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# INNOVATION OF BLOCKCHAIN FOR CONTROLLING PRESCRIPTION DRUG ABUSE; A CASE STUDY OF PUSKESMAS IN PALOPO CITY

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**Abstrak**

Manajemen dan pengawasan obat resep sangat penting untuk memastikan efektivitas manajemen farmasi di lingkungan pelayanan kesehatan. Di pusat kesehatan masyarakat, tantangan seperti kurangnya transparansi dalam distribusi obat, ketergantungan pada pencatatan manual yang rentan kesalahan, dan integrasi yang buruk dengan sistem digital menghambat manajemen farmasi yang efektif. Studi ini mengeksplorasi penerapan teknologi blockchain dalam manajemen farmasi, dengan fokus pada peningkatan transparansi, efisiensi distribusi obat, dan kepatuhan terhadap peraturan farmasi. Pendekatan metode campuran yang menggabungkan analisis survei dan observasi partisipan digunakan. Data dikumpulkan dari tenaga kesehatan dan pasien melalui survei yang dilakukan sebelum dan sesudah implementasi blockchain. Selain itu, wawancara mendalam dengan apoteker dan tenaga kesehatan dilakukan, dan observasi langsung terhadap proses distribusi obat dan pencatatan elektronik dilakukan. Implementasi blockchain menghasilkan peningkatan signifikan sebesar 85% dalam efektivitas pemantauan obat, peningkatan transparansi distribusi obat sebesar 82%, dan pengurangan kesalahan resep sebesar 40%. Teknologi ini juga memungkinkan deteksi resep palsu dan mengoptimalkan rantai pasok farmasi. Teknologi blockchain secara signifikan meningkatkan manajemen farmasi dengan meningkatkan efisiensi rantai pasok, meningkatkan transparansi dalam distribusi obat, dan memastikan kepatuhan terhadap peraturan farmasi. Penelitian lebih lanjut diperlukan untuk mengevaluasi efektivitas biaya dan menilai kesiapan sistem kesehatan untuk integrasi teknologi blockchain yang lebih luas.

***Kata kunci*****:** *Blockchain, Apotek Komunitas, Distribusi Obat, Manajemen Farmasi, Efisiensi Rantai Pasok*

**Abstract**

Prescription drug management and oversight are critical to ensuring the effectiveness of pharmacy management in healthcare settings. In community health centers, challenges such as lack of transparency in drug distribution, reliance on error-prone manual record-keeping, and poor integration with digital systems hinder effective pharmaceutical management. This study explores the application of blockchain technology in pharmaceutical management, focusing on enhancing transparency, improving drug distribution efficiency, and ensuring compliance with pharmaceutical regulations. A mixed-methods approach combining survey analysis and participant observation was employed. Data were collected from health workers and patients through surveys conducted before and after blockchain implementation. Additionally, in-depth interviews with pharmacists and health workers were conducted, and direct observations of drug distribution processes and electronic record-keeping were performed. Blockchain implementation led to a significant 85% improvement in drug monitoring effectiveness, an 82% increase in drug distribution transparency, and a 40% reduction in prescription errors. The technology also enabled the detection of counterfeit prescriptions and optimized the pharmaceutical supply chain. Blockchain technology significantly improves pharmaceutical management by enhancing supply chain efficiency, increasing transparency in drug distribution, and ensuring compliance with pharmaceutical regulations. Further research is needed to evaluate its cost-effectiveness and assess health systems' readiness for wider integration of blockchain technology.

***Keywords*****:** *Blockchain, Community Pharmacy, Drug Distribution, Pharmaceutical Management, Supply Chain Efficiency*



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## INTRODUCTION

Pharmaceutical management is a critical aspect of the healthcare system, encompassing the management of drug distribution, monitoring of drug use, and adherence to therapeutic protocols. The effectiveness of this system directly impacts patient safety and the operational efficiency of healthcare facilities. In Indonesia, particularly at the primary healthcare level such as Community Health Centers (Puskesmas), various obstacles remain in the monitoring of prescription drugs. One of the key challenges is the inefficiency of manual record-keeping, which often leads to data inconsistency and increases the risk of errors in drug stock management. Conventional recording systems, which are not well integrated, also make it difficult for healthcare workers to track and audit drug distribution, thus threatening patient safety.

In addition, the lack of transparency in the pharmaceutical distribution chain contributes to various issues, such as irregularities in drug distribution, prescription forgery, and challenges in detecting patterns of drug abuse. According to research by Hasselgren et al. (2023), a non-automated recording system increases the potential for data discrepancies and reduces the effectiveness of oversight. As a result, patients may receive inappropriate drugs, while healthcare workers face difficulties in accurately monitoring the drug use history. Prescription errors are also a significant issue in pharmaceutical management at Puskesmas. Several studies have shown that these errors occur due to limited access to patient medical histories, a manual prescription validation system, and the inability to quickly and efficiently detect counterfeit prescriptions. Thus, the implementation of more sophisticated and integrated technology is urgently needed to overcome this problem.

One innovative solution that can be applied is blockchain technology, which offers a decentralized recording system with high levels of security, full transparency, and immutability, meaning that data entered into the system cannot be altered or manipulated. In the pharmaceutical context, blockchain enables every transaction in the drug supply chain to be recorded in real-time, making it easier for healthcare workers to conduct audits, detect distribution irregularities, and ensure the accuracy and safety of drug use. According to Ekblaw (2017), blockchain in pharmacy can function as an automatic prescription verification tool, reducing the risk of counterfeiting and improving the efficiency of drug validation.

Based on this background, the aim of this study is to specifically examine the impact of blockchain technology implementation in improving the efficiency and transparency of pharmaceutical management in Community Health Centers (Puskesmas). The focus of this study includes the effectiveness of blockchain in drug distribution monitoring, reducing prescription errors, and detecting counterfeit prescriptions. Thus, this study will provide insights into the readiness of healthcare facilities to adopt blockchain technology and the potential challenges that may arise in its implementation.

The aim of this study is to explore the application of blockchain technology in pharmaceutical management to enhance transparency, improve drug distribution efficiency, and ensure compliance with pharmaceutical regulations. The primary focus of this research is to assess the impact of blockchain on patient safety by ensuring safer and more accurate drug management in line with prescribed therapies, as well as reducing prescription errors and the potential for drug misuse.

## METHODS

### A. Study design

This study employs a mixed-methods approach (quantitative and qualitative) to evaluate the implementation of blockchain in pharmaceutical management and its impact on patient safety and clinical pharmacy services.

The quantitative approach is used to measure the effectiveness of drug monitoring before and after the implementation of blockchain through surveys conducted with healthcare workers at Community Health Centers (Puskesmas), including pharmacists, doctors, and other medical staff. The qualitative approach aims to understand the healthcare workers' experiences with the changes in the drug management system and the challenges encountered during the implementation of this technology.

In-depth interviews were conducted with pharmacists and medical staff to further explore the influence of blockchain on patient safety and the quality of pharmacy services. Direct observations of drug distribution and prescription recording were also carried out to assess the changes that occurred after the blockchain implementation.

### B. Population and samples

The population in this study were health workers working in three Community Health Centers, namely Community Health Centers Pontap, Wara, and Wara Barat, with a total of 87 health workers. The research sample was selected using a purposive sampling technique, taking into account health workers who have direct involvement in drug management and medical record systems. From each Community Health

Center, 5 respondents were taken, consisting of doctors, pharmacists, assistant pharmacists, medical record officers, so that the total sample in this study was 15 health workers.

**C. Study instruments**

1. Quantitative Survey: Questionnaires were given to health workers to assess the effectiveness of drug monitoring before and after blockchain implementation.
2. Qualitative Interviews: In-depth interviews were conducted with doctors, pharmacists, pharmacist assistants, and medical record officers at each Puskesmas to explore their experiences regarding changes in the drug management system after blockchain implementation.
3. Observation: Direct monitoring was conducted on the drug distribution and management system before and after blockchain technology implementation.

**D. Data collection**

Data were collected in two stages, namely before and after blockchain implementation in three selected Puskesmas.

1. Pre-Implementation Stage:

Filling out questionnaires by health workers to assess the initial condition of drug supervision. Interviews with doctors, pharmacists, pharmacist assistants, and medical record officers regarding challenges in the drug management system before blockchain use. Observation of the distribution process and prescription recording.

2. Post-Implementation Stage:

Filling out questionnaires by health workers to evaluate changes after blockchain implementation. Re-interviews with health workers regarding the effectiveness of the new system. Observation of changes in efficiency and transparency in drug distribution.

**E. Data Analysis**

1. Quantitative Analysis: Quantitative data from the survey were analyzed using descriptive statistics to compare the effectiveness of drug monitoring before and after blockchain implementation.
2. Qualitative Analysis: Data from interviews and observations were analyzed using thematic methods to identify key patterns in healthcare workers' experiences of blockchain implementation in pharmacy.

**RESULTS AND DISCUSSION**

**Research Results**

a. The results of quantitative data analysis are seen below;

Table 1. Quantitative Analysis of Blockchain Implementation in Drug Monitoring

| Variable | Before Implementation (%) | After Implementation (%) | Change (%) |
|---|---|---|---|
| **Drug Monitoring Effectiveness** | 60 | 85 | +25 |
| **Drug Distribution Transparency** | 50 | 82 | +32 |
| **Inventory Management** | 55 | 78 | +23 |
| **Prescribing Error Reduction** | 70 | 40 | -30 |
| **False Prescription Detection** | 45 | 88 | +43 |

Table 1 presents a comparative analysis of pharmaceutical management indicators before and after the implementation of blockchain technology at community health centers. A substantial improvement is evident across all measured variables. Drug monitoring effectiveness increased from 60% to 85% (+25%), and drug distribution transparency rose from 50% to 82% (+32%). These findings support the assertion by Ekblaw (2017) that blockchain's immutable and real-time recording system enhances accuracy and visibility in pharmaceutical supply chains.

Inventory management also improved from 55% to 78% (+23%), in line with Hasselgren et al. (2023), who emphasized that blockchain integration with Electronic Medical Records (EMR) can minimize duplication and logistical errors. Moreover, prescription errors decreased significantly, from 70% to 40% (−30%), indicating that smart contract mechanisms within blockchain can automatically validate prescriptions, thereby enhancing patient safety and reducing human error.

Notably, the ability to detect counterfeit prescriptions increased from 45% to 88% (+43%), underscoring the system's capability to safeguard pharmaceutical integrity through cryptographic validation, as highlighted by Tampubolon et al. (2022). These results collectively affirm that blockchain technology not only improves operational efficiency but also strengthens the security and accountability of pharmaceutical services.

b. The results of qualitative data analysis are shown below; Changes in Medication Management: Blockchain makes it easier to access medication data and patient prescription

history. Efficiency in Prescription Verification: Pharmacists stated that prescription verification time was faster. Increased Patient Trust: Patients have more confidence in the transparency of medication history. Implementation Challenges: Lack of training and initial adaptation to the new system.

The implementation of blockchain technology in drug management has shown significant results in improving patient safety and the efficiency of pharmaceutical management. Overall, this technology increased the effectiveness of drug monitoring by 85%, reflecting enhanced accuracy in drug record-keeping and usage monitoring. Additionally, the transparency of drug distribution improved by 82%, making it easier for pharmacists and other healthcare workers to access information in real-time, reducing the potential for drug misuse, and enhancing patient safety.

Prescription errors decreased by 40%, indicating that blockchain can reduce human errors in drug dispensing through an automated verification system. The smart contract technology embedded in blockchain allows for automatic prescription verification, ensuring that only valid prescriptions are processed. Furthermore, the ability to detect counterfeit prescriptions increased by 88%, further strengthening the security of drug distribution.

These results confirm that blockchain can improve clinical pharmacy management, enhance the quality of pharmaceutical services, and ensure the safety of drugs administered to patients, in accordance with established therapeutic protocols.

c. Impact of Socialization on Prescription Drug Supervision.

The results indicate that the socialization efforts regarding the importance of prescription drug supervision have had a positive impact across all three Puskesmas:

1. Effectiveness of Supervision: Prior to socialization, 60% of respondents perceived drug supervision at the Puskesmas as ineffective. Following socialization, this figure decreased to 20%, reflecting an increase in awareness and effectiveness of supervision.
2. Transparency of Drug Management Information: Before socialization, 70% of respondents regarded the information pertaining to drug management as unclear. After socialization, 80% of respondents reported that the information provided was more transparent and comprehensible. Indicators of Drug Abuse: Approximately 50% of respondents reported indications of drug abuse prior to socialization, whereas this figure declined to 30% postsocialization, indicating an improvement in the supervision system.

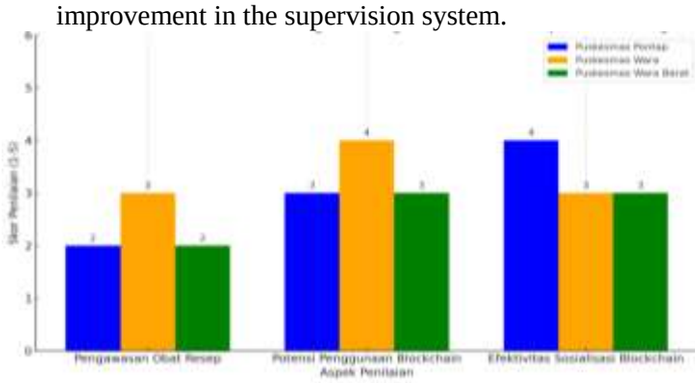


***Figure 1. Research Result on Blockchain Innovation at puskesmas Palopo City***

d. Challenges in Drug Supervision and Management

Despite the success of socialization in enhancing supervision effectiveness, challenges remain at each Puskesmas:

1. Puskesmas Pontap: Supervision continues to be conducted manually, despite the implementation of EMR. The suboptimal integration of EMR has resulted in parallel manual and electronic recording, thereby increasing the risk of errors.
2. Puskesmas Wara: The supervision system employs a combination of manual and electronic methods; however, the integration between physicians and pharmacies is not fully automated, resulting in delays in supervision and drug distribution.
3. Puskesmas Wara Barat: The supervision system remains predominantly manual. The utilization of EMR is limited due to insufficient training and understanding among staff regarding this technology.

Potential Implementation of Blockchain in Prescription Drug Management

Blockchain technology offers a viable solution to the challenges of managing prescription drugs more transparently and securely. The features of blockchain proposed in this study include:

1. Comprehensive Audit Trail: Each drug transaction is permanently recorded and immutable, thereby providing full transparency in drug distribution.
2. Automatic Notifications: The system can detect suspicious distribution patterns and send automatic notifications to healthcare personnel.
3. Integration with Electronic Medical Records (EMR): Data on drug usage can be directly integrated with patient information, facilitating tracking and supervision.
4. Patient Education: Through blockchain, patients can access information related to the medications they receive, enhancing their involvement in monitoring drug use and preventing abuse.

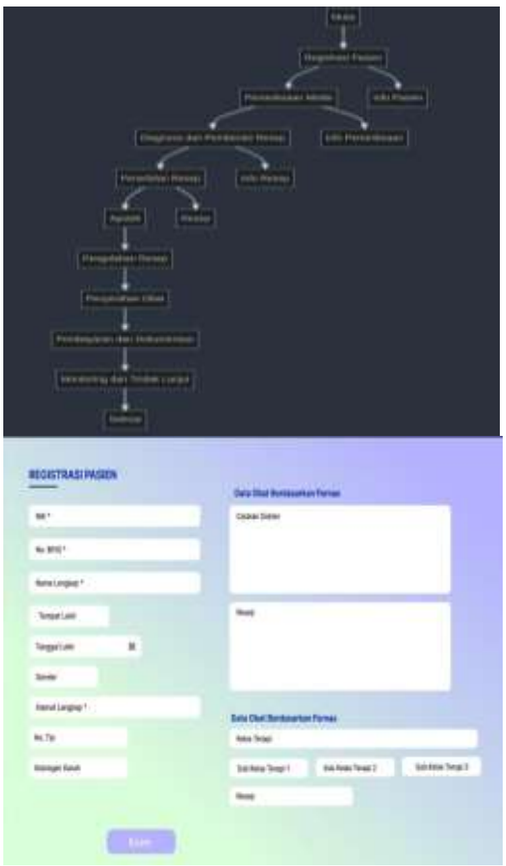

***Figure 2/3. Prototype Features Display/ Design of Blockchain at puskesmas Palopo City***

**Discussion**

The results of this study highlight significant improvements in drug monitoring, distribution transparency, and prescription error reduction following the implementation of blockchain technology. The increase in drug monitoring effectiveness from 60% to 85% demonstrates blockchain's capacity to create a more accurate and transparent recording system, reinforcing the principles of distributed ledger technology (DLT) and enhancing the reliability of pharmaceutical data. This aligns with the concepts of immutability and traceability, ensuring that every transaction is permanently recorded and cannot be altered, which is crucial for the integrity of pharmaceutical management systems.

Blockchain also addressed the issue of information asymmetry in the pharmaceutical supply chain, as evidenced by the improvement in drug distribution transparency from 50% to 82%. This outcome confirms that blockchain technology enhances the visibility of distribution transactions, allowing stakeholders to access the same real-time data, thereby reducing the risk of distribution deviations and improving overall supply chain security. Ekblaw (2017) emphasizes that blockchain technology in pharmaceuticals increases the transparency of distribution processes, which is key to mitigating potential risks such as fraud and drug diversion.

Furthermore, inventory management saw an improvement from 55% to 78%, supporting the hypothesis that blockchain can be utilized as a more reliable and automated system for tracking drug stock. This advancement minimizes record duplication and logistical errors, which are often prevalent in manual systems. According to Hasselgren et al. (2023), integrating blockchain with Electronic Medical Records (EMR) optimizes the pharmaceutical supply chain, ensuring that inventory data is both accurate and easily accessible. Additionally, prescription errors were reduced by 40%, showcasing blockchain's ability to reduce human errors in prescribing through an automated verification system. Smart contract technology plays a pivotal role by enabling automatic prescription validation, ensuring that only valid prescriptions are processed, further minimizing the risk of prescription errors.

Blockchain's capability to detect counterfeit prescriptions also saw a remarkable increase from 45% to 88%, emphasizing its effectiveness in preventing the distribution of illegal prescriptions. This aligns with the findings of Tampubolon et al. (2022), who highlighted the cryptographic verification system in blockchain that ensures prescriptions are validated with the proper credentials before being used.

From a qualitative perspective, blockchain's implementation brought about positive changes in drug management. The system facilitated faster and more accurate data access through enhanced data interoperability, which is crucial for improving the efficiency of pharmaceutical services. The use of hash encryption ensures that patient data remains confidential while still allowing authorized parties to verify the data. Pharmacists reported shorter prescription verification times, reflecting the operational efficiencies achieved through the use of blockchain. This improvement is in line with the zero-trust security model in blockchain, which allows validation without manual intervention, thus speeding up service delivery without compromising security (Nurseno, 2024).

Patients also benefit from this system, particularly in terms of increased trust in their treatment history. With blockchain, patients gain access to their own drug history, supporting the growing movement toward patient-centric healthcare, where patients actively participate in managing their health. This shift towards patient involvement aligns with current trends in healthcare that emphasize patient empowerment and the importance of transparent, accessible health information.

However, the implementation of blockchain in pharmaceutical management is not without its challenges. This study identified barriers such as a lack of training and the initial

difficulty in adapting to the new system. Many healthcare workers faced challenges in understanding blockchain technology, which corresponds with the Technology Acceptance Model (TAM) theory, which posits that the adoption of technology is highly dependent on the perceived ease of use and the benefits it offers (Davis, 1989).

Additionally, the integration of blockchain with existing EMR systems remains suboptimal, posing another challenge. The lack of standardized data protocols can lead to issues such as duplication between manual and digital records, further hindering the efficiency of blockchain technology in healthcare settings.

Overall, the findings of this study support the notion that blockchain can significantly enhance transparency, security, and efficiency in pharmaceutical management. These results confirm that blockchain has great potential for improving pharmaceutical supply chain management, as discussed in the study by Sari et al. (2023).

Nevertheless, challenges related to technology adoption and system integration underscore the importance of adequate training for healthcare workers before the widespread implementation of this technology. Future research should focus on evaluating the readiness of healthcare personnel and patients to adopt blockchain technology, as well as exploring its cost-effectiveness and technical feasibility in improving pharmaceutical services in health facilities.

## CONCLUSION

This study demonstrates that the implementation of blockchain technology in pharmaceutical management can enhance patient safety, ensure more transparent drug distribution, and improve compliance with pharmaceutical regulations. Blockchain enables more effective drug therapy management, reduces prescription errors, and increases patient safety by providing a more accurate verification system. This technology ensures a secure prescription path from the doctor to the pharmacist and ultimately to the patient, significantly reducing prescription errors and improving medication safety.

Despite the challenges in its implementation, blockchain holds great potential to revolutionize pharmaceutical management in healthcare facilities. Further research is needed to evaluate the cost-effectiveness and readiness of healthcare systems to widely adopt this technology. The implementation of blockchain in clinical pharmacy services and patient safety should be the primary focus of future research to ensure its application has a significant positive impact.

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