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ARTICLE

A Novel Application of Blockchain Technology and Its Features in an Effort to Increase Uptake of Medications for Opioid Use Disorder

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ARTICLE INFO

Article history
Received: 11 January 2023
Revised: 28 January 2023
Accepted: 2 February 2023
Published Online: 8 February 2023

Keywords:
Blockchain
Opioid use disorder
Data Security

ABSTRACT

The opioid crisis has impacted the lives of millions of Americans. Digital technology has been applied in both research and clinical practice to mitigate this public health emergency. Blockchain technology has been implemented in healthcare and other industries outside of cryptocurrency, with few studies exploring its utility in dealing with the opioid crisis. This paper explores a novel application of blockchain technology and its features to increase uptake of medications for opioid use disorder.

1. Background

The misuse of an addiction to opioids is a national public health crisis that has a significant impact on society. In 2017, an estimated 1.7 million Americans suffered from opioid use disorder (OUD) and over 47,000 Americans died due to an opioid overdose. Among adult patients who suffered from chronic8 pain, between 21% to 29% who were prescribed opioid medication misused it, and 8% to 12% developed OUD [1]. The economic burden of non-medical opioid use attributed to health care services,

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DOI: https://doi.org/10.30564/aia.v4i2.5398
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premature mortality, criminal justice activities, child and family assistance programs, education programs and lost productivity was estimated to be $188 billion [2]. Effective treatment for opioid misuse is available. Food and Drug Administration approved medications for opioid use disorder (MOUD) are methadone, buprenorphine, and naltrexone. Studies showed that treatment with MOUD resulted in decreased mortality, reduced opioid use, retention in an opioid treatment program (OTP) [3,4], and long-term treatment improved outcomes [4]. Federal regulations mandate that counseling and behavioral therapy accompany methadone treatment and buprenorphine providers have the capacity to recommend counseling to patients.

As digital tools continue to proliferate, researchers and clinical practitioners have adopted them to address public health issues. Applications of technology like mobile health to educate [5], improve access [6], and program maintenance [7] of MOUD have been studied. Papers about the utility of blockchain technology in mitigating the opioid crisis have been proposed for data collection [8], pain management [9], prescription tracking, and pharmaceutical supply chain [10]. This paper highlights features of the blockchain technology as it applies to MOUD.

2. A Primer on Blockchain

Blockchain is an immutable distributed public ledger [11]. It came to prominence as the transformative technology that launched Bitcoin. Blockchain has utility beyond cryptocurrency and has applications in a variety of industries such as finance, e-commerce, governance, and healthcare [12]. Our main inspiration for this paper is the successful use of Blockchain technology in Decentralized Finance (DeFi). DeFi is a decentralized permissionless replication of the current traditional financial infrastructure that provides secure transactions using smart contracts and blockchain verification [13]. Blockchain has potential to decrease both the cost and time for transaction completion compared to the traditional banking system. Moreover, it has potential to lead to the democratization of financial transactions and loosens restrictions on the transnational flow of money [14]. DeFi ensures that all financial transactions are transparent and public while preserving privacy through encrypting user information.

3. Features of Blockchain that are Relevant to MOUD

3.1 Immutable Chain

A key feature of blockchain technology is the immutable block. A block is akin to a digital folder that contains transactions, timestamp of the transactions, and an encrypted code called a hash [11]. Blockchain sequence follows a linked list data structure and hashes connect blocks as each block contains its hash and the hash from the previous block, as shown in Figure 1 [15]. In the case of patients with OUD, patient records could be developed into blocks, and before adding each block to the chain, transactions would need to be verified by the network. Upon verification, new blocks would be secured and stored chronologically at the end of the chain. Once the block is added to the chain, data cannot be altered, even by the data owner, allowing for secure storage and sharing of patient data.

Signature is a key component to ensure the secure communication between blocks. Verification happens by checking the sender's private key and the recipient's public key, as shown in Figure 1. OUD patient records on the blockchain could only be added but not changed. If a MOUD provider wants to change a patient's record, the new information would need to be included in a new block and added to the chain. Prescription drug monitoring programs (PDMP) might benefit from the immutability feature of the blockchain. Each transaction, or data entry, by the prescriber and pharmacist, is verified and secured before they are added to the blockchain as separate blocks which leads to accurate data of the patient's prescription in real-time.

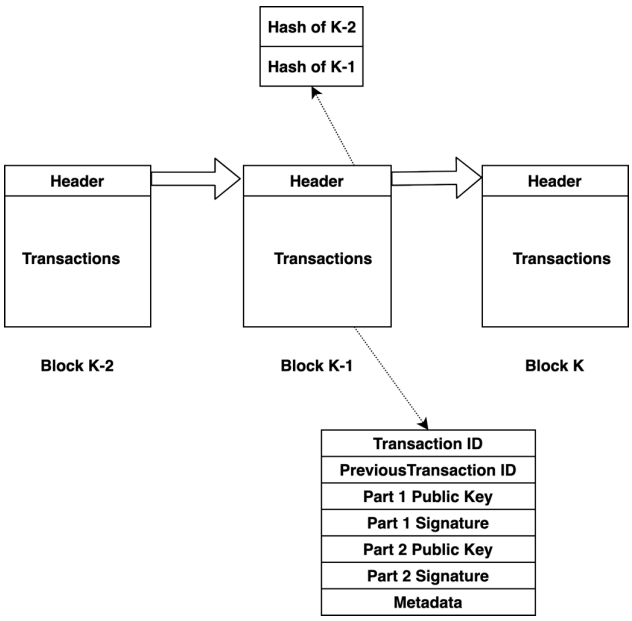

Figure 1. Block structure [15].

Source: B. Rawat D, Chaudhary V, Doku R. Blockchain Technology: Emerging Applications and Use Cases for Secure and Trustworthy Smart Systems. JCP. 2020 Nov 10;1(1): 4-18.

3.2 Decentralized Network and Interoperability

A decentralized network refers to the structure of the blockchain. The blockchain is a distributed ledger technology in that the ledger is distributed to all participating computers (or nodes) in the network and can be accessed by all users on the network. There is no centralized authority that manages the blockchain. Nodes act in concert to verify new transactions on the network and a copy of the updated blockchain is downloaded. As there is no gatekeeper, users access the data through encrypted keys. A public (permissionless) blockchain is open source in that the public has access to all data, and transactions can be recorded and verified by everyone in the network. It has high transparency and accountability. On the other hand, a private (permission) blockchain can only be read by those with required access, typically granted by a single organization. Transparency is reduced in favor of greater access control. A consortium blockchain is a hybrid of public and private blockchain. The network is managed by a group of stakeholders instead of one central organization (private) or the public. Transactions are verified by a group of preapproved entities, and have a high degree of control over who can access the data [16]. With respect to healthcare, a consortium blockchain could afford patients more control of their data and medical records since their data are not tied to a hospital or physician. They have the capacity to grant access to physicians, opioid treatment program (OTP), counselor, pharmacy, and PDMP. Each of these entities then can view or update the patient's medical records without needing approval or authorization. Communication between all involved in the patient's treatment is seamless and issues with disparate medical records dissipate.

3.3 Secure Data Storage

The distributed ledger is the backbone of blockchain technology, where it is composed of a write-only database that is continuously distributed across all network nodes [15]. Nodes execute blocks of programs known as smart contracts. Then, the network uses consensus algorithms to choose final version of the database from all updated nodes.

Patient medical records should be kept private, secure, and confidential, marginalized patients such as those with OUD will discontinue treatment or avoid seeking treatment due to the fear of stigma [17,18] and perceived violations of privacy and confidentiality [17]. Due to potential legal consequences, as well as facing stigma from family and friends, individuals who misuse opioids value privacy and confidentiality. Additionally, individuals who misuse opioids may also experience stigma from their healthcare provider.

Therefore, OUD patients need a very secure method of storing and sharing their data to avoid further stigmatization or negative consequences associated with identifying such patients. One relevant project to keep MOUD patient data is the InterPlanetary File System (IPFS), a peer-to-peer network for storing data and making it available. IPFS splits data files into smaller chunks, encrypts them, and distributes them among different nodes on the network [19]. Files can then be queried back using a content identifier (CID).

3.4 Privacy

Users are provided with a pair of cryptographic keys: public and private. The public key is visible to the public and serves as the user's public identity. The private key is used to initiate and sign transactions and guarantee user authenticity [16]. In blockchain, protected health information (PHI) will be accessible to others if granted permission by the patient. Patients have agency over who can view their data, update it, and for how long entities have access. The patients own their data on blockchain and may grant access to treatment programs, pharmacies, counselors, etc. If a patient transfers to another clinic or stops the program, access to the blockchain can be revoked. Patients may also view a history of who accessed their data.

3.5 Transparency

In dealing with the opioid crisis, data provenance will keep a record of history of MOUD participation, from date of entry into a program, which OTP the patient goes to, type of mediation using, visits with counselors, insurance billing; all of these events will be updated into the blockchain creating a transparent history of the patient's treatment. This is especially useful for populations without regular access to a healthcare provider such as those without insurance, homeless, and individuals recently released from prison.

3.6 Efficiency

One key feature of blockchain technology is its capacity for efficiency. Registration on the blockchain can be used as authentication for enrollment in programs. Treatment facilities may use blockchain identity authentication prior to providing treatment to patients, obviating the need to keep records in-house and minimizing the potential for private information to be stolen due to network attacks. Removal of barriers to use of PDMP would lead to increasing use [20]. PDMP could benefit from blockchain technology in delivering timely data to the network there-

by minimizing the interval between dispensing prescriptions and submission to the PDMP. This enhances patient safety by providing accurate information on a patient's recent prescription.

3.7 New Paradigms: DeSci and DAOs

Like the established DeFi, Decentralized Science (DeSci) is a new way of doing science built on blockchain technology. It is a new paradigm that utilizes smart contracts, blockchain, and other decentralized technologies to address the inefficiency of MOUD scientific research. DeSci is defined as an interoperable system that allows multiple stakeholders in the scientific research community to collaborate without trusting (or knowing) each other [21]. Trustless scientific collaboration in that regard can happen within Decentralized Autonomous Organizations (DAOs), which are collective democratic management organizations using programs running on the blockchain [22]. One application of DAOs in providing MOUD is through facilitating treatment agreement contracts between patients and providers, Medicaid prior authorizations, and expansion of access. Despite availability of MOUD, access and initiation by patients remain low [23]. One of the possible ways to increase MOUD access is to expand training and credentialing of eligible providers [23]. Once qualified practitioners submit all necessary documents (Waiver Notification of Intent, training certificate) to a DAO, smart contract may fast track credentialing process using decentralized governance structure and in-network due diligence.

4. Challenges in Implementation

Like any new technology, blockchain is developing every day and faces several challenges related to MOUD application. The most challenging is scalability; permissionless blockchain allows higher computational resources across the network but limited transaction volume. For example, the bitcoin blockchain allows only 7 transactions per second with almost 10 million users and 200,000 daily submitted transactions [24]. On the other hand, permission-based blockchains allow higher transaction volume with limited computational power based on their limited network base. Another related challenge is the cost of operation, as is still unknown what would be the exact cost of operating blockchain technology in healthcare.

5. Conclusions

Though effective treatment for opioid use disorder exists, barriers challenge uptake for those who would most benefit from treatment. Key features of the blockchain technology presented highlight ways in which innovative technologies may be implemented by healthcare and public health practitioners in addressing limitations.

Author Contribution

All authors contributed to the manuscript conception and design. All authors read and approved the final manuscript.

Conflict of Interest

None of the authors report a conflict of interest.

Funding

This work was supported by the National Center for Complementary and Integrative Health under Grant 4R33AT010606-03 and National Institute on Drug Abuse.

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