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BLOCKCHAIN APPLICATIONS IN MEDICAL SCIENCES

Medicine

Dr. Vasantmadhav Hegadekatti M.D. Consultant Physician & Associate professor Department of Medicine, Karwar Institute of Medical Sciences Karwar -581301 India

Dr. Kartik Hegadekatti* I.R.T.S. Divisional Manager, Commercial. South Western Railway, Ministry of Railways, Government of India Bangalore, India.*Corresponding Author

ABSTRACT

Many problems relating to record keeping, medico-legal issues and ethics exist in the medical field. Blockchain Technology can enhance the efficiency of the Medical sciences. This paper looks into the various aspects of Blockchain technology applications in Medical science.
Firstly, we discuss the basics of Blockchains and Cryptocurrencies like Bitcoins. Then we discuss Blockchain applications in the Medical sciences. The paper concludes by summarizing the applications of Blockchain Technology in Medical sciences.

KEYWORDS

Medical, Blockchain, application, medico legal, medical record, patient privacy

INTRODUCTION

A Blockchain is a widely distributed collection of data that keeps a continually expanding register of records, fully and unfailingly protected from any alteration or modification. Each block has a time-stamp and the link to the previous block. [2] A cryptocurrency is a medium of exchange [sort of digital money] using coding procedures to safeguard transactions. They are also used to create additional units of the currency.

A Cryptowallet is an encoded electronic device that allows an individual to make electronic cryptocurrency dealings. Each wallet has two keys. A public key visible to everyone. But it can be operated by only a person who has a private key. Dealings on the cryptocoin network are usually anonymous.

When people send cryptocoins to each other, someone has to keep record of who spent how much and when. In case of fiat money [like dollars] it is done by intermediaries like banks. But the cryptocoin network details all the transactions made during a certain timeframe into a list. This list is known as a block. Chronologically created multiple blocks are linked to each other serially, through a set of mathematical algorithms. These interlinked blocks form 'Blockchains.' A certain set of people who actively track these transactions on their computers, called 'miners' verify these transactions mathematically and register them on the Blockchain. These miners are rewarded with freshly created Cryptocoins. These operations are run on a highly secure controlled Blockchain platforms. Nationcoins are completely managed by the Sovereign Authority i.e. the Government. This system is based on the K-Y Protocol [1]. The K-Y Protocol is a set of rules and instructions to implement the Regulated and Sovereign Backed cryptocurrency Using Blockchain applications for medical science has several advantages [2]. Likewise, there are several areas in medical science where Blockchain technology can be deployed. We will now analyze each application in detail.

(I) RECORD KEEPING

A medical record is a document that records patient health data (past and present) and also documents treatment strategy for the patient's health condition.

A health record begins the moment a patient registers himself/herself at a health unit (referred to as a clinic). A great amount of confidential data is stored in a patient's medical record. A medical record contains subjective data–a doctor's perception/observation of the patient's illness; and objective data-catalogue of health parameters (numerical or otherwise) measured by health personnel. The sum total of all this information is used to arrive at a conclusion (usually diagnosis) which decides treatment options.

Due to the importance of medical records in arriving at a conclusion, great care needs to be taken to maintain clarity and accuracy, chronologically within the records. This is necessary to maintain effective communication between health care personnel and patients.

Medical records have great medico-legal significance. Certified medical records have legal status in the court of law.

Due to the legal aspects involved, medical records are subject to tampering. Many a time, there is post-facto editing of medical records which may impact a legal case where such records are involved. It is therefore pertinent that there be a way out to make medical records tamper proof after they have been created and filed in the original form. Thus, medical records need to be tamper proof, clear, accurate, unambiguous and confidential to provide a holistic healthcare experience for the patient.

Blockchain technology provides a method where data, once created, can be stored tamper proof. Access to such data can be made permission-based. This provides a high level of confidentiality.

The idea is to create a controlled blockchain of medical records. It can be hospital based, regional or even national.

Envisage a scenario where patient A goes to a hospital and gets healthcare. Medical data generated about the patient is logged into a blockchain. Considering each medical record as a discrete set of information, it is logged as a transaction. Across a nation if 5 patients undergo medical checkup every minute, a block of several sets of data can be generated every few minutes. This data can be processed and credentials of healthcare personnel (filing the data) can be verified. If authentic, this data is added to the medical blockchain. If every patient has a unique immutable medical ID. i.e. a patient's medical ID will remain the same, throughout the country, (no matter where he gets his health check), then, across a given period, we will be able to gather a near complete health picture of a particular patient, without actually revealing his/her identity.

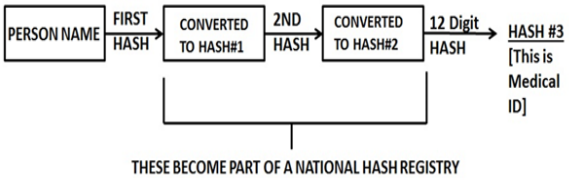

FIG 1 -PATIENT REGISTRATION AND CREATION OF ID

The medical ID of the patient will be linked to individual ID through an elaborate Layered ID Security (LIS). This is necessary to prevent data theft. The LIS works in the following manner.

The hash registry will have 2 parts. Part I will contain all hash #1 of all patients. Similarly, part II will contain hash #2 of all patients. If some thief tries to match medical ID with individual ID, he will first have to get his hands on the hash register. He would need to have access to

both parts of the hash register to successfully link a medical ID with individual ID. Both parts of hash registry will be stored separately under different private keys. Access to the keys will have a multi-layered security system. It will be accessible only through court orders for various legal purposes (Insurance claims, inheritance, medico legal cases etc.)

The above envisaged system has several advantages.
(1) Post-Facto tampering of data becomes impossible.
Frauds related to post-facto tampering of medical records will become impossible to execute as the medical records become permanent on the blockchain. Health personnel have to log medical records with great care and responsibility because it will be impossible to alter it later.

(2) Standardization of Medical Record Keeping (MRK) will become possible.

A national (or international) standard for MRK will be possible as data entry into blockchain has to meet uniform standards. Currently, various institutes follow various methods for MRK. But with the advent of blockchain in medical science, the medical community has to set a uniform standard for MRK. This is necessary to ensure reliability and credibility of medical records on the blockchain.

(3) A single medical ID can be tracked across the past and also into real time. A particular case can be studied by a group of specialists or medical students in real time (even as data is being entered) without the patient's individual ID being disclosed. For instance, patient A with medical ID 123, consults his physician. The physician orders a few lab tests. Meanwhile, the case history is added to the blockchain. This can be viewed by another team of specialists thousands of miles away. Two days later, test results arrive, the physician uploads his observations and lab results on blockchain. The distant team gets to know in real–time that medical ID 123 has such-and-such disease and the treatment planned. If the diagnosis or treatment is found wanting, the institution providing the treatment can be contacted, and the issue discussed. In all this procedure, the patient's personal identity is kept confidential.

(II) RECORD TOKENIZATION AND FEE HEDGING FOR PATIENTS [3]

Medical records can be tokenized, as follows-.

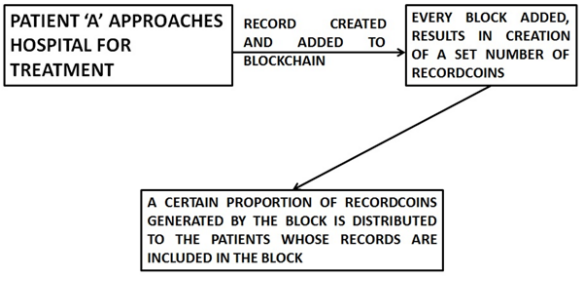

Fig 2 -Medical records tokenization

In order to discourage spurious filing of patient records to corner more coins, the number of records filed per block and per day will be restricted.

This record coin will serve as a record that a patient's medical record has been verified. and the medical record is now tokenized. However, the token will not contain any medical data of the patient. Hence, it can be freely traded, bartered or exchanged by the patient.

If a patient is severely ill, he/she will be having extensive medical records. As a result, he/she will also have quite a good number of record coins in their wallets. Depending on the price of the record coins (as decided by the market or the government), the patient can monetize his/her record coins and pay for a part or whole of her treatment.

In this way, a patient can monetize her medical records and use the money to pay for the treatment. In a way, the disease pays for its own cure.

Medical record tokenization has many features: -
(1) A poor patient can at least pay for a part of her treatment by monitoring medical record tokens.
(2) The several millions in the world without the safety net of social security or medical insurance can pay for a part of treatment through this method. In a way, the medical blockchain automatically provides a sort of health insurance (at least partly)
(3) The Medical Record Tokens (MRTs) can be bought by research institutions, pharmaceutical companies etc. MRTs will become the internal payment system where the payer can have access to medical records-sans patient's personal identity-for research and development purposes. Layered ID Security System (LISS) will ensure the patient's personal identity.

(III) CREDIT RATING OF HEALTH INSTITUTIONS

Picturize a medical blockchain where hundreds of institutions are logging in thousands of discrete units of medical data on the blockchain every day. Over time, several medical cases will see the conclusion of patient's treatment. Either the patient's health improves, worsens or there will be no change. All these results on a case-by-case basis can be evaluated by anyone on the blockchain. Based on this evaluation, health institutions can be graded and ranked.

A medical blockchain can thus be used as a reliable indicator of a hospital's performance and all of this can be done without revealing the patient's individual identity.

A credit–rating system for health care institutions can thus be established. This will improve the standing of an institute in the eyes of the public. Consequently, those hospitals which provide inferior or sub–standard services can improvise their healthcare model to move up the rankings. Just like the LISS, if need be hospital's identity can also be protected through a layered security system.

Over a time, a hospital's credibility and reliability can be objectively gauged. Similarly, a doctor's success rate can be evaluated by using patient's health records on the blockchain (make separate sub heading)

(IV) PATTERN RECOGNITION AND MACHINE LEARNING

Data on the medical blockchain has a unique feature. It is devoid of the patient's individual personal ID. This allows any person or entity to freely use permitted medical blockchain data for R & D purposes. Pattern recognition and machine learning are two such methods of R & D.

Using pattern recognition and machine learning, a medical blockchain based Artificial Intelligence can be developed which can predict disease progression and treatment response in patients, this will be a giant leap for medical science. It might be possible that

(V) IN THE PHARMACEUTICAL INDUSTRY

A medical blockchain can also be used by the pharmaceutical industry for various functions.

(1) Supply Chain Management and Logistics of Drugs
Pharmaceutical companies manufacture drugs in large quantities. Due to the extensive areas of distribution and variety of drugs to be transported, drug logistics is a challenging task. Various drugs have different storage conditions. Drugs are also subject to pilferage and misuse.

Drug production and supply chain management can make use of blockchain technology.

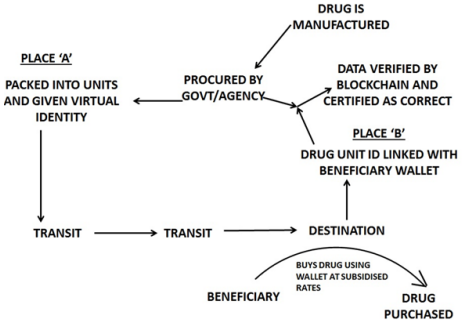

Fig 3 -Blockchain in Pharma industry

(2) Post-Facto Clinical Trial for Improvement in Drug Dynamics.
Clinical trials occur in controlled settings once a drug comes into use in the market, many new things about the drug become known. Some

patients may respond to the drug way differently than that predicted by clinical trials. Such information [i.e. the effects of the drug when used by the general population] is not reliably recorded. Neither any system exists for recording such data.

But, by medical blockchain, healthcare personnel can glean valuable data about drug dynamics. Data on the blockchain (sans patient's personal identity) can be found which refer to a drug's efficacy, reaction, adverse effects, etc. This can be further processed using data analytics over a medium to long period, a coherent picture of drug impact with the general population as sample size will be available. The drug company can either improve upon or take other actions regarding the drug to make it better and more efficient. This process of evaluating drug impact using blockchain when the drug is used by general population can be called a post–facto clinical trial.

A post-facto clinical trial provides several advantages hitherto not possible by conventional methods.

(a) Drug efficacy can be improved to provide better patient satisfaction.
(b) Drug analogs can be synthesized without the side–effects of the original drug.
(c) A chemically different drug with similar effect can be created and fresh patent obtained for increased profitability.

(3) Preserving Corporate Secrets in the Pharma Industry
A pharmaceutical blockchain, Pharmachain can be used by pharma company. All drug trials and proprietary information can be stored on the Pharmachain. It will be a controlled blockchain i.e. permissioned. This will make it possible to keep track of personnel access to sensitive company data.

The Pharmachain will be an R & D blockchain. It can be monetized. A company having robust pharma R & D will have a heavier blockchain (logically speaking) as its scientist will log more details which R & D are related. Each block will lead to generation of a certain number of Pharmacoins.

Like any other brand tokenization model, Pharmacoins can be monetized to create revenue for the pharma company. For a pharma company to have a credible blockchain presence, product to blockchain ratio has to be higher.

$$\text{PB RATIO} = \frac{\text{NUMBER OF PRODUCTS}}{\text{TOTAL NUMBER OF TRANSACTIONS IN BLOCKCHAIN}}$$

Fig -4

Higher the PB ratio, more credible is the research by the company.
Similarly, pharma R & D profitability can be measured as RB ratio (revenue to blockchain ratio)

$$\text{RB RATIO} = \frac{\text{TOTAL REVENUE OF COMPANY}}{\text{TOTAL NUMBER OF TRANSACTIONS IN BLOCKCHAIN}}$$

Fig 5

Thus R&D output can be quantified through blockchain technology.

(VI) IN FORENSICS AS PROOF-OF-EXISTENCE

Any information put up on the blockchain becomes resistant to tampering. This can serve as a source of immutable medical record which can be used in a court of law.

Since the data is resistant to manipulation, the court can see with precision, a timeline of events recorded on the blockchain. This feature will help the court in a large variety of cases involving medical records. Even insurance disputes can be settled by with the help of medical blockchain.

(VII) IN THE REGISTRATION OF BIRTH & DEATH CASES.

The medical blockchain can be used to register birth and death cases as well. In fact, by doing so, it will be possible to record the full–spectrum of medical data of a citizen right from birth, intervening life period and death. Hitherto, it was very difficult to put all health records of all citizens in one place. Now with blockchain, it will be possible to record the whole gamut of medical data of all citizens from birth to death in a single place and in a safe manner.

CONCLUSION

We have seen how blockchain can be applied in medical science to achieve a wide array of functions hitherto not possible by centralized record keeping.

Recording medical data on the blockchain makes it difficult to tamper with. It provides a high level of confidentiality and selective access. Moreover, it will greatly help to standardize medical record keeping across a vast geographical area.

Blockchain based medical data can also help in
(1) Tokenizing & monetizing health records.
(2) Offset a portion of cost of medical care.
(3) Credit rating of hospitals and doctors.
(4) Forensics and medico-legal cases.
(5) Pharmaceuticals.
(6) Pattern recognition and deep learning.

Thus, with its varied applications in the field of medical science Blockchain needs to be adopted by governments and institutions in order to provide public with wholesome healthcare.

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