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Blockchain for Monitoring the Safe Supply Chain of Medicines: Reducing the Circulation of Illegal Drugs in Indonesia

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ABSTRACT

The pharmaceutical supply chain in Indonesia faces significant challenges, including counterfeit drug infiltration and insufficient traceability. This study explores the application of blockchain technology as a solution to monitor and secure the supply chain, reducing the circulation of illegal drugs. Using a qualitative approach, data were collected from five informants, including experts in blockchain technology, pharmaceutical supply chain management, and regulatory oversight. The findings reveal blockchain's potential to enhance transparency, accountability, and regulatory compliance through features such as decentralized ledgers and smart contracts. However, challenges such as high implementation costs, technical barriers, and regulatory gaps hinder its adoption. The study concludes with recommendations, including capacity building, collaborative pilot programs, and the development of supportive policies, to facilitate blockchain integration in Indonesia's pharmaceutical sector.

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1. INTRODUCTION

1.1. Introduction

The circulation of illegal drugs in Indonesia is a multifaceted issue exacerbated by the complex and fragmented nature of the pharmaceutical supply chain, which involves numerous stakeholders and lacks centralized control, making it susceptible to exploitation by illicit actors [1]. This vulnerability leads to significant public health threats, economic losses, and undermines the integrity of healthcare systems, as counterfeit and illegal medicines infiltrate the market [2]. High throughput times and profit margins attract illegal producers who develop independent distribution networks, further complicating supply chain management [1]. Despite regulatory efforts, enforcement remains inadequate, with illegal medicines accounting for a significant market share, particularly in categories like erectile dysfunction drugs, as identified by the Indonesian FDA [3], [4]. These challenges are compounded by the hidden nature of drug networks and the need for specialized skills and international cooperation to

effectively combat them [5]. Technological solutions such as blockchain could enhance transparency and traceability, addressing the deficiencies in traditional supply chain mechanisms and reducing counterfeit drug infiltration [1].

Blockchain technology has emerged as a transformative solution for addressing inefficiencies in pharmaceutical supply chains by enabling a decentralized, immutable ledger that enhances traceability, transparency, and trust among stakeholders [6], [7]. The technology is particularly effective in verifying the authenticity of medicines, tracking their journey from manufacturer to end-user, and preventing unauthorized tampering or diversion [8], [9]. Its real-time visibility provides stakeholders with a tamper-proof record of transactions, improving transparency and accountability [7], [8]. Additionally, the use of cryptographic principles and smart contracts reduces fraud risks and enhances product authenticity verification, addressing critical issues such as counterfeiting and data discrepancies [9], [10]. Blockchain also streamlines operations through automation, minimizes errors and delays, and fosters compliance with regulatory standards by maintaining a transparent, verifiable record of all transactions, thereby improving patient safety and public health [6], [10],

The prevalence of illegal drugs in Indonesia's pharmaceutical supply chain has led to severe consequences, including public health risks, financial losses, and diminished trust in healthcare systems. Current centralized monitoring mechanisms are inadequate, creating opportunities for counterfeit and illegal medicines to infiltrate the supply chain, putting millions at risk. Blockchain technology offers a promising solution to these challenges by providing a decentralized ledger system that enhances transparency, traceability, and security [6], [11]. This system allows stakeholders to access real-time data on drug provenance and distribution, ensuring regulatory compliance and increasing consumer confidence [6]. Blockchain's immutable records enable verification of product authenticity and tracking of a drug's journey from production to end-user, while role-based authorization and permissioned networks prevent data tampering, reducing counterfeit risks [12], [13]. Innovations like Janus, which integrates blockchain with cloning-resistant hologram tags, demonstrate scalability and resilience against counterfeiting threats [13]. Additionally, blockchain facilitates smart contracts and real-time ownership transfer, optimizing supply chain operations and reducing delays, while IoT integration enhances data integrity and accountability, streamlining processes and addressing inefficiencies [6], [14].

The urgency to address the issue of illegal drugs in Indonesia is underscored by the rising number of cases involving counterfeit medicines and their adverse effects on public health. The rapid growth of e-commerce platforms and informal distribution channels further complicates the problem, making it critical to adopt innovative and robust solutions. Blockchain technology, with its capacity for secure, decentralized, and transparent data management, offers a promising pathway to enhance the

safety and traceability of the pharmaceutical supply chain. Immediate action is necessary to leverage this technology to protect public health and strengthen the integrity of healthcare delivery systems in Indonesia.

1.2. Research Objective

This study aims to explore the application of blockchain technology in monitoring the safe supply chain of medicines in Indonesia. Specifically, it seeks to:

1. Identify the potential benefits of blockchain technology in reducing the circulation of illegal drugs.
2. Analyze the challenges and feasibility of implementing blockchain in Indonesia's pharmaceutical industry.
3. Provide actionable recommendations for stakeholders, including policymakers and supply chain actors, to ensure the effective adoption of blockchain solutions.

2. LITERATURE REVIEW

2.1. Blockchain Technology

Blockchain technology, with its decentralized, transparent, and immutable characteristics, has significantly transformed supply chain management by enhancing traceability, transparency, and security. This technology ensures tamper-proof record-keeping, preventing fraud and ensuring product authenticity while reducing costs and increasing efficiency through the elimination of intermediaries [15], [16]. Blockchain provides an unalterable record of goods' journeys, enabling real-time visibility into inventory levels and locations, which improves forecasting, demand planning, and logistics management [15], [17]. Secure digital fingerprints combat counterfeiting, as demonstrated by Everledger in the diamond industry, which reduced conflict diamonds and supported ethical sourcing (Oriekhoe et al., 2024). Efficiency and cost reduction are achieved through smart contracts that automate contractual conditions and facilitate faster, cheaper transactions [16], [18]. Despite its transformative potential, blockchain faces challenges such as scalability, regulatory uncertainties, and privacy concerns, necessitating future research on its integration with IoT and AI, as well as the development of industry-specific solutions [15], [17].

2.2. Supply Chain

The complexity of the pharmaceutical supply chain, particularly in regions like Indonesia, creates vulnerabilities that enable counterfeit drugs to infiltrate the market, resulting in severe health and economic repercussions. The fragmented nature of the supply chain and inadequate regulatory frameworks exacerbate these challenges, necessitating innovative technological solutions to enhance traceability and security. Blockchain technology offers a decentralized, transparent system that tracks the entire lifecycle of pharmaceutical products, ensuring authenticity and reducing counterfeits by creating a secure, single source of truth [19]. Distributed ledger-based architectures, such as EasyChain, further enhance serialization and regulatory compliance, providing robust solutions to counterfeit issues [19]. IoT and RFID systems enable real-time tracking and monitoring of drug transportation, enhancing transparency and safety by allowing stakeholders to detect and respond

to tampering or unauthorized access [20]. Integrating IoT frameworks like the Global Data Plane (GDP) with blockchain strengthens trace and track capabilities, maintaining an immutable record of drug transactions and holdings [21]. Enhanced traceability systems, crucial for verifying drug provenance, provide scalable infrastructure to prevent fraud and make it difficult for counterfeit drugs to infiltrate the supply chain [21].

2.3. *Pharmaceutical Supply Chains*

Blockchain technology has emerged as a transformative tool in the pharmaceutical supply chain, addressing critical issues such as transparency, traceability, and security. By leveraging its decentralized and immutable ledger, blockchain ensures that each transaction is securely recorded and verifiable, enhancing the authenticity and integrity of pharmaceutical products [22], [23]. Real-time tracking capabilities allow for monitoring from production to delivery, mitigating risks associated with counterfeit drugs and unauthorized distribution [10], [23]. The technology's cryptographic security features protect sensitive information, ensuring data integrity and preventing tampering and fraud [9], [10]. Furthermore, smart contracts automate compliance with regulatory standards, streamlining operations, reducing human error, and ensuring adherence to contractual obligations [10], [14]. Successful implementations, such as the MediLedger Project, demonstrate blockchain's potential to verify drug legitimacy, enhance data interoperability, and improve supply chain visibility while reducing operational costs [9], [23].

2.4. *Blockchain Adoption in Indonesia*

The adoption of blockchain technology in Indonesia shows promise but is hindered by several challenges, including technical, regulatory, and cultural barriers. Inadequate technological infrastructure, particularly in sectors like finance and land administration, coupled with high implementation costs, poses significant obstacles [24]–[26]. The absence of comprehensive regulations governing blockchain technology further exacerbates the situation, creating legal ambiguities in areas such as data protection and financial services [26], [27]. Additionally, limited awareness and understanding among stakeholders impede its widespread adoption, emphasizing the need for public education and collaborative efforts to build a supportive ecosystem [24], [28]. Despite these challenges, blockchain holds significant potential to enhance transparency, efficiency, and trust across various sectors, including finance, logistics, and land administration [24], [25], [28]. Government initiatives, such as digital transformation programs spearheaded by the Ministry of Communication and Information Technology, indicate a growing interest in leveraging advanced technologies to address national challenges and pave the way for broader blockchain adoption [24].

2.5. *Gaps in the Literature*

While existing studies highlight the benefits of blockchain for supply chain management, limited research focuses on its application in Indonesia's pharmaceutical industry. Furthermore, few studies examine the practical challenges of implementing blockchain in developing countries with complex

supply chain structures and regulatory environments. This research addresses these gaps by exploring the feasibility, potential benefits, and obstacles of blockchain adoption in Indonesia's pharmaceutical supply chain.

3. RESEARCH METHODOLOGY

3.1. Research Approach

The research adopts a qualitative research design in exploring the use of blockchain technology for tracking the safe supply chain of medicines in Indonesia. A qualitative design is especially suitable for obtaining detailed information on intricate matters, such as the incorporation of new technologies into established systems and the views of the main stakeholders. The focus is laid on elaborating the particular challenges and opportunities of blockchain implementation in the pharmaceutical sector, giving an overall perspective of its potential impact.

3.2. Data Collection and Informants

Five key informants were selected through purposive sampling with the objective of ensuring a range of expertise and knowledge relevant to the research topic. These informants included a blockchain technology expert, a supply chain manager in the pharmaceutical industry, a representative from the regulatory bodies, a healthcare provider, and an IT consultant experienced in blockchain adoption in Indonesia. Data were collected through in-depth, semi-structured face-to-face or virtual interviews based on guiding questions on current issues, benefits, feasibility, and recommendations for blockchain adoption. The interviews lasted approximately 60 minutes each and were recorded with consent. More data were collected from relevant documents, reports, and articles to supplement the study. The data were analyzed thematically using NVivo software through processes such as transcription, coding, and theme identification to arrive at significant findings and recommendations.

4. RESULTS AND DISCUSSION

4.1. Current Challenges in Indonesia's Pharmaceutical Supply Chain

The informants continued to highlight significant vulnerabilities in the pharmaceutical supply chain, including traceability issues, lack of control by regulators, and susceptibility to entry of counterfeit drugs. In the view of one informant, a regulator representative, "the fragmented nature of the supply chain makes it difficult to monitor each step." Another challenge that was emphasized was the lack of digitalization in inventory systems, particularly for small-scale distributors and retailers.

4.2. Perceived Benefits of Blockchain Technology

There was unanimity across all informants about the disruptive potential of blockchain technology in addressing these challenges. As per the blockchain expert, "the decentralized nature of blockchain allows for transparent, tamper-proof records, which is critical for tracing medicines from production through delivery." Informants also pointed out the possibility of using smart contracts to automate compliance with regulatory requirements, reducing administrative burdens while enhancing accuracy.

The pharmaceutical company's supply chain manager highlighted the contribution of blockchain to minimizing risks associated with human error, fraud,

and unauthorized alteration of documents. "With blockchain," they explained, "everyone in the chain is held accountable, so there is less chance of counterfeit drugs reaching the market."

4.3. *Feasibility and Implementation Challenges*

Despite its potential, the informants identified some challenges to the implementation of blockchain in Indonesia. These are:

1. Insufficient IT infrastructure and expertise in blockchain technology.
2. Exorbitant initial cost of implementing blockchain.
3. Absence of a clear legal framework for the use of blockchain in pharmaceuticals.
4. Opposition from small-scale stakeholders owing to ignorance and perceived complexity of the technology.

The IT consultant stated that "while larger companies can take up blockchain, smaller players in the supply chain may fall behind, creating an implementation gap."

4.4. *Adoption Recommendations*

Informants offered actionable suggestions to overcome these challenges:

a. Conducting training programs for stakeholders to familiarize themselves with the blockchain technology.
b. Having a legal framework in place to institutionalize and encourage the adoption of blockchain in pharma.
c. Initiation of pilot projects with key stakeholders to demonstrate the effectiveness of blockchain.
d. Partnerships: Encouraging collaborations between government agencies, private organizations, and technology providers for resource and expertise sharing.

4.5. *Discussion*

The results align with existing literature, which highlights the potential of blockchain in enabling transparency and traceability in supply chains [29], [30]. The technology addresses the major pain points in the Indonesian pharmaceutical supply chain with real-time tracking and tamper-proof documentation. These features reduce the possibilities of counterfeit drugs getting into the system and ensure product authenticity throughout the supply chain.

The findings also corroborate studies that have quoted hindrances to the use of blockchain in developing countries, such as technical limitations, economic factors, and regulatory uncertainty [31]. The lack of a coordinated mechanism to address these challenges has slowed progress, demonstrating the need for concerted action by policymakers, industry stakeholders, and technology providers.

Resistance from stakeholders and lack of awareness among small players in the supply chain were significant obstacles. However, this can be overcome by targeted education and training initiatives. As the MediLedger Project in the U.S. has demonstrated, multi-stakeholder pilot projects are best to prove the worth of blockchain and establish trust among stakeholders. These can be utilized as a model for Indonesia's pharmaceutical sector.

The study emphasizes the necessity of a favorable regulatory landscape to facilitate the adoption of blockchain. Policymakers must

come up with guidelines for blockchain integration, address data privacy concerns, and encourage innovation through subsidies or tax rebates. These efforts will not only encourage adoption but also align blockchain solutions with national public health agendas.

The introduction of blockchain into Indonesia's pharmaceutical supply chain also impacts other industries, such as agriculture and logistics, where authenticity and traceability are important. By addressing implementation challenges, Indonesia is able to be a regional leader in the application of blockchain technology to supply chain management.

5. CONCLUSION

The findings in this research highlight the game-changing potential of blockchain technology in addressing Indonesia's most critical pharmaceutical supply chain challenges. With enhanced transparency, traceability, and accountability, blockchain offers a practical means of addressing the sale of counterfeit drugs. The technology also makes regulatory compliance easier with automated processes, ensuring product safety and authenticity.

However, the use of blockchain faces significant barriers, including technical challenges, high costs, and legal ambiguity. To circumvent these issues, there is a need to conduct capacity-building activities, establish a clear legal framework, and foster collaboration between stakeholders through public-private partnerships. Pilot projects can provide practical demonstrations of the benefits of blockchain, facilitating wider adoption and trust among supply chain stakeholders.

Last but not least, the use of blockchain in Indonesia's pharmaceutical supply chain can improve public health outcomes, reduce financial losses, and establish the country's reputation for safe and reliable pharmaceutical delivery. Whatever is learned from this industry could also instruct blockchain deployments in other industries, paving the way for broader technological development in Indonesia.

REFERENCES

[1] P. S. Samreen, P. R. Kulkarni, and D. V. Warad, "Drug Traceability in Supply Chain of Healthcare using Blockchain-Based Approach," *Int. J. Multidiscip. Res.*, vol. 6, no. 2, pp. 1–13, 2024, doi: 10.36948/ijfmr.2024.v06i02.17739.

[2] R. H. Mustamu, "Manajemen rantai pasokan industri farmasi di Indonesia," *J. Manaj. dan Kewirausahaan*, vol. 9, no. 2, pp. 99–106, 2007.

[3] E. Yuliani, W. T. Novianto, and H. Purwadi, "The Urgency of Law Enforcement of Illegal Medicine Distributions in Indonesia," *J. Heal. Policy Manag.*, vol. 4, no. 2, pp. 76–85, 2019.

[4] F. Elfarabi, F. Handayani, Y. R. Arrahman, and A. A. Santoso, "Profil Peredaran Obat Disfungsi Ereksi Ilegal," *Erud. Indones. J. Food Drug Saf.*, vol. 1, no. 2, pp. 44–56, 2021.

[5] E. Suhartini, M. Roestamy, and A. Yumarni, "Prevention And Eradication Of Drug Trafficking In Indonesia," *UNTAG Law Rev.*, vol. 2, p. 100, Nov. 2018, doi: 10.36356/ulrev.v2i2.918.

[6] K. Yadav, "Integrating Blockchain Technology in Pharmaceutical Supply Chains," *Commun. Appl. Nonlinear Anal.*, vol. 32, pp. 147–156, Nov. 2024, doi: 10.52783/cana.v32.2260.

[7] G. Surapareddy, "ENVIRONMENTAL JUSTICE," 2024, pp. 128–138. doi: 10.58532/V3BJSO10P2CH8.

[8] A. Shete, S. Bhutada, M. Patil, P. Sen, N. Jain, and P. Khobragade, "Blockchain technology in pharmaceutical supply chain : Ensuring transparency, traceability, and security," *J. Stat. Manag. Syst.*, vol. 27, pp. 417–428, Jan. 2024, doi: 10.47974/JSMS-1266.

[9] I. Raza Bukhari, *Impact of Blockchain Technology on Supply Chain Management*. 2023.

[10] A. Adekola and S. Dada, "The role of Blockchain technology in ensuring pharmaceutical supply chain integrity and traceability," *Financ. Account. Res. J.*, vol. 6, no. 11, pp. 2120–2133, 2024.

[11] V. Bali, T. Khanna, P. Soni, S. Gupta, S. Chauhan, and S. Gupta, "Combating drug counterfeiting by tracing ownership transfer using blockchain technology," *Int. J. E-Health Med. Commun.*, vol. 13, no. 1, pp. 1–21, 2022.

[12] M. Dave, K. Patil, R. Jaiswal, and R. Pawar, "Monitoring supply chain of pharmaceutical drugs using blockchain," in *2022 IEEE Delhi Section Conference (DELCON)*, 2022, pp. 1–5.

[13] V. Crossland, C. Dellwo, G. Bashar, and G. G. Dagher, "Janus: Toward preventing counterfeits in supply chains utilizing a multi-quorum blockchain," *Blockchain Res. Appl.*, vol. 4, no. 4, p. 100157, 2023.

[14] G. Tiwari, P. Channakkalavara, G. Singh, and P. N. K. Sarella, "Enhancing Security, Transparency, and Efficiency of Blockchain Technology in Pharmaceutical Supply Chain," *Int. J. Pharm. Qual. Assur.*, vol. 15, no. 02, pp. 1009–1016, 2024, doi: 10.25258/ijpqa.15.2.71.

[15] O. I. Oriekhoe, B. I. Ashiwaju, K. C. Ihemereze, U. Ikwue, and C. A. Udeh, "Blockchain technology in supply chain management: A comprehensive review," *Int. J. Manag. Entrep. Res.*, vol. 6, no. 1, pp. 150–166, 2024.

[16] P. Alhat, "Blockchain Technology," *Interantional J. Sci. Res. Eng. Manag.*, vol. 08, pp. 1–5, Apr. 2024, doi: 10.55041/IJSREM30694.

[17] J. Moosavi, L. M. Naeni, A. M. Fathollahi-Fard, and U. Fiore, "Blockchain in supply chain management: a review, bibliometric, and network analysis," *Environ. Sci. Pollut. Res.*, pp. 1–15, 2021.

[18] Nishant and S. Sharma, "Blockchain Technology: A New Era of Transaction Processing," *Int. J. Multidiscip. Res.*, vol. 6, no. 2, pp. 1–4, 2024, doi: 10.36948/ijfmr.2024.v06i02.18924.

[19] A. K. Bapatla, S. P. Mohanty, E. Kougianos, D. Puthal, and A. Bapatla, "PharmaChain: A blockchain to ensure counterfeit-free pharmaceutical supply chain," *IET Networks*, vol. 12, no. 2, pp. 53–76, 2023.

[20] N. Kumareshan, K. N. Venkatesh, K. Manoj, T. Prasanna, K. Prasanna, and L. Kamaleshwaran, "Implementation of an Anti-counterfeit Pharmaceutical Supply chain System," in *2023 Second International Conference on Advances in Computational Intelligence and Communication (ICACIC)*, 2023, pp. 1–5.

[21] Archa, B. Alangot, and K. Achuthan, "Trace and track: Enhanced pharma supply chain infrastructure to prevent fraud," in *Ubiquitous Communications and Network Computing: First International Conference, UBICNET 2017, Bangalore, India, August 3-5, 2017, Proceedings 1*, 2018, pp. 189–195.

[22] S. Chaabaoui, Z. Oughannou, and H. Chaoui, "A Systematic Review of Blockchain Applications in Pharmaceutical Supply Chain Traceability and Security," in *2024 10th International Conference on Optimization and Applications (ICOA)*, 2024, pp. 1–7.

[23] W. Akram *et al.*, "Blockchain technology: A potential tool for the management of pharma supply chain," *Res. Soc. Adm. Pharm.*, vol. 20, no. 6, pp. 156–164, 2024.

[24] M. Tanley, Albert, A. Roberto, N. Livanio, F. Nata, and Joosten, "Analisis Potensi Dan Tantangan Teknologi Blockchain Dalam Mendukung Digitalisasi Ekonomi Di Indonesia," *Indones. J. Educ. Comput. Sci.*, vol. 2, pp. 161–171, Dec. 2024, doi: 10.60076/indotech.v2i3.933.

[25] P. Y. Siahaan and J. Ng, "Analisis Implementasi Teknologi Blockchain dalam Meningkatkan Transparansi dan Kepercayaan di Sektor Keuangan di Indonesia," *J. Sist. Inf. dan Ilmu Komput.*, vol. 2, no. 4, 2024.

[26] A. S. Kriswandaru, B. Pratiwi, J. Laksito, W. Ariani, and S. Sholikatun, "Analisis Yuridis terhadap Penggunaan Teknologi Blockchain dalam Pengamanan Data Pribadi: Studi Kasus di Indonesia," *Perkara J. Ilmu Huk. dan Polit.*, vol. 2, no. 4, pp. 531–540, 2024.

[27] L. A. Putri, "Problematika Penggunaan Teknologi Blockchain di Sektor Industri Jasa Keuangan Indonesia," 2021.

[28] J. P. Nugraha and K. Kusmiarto, "Prospek Pemanfaatan Teknologi Blockchain untuk Mengoptimalkan Keamanan Dokumen Pertanahan Elektronik: Sebuah Tinjauan Literatur Secara Sistematik," *Kadast. J. L. Inf. Technol.*, vol. 2, no. 1, pp. 66–84, 2024.

[29] N. Kshetri, "1 Blockchain's roles in meeting key supply chain management objectives," *Int. J. Inf. Manage.*, vol. 39, pp. 80–89, 2018.

[30] M. Crosby, P. Pattanayak, S. Verma, and V. Kalyanaraman, "Blockchain technology: Beyond bitcoin," *Appl. Innov.*, vol. 2, no. 6–10, p. 71, 2016.

[31] S. Widyastuti, S. Usman, and I. S. Ismail, "Tingkat Pengetahuan Masyarakat Terhadap Penggunaan Obat Tanpa Resep Sebagai Swamedikasi Menggunakan Model Formulir Keamanan Pengobatan Di Kelurahan Tanah Loe Kecamatan Gantarang Keke Kabupaten Bantaeng," *Pharmed J. Pharm. Sci. Med. Res.*, vol. 5, no. 2, 2022.