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ORIGINAL RESEARCH

Blockchain Applications in the Pharmaceutical Industry

Mark Gaynor, PhD[1], Kathleen Gillespie, PhD[1], Allison Roe[1], Erica Crannage, PhD[2] and J.E. Tuttle-Newhall, MD[3]

[1]College of Social Justice and Public Health, Saint Louis University, St. Louis, Missouri, USA; [2]Associate Professor, Pharmacy Practice, University of Health Sciences and Pharmacy, St. Louis, Missouri, USA; [3]Department Chair of Surgery, East Carolina University, Greenville, North Carolina, USA

Corresponding Author: Mark Gaynor, Email: mark.gaynor@slu.edu

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Abstract

Methods: We utilized a 4D framework using ease of implementation, novelty, necessity, and fit of the overall industry to examine the adoption of blockchain technology in the pharmaceutical industry. Based on the 2D framework of difficulty and novelty as driving factors for the development of foundational technologies in the world of business by Iansiti and Lakhani, each application was ranked and scored for the best potential implementation. The potential applications proposed in this paper can be grouped into two main categories. The first category, management, includes best-use cases, such as health records, clinical trials, and inventory systems. The second category, monitoring, highlights cases, such as pharmaceutical products, preventing counterfeits, optimizing supply chains, and addressing prescription misuse and abuse.
Results: Each application was ranked by the four metrics in the framework, giving the greatest weight to necessity and ease of implementation. Using the highlighted methodology earlier, the applications for best implementation include Prescription Drug Misuse and Abuse Prevention, Prevention of Counterfeits, Clinical Trial Outcomes, and Smart Contracts.
Conclusion: Blockchain technology offers a new and promising solution to the pharmaceutical industry's needs. To promote the most appropriate use, each application of blockchain technology must fit within the framework of necessity, ease of implementation, familiarity amongst stakeholders, and fit of the overall industry. By using the extended framework proposed by Iansiti and Lakhani, we show how blockchain, in all these domains, shows promise to improve pharmaceutical industry performance.

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In recent years, blockchain technology has made great strides in diverse industries, but it has fallen behind within the pharmaceutical industry. The pharmaceutical industry is complex and would benefit greatly from the distributed database and emphasis on information privacy promoted by blockchain technology. Based on the 2D framework of difficulty and novelty as driving factors for the development of foundational technologies in the world of business by Iansiti and Lakhani,[1] this paper identifies the potential best application for blockchain technology in the United States pharmaceutical industry by identifying current trends, companies exploring the possibilities of blockchain technology, and industry concerns with opportunities for improvement.

As society becomes more familiar with the revolution of blockchain technologies in transaction processing, record management, surveillance, and data management, blockchain will likely be implemented at greater rates into a diverse set of industries, including healthcare. This paper evaluates and discusses the ways that blockchain technology can be implemented in the pharmaceutical industry and transform multifaceted problems.

Since the invention of the cyber currency, Bitcoin, blockchain technology has been implemented across

many industries to solve a plethora of problems. Blockchain technology links blocks that store transactions to one another in a distributed ledger. The use of a distributed ledger in a blockchain is crucial due to its unique security features. Distributed ledgers are "a type of database that (are) shared, replicated, and synchronized among the members of a network. The distribution ledger records the transactions, such as the exchange of assets or data, among the participants in the network.".[2] In a private ledger within a block, access is limited to authorized members, while in a public ledger, data are independently verified, and transaction participants can remain anonymous.[3] A public ledger does not require membership, while a private blockchain requires contributions of a ledger to be approved by an organization to confirm the transaction is allowed. In any given network, participants interact to view, store, and exchange information. The ledger of any blockchain is permanently recorded as an incorruptible set of data.[3]

Figure 1 illustrates a simple blockchain. Each block holds a piece of data (e.g. a transaction), a hash of the preceding block, and a hash for the data within the block.[4] The dashed lines represent the region that each block hash covers. Every block (except the root block) is linked to the previous block and each subsequent block in the secure chain. If any alterations to the data were to occur, the hash of the changed block and each hash following the chain will also be altered.[5]

The blockchain can be viewed as a distributed ledger that is a permanently recorded set of data that is incorruptible.[3] Individuals in each blockchain network interact to store, exchange, and view information. The data are *confirmed and then validated as transaction blocks are linked and chained from the beginning of the chain to the most current block*.[2] With each transaction, the blockchain becomes increasingly difficult to alter, as each block must be verified by all users in the ledger.[4] Additionally, a blockchain network will conduct automatic self-checks that decrease corruptibility and maximize the overall transparency among stakeholders in a blockchain.[6] These two concepts work together to uphold the overall integrity of a blockchain.

Blockchain technology does not depend on a centralized authority. Instead, each record is accessible to all members of a blockchain and can be easily verified. However, due to security needs in health care, these blocks could operate as semipublic – using permission rights to verify data before it permanently joins a blockchain.[4] This approach allows restricted access. Simultaneously, an audit trail accompanies each transaction to verify and authenticate it. Each of these records will have a corresponding timestamp and cryptographic signature.[2] If a set of data were to have a private key, it would act as a password allowing specific individuals the ability to access data within a contained transaction.[7] In a public key system, a user is traced by their address on the blockchain to prove original ownership. Blockchain uses both a public and private key model to ensure that the stored data are not only incorruptible but also traceable to a source while maintaining anonymity.[4]

A cryptographic hash acts as the digital signature to authenticate each block of data in a blockchain.[2] Hashing complements the use of both private and public keys by authenticating that the information in a transaction has remained unaltered. Together, these blockchain functions support the elimination of centralized intermediaries in establishing trust.[7] The elimination of a centralized authority fosters trust and facilitates more efficient data and information transfer.[6]

Problem Overview within the Pharmaceutical Industry

In 2023, the United States encompassed over 43% of the total global pharmaceutical industry market share.[8] This is expected to continue increasing with a predicted annual growth rate of 5.96% between the years 2024 and 2028.[9] Due to this, the United States will continue to grapple with complex issues related to the management of high-value pharmaceutical products. Within the United States, pharmaceuticals account for a growing share of the healthcare economy. Retail prescription

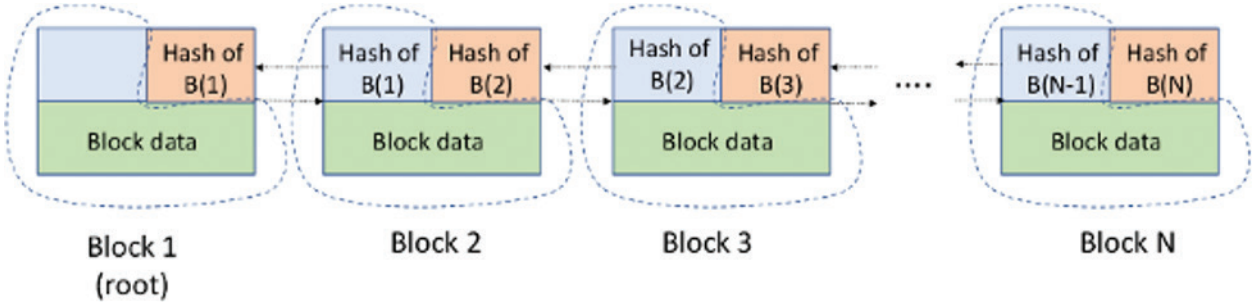

Fig. 1. Visual representation of a simple blockchain. Comprised of a root block, a hash of the preceding block, and a hash of the data in the block. Reproduced from the author, Gaynor et al.5 B(1) etc.: abbreviation for "Block."

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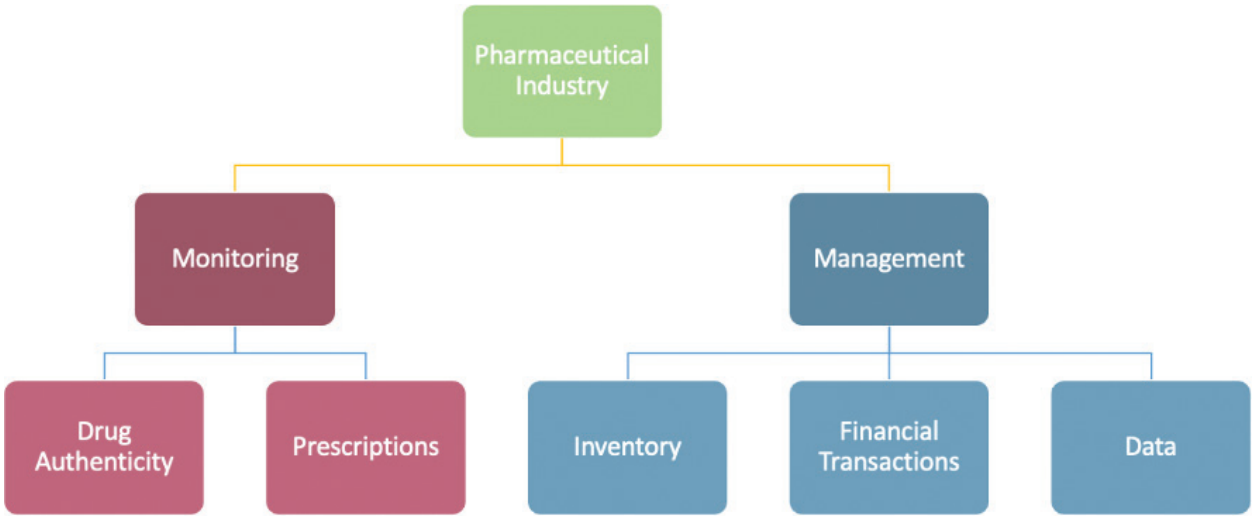

Fig. 2. Blockchain functioning across the pharmaceutical industry is divided into two categories: (1) monitoring and (2) management. These categories reflect implementation strategies using different components and functions. However, when combined, they work together to support best practices and a potential framework for blockchain technology in the pharmaceutical industry.

expenditures accounted for over $300 billion of the $2.3 trillion spent on healthcare in 2021 or 9% of the total retail market.[10]

The pharmaceutical industry encompasses several key internal stakeholders, including pharmaceutical manufacturers, pharmaceutical wholesalers, health systems, pharmacies, and individual patients with prescription needs (see Appendix for greater detail). Most prescription drugs are sold by the manufacturer to a wholesaler. The wholesaler then sells the drug to pharmaceutical benefits management companies, health systems, group purchasing arrangements, and retail pharmacy companies. Prices within this market change frequently, and there is a complex practice of rebates, discounts, and chargebacks that can occur from the point of the original sale to the wholesaler until after the drug is dispensed. Thus, multiple organizations require secure access to financial transactions over time. Different organizations have different abilities to make requests to alter those transactions and then to approve or deny them.

The pharmaceutical industry also has several external stakeholders that include the general public, government entities that oversee and regulate the industry, and accreditation and trade organizations—all of which add increased regulation and verification pressure on the pharma sector. Current challenges include the ability to monitor pharmaceuticals throughout the supply chain, protection against fraud, the ability to follow a streamlined research and development process (including clinical trials), and lack of prevention for misuse and abuse of addictive substances. By implementing blockchain technology, the pharmaceutical industry can improve population health outcomes and provide better transparency among stakeholders.

Applications in the Pharmaceutical Industry

Blockchain technology can be implemented to create more efficient, secure, and transparent systematic approaches within the pharmaceutical industry. By prioritizing applications that meet these needs, it is easier to create areas of possible application. These can be categorized into two main categories: monitoring and management.

Numerous companies and organizations are utilizing blockchain technology to revolutionize the pharmaceutical industry. Many of these current applications use blockchain technology to provide real-time tracking and data transparency within the pharmaceutical industry, increasing patient safety, understanding, and overall health outcomes. These applications will be expanded upon below within the outlined hierarchical structure.

Monitoring

The pharmaceutical industry's ability to monitor goods and products is essential. Many stakeholders are involved in the delivery of one specific product to any individual consumer. However, given the industry's multifaceted nature, there is a deficiency in authenticating products and preventing prescription misuse. Blockchain technology's inherent lack of central governance can enhance visibility, authentication, and information flow, ultimately improving patient care in the context of pharmaceutical needs.

The successful implementation of blockchain technology occurs when it integrates seamlessly with existing technology systems within the pharmaceutical industry.

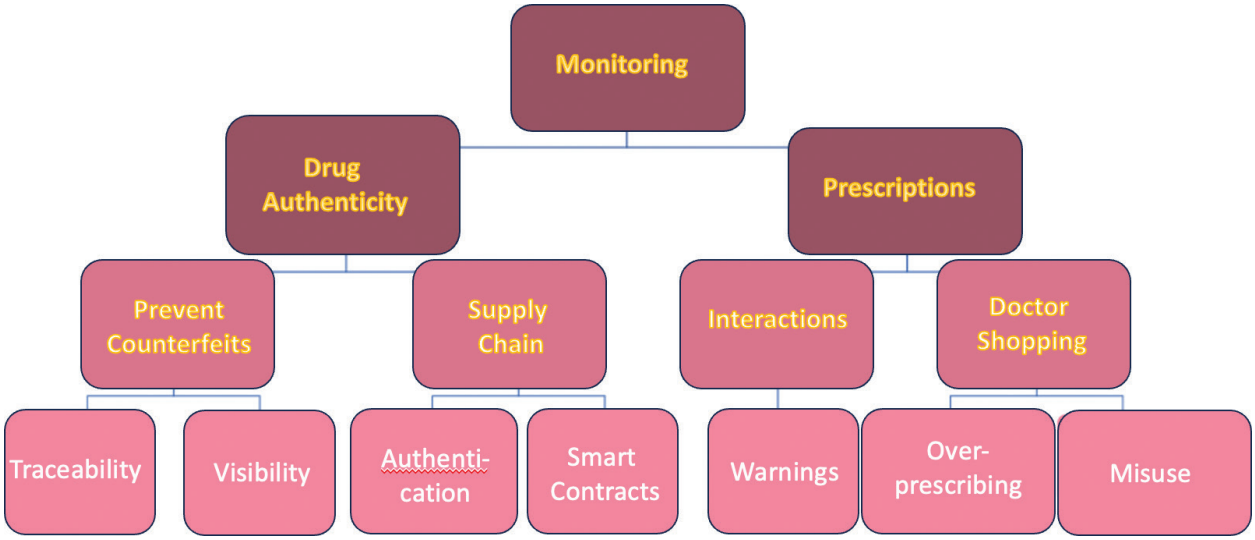

Fig. 3. Potential opportunities for blockchain technology monitoring in the pharmaceutical industry, specifically as it relates to the prevention of counterfeits, supply chain function, prescription misuse, and warnings. Flow diagram with permission from the author, Gaynor.[4]

Further analysis of potential applications for monitoring pharmaceutical products includes:

1. To avoid counterfeit products, the ability to track and trace pharmaceutical products is essential. MediLedger uses blockchain as a verification system across the pharmaceutical industry. The network forms groups among stakeholders to expedite the ability to verify the authenticity of a medication or product in a sale, or more specifically, a return.[11] Verifying drugs as authentic before being resold after a return can take up to 48 hours. However, MediLedger significantly shortens this process using a blockchain network and barcode scanners.[12] This process uses serial numbers for verification. The network first launched in 2019 and is working to reduce the complications in the sale and transfer of products. Today, MediLedger partners with some of the biggest names in the pharmaceutical industry including Bayer, McKesson, Pfizer, etc.
2. The pharmaceutical supply chain presents unique challenges, given the high value and specific storage conditions required for some products. The use of *smart contracts* is one way that blockchain technology can be used to promote proper supply chain monitoring. Smart contracts automate the tracking of products throughout a supply chain. Sensors are attached to products to record key information, such as environmental factors (humidity or temperature) and shipping errors (being dropped or lost). The parties involved in each transaction can set guidelines for shipping conditions that must be met. By doing so, they build trust through error reduction and decreased risk of manipulated conditions.[13] Smart contracts automatically track, generate notifications for updates, and create automated payments when all conditions are met. This process not only alleviates the burden of ensuring proper shipping conditions but also creates better interparty relationships.
3. Many prescriptions have intense or adverse effects when combined inappropriately, known as contraindications. Public–private partnerships, like PharmaLedger, leverage blockchain technology to address this concern by providing consumers with more information and eliminating the need for printed warnings, information, and instructions. PharmaLedger collaborated with its stakeholders to create a secure electronic Product Information (ePI) solution that instantly allows anyone with a smartphone to scan medical packaging and receive information regarding the use of a product.[14] In real-time, the ePI system can continuously update information from a manufacturer, preventing the continuous spread of out-of-date information in the ePI.[15]
4. The misuse and abuse of prescription medications, particularly high-value or addictive ones, pose significant concerns. Historically, it has been difficult to track and monitor these cases across providers, health systems, and states. By operating on a blockchain, all health providers can access essential medical information, including prior prescribed medications. Using permission rights, the blockchain will track in real-time who is accessing and viewing all records of an individual while performing regular audits to ensure patient data safety in the case of unauthorized access. Blockchain technologies offer a new way to grant healthcare providers the necessary information to

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prevent over prescription and misuse of pharmaceuticals. Companies such as HealthChain can help curb this problem by using blockchain technology to provide healthcare professionals with more efficient, interoperable data on an individual's prescription history.[16] Once a patient's prescription is entered into the blockchain, it can be easily verified and will remain a permanent record throughout time. HealthChain strives to provide better patient outcomes through safer prescription practices.

Management

The healthcare industry, including pharmaceutical makers, generates an enormous amount of data. Personal health information includes a wide variety of data sources, such as electronic health records, wearable devices, health apps, etc. Protecting these data is essential as much of it includes high-value personal health information.

The distributed ledger and cryptographic hashing features of a blockchain allow for better data governance. The future of blockchain technology implementation within pharmaceutical industry management includes the following applications:

1. In the United States, the rate of prescription recalls remains high. According to the United States Food and Drug Administration (FDA), in 2023 alone, there were over 1,500 recalled products in medical devices, biologics, and drugs.[17] The current system that is used to issue recalls to patients is tedious and cannot ensure the rate at which messages are received. The implementation of blockchain technology can effectively track the distribution of medications and identify patients impacted by the recall through an indisputable record system, enabling targeted alerts to only those individuals who received the recalled product. This application can also be used to prevent the distribution or use of expired medications.
2. Efficiently managing the distribution of all pharmaceutical goods throughout the supply chain can be complex. Not only is the location of the product in shipping important but so is locating the product in the scenario of supply shortages. The decentralization of blockchain promotes the ability for multiple actors to form a network displaying the status of drug supplies at pharmacies. This collaboration can efficiently improve patient outcomes. In 2019, WakeMed Health and Indiana University Health piloted a program in collaboration with Good Shepard Pharmacy, called RemediChain. RemediChain focused on product tracking to address inventory shortages of high-value goods.[18] Additionally, they propose using this technology across networks in cases of shortages, emergencies, and negotiations.[18] Currently, they accept donated medications and match them to patients who are in immediate need. In real time, they can verify products and produce urgent sales with the hopes of relieving pharmaceutical waste. Since implementation, RemediChain estimates they have prevented $17 million worth of pharmaceutical product waste.[18]
3. Each prescription issued to an individual comes with a record and transaction trail of personal health information. Protecting personal health information efficiently and effectively is a priority; however, current privacy protection practices result in information silos. Blockchain technology allows for personal health information to be stored within a network, granting healthcare providers wider access to a patient's essential health information while securely storing it through cryptographic signatures. Patientory, a mobile app utilizing blockchain technology, is designed to grant patients the right to port and share their medical information to improve communication, store data, and even improve payment systems.
4. The clinical trial company, Triall, is working to address some of their top concerns by decentralizing clinical trial information and data. To date, they have been used as the primary source for data governance in over 7,000 clinical trials.[19] The use of blockchain technologies in clinical trials can promote greater participant monitoring, data management, and documentation management.[19] This is particularly important in clinical trial research, which has a large influx of patient information and data. Paperless clinical trials can reduce the overall cost and prevent stalls from ineffective paper management.[20] Additionally, the blockchain allows greater access for stakeholders to evaluate outcomes and needs.
5. Blockchain technologies in genomic sequencing are offering a unique new way for individuals to take ownership and data governance of their health information into their own hands. Companies such as Nebula and EncrypGen use blockchain technology along with cyber currency to allow individuals to gain autonomy over their genetic information. These companies provide patients with information regarding their genomic sequences and allow them to release it directly to pharmaceutical and clinical trial leaders as they deem appropriate.[21] Unlike ever before, this application removes intermediary parties left in control of entire genomic sequences and the sale of individuals' personal health information.

Blockchain technology provides a new cryptographically secure way to store, share, and manage data across the pharmaceutical industry. Similarly, blockchain technology offers a unique capability in managing inventory and supplies across hospital and healthcare systems by

decentralizing management and enhancing accessibility. Figure 4 portrays a hierarchy for possible applications of blockchain technology within the management of both data and inventory in the pharmaceutical industry.

Technology Selection Algorithm

Our selection algorithm for technology in the pharmaceutical industry is based on the framework presented by Iansiti and Lakhani.[1] Their framework presents the essential components of Ease of Implementation and Industry Familiarity. This framework was extended by Gaynor to include Necessity.[4] In this article, we extend our framework to include Fit-for-Purpose.[22] This extended framework enables us to rank applications of blockchain technology in the pharmaceutical industry based on essential metrics and to select the applications most likely to be adopted with this emerging technology.

Figure 5 illustrates nine potential applications for blockchain technology in the pharmaceutical industry ranked by their overall score. Applications with the highest scores are the most likely to be successfully implemented. Each of the nine applications was ranked on Ease, Familiarity, Fit, and Necessity. After this ranking, their scores were summed and given an official ranking.

Selection Algorithm Applications

Each of the nine applications was ranked on a scale of 1–5 in the four metrics: Ease, Familiarity, Fit, and Necessity, to select applications that can best be implemented in the pharmaceutical industry. Figure 6 presents this model. Low performers in any given category received a grade of one (furthest left), and high performers received a grade of five (furthest right). Any score of three or below can be immediately removed from consideration of possible best applications.

The four metrics, Ease, Familiarity, Fit, and Necessity, each play a different and essential role in determining how applications could function in the pharmaceutical industry.

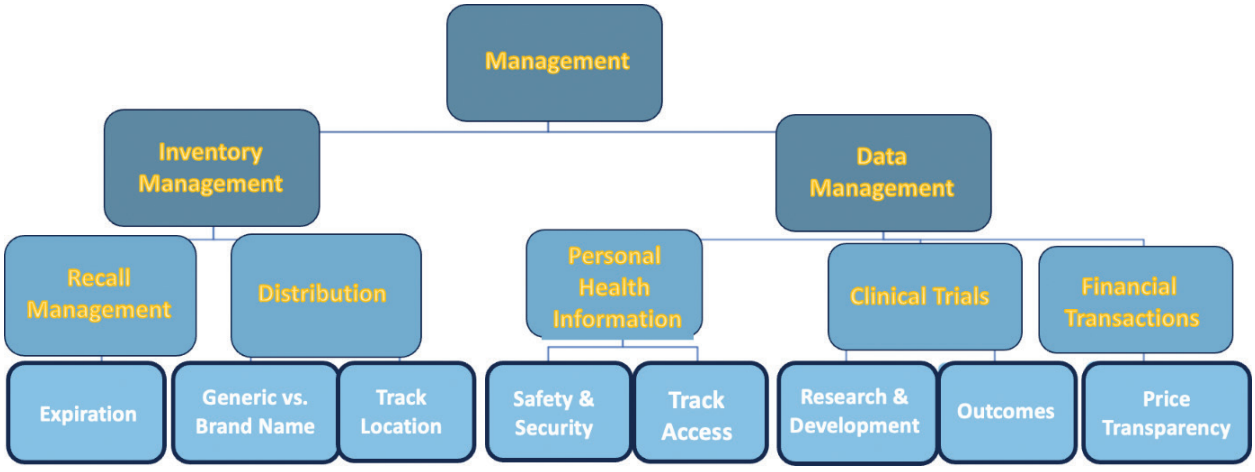

Fig. 4. Systematic analysis of Management functions of blockchain technology. Management functions can be defined as inventory management or data management. Reproduced with permission from the author, Gaynor et al.[4]

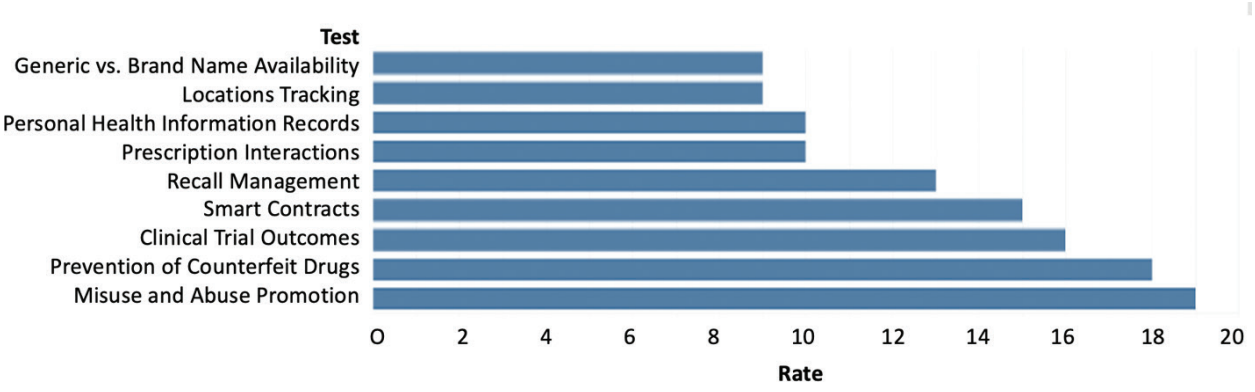

Fig. 5. Selection of algorithms for the application of blockchain trichology in the pharmaceutical industry. The graph depicts the total score of each application of the nine applications based on the decision matrix of Ease, Familiarity, Fit, and Necessity.

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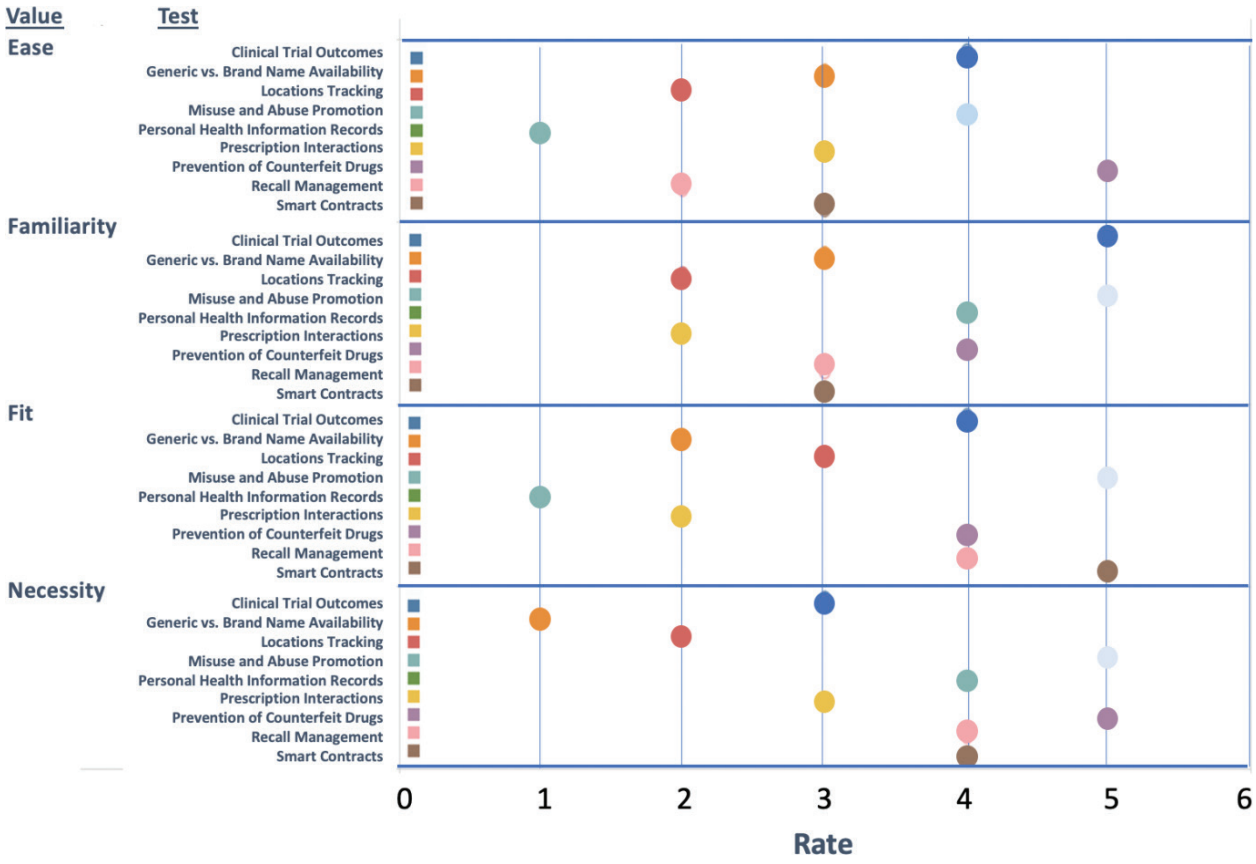

Fig. 6. The best applications for blockchain technology are shown by individualizing scores in the decision matrix of Ease, Familiarity, Fit, and Necessity.

1. Ease of implementation relates to the simplicity and convenience of executing an application or task. This often relates to the question of what requires the least amount of effort or resources. This is the second most important metric in considering the best application for adoption. An application that ranks the highest in this metric is the prevention of counterfeit products, while the lowest performer is personal health information due to the complexities of interoperability in health data.
2. While important, familiarity holds less weight than Ease and Necessity. Familiarity relates to the expectations and readiness to adopt a new product. Applications ranking high in Familiarity include clinical trial outcomes due to their importance and relevance in the pharmaceutical industry, and the lowest-ranking application includes prescription interactions.
3. Fit is important as it relates to the overall alignment with strategic goals and needs of the pharmaceutical industry. Smart contracts rank high in overall Fit as they enable multiple parties in the pharmaceutical industry to build trusting relations for high-value pharmaceutical goods throughout their transportation. The lowest performer in Fit is personal health information, as this is not of utmost importance to stakeholders.
4. Necessity relates to the importance of an application. The Necessity metric is the most important attribute in considering potential applications. Without genuine need, the success of implementation is likely to be minimal. A high performer in Necessity is prescription abuse and misuse, while a low performer is generic vs. brand name availability. Pharmacists, insurers, and other stakeholders are invested in preventing patient prescription misuse while caring far less about the availability or use of generic vs. brand-name products.

The four categories for best implementation are (1) Prescription Drug Misuse and Abuse Prevention, (2) Prevention of Counterfeits, (3) Clinical Trial Outcomes, and (4) Smart Contracts. These four categories ranked the overall highest in creating innovative solutions for current pharmaceutical industry needs.

1. As seen in recent years, Prescription Drug Misuse and Abuse Prevention for addictive prescription drugs, such as opiates, has become concerningly more prevalent. The dire need for a new system to track and prevent

misuse of these drugs creates an opportunity for the success of new technology. Blockchain technology can create an indisputable record and transaction history of any individual's prescription history, creating a safer prescribing practice. Prescription Drug Misuse and Abuse Prevention ranks particularly high in the metrics of Familiarity and Necessity.

2. The Prevention of Counterfeit Drugs ranks highest in terms of Ease of implementation. This can be attributed to applications, such as Mediledger, which already exist and have key pharmaceutical stakeholders engaged. Applications such as this are beneficial as they reduce the burden of the verification process for pharmaceutical companies and members throughout their sale and transfer.
3. Clinical Trial Outcomes are essential to the pharmaceutical industry's function. With a high level of innovation and an influx of health data in clinical trial information, data tracking and reporting can become burdensome and lack transparency. Clinical Trial Outcomes rank highest in Familiarity due to the ongoing number of clinical trials in the United States.
4. Smart Contracts can allow for the monitoring and supply chain management of high-value goods. In the pharmaceutical industry, this can be particularly useful in ensuring shipping conditions (e.g. temperature and orientation) are met to deliver quality products. Once products meet these conditions, automated payments are issued. Smart contracts have proven to be beneficial in other high-value industries. For these reasons, Smart contracts rank particularly high in the necessity and overall Fit of the industry.

Limitations

Potential limitations of this analysis include the inability to perfectly predict technology implementation and outcomes. Technology has been notoriously unpredictable for decades. However, these potential limitations are addressed by emphasizing the importance of Necessary applications. Without a genuine need, the likelihood of achieving favorable outcomes is diminished.

While this analysis can identify those areas of the pharmaceutical industry where blockchain technology may be most appropriate, the adoption of blockchain is not certain. The structure of the pharmaceutical industry in the U.S. will limit the adoption of some applications. Most of the organizations involved are for-profit enterprises; all are interested in improving efficiency and minimizing costs where appropriate. Many of the applications identified above have benefits that will accrue to parties outside of the pharmaceutical industry. Such benefits are referred to by several terms. They can be called external benefits or spillover effects, or the product may be said to have public goods aspects. One example of this is the idea of Network Neutrality, which defines a free and open architectural principle where data are treated equally on a network.[23–26] If the industry must bear all the costs of creating and maintaining the network but is not able to reap all of the benefits (by, for example, charging user fees), it is unlikely that network neutrality and the use of blockchain will be voluntarily adopted.

Prescription Drug Misuse and Abuse Prevention is another example where spillover effects matter. The primary benefits of reducing or preventing prescription drug misuse and abuse are the additional years of life gained by prevented overdoses and the reduced medical expenditures to treat the abuse. These benefits accrue to many people and organizations, primarily outside of the pharmaceutical industry. A for-profit pharmaceutical firm will have little economic incentive, beyond the threat of lawsuits, to develop and use programs that reduce misuse and abuse because they cannot recoup their costs. To promote the adoption of these programs, pharmaceutical firms need an incentive. The incentive can be financial (e.g. subsidies, grants, and tax benefits) or legal (e.g. legislation and regulation).[27]

Conclusion

Blockchain technology offers a new and promising solution to the pharmaceutical industry's needs. The distributed database prioritizes privacy in the verification and authentication process. The implementation of blockchain technology must fit within a framework that supports necessity, ease of implementation, familiarity amongst stakeholders, and fit within the overall industry. Based on these four metrics, the hierarchical structure outlined throughout this paper suggests that applications that best fit these include Prescription Drug Misuse and Abuse Prevention, Prevention of Counterfeits, Clinical Trial Outcomes, and Smart Contracts. Future research in blockchain technology includes further exploring the economic impact and adoption, ethical and legal considerations for data ownership and privacy, and AI integration for potential data analysis from the blockchain.

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Contributors

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evaluation and proofreading. Allison Roe constructed the context of the text along with figures. Dr. Erica Crannage provided text and proofreading on the pharmaceutical industry. Dr. J.E. Tuttle-Newhall provided a proofreading of the paper and healthcare industry context.

Application of AI-Generated Text or Related Technology

After completing the manuscript, the authors used ChatGPT3.5 as a corrective suggestion and proofreading tool. Some of these suggestions were incorporated into the article.

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Appendix

There are several companies breaking into the space of blockchain solutions within the United States pharmaceutical industry. This market is new and evolving, with relatively high volatility. The following list is not comprehensive of all companies within the blockchain and pharmaceutical realm but instead is a representation of the innovative technologies that exist on the market today.

1. Embleema is a clinical research platform that utilizes blockchain technology to expedite the regulatory review process. They have several key factors in their technologies, including participant recruiting, secure and safe data sharing, audit trail of research data, evidence, and the United States Food and Drug Administration (FDA) engagement for approval. Today, Embleema is engaged with a variety of stakeholders, including academic medical centers, governmental agencies, biomedical technical companies, research institutes, hospitals, and universities.
2. Healthchain is founded on creating a connection between providers, payers, and patients. They have several different applications that can be tailored to specific needs. By creating an integrated and interoperable system, Healthchain could be utilized in the pharmaceutical industry to provide real-time tracking of a patient's prescription history.
3. LedgerDomain is focused on Drug Quality and Security Act (DSCSA) compliance. Through their portal systems, pharmacies can quickly trace and verify products. LedgerDomain does this by creating Authorized Trading Partners (ATP) to drive the supply chain forward. This creates interoperable, data-driven, and enhanced security.
4. MediLedger uses blockchain as a verification system across the pharmaceutical industry. Their technology was born out of a collaboration with Chronicled and has powered accurate, private, and decentralized transactions between manufacturers, group purchasing organizations, and wholesalers in the pharmaceutical supply chain. MediLedger is engaged with pharmaceutical companies, such as Pfizer, McKesson, Cardinal Health, etc.
5. Nebula Genomics offers full genomic sequencing directly to patients. Nebula Genomics is working to utilize a blockchain network to eliminate key concerns of cost, regulatory matters, and privacy. Ultimately, this will provide users with full control over their health information and genomic sequence provided by Nebula Genomics.
6. PharmaLedger's blockchain technology has three primary product lines: product trust, decentralized trials, and supply chain. Each of these solutions offers different value. For example, in the product trust space, PharmaLedger collaborated with stakeholders to create a secure electronic Product Information (ePI) solution that allows for instant product information after scanning product packaging via smartphone.
7. Remedichain utilizes blockchain technology to repurpose unused and unopened prescription medications for those who may not otherwise be able to afford them. It has created a blockchain database that can authenticate and redistribute high-value goods.
8. SoluLab uses blockchain technology to create a decentralized tracking system on the lifecycle of pharmaceutical products. This includes the sourcing of raw materials, manufacturing processes, distribution, and ultimately reaching the end consumer. By leveraging blockchain, SoluLab helps pharmaceutical companies ensure the authenticity of their products, prevent counterfeiting, and streamline regulatory compliance.
9. Triall is a clinical trial platform that works to streamline the full clinical trial lifecycle from study-design, execution, and post-study evaluation. To date, they have been used as the primary source for data governance in over 8,000 clinical trials.

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