that were not reliant on centralised authorities or financial institutions, recent modifications have extended its functionality to cover digital contracts and assets as well. Better transactions that include medical information, insurance billing, and smart contracts have been possible because to advancements in blockchain technology.

Zhang, P. et al., mentioned that by providing secure and pseudoanonymous transactions, alongside agreements directly between interacting parties, blockchain technology frees users from needing to rely on a centralised authority to certify information integrity and ownership, as well as mediate transactions and exchange of digital assets. While possibly addressing urgent concerns, the features it has, such as immutability, decentralisation, and openness, may also be used to help ensure the medical history remains full and information about patients can be readily found. Healthcare system efficiency and effectiveness demand safe and seamless communication between different systems and platforms.

5. BLOCKCHAIN INTEGRATION TECHNOLOGIES

This definition combines the principle of HIE with the blockchain, but concentrates more on maintaining a patient's personal health record (PHR). No development PHR based on this technology has been announced, but concepts such as MedVault are using alternate blockchains such as Colu to explicitly store patient information on the blockchain. Others like eHealthWallet have already created blockchain-based PHR prototype. Patients may then disclose or permit access to their data through physicians and other health agencies [5,6].

The majority of the proposals create blockchain's power to archive patients' health history immutably, enabling them to grant and withdraw their medical records as they wish. In a standard scheme, a health association maintains and maintains the patient's health record (e.g. hospital, clinic, etc.). Information may be communicated openly between the organisation and a Regional Health Information Organization (RHIO) or any entity which has a business relationship with the institution of origin. If the organisations are not entered into a business arrangement, one-off demands can be made, however time and wait may be required [7,8].



Fig. 2. Dashboard for Blockchain Data Analytics

Because meaningful application stage 3 is being introduced in healthcare institutions, a drive has been made to develop patient-oriented application programming interfaces (APIs), which enable patients to retrieve their records directly from the hospital and to share them with the provider as necessary.

A patient-controlled blockchain-enabled smart contracts can be used to allow the direct exchange of medical records between institutions. Including the patient's preferences and allow the patient to decide the subset of the record to be exchanged or to place an end date on the authorization [9,10].

Block chain from Gordon et al. has these five features for effective patient-driven interoperability:

Digital access laws: The blockchain-enabled digital access rule is standardised, enabling it to be accessed by various organisations and allowing patient editing of the rules at any time using a smartphone or mobile app.

Data aggregation: by using the digital access law, patients should also compile their data (or metadata) through organisations, making a full record of their wellbeing.

Data liquidity: As soon as a patient (or legal representative) accepts the transition to digital access laws, data can be quickly distributed to

the requesting organisation to allow access to critical time information such as allergies, "code status," etc.

Patient identity: while no national patient identification is available, organisations may use the public key of the person allocated by blockchain to fit their local identity to start exchanging data between systems. Immutability of data: Since all updates to the blockchain are registered and unchanged, the leakage probability is kept to a minimum and the database can be checked at any time.

The emerging status of technology for blockchain-based personal health records is subject to many limitations [11]:

The first challenge for the block chain is its failure to manage the clinical data transaction rate. Blockchain records modifications to a limited volume of data (such as balance of accounts, identity of the owner, etc.). On the other hand, the costs involved with creating a massive ledger to record a large amount of data, and the difficulty involved in doing proof-of-work on this ledger, prevent storing a large amount of data on the blockchain [12]. Proposed solutions include that using a different approach to consensus than proof-of-work, verify evidence using proof-of-stake. Patient data can be held on private (permissioned) regional blockchains with throughput capacities to support high transaction volumes while being validated only occasionally.



Fig. 3. Multi-Dimensional Dashboard for Blockchain Data Analytics

The lack of anonymity and authentication is a second weakness of blockchain. Though the public key used in generating the Blockchain identifier is cryptographically derived, this is also pseudonymous because, if associated with a patient, other simple demographic information can be used to identify the patient, and the flow of transactions can be traced on the Blockchain [13] after the public key has been connected to the patient. Some solutions have been proposed to this problem:

- Use blockchain approved (member only) to prevent public disclosure.
- Basic demographic information can be encrypted as well to keep it out of reach.
- Store confidential data off-chain, using pointers and metadata in a chain with an emphasis on authorization for access to the requested data. This also allows patients to delegate separate rules of access to their data for various uses

Since several blockchain initiatives rely on medical data, patient engagement is needed more than the conventional institutional model. Institutional control must be set up such that such credentials can be assigned. It would be critical to obtain patient buy-in in order to make public key management more user-friendly. In order to make improvements to the block chain, the patient would still need to keep track of their secret [14]. If this happens, there must be a method to retrieve missing password.

Incentives provide the greatest hurdle to universal implementation of blockchain in healthcare. Thought-provoking An introduction of a patient-facing API is required, but the management of access control of patient records to patients is not part of stage 3 [15]. Setting up a blockchain would not have much of an incentive for the institution as it just gives the patient more leverage. There are a few solutions to the problem:

- Work for the administration to enhance government support for patient-controlled medical records [16].
- Researchers who pay for a blockchain to be developed would obtain access to patient data, which can be used for analysis [17].

Previous examples use the blockchain as a safe reference point for credentials, access, and data

positions, but not as a direct data storage medium. Another venture, Tierion, has developed a project called Chainpoint that proposes to store individual medical data on the blockchain using Proof of Existence and Merkle Roots, thus reducing transaction demands on the infrastructure.

Using a blockchain technology will help cut down on administration expenses and expedite the claims process by using smart contracts to automate claims adjudication and payment processing. An example is that, in the case of a process or by seeing a vendor, a transaction is registered in the blockchain [18]. According to the contract's defined conditions, premium payout and patient co-payment are both issued without insurance consent [19].

A critical issue in the developed world is the high percentage of counterfeit pharmaceuticals. It is estimated that one in ten prescription devices on the market are counterfeit [20]. To ensure patient protection, it is crucial to preserve a robust audit trail as well as the drug's credibility. The platform can also be used in the prescription drug distribution process, and by doing so, it can use smart contracts to record and verify prescriptions [21].

Additionally, the company is interested in data processing, which includes securing the country's health record database through a partnership with the eHealth authority of Estonia [22]. Other than that, recent developments have seen a partnership with Guardtime's MyPCR mobile app and Instant Access Medical and Healthcare Gateway in the UK for managing patient health data and ensuring prescription adherence [23].

6. IMPLEMENTATION PATTERNS ON BLOCKCHAIN IN HEALTHCARE

Blockchain Health is a tool designed for healthcare study data management that allows users to grant researchers permission to access their medical data, as well as watch how that data is being used [24].

BlockMedx is an organisation whose goal is to use the blockchain technology to transfer prescriptions for controlled substances such as narcotics from doctors to pharmacies, which are then delivered to patients [25]. The organisation that has collaborated with many pharmaceutical manufacturers and seeks to provide a transparent, stable, and interoperable network for the pharmaceutical supply chain.

```
E:\Python27\blockchain>python blockchainhash.py
Block #1 inserted in Blockchain
Hash Value: e7de0e16bd31d89de438f3034b744dc10f1eea4adff948960e0828914d0f7b66

Block #2 inserted in Blockchain
Hash Value: 919225537d90c280e04dc9d344389789d359e97b12a28069729db2c256b4422e

Block #3 inserted in Blockchain
Hash Value: 377247057a84c0ba35c1ea0196fefcc8660ee9ac5dcbbd4b424411ffc3d224f2

Block #4 inserted in Blockchain
Hash Value: 7755fe827549ac829c8d509783d3fafd2e4fe019afca8ea8ce8bb84014c1f9c1

Block #5 inserted in Blockchain
Hash Value: 707d280e76a49a6576b6016cfac4a667cc42bd90f6448858df2dabdc831086a7

Block #6 inserted in Blockchain
Hash Value: 1738e933f8a662141c258ead3fdb6a55cb18281169901653667f135c855e0c10
```

Fig. 4. Blocks Generation

```
E:\>cd Python27
E:\Python27>cd blockchain
E:\Python27\blockchain>python blockchainserver.py
* Serving Flask app "blockchainserver" (lazy loading)
* Environment: production
WARNING: Do not use the development server in a production
Use a production WSGI server instead.
* Debug mode: off
* Running on http://127.0.0.1:5000/ (Press CTRL+C to quit)
```

Fig. 5. Execution on Python Based Server

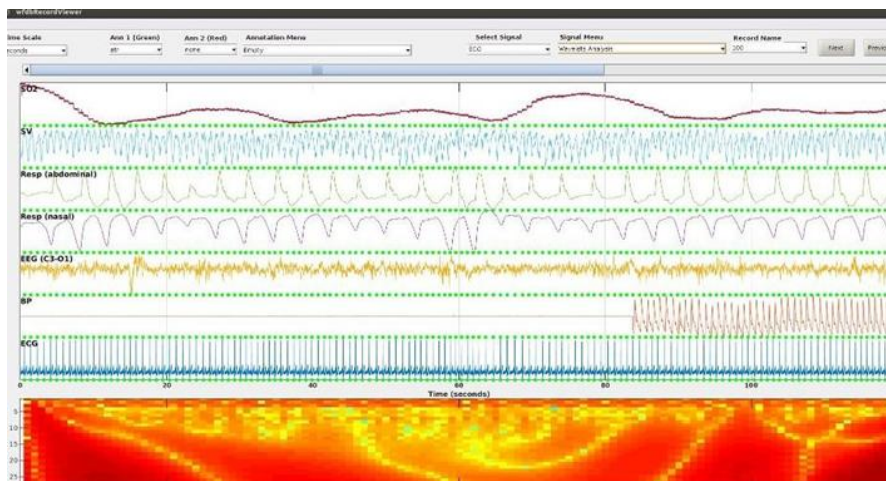


Fig. 6. Log Record

Table 1. Analytics of Parameters

Attempt	Security Parameter: Traditional	Security Parameter: Blockchain Based
1	83	99
2	76	97
3	79	98
4	77	93
5	74	97

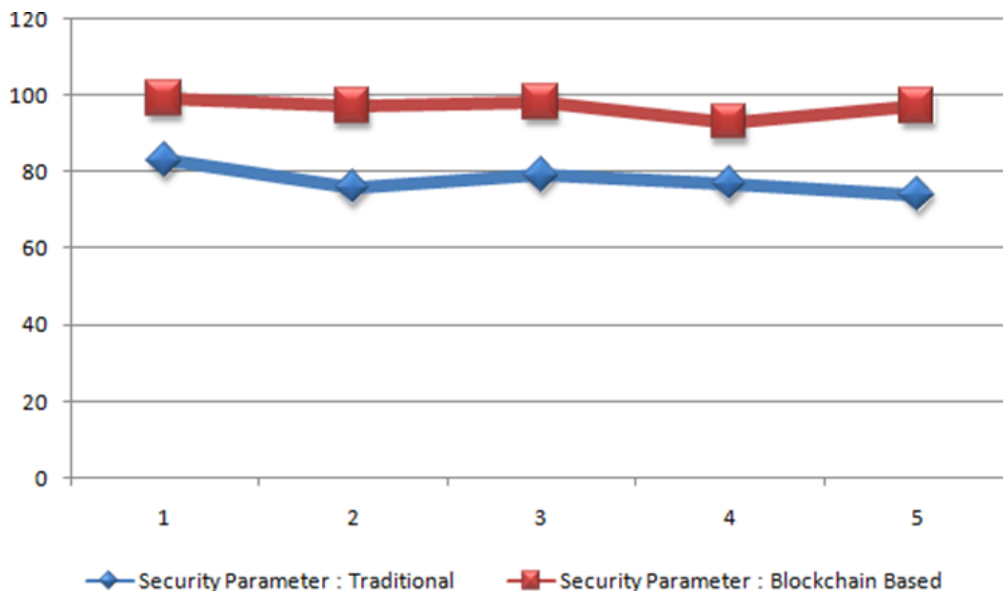


Fig. 7. Analytics of Parameters

VeriPharm conducted a proof of concept demonstrating how one company's pharma manufacturing pipeline could be easily tracked and verified from raw materials to product administration, allowing verification in real time and leading to more efficacious drugs [26]. Blockchain technology has a large number of possible applications within healthcare, and it is very likely that we will see progress in this field in the future. The first healthcare-oriented blockchain meeting, Distributed: Wellness, was held in Nashville, TN, in 2016 [27]. The ONC's Tech Lab released a Blockchain Challenge in July, 2016. Creative. Blockchain technology can gradually be incorporated into medical conferences as the healthcare blockchain ecosystem expands [28].

7. CONCLUSION

The structure of a blockchain (inherent in the database design) mandates that it is a special form of database. The data is structured so that you can only read it once. Thus, blockchain databases are created with the only-ever-created rule in mind, which ensures they are uneditable and cannot be erased. Blockchain decentralised ledgers (computer file assets) store data as a transactional asset, with storage capacity that must be equal to or less than 1 kB. Often, data entry and distribution is quicker and more reliable and cheaper when done through the InterPlanetary File System (IPFS) rather than centralised databases. A blockchain in healthcare implementation is justified because it

includes all of the different tasks involved in maintaining a traditional healthcare information system, including but not limited to performing backup data systems, keeping recovery processes in place, and ensuring that all of the information is up-to-date. Blockchain systems store data in a distributed manner, removing the central point of failure that results in a system backup. On top of that, every node stores an identical copy of the data. Reducing the number of transactions occurring between information systems frees up space for more important transactions, thereby allowing the healthcare infrastructure to function more efficiently.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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