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Blockchain for Pharmaceutical Industry: Present, Past and Future

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Abstract:

To better understand the characteristics and evolution of research in Blockchain Technologies for pharma sector, this work reports results from the survey study targeting the Blockchain technologies for pharma industry (BTPI). Despite the existing survey studies on BTPI, our contribution in this work is to provide information to researchers and practitioners willing to enter the Blockchain field, being a source of information to strengthen the research field, guide new studies, and motivate new collaboration among research groups. A survey of Blockchain technologies for pharma industry is conducted with five research questions in which study of high-quality papers published in various journals in the last 5 years from 2018 to 2023 were evaluated. Results shows the increasing interests in this research area. Detailed research result and analysis is done.

Introduction

A lot of research work is carried out on blockchain technology to extend its application to non-financial fields such as healthcare, education, transportation, Internet of Things, agriculture, supply chain, economy finance, etc. One of the non-financial fields where blockchain technology has shown significant impact is the pharmaceutical industry. Blockchain technology has the potential to revolutionize the pharmaceutical industry by improving supply chain transparency, enhancing drug traceability, and ensuring the authenticity of medications.

By leveraging blockchain technology, the pharmaceutical industry can create an immutable record of every step in the supply chain, from the production of raw materials to the final delivery of medications to patients. This record can be accessed by all stakeholders, including manufacturers, distributors, pharmacies, and regulators, ensuring transparency and accountability throughout the entire process. Additionally, blockchain technology can enable seamless tracking and authentication of pharmaceutical products. This can help prevent the circulation of counterfeit drugs in the market, as each medication can be assigned a unique digital signature that can be verified at every stage of the supply chain.

Distributed ledger technology (DLT) is a foundation of Blockchain. Through a network of computers, DLT provides a consensus validation method that enables peer-to-peer transactions without the requirement for a middleman or a centralised authority to update and manage the data generated by the transactions (Michael, Cohn, & Butcher, 2018). Each transaction is verified before being added as a new "block" to an already established chain of transactions. This process gives origin to the term "blockchain." In general, a transaction cannot be changed or withdrawn once it has been added to the chain.

"Blockchain is a distributed ledger technology that records transactions in such a way that is secure and transparent. It can be a private blockchain or public blockchain."

Modern cryptocurrencies, or electronic cash secured by cryptographic processes rather than a central repository or authority, were developed in 2008 by combining the blockchain concept with several other technologies and computing concepts. Bitcoin was the first cryptocurrency to use a blockchain (Yaga, Mell, Roby, & Scarfone, 2019).

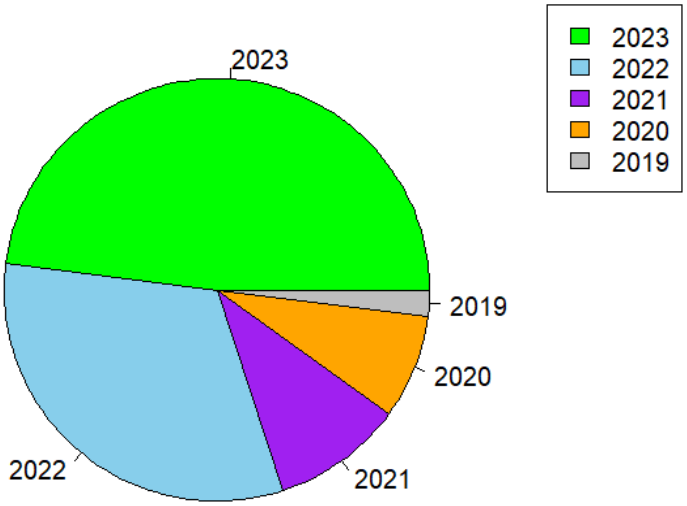

Figure 1 Percentage of research on blockchain applications in healthcare industry.

Public blockchains, such as Bitcoin and Ethereum, are accessible to everyone and are upheld by a decentralised community of users. Private blockchains are only accessible to a certain group or organisation and may have varying permission levels for users.

Blockchain technology is expected to disrupt a variety of businesses and sectors after its initial use as the peer-to-peer payment system Bitcoin (Zhao, Fan, & Yan, 2016). Blockchain technology is attaining interest in various sectors such as healthcare (El-Gazzar & Stendal, 2019).

This paper targets the applications of blockchain in pharmaceutical industry. This paper addresses the following research questions.

RQ1: To study major advantages of application of blockchain in the context of Pharma industry?

RQ2: How can blockchain enhance the security and integrity of pharmaceutical supply chains?

RQ3: What cryptographic methods are most suitable for ensuring data integrity in pharmaceutical transactions on the blockchain?

Related Work:

In the recent paper on blockchain applications for pharmaceutical industry [29], the authors present a comprehensive analysis of the use of blockchain technology in the pharmaceutical industry. The paper is a systematic literature review (SLR) that focuses on the adoption of blockchain technology in the pharmaceutical industry, including in applications such as tracking and tracing, counterfeit prevention, distribution, and data security. The authors collected, analyzed, qualified, and discussed studies retrieved from seven databases. The initial search yielded 2,185 papers, which were screened, discussed, voted on, critically appraised, and collected by a snowball workflow that finally yielded 38 papers. The blockchain application areas covered in the papers were classified as counterfeit drug prevention, drug distribution, tracking and tracing, and safety and security.

The most frequent category was counterfeit drug prevention, which is consistent with the primary objective of the pharmaceutical industry. The newer topics discussed in this study were data governance, data quality, pharmaceutical turnover, and prescription drug monitoring. The authors discuss issues surrounding each of these topics and research studies, along with their limitations and solutions. They also examine the challenges and future research directions of applying blockchain technology in the pharmaceutical industry.

Overall, blockchain technology has the potential to improve efficiency, transparency, and trust in the pharmaceutical industry. However, there are still some deficiencies in the implementation of blockchain technology in the pharmaceutical sector. These include issues related to scalability, interoperability with existing systems, and regulatory challenges. Despite these challenges, the potential benefits of blockchain technology in the pharmaceutical industry cannot be ignored. However, a study shows an in-depth analysis of the pharmaceutical industry to understand the pros and cons of blockchain for consumer perceptions in the pharmaceutical industry [30]. The research will also explore the role of patient privacy and security in the implementation of blockchain technology in the pharmaceutical industry.

The findings of a well-structured research will contribute to the growing body of knowledge regarding the application of blockchain technology in healthcare and specifically in the pharmaceutical industry. This study also analyses the feasibility and potential impact of implementing blockchain technology in the pharmaceutical industry. The research provides valuable insights into the specific challenges and opportunities that arise when implementing blockchain technology in the pharmaceutical sector. Moreover, it will propose an implementation framework that outlines industry-specific barriers, mitigation measures, and enablers for blockchain adoption in pharma logistics networks [31].

This framework will assist future managers in the pharma industry in understanding and addressing the unique challenges they may face when implementing blockchain technology, particularly in the context of drug counterfeiting [32]. By addressing these challenges and leveraging the potential of blockchain technology, the pharmaceutical industry can enhance supply chain transparency, improve patient safety, and combat drug counterfeiting effectively.

The Drug Supply Chain Security Act (DSCSA), which was recently enacted in the US to combat the issue of counterfeit drugs among other things, has drawn attention to supply chain security. A blockchain-based solution to increase supply chain security for the pharmaceutical industry is proposed to tackle the problem of counterfeit drugs in a working paper [33]. The issue of counterfeit drugs is predominant in the world especially in developing countries. The market of counterfeited drugs has reached billions of dollars annually. These problems have been described in a research paper along with a suggested solution [34]. IoT and blockchain technology are becoming more and more significant on a worldwide scale in a variety of fields in the future. In a plethora of diverse applications ranging from financial services, security analysis, food, agriculture, and the health business, it has garnered significant attention and huge interest.

The pharmaceutical industry is one of the fastest-growing sectors and is widely regarded as leading the way in healthcare delivery. The use of blockchain and IoT technologies becomes necessary for the secure provision of healthcare management. Early in the development of medical science, the pharmaceutical industry assists in bringing promising medications to market. It was necessary to conduct a thorough review of the safety and appropriate validation of the medical drug items that were sold to customers. Use examples involving blockchain and IoT meet the needs for medication security and timely delivery without unintentional interactions. Using Blockchain and IoT, a thorough examination of developments in the pharmaceutical industry's healthcare sector is conducted in a recent research paper [35].

Methodology:

Research questions are framed after performing a questionnaire survey. Participants were academic experts, industry professional and blockchain experts. This section provides the steps followed for conducting this research study.

RQ1: To study major advantages of application of blockchain in the context of Pharma industry?

This research question is relevant as every new technology must have relevant cases to be applied for betterment of society. Studying the major advantages of applying blockchain in the Pharma industry is relevant due to the potential transformative impact on supply chain management, data integrity, regulatory compliance, and overall operational efficiency within this critical sector. We asked our participant to provide score in the range of 1-5. This research question got an average score of 4.

Various vision papers on the applications of blockchain technology for pharma industry was also present. Our aim is to consider only real-world applications of blockchain for pharmaceutical industry. White papers and vision paper are not included in this study. This becomes the exclusion criteria for this research study.

RQ1: To study major advantages of application of blockchain in the context of Pharma industry?

Pharmaceutical supply chain is an important aspect of healthcare management system [5]. Recent years have seen a proliferation of studies on blockchain technology as a potential distributed solution [6]. Blockchain ensures transparency and traceability across the pharmaceutical supply chain, reducing the risk of counterfeit drugs and improving overall visibility [7]. The cryptographic features of blockchain enhance the security and integrity of sensitive pharmaceutical data, protecting it from tampering [8].

Blockchain facilitates smart contracts, automating aspects of clinical trials such as participant consent, data collection, and result reporting, leading to more efficient trials [9]. Blockchain's transparent and tamper-resistant ledger helps prevent the counterfeiting of pharmaceuticals, ensuring the authenticity of products [10]. Blockchain enables rapid and accurate identification of affected batches during product recalls, reducing the time and resources needed [11]. Blockchain fosters collaboration among different stakeholders in the pharmaceutical ecosystem, improving overall efficiency [12].

RQ2: How blockchain enhances the security and integrity of pharmaceutical supply chains?

Blockchain provides an immutable ledger, meaning once data is recorded, it cannot be altered or tampered with [13]. The decentralized nature of blockchain removes the need for a central authority, reducing the risk of a single point of failure and enhancing trust [14]. All participants in the supply chain have real-time access to

a transparent and auditable record of transactions, ensuring accountability [15]. Smart contracts on blockchain can automate compliance checks and ensure that all parties adhere to predefined rules and regulations [16].

One of the causes of drug counterfeiting is the pharmaceutical industry's unreliable supply chain system. It is challenging to maintain track of medications because their ownership changes before they are delivered to the client from the producer to the wholesaler, distributor, and finally the pharmacist. Data sharing, storing, openness, and traceability are all guaranteed by the system put in place using hyper ledger fabric [17]. Blockchain technology improves automation, transparency, and efficiency [18]. Block chain technology enables efficient data sharing. BCT provides complete data visibility and a single source of truth [19]. Counterfeit drugs have prompted the industry to use RFID technology. RFID technology can improve inventory accuracy and reduce the risk of shortages of essential drugs. It can also help with the implementation of First Expired, First Out (FEFO) in warehouses [20].

Permissioned blockchain networks enable secure data sharing among authorized participants, reducing the risk of unauthorized access [21]. Real-time visibility into the movement of pharmaceuticals across the supply chain minimizes delays and ensures timely identification of any discrepancies [22]. Blockchain enables end-to-end traceability, allowing stakeholders to trace the journey of pharmaceuticals from manufacturing to distribution [23]. Consensus mechanisms in blockchain ensure that all participants agree on the state of the ledger, enhancing overall agreement and reducing the risk of discrepancies [24]. RFID tags can be used to ensure supply chain integrity by automatically identifying products for efficient logistics management [25]. Further RFID can be used for following purpose:

- Authenticating products for patient safety
- Implementing anti-counterfeit measures for brand protection
- Tracking and tracing products in real time
- Improving inventory accuracy for distributors and retailers
- Reducing the risk of essential drug shortages

RQ3: What cryptographic methods are most suitable for ensuring data integrity in pharmaceutical transactions on the blockchain?

The huge risks involved in medical products, from medicine discovery to distribution, make data integrity in pharmaceutical transactions on the blockchain imperative [26]. When needed, cryptographic techniques can

offer non-repudiation and secrecy in addition to assisting in ensuring the immutability and legitimacy of these transactions [27].

Results and Analysis:

Blockchain improves smart contracts, automating aspects of clinical trials such as participant consent, data collection, and result reporting, leading to more efficient trials. Blockchain's transparent and tamper-resistant ledger helps prevent the counterfeiting of pharmaceuticals, ensuring the authenticity of products. Blockchain technology improves automation, transparency, and efficiency.

Conclusion:

Blockchain technology has major advantage in improving the healthcare services in the areas of Healthcare supply chain Security & Authentication, Clinical Trials & Precision Medicine, Personalizing the Healthcare Services, Pharma Data Management, Strengthening Public Health Surveillance, electronic Healthcare to Customers, Healthcare Administration & Medicine Management, Telehealth & Telemedicine, Managing Medical Imaging, Developing Smart Healthcare System, and Healthcare Information System.

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