IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

Pharma and Counterfeit Drug Prevention Supply Chain and Smart Contracts System in Blockchain

[1] Dr. Rohini Hanchate, [2] Aniket Kaygude, [3] Avadhut Kulkarni, [4] Vedant Gorule

[1] Professor, [2] Student, [3] Student, [4] Student
[1] Computer Engineering Department,
[1] PCET's Nutan Maharashtra Institute of Engineering and Technology, Pune, Maharashtra, India

Abstract: Drug safety and effectiveness depend on the reliability of pharmaceutical supply chains. Yet fake medications remain a big risk to public health and shake people's faith in medical treatments. This paper shows a blockchain-based system for managing drug supply chains working with smart contracts to boost openness, security, and the ability to track products. The system uses shared ledger tech to log every deal in the drug supply chain, making sure records cannot be changed and drugs can be checked in real time. Smart contracts handle compliance, regulatory checks, and drug authentication without people having to step in. The system aims to tackle big issues like catching fraud, fixing supply chain problems, and stopping fake drugs. By using blockchain security, the solution cuts down on risks of data tampering and people getting in who should not. With live monitoring and an app for shoppers to check their purchases, end-users can make sure the drugs they buy are genuine, which builds trust in the drug industry. This approach not only makes the supply chain work better but also helps follow regulations by creating a record that cannot be messed with. Using blockchain in drug logistics can cut down on fake drugs and lead to better healthcare results.

IndexTerms - Blockchain smart contracts pharmaceutical supply chain, drug authentication, transparency stopping fake drugs, following regulations, tracking products shared record-keeping, supply chain protection.

INTRODUCTION

The pharmaceutical sector is vital, for healthcare (Pritam, 2021)[1] worldwide by overseeing the creation and delivery of medicines that're safe and efficient for patients well-being However concerns have heightened given the rise in counterfeit drugs infiltrating supply chains This has sparked worries about patient safety and adherence to regulations Current supply chain structures tend to depend on centralized databases which can be at risk of data tampering unauthorized changes and inefficiencies Without real time monitoring systems there is a constraint, on tracking a drugs path from production to its ultimate users. These flaws result in setbacks, for drug companies. Also present significant health hazards by enabling the circulation of inferior or counterfeit medications necessitating a strong and clear system, for ensuring complete drug traceability from start to finish.

Blockchain technology provides a solution, for boosting security and transparency in pharmaceutical supply chains by utilizing its unchangeable ledger system. Through the use of contracts within this framework regulatory approval processes and drug authentication can be automated effortlessly without interference. By using FSSAI licenses for authentication purposes, in the supply chain process enables stakeholders to confirm the genuineness of products Tracking shipments promptly helps identify any discrepancies or anomalies and reduces the prevalence of medications in circulation, within the system. Utilizing a system based on technology improves adherence, to regulations. Increases consumer and healthcare professional trust while lowering fraud cases.

1.1. Problem Definition

In the pharmaceutical sector is struggling with an issue as medications are getting into circulation through the distribution network. This poses risks to patient well-being and adherence, to regulations. Current systems do not provide visibility or immediate monitoring and strong verification measures to combat the distribution of drugs effectively. Traditional databases are vulnerable, to manipulation and operational shortcomings which worsen the problem. The absence of an unchangeable tracking system makes it hard for stakeholders to confirm the legitimacy of products. Overcoming these obstacles calls for a strategy that guarantees traceability from start, to finish while also boosting security measures and streamlining compliance procedures.

1.2. Objectives

The primary objectives of this research are as follows:

- Implementing a system based on technology to ensure the tracking of pharmaceutical products, from end, to end.
- To stop the spread of medications smart contracts and distinctive cryptographic (Hanchate, 2023)[2] markers are utilized.

- To enhance efficiency by automating compliance checks and transaction verification processes for recalls.
- To use the decentralized architecture of blockchain technology to guarantee data security and privacy.

RELATED WORK

2.1 Traditional Supply Chain Management

The conventional approach, to managing pharmaceutical supply chains depends heavily on centralized systems that oversee the validation and monitoring of drug legitimacy. These systems utilize databases managed by drug manufacturers, distributors, and regulatory bodies to house information pertaining to medications. However, centralized databases are susceptible to tampering, cyber breaches and shortcomings, in tracking. Moreover, manual documentation procedures frequently result in inaccuracies, delays and a lack of transparency thus hindering the identification of drugs. Stakeholders face challenges in verifying drug authenticity and compliance due, to the absence of an unchangeable verification system.

2.2 Blockchain-Based Supply Chain Solutions

Blockchain technology has become an answer to enhance transparency and security, in the supply chain industry. Various blockchain driven approaches have been suggested to monitor and validate goods by utilizing ledgers and smart contracts. These setups improve traceability by guaranteeing that each transaction is securely documented and can be verified by all parties involved. In contrast, to databases blockchain removes the concerns of data tampering and unauthorized alterations thereby establishing a sense of trust and security throughout the supply chain.

2.3. Strengths

- Block chain technology guarantees an unchangeable record of transactions that prevents any alterations and fosters trust among parties involved in the supply chain industry.
- Smart contracts streamline validation processes by automating compliance verifications and tracking recalls and audit trails, in time to minimize mistakes and improve efficiency.
- The transparency of block chain technology aids, in identifying behaviours. Reduces the occurrence of fraudulent activities, in the pharmaceutical supply chain.

2.4. Challenges

- Slowing down processing and affecting real-time tracking.
- Small local drugstores and suppliers might not have the knowledge, about technology and the expensive costs associated with its implementation could hinder widespread acceptance.
- Incorporating technology, into pharmaceutical laws necessitates substantial adjustments in policies and widespread acceptance, across the industry—a process that may prove intricate and time consuming to execute.

2.5. Comparison Table of AI-Based Techniques

Approach	Transparency	Security	Scalability	Regulatory Compliance	Computational Efficiency
Centralized Database	Low	Low	High	Moderate	Low
Blockchain	High	High	Low	Low	High
Smart-Contracts	High	High	Moderate	Moderate	High
Hybrid Blockchain	High	High	High	High	Moderate
Hyper ledger Fabric	High	High	High	High	High
AI-Integrated Blockchain	High	Very High	Moderate	High	Very High

A detailed overview of supply chain tracking options is presented in a comparison chart that includes aspects, like transparency levels., security measures, scalability potential, adherence to regulations and cost of implementation. This chart acts as a tool for individuals involved in the sector to evaluate the appropriateness of block chain and conventional methods in guaranteeing the tracking of drugs and preventing counterfeiting. Through an examination of these criteria leaders can decide on the approach, for improving the reliability and conformity of supply chains.

BLOCKCHAIN PHARMACEUTICAL SUPPLY CHAIN

3.1. Fundamentals of Blockchain in Drug Traceability

Blockchain tech offers an transparent ledger, for monitoring pharmaceutical products throughout the supply chain without central authority interference or data tampering risks It guarantees honesty and real time validation of drug legitimacy through security measures and agreement mechanisms Additionally smart contracts streamline regulatory compliance tasks cutting down on manual work and boosting operational effectiveness Overall the incorporation of blockchain systems improves product traceability combats counterfeit medications and reinforces adherence, to regulations.

3.2. Case Studies

- **Blockchain for Drug Authentication:** Utilizing Ethereum based contracts to authenticate medicines, through technology aiming to ensure genuine products and combat the spread of counterfeit drugs.
  Object
- **Hyper ledger for Supply Chain Transparency:** Utilizing hyper ledger, in Supply Chain Management for Ensuring Transparency; Implementing permissioned block chain systems to guarantee effective tracking of pharmaceuticals, across producers, distributors and sellers.
- **AI-Integrated Block Chain Solutions:** Utilizing the combination of machine learning and block chain technology to improve fraud detection capabilities and anticipate inefficiencies in the supply chain while also enhancing the optimization of drug distribution processes.

3.3. Impact On Security and Data Integrity

Implementations of technology, in pharmaceutical supply chains improve the safety of drugs by allowing for tracking from start to finish while also lowering the presence of fake medications and guarantee compliance with regulations in place. Through the utilization of techniques and resources, in the industry sector suppliers can authenticate the validity of medications thereby improving trustworthiness and security across the supply chain.

DISCUSSION

Incorporating technology, into the pharmaceutical supply chain offers advantages, over centralized systems by boosting transparency and security well as enhancing the tracking of products. However; issues such, as scalability and meeting requirements are obstacles to adoption of this technology. Current blockchain models that rely on Proof of Work (PoW) and Proof of Stake (PoS) in face challenges such as transaction speed limitations and high computational costs which make them less suitable, for large scale supply chain networks. To address these challenges; experts are investigating optimization methods to improve transaction efficiency without compromising security. Fulfilling the criteria remains a struggle, for implementing technology in the field as it requires compliance with FDA and EMA guidelines through cooperative initiatives, within the industry sector. Smart contracts must possess adaptability to accommodate evolving regulations while maintaining the values of decentralization. Furthermore effectively incorporating blockchain into supply chains demands investments, building infrastructure and garnering extensive backing from involved parties. It is crucial to educate stakeholders provide user interfaces and offer incentives to companies to ease the transition process. Tackling these obstacles can greatly enhance drug traceability, combat medicines, and improve global drug safety.

FUTURE INNOVATIONS

The use of technology, in the sector is relatively recent; however, there are multiple opportunities to improve security, effectiveness and regulatory compliance, in supply chains. Another emerging trend involves combining intelligence (AI) with blockchain technology to support analysis and anomaly detection. Stakeholders may leverage AI algorithms to identify medications boost efficiency and automate decision making processes to enhance supply chain intelligence. Nevertheless, it's crucial to keep in mind the necessity, for compatibility among networks due, to the fact that each network is operated by distinct pharmaceutical companies and regulatory bodies., Utilizing cross chain communication protocols and blockchain bridges facilitates data transfer while upholding the security of the supply chain.

CONCLUSION

The use of technology is instrumental, in enhancing the tracking and security of pharmaceuticals in the supply chain through the application of technology and smart contracts to boost transparency and reduce the threat of products. This is due, to blockchain providing a record that monitors the flow of medications precisely enabling stakeholders to confirm their legitimacy and uphold compliance with guidelines. Smart contracts further streamline compliance checks and recall processes by automating them to reduce errors. Nevertheless, some challenges like scalability issues and integration with regulations need to be tackled. One way to address this is by incorporating Proof of Stake mechanisms along with leveraging storage solutions. Additionally collaboration with authorities is crucial for ensuring implementation, across the board. In the coming years ahead advancements, like AI driven analytics have the potential to enhance supply chains by foreseeing trends, in pharmaceuticals, refining logistics operations and spotting anomalies thus building secure networks. Tackling these obstacles will pave the way for blockchain technology to transform drug verification procedures boost patient wellbeing and fortify distribution of products.

REFERENCES

1. Ahire, Pritam Ramesh, and K. Ulaga Priya. "Monitoring Body Mass Index (BMI) Pre & Post Covid-19 Outbreak: A Comprehensive study in Healthcare." *2024 MIT Art, Design and Technology School of Computing International Conference (MITADTSoCiCon)*. IEEE, 2024.

2. Ahire, Pritam. "Predictive and Descriptive Analysis for Healthcare Data, A Hand book on Intelligent Health Care Analytics-Knowledge Engineering with Big Data" https://www. wiley. com/enus/Handbook+ on+ Intelligent+ Healthcare+ Analytics% 3A+ Knowledge+ Engineering+ with+ Big+ Data-p-9781119792536 Published by Scrivener Publishing." (2021).

3. Ahire, Pritam, et al. "LSTM based stock price prediction." *International Journal of Creative Research Thoughts* 9.2 (2021): 5118-5122.

4. Ahire, Pritam R., and Preeti Mulay. "Discover compatibility: Machine learning way." *Journal of Theoretical & Applied Information Technology* 86.3 (2016).

5. Ahire, Pritam R., Rohini Hanchate, and Vijayakumar Varadarajan. "Indigenous Knowledge in Smart Agriculture." *Advanced Technologies for Smart Agriculture*. River Publishers, 2024. 241-258.

6. Hanchate, R., & Anandan, R. (2023). Medical Image Encryption Using Hybrid Adaptive Elliptic Curve Cryptography and Logistic Map-based DNA Sequence in IoT Environment. *IETE Journal of Research*, 1–16. https://doi.org/10.1080/03772063.2023.2268578

7. Ahire, Pritam Ramesh, Rohini Hanchate, and K. Kalaiselvi. "Optimized Data Retrieval and Data Storage for Healthcare Applications." *Predictive Data Modelling for Biomedical Data and Imaging*. River Publishers 107-126.

8. Ali, A. 2001. Dr. Chetanpal Singh, Dr. Rahul Thakkar, and Jatinder Warraich, "Blockchain in Supply Chain Management", https://www.researchgate.net/publication/364580709_Blockchain_in_Supply_Chain_Management.

9. Gupta A, Patel J, Gupta M, Gupta H., (2017), Issues and Effectiveness of Blockchain Technology on Digital Voting. International Journal of Engineering and Manufacturing Science, Vol. 7, No. 1

10. Jie Zhang Nian Xue and Xin Huang, "A Secure System For Pervasive Social Network-based Healthcare". IEEE Access 2017.

11. Ariel Ekblaw, Asaph Azaria, John D. Halamka, MD, Andrew Lippman, "A Case Study For Blockchain In Healthcare: "Medrec" Prototype For Electronic Health Records and Medical Research Data." Using Blockchain For Medical Data Access and Permission Management August 2016.

12. Dongsheng Zhang. "Resilience enhancement of container-based cloud load balancing service." Technical report, PeerJ Preprints, 2018.

13. Saad Khan, Simon Parkinson and Yongrui Qin, "Fog Computing Security: A Review of Current Applications and Security Solutions". Journal of Cloud Computing: Advances, Systems and Applications. 2017

14. S. Nakamoto. "Bitcoin: A Peer-to-Peer Electronic Cash System," Whitepaper, 2008.

15. P. Zhang, J. White, D. C. Schmidt, and G. Lenz. "Applying Software Patterns to Address Interoperability in Blockchain-Based Healthcare Apps," IEEE Software, 2017.

16. Griggs KN, Ossipova O, Kohlios CP, Baccarini AN, Howson EA, Hayajneh T. "Healthcare Blockchain System Using Smart Contracts for Secure Automated Remote Patient Monitoring," Journal of Medical Systems, 2018.

17. Zyskind G, Nathan O, Pentland A. "Decentralizing Privacy: Using Blockchain to Protect Personal Data," IEEE Security and Privacy Workshops (SPW), 2015.

18. Meidute-Kavaliauskiene I, Yıldız B, Çiğdem Ş, Činčikaitė R. An Integrated Impact of Blockchain on Supply Chain Applications. Logistics, 2021; 5(2): 33.