The Blockchain Model for Drug Management to Increase The Transparency of Drug Distribution and Drug Authenticity

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***Abstract*— Drug distribution is a very complex process that involves various parties, starting from the pharmaceutical industry, drug distributors, pharmacies, drugstores, and customers. The drug distribution network is very broad and involves many parties, making it difficult for customers and related parties to obtain transparent transactions in the drug distribution network as well as information about the authenticity of the drugs that customers will consume. On the other hand, blockchain technology offers features that can increase transaction transparency, so that blockchain can be a solution to drug distribution problems. Thus, the aim of this research is to build a blockchain model to increase the transparency of transactions between parties involved in the drug distribution network and provide information on guaranteeing the authenticity of medicines for customers. The research method uses a qualitative approach through a literature review to identify problems related to drug distribution. Literature review is also used to study conventional drug distribution mechanisms to find out the root causes of the drug distribution process. The output of the research is a model for adopting blockchain technology to increase the transparency of drug distribution transactions. The conclusion of this research shows that the adoption of blockchain technology can increase the transparency of drug distribution. The limitation of this research is that it uses simulations of only a few nodes in the blockchain so that future research can be carried out involving many nodes in the blockchain.**

Keywords— drugs distribution, blockchain, transparency

I. INTRODUCTION

Drug distribution involves a wide network of drug manufacturers, distributors, pharmacies, drugstores, and customers [1][2][3]. Each party in the network has different roles and responsibilities in the distribution process, and good coordination between these parties is essential to ensuring that medicines reach the customers who need them. Drug distribution is also related to strict regulations because it will have a serious impact if the drug to be consumed endangers [4][5][6].

The low transparency of transactions along drug distribution channels is due to the unavailability of a system that can offer valid information and real-time transaction transparency for the parties involved in the drug distribution process[7] [8][9] Blockchain technology, as an information technology-based technology that has the ability to provide mechanisms with transparency and high information validity, can be a solution for drug distribution [10][11][12]. The concept of peer-to-peer validation on the blockchain can be used by all parties involved in the drug distribution channel to guarantee the validity of information along the drug distribution channel[13][14][15].

Thus, the aim of this research is to adopt blockchain technology in drug distribution. The research method uses a quantitative approach with a literature review.

II. LITERATURE REVIEW

A. Blockchain Technology

The first advantage of blockchain is that it does not have a central authority that controls it, so no single entity can manipulate the data in it [16][17][18].Blockchain also offers high security because it uses a cryptographic system to protect data [19][20][21]. Blockchain also offers transaction transparency that is publicly viewable by everyone connected to the blockchain network [22][23]. Data already stored on the blockchain cannot be changed or deleted, thus making the blockchain very suitable for storing sensitive and important data. Finally, Blockchain also allows its use to create smart contracts, which are pieces of program code that can be executed automatically when certain conditions are met [24][25][26].

B. Drug Distribution Mechanism

Figure 1 describes the drug distribution mechanism in Indonesia. The initial process of the drug industry, which has the authority and permission from the government to produce drugs, Every drug that is produced must be registered with a drug and food management agency [27][28]. If the drug is not produced domestically, the drug or food from other countries must pass through this agency's inspection process [29].

After passing the inspection and obtaining a distribution permit, drugs produced by the drug industry or drugs originating from other countries can be sold through drug wholesalers or to major hospitals [30].

From wholesalers, drugs will be distributed to pharmacies or drugstores. Wholesalers also sell drugs to pharmacies or small hospitals. Meanwhile, hospitals can get drugs directly from drug manufacturers or through wholesalers. In the end, the drug will be used by patients or customers through pharmacies, drugstores, health centres, or hospitals [30][31].

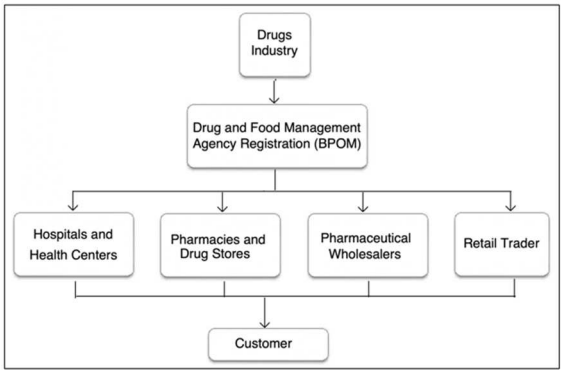

Fig. 1. Drug Distribution Mechanism (Created by Author)

C. Blockchain and Supply Chain

In the event of a pandemic, one use of blockchain technology in agricultural ecosystems is depicted in Figure 2. By using blockchain technology, the government, warehouses, farmers, procurement agencies, government warehouses, and beneficiaries can all work together more efficiently. Only transactions between beneficiaries and retailers, farmers, or government agencies involved in procurement are recorded in smart contracts [32].

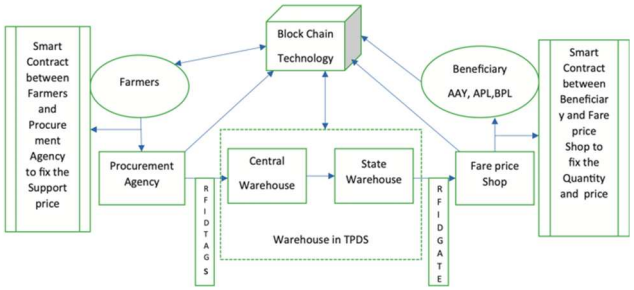

Fig. 2. Adoption Blockchain on Supply Chain (Kumar 2021)

D. Blockchain and Power Distribution

In Figure 3, we see how blockchain technology can be used to improve the distribution of electricity. The market begins the process of configuration and permissions. Energy trading pertaining to bid/offer submission and market schedule are two more areas where blockchain is designed to support, with the participant's approval. The next step is to use blockchain technology for market settlement and state estimation [33]

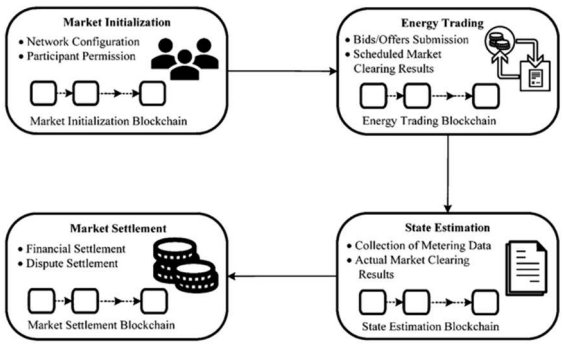

Fig. 3. Blockchain and Power Distribution (Adeyemi 2020)

III. Research Methode

The initial stage of research is the identification of problems related to drug distribution from drug manufacturers to patients or customers. Based on the literature review, there are two problems with drug distribution: the lack of transparency of information and transactions in drug distribution channels, and the circulation of counterfeit drugs.

After finding the research problem, the search for alternative solutions is continued with an information technology approach. Based on a literature review, blockchain technology has the feature of providing transaction transparency and high data security. So, research establishes blockchain technology as a solution to the problem of drug distribution.

The next stage is studying some of the previous research on blockchain and goods distribution systems to initiate the creation of the proposed model. After studying some of the previous research, the final stage of the research was to build a blockchain model for drug distribution. Figure 4 show the research method.

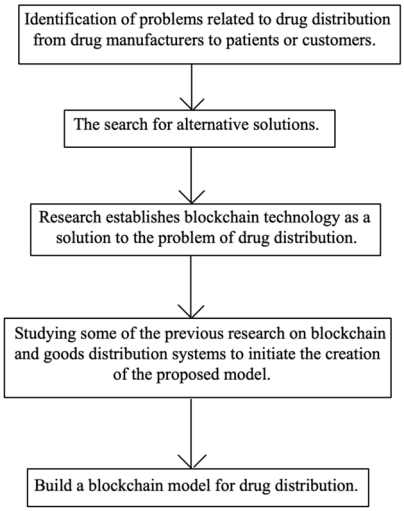

Fig. 4. Research Method

IV. Result and Disscussion

A. Previous Research on Blockchain and Drug Distribution

In Figure 4, we see how blockchain technology can be used to strengthen the safety of drug distribution and address coordination issues. The lack of a centralized monitoring system to ensure sufficient market control and provide real-time price, availability, and authentication data is a major obstacle to effective drug market coordination management. This research presents blockchain-based strategies for addressing problems like shaky coordination, insecure drug delivery, and questionable pharmaceuticals [34].

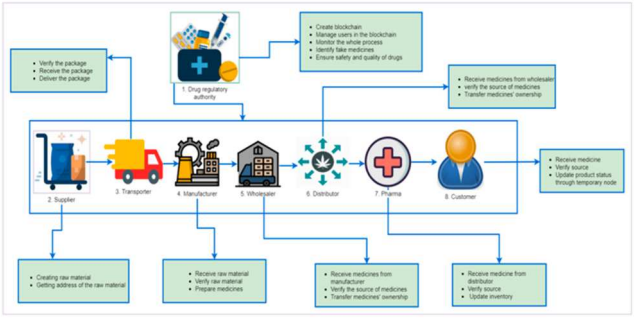

Fig. 5. Blockchain for Drug Distribution (Humayun 2022)

B. *Proposed Conceptual Model*

Figure 6 describes the conceptual model. The first part of the proposed model describes the parties that play a role in drug distribution, namely the government, drug factories, hospitals or health centres, drug dealers, pharmacies or drug stores, and drug retailers . The Government of the Republic of Indonesia in this case is represented by drug and food management (BPOM) as the party that has the authority and responsibility for drug distribution to create a blockchain network [35].

The initial process of the drug distribution mechanism using the blockchain is that every part involved in drug distribution must register on the blockchain network [36]. The registration process will proceed to the peer-to-peer information validation process for all nodes in the blockchain network. After the information received is valid then the data/information becomes part of the blockchain network [37].

The first party to register into the block chain network is the drug manufacturer as the owner of the drug brand [44]. All drugs that have passed the inspection process by BPOM and have received distribution permits will be registered on the blockchain network[38].

The second party that registers their institution on the blockchain network is the hospital. Hospitals can buy directly from drug manufacturers so that transactions between drug manufacturers and drug manufacturers can be monitored on the blockchain network[39]. Transactions between drug manufacturers and hospitals are stored in smart contracts that are part of the block chain network[40].

Wholesalers can also transact with drug manufacturers so that wholesalers must register into the block chain network. Transactions between wholesalers and drug manufacturers are stored on smart contracts[40].

The final party involved in drug distribution is the drug retailer. Retail drug dealers do not have access to buy drugs from drug factories, so retail drug dealers buy drugs via wholesalers. So, retail drug dealers must register into the blockchain network and transactions between retailers and wholesalers are stored in smart contracts [41].

All drug buying and selling transactions from drug manufacturers to retail traders are stored in smart contracts. The smart contract will go through a validation process for all nodes in the blockchain network before entering the block chain network. This process guarantees transaction transparency in all drug distribution channels[41].

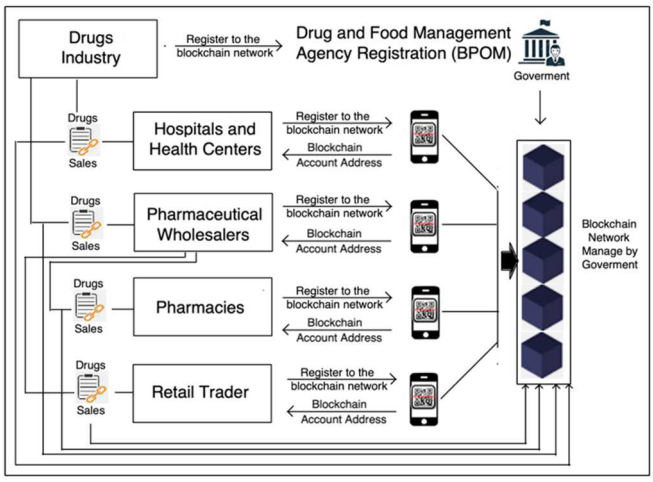

Fig. 6. The Conceptual Model

C. *Blockchain Supply Chain Drug with Exampel Scenario*

Figure 7 describes an example of implementing blockchain in a drug sales supply chain. initial process of selling drugs from drug manufacturers to drug wholesalers and hospitals. The scenario is illustrated with the example of selling 100 drugs to wholesalers and 200 drugs to hospitals. Sales scenarios are also made up for pharmacy stores. From wholesalers, 100 drugs are sold to 2 pharmacy stores, where pharmacy store 1 buys 10 drugs and pharmacy store 2 buys 90 drugs.

D. *Drugs Transaction on the Blockchain*

Figure 8 describes drug transactions on the blockchain. The picture explains the linkages between blocks with different hash values in each block. Each block is connected to the previous hash and hash value.

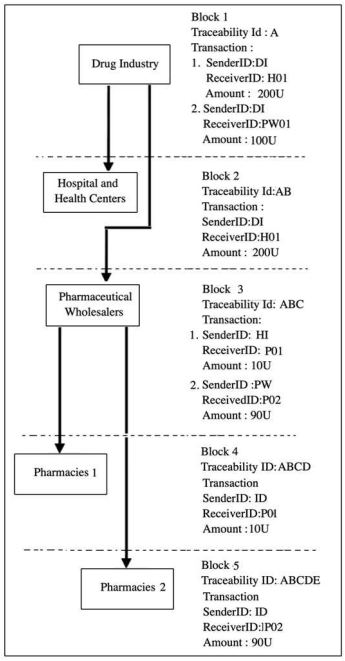

Fig. 7. Blockchain in Drug Sales

Fig. 8. Blockchain Drug Transaction

TABLE I. BLOCKCHAIN DRUG TRANSACTION

Block Number	Transaction	Block Asset
1	Sales of 100 units of drugs from drug manufacturers to pharmaceutical wholesalers and 200 units to hospitals with traceability ID : A	0000cdaa4b7cf9559b6ff80a273b40282c3c49513b4cac55d2bd372b01133cb9
2	Purchase of 200 units of drugs by the hospital from drug manufacturers with traceability ID : AB	00002f41e8683aae541698521b98bcfdbcc7896a4c68d9edc72cfb65b71658ad
3	Sales of 100 units of drugs from wholesalers to pharmacies 1 10 units and pharmacies 2 90 units with traceability ID : ABC	0000e9f744d8f6c3e8e6c3139fc19c42d48757a9285ee73d396ba0aaae65494c
4	Purchase of 10 units of drugs by pharmacy 1 from wholesalers with traceability ID : ABCD	000025b5334804e8d28bd95d61e74dab093a28ec9baa301b520179da29b738a8
5	Purchase of 90 units of drugs by pharmacy 2 from wholesalers with traceability ID : ABCDE	000007901335d65b5ac1172d62f0790f6fb2e917debe79e14211bfc75ed8af73

V. CONCLUSION

Medicine, as one of the products consumed by the general public, must be guaranteed to be safe for consumption. The long supply chain from the factory to the consumer requires a monitoring mechanism that is easy to trace. With the adoption of blockchain technology in government-initiated drug distribution, it will be easier for consumers and other related parties to track the distribution and authenticity of drugs that customers will consume.

The limitation of this research is that it uses simulations of only a few nodes in the blockchain so that future research can be carried out involving many nodes in the blockchain.

REFERENCES

[1] K. Abbas, M. Afaq, T. Ahmed Khan, and W.-C. Song, "A Blockchain and Machine Learning-Based Drug Supply Chain Management and Recommendation System for Smart Pharmaceutical Industry," *Electronics (Basel)*, vol. 9, no. 5, p. 852, May 2020, doi: 10.3390/electronics9050852.

[2] K. C. Bandhu, R. Litoriya, P. Lowanshi, M. Jindal, L. Chouhan, and S. Jain, "Making drug supply chain secure traceable and efficient: a Blockchain and smart contract based implementation," *Multimed Tools Appl*, Nov. 2022, doi: 10.1007/s11042-022-14238-4.

[3] R. Singh, A. D. Dwivedi, and G. Srivastava, "Internet of Things Based Blockchain for Temperature Monitoring and Counterfeit Pharmaceutical Prevention," *Sensors*, vol. 20, no. 14, p. 3951, Jul. 2020, doi: 10.3390/s20143951.

[4] M. Zaki, J. Pardo, and G. Carracedo, "A review of international medical device regulations: Contact lenses and lens care solutions," *Contact Lens and Anterior Eye*, vol. 42, no. 2, pp. 136–146, Apr. 2019, doi: 10.1016/j.clae.2018.11.001.

[5] S. J. Trenfield *et al.*, "Shaping the future: recent advances of 3D printing in drug delivery and healthcare," *Expert Opin Drug Deliv*, vol. 16, no. 10, pp. 1081–1094, Oct. 2019, doi: 10.1080/17425247.2019.1660318.

[6] Z. Zhao *et al.*, "Injectable Microfluidic Hydrogel Microspheres for Cell and Drug Delivery," *Adv Funct Mater*, vol. 31, no. 31, p. 2103339, Aug. 2021, doi: 10.1002/adfm.202103339.

[7] M. Uddin, "Blockchain Medledger: Hyperledger fabric enabled drug traceability system for counterfeit drugs in pharmaceutical industry," *Int J Pharm*, vol. 597, p. 120235, Mar. 2021, doi: 10.1016/j.ijpharm.2021.120235.

[8] T. K. Mackey and R. E. Cuomo, "An interdisciplinary review of digital technologies to facilitate anti-corruption, transparency and accountability in medicines procurement," *Glob Health Action*, vol. 13, no. sup1, p. 1695241, Feb. 2020, doi: 10.1080/16549716.2019.1695241.

[9] F. Jamil, L. Hang, K. Kim, and D. Kim, "A Novel Medical Blockchain Model for Drug Supply Chain Integrity Management in a Smart Hospital," *Electronics (Basel)*, vol. 8, no. 5, p. 505, May 2019, doi: 10.3390/electronics8050505.

[10] P. Centobelli, R. Cerchione, P. Del Vecchio, E. Oropallo, and G. Secundo, "Blockchain technology for bridging trust, traceability and transparency in circular supply chain," *Information & Management*, vol. 59, no. 7, p. 103508, Nov. 2022, doi: 10.1016/j.im.2021.103508.

[11] K. Zheng *et al.*, "Blockchain technology for enterprise credit information sharing in supply chain finance," *Journal of Innovation & Knowledge*, vol. 7, no. 4, p. 100256, Oct. 2022, doi: 10.1016/j.jik.2022.100256.

[12] H. Feng, X. Wang, Y. Duan, J. Zhang, and X. Zhang, "Applying blockchain technology to improve agri-food traceability: A review of development methods, benefits and challenges," *J Clean Prod*, vol. 260, p. 121031, Jul. 2020, doi: 10.1016/j.jclepro.2020.121031.

[13] Erick Fernando, "Blockchain Technology for Tracing Drug with a Multichain Platform: Simulation Method," *Advances in Science, Technology and Engineering Systems Journal*, vol. 6, no. 1.

[14] Miss. Divya Naikwadi, "DRUG TRACEABILITY IN HEALTHCARE SUPPLY CHAIN OF MEDICAL RECORD SYSTEM USING BLOCKCHAIN TECHNOLOGY," *International Research Journal of Modernization in Engineering Technology and Science*, vol. 4, no. 5, 2022.

[15] D. Sinclair, H. Shahriar, and C. Zhang, "Security requirement prototyping with hyperledger composer for drug supply chain," in *Proceedings of the 3rd International Conference on Cryptography, Security and Privacy*, New York, NY, USA: ACM, Jan. 2019, pp. 158–163. doi: 10.1145/3309074.3309104.

[16] L. Meria, Q. Aini, N. P. Lestari Santoso, U. Raharja, and S. Millah, "Management of Access Control for Decentralized Online Educations using Blockchain Technology," in *2021 Sixth International Conference on Informatics and Computing (ICIC)*, IEEE, Nov. 2021, pp. 1–6. doi: 10.1109/ICIC54025.2021.9632999.

[17] A. I. Abdi, F. E. Eassa, K. Jambi, K. Almarhabi, and A. S. A.-M. AL-Ghamdi, "Blockchain Platforms and Access Control Classification for IoT Systems," *Symmetry (Basel)*, vol. 12, no. 10, p. 1663, Oct. 2020, doi: 10.3390/sym12101663.

[18] M. Ur Rahman, B. Guidi, and F. Baiardi, "Blockchain-based access control management for Decentralized Online Social

Networks," *J Parallel Distrib Comput*, vol. 144, pp. 41–54, Oct. 2020, doi: 10.1016/j.jpdc.2020.05.011.

[19] Mohan Kubendiran, "Enhanced Security Framework for E-Health Systems using Blockchain," *Journal of information system processing*.

[20] K. S and G. Sarath, "Securing Land Registration using Blockchain," *Procedia Comput Sci*, vol. 171, pp. 1708–1715, 2020, doi: 10.1016/j.procs.2020.04.183.

[21] A. Sarfaraz, R. K. Chakrabortty, and D. L. Essam, "A tree structure-based improved blockchain framework for a secure online bidding system," *Comput Secur*, vol. 102, p. 102147, Mar. 2021, doi: 10.1016/j.cose.2020.102147.

[22] P. E. Velmovitsky, F. M. Bublitz, L. X. Fadrique, and P. P. Morita, "Blockchain Applications in Health Care and Public Health: Increased Transparency," *JMIR Med Inform*, vol. 9, no. 6, p. e20713, Jun. 2021, doi: 10.2196/20713.

[23] M. Kassen, "Blockchain and e-government innovation: Automation of public information processes," *Inf Syst*, vol. 103, p. 101862, Jan. 2022, doi: 10.1016/j.is.2021.101862.

[24] A. Singh, R. M. Parizi, Q. Zhang, K.-K. R. Choo, and A. Dehghantanha, "Blockchain smart contracts formalization: Approaches and challenges to address vulnerabilities," *Comput Secur*, vol. 88, p. 101654, Jan. 2020, doi: 10.1016/j.cose.2019.101654.

[25] Y. Mezquita, D. Valdeolmillos, A. González-Briones, J. Prieto, and J. M. Corchado, "Legal Aspects and Emerging Risks in the Use of Smart Contracts Based on Blockchain," 2019, pp. 525–535. doi: 10.1007/978-3-030-21451-7_45.

[26] H. R. Hasan and K. Salah, "Combating Deepfake Videos Using Blockchain and Smart Contracts," *IEEE Access*, vol. 7, pp. 41596–41606, 2019, doi: 10.1109/ACCESS.2019.2905689.

[27] A. Kumar, E. K. Zavadskas, S. K. Mangla, V. Agrawal, K. Sharma, and D. Gupta, "When risks need attention: adoption of green supply chain initiatives in the pharmaceutical industry," *Int J Prod Res*, vol. 57, no. 11, pp. 3554–3576, Jun. 2019, doi: 10.1080/00207543.2018.1543969.

[28] L. A. M. Chowdhury, T. Rana, and M. I. Azim, "Intellectual capital efficiency and organisational performance," *Journal of Intellectual Capital*, vol. 20, no. 6, pp. 784–806, Nov. 2019, doi: 10.1108/JIC-10-2018-0171.

[29] W. S. Alrobaish, P. Vlerick, P. A. Luning, and L. Jacxsens, "Food safety governance in Saudi Arabia: Challenges in control of imported food," *J Food Sci*, vol. 86, no. 1, pp. 16–30, Jan. 2021, doi: 10.1111/1750-3841.15552.

[30] N. Campling *et al.*, "Issues affecting supply of palliative medicines into community pharmacy: A qualitative study of community pharmacist and pharmaceutical wholesaler/distributor perspectives," *Exploratory Research in Clinical and Social Pharmacy*, vol. 6, p. 100132, Jun. 2022, doi: 10.1016/j.rcsop.2022.100132.

[31] A. Kotwani, A. Bhanot, G. L. Singal, and S. Gandra, "Marketing and Distribution System Foster Misuse of Antibiotics in the Community: Insights from Drugs Wholesalers in India," *Antibiotics*, vol. 11, no. 1, p. 95, Jan. 2022, doi: 10.3390/antibiotics11010095.

[32] A. Kumar, "Improvement of public distribution system efficiency applying blockchain technology during pandemic outbreak (COVID-19)," *Journal of Humanitarian Logistics and Supply Chain Management*, vol. 11, no. 1, pp. 1–28, Nov. 2020, doi: 10.1108/JHLSCM-06-2020-0050.

[33] A. Adeyemi *et al.*, "Blockchain technology applications in power distribution systems," *The Electricity Journal*, vol. 33, no. 8, p. 106817, Oct. 2020, doi: 10.1016/j.tej.2020.106817.

[34] M. Humayun, N. Z. Jhanjhi, M. Niazi, F. Amsaad, and I. Masood, "Securing Drug Distribution Systems from Tampering Using Blockchain," *Electronics (Basel)*, vol. 11, no. 8, p. 1195, Apr. 2022, doi: 10.3390/electronics11081195.

[35] I. D. G. N. S. , P. M. N. T. , C. M. F. , & P. A. F. J. Agung, "Juridical Study Of Food Criminal Action Based On Law Of The Republic Of Indonesia No.18 Of 2012," *Law Science and Field*, vol. 11, no. 5, 2022.

[36] S. M. Hosseini Bamakan, S. Ghasemzadeh Moghaddam, and S. Dehghan Manshadi, "Blockchain-enabled pharmaceutical cold chain: Applications, key challenges, and future trends," *J Clean Prod*, vol. 302, p. 127021, Jun. 2021, doi: 10.1016/j.jclepro.2021.127021.

[37] H. Si, C. Sun, Y. Li, H. Qiao, and L. Shi, "IoT information sharing security mechanism based on blockchain technology," *Future Generation Computer Systems*, vol. 101, pp. 1028–1040, Dec. 2019, doi: 10.1016/j.future.2019.07.036.

[38] A. Musamih, R. Jayaraman, K. Salah, H. R. Hasan, I. Yaqoob, and Y. Al-Hammadi, "Blockchain-Based Solution for the Administration of Controlled Medication," *IEEE Access*, vol. 9, pp. 145397–145414, 2021, doi: 10.1109/ACCESS.2021.3121545.

[39] F. Jamil, L. Hang, K. Kim, and D. Kim, "A Novel Medical Blockchain Model for Drug Supply Chain Integrity Management in a Smart Hospital," *Electronics (Basel)*, vol. 8, no. 5, p. 505, May 2019, doi: 10.3390/electronics8050505.

[40] I. A. Omar, R. Jayaraman, M. S. Debe, K. Salah, I. Yaqoob, and M. Omar, "Automating Procurement Contracts in the Healthcare Supply Chain Using Blockchain Smart Contracts," *IEEE Access*, vol. 9, pp. 37397–37409, 2021, doi: 10.1109/ACCESS.2021.3062471.

[41] K. C. Bandhu, R. Litoriya, P. Lowanshi, M. Jindal, L. Chouhan, and S. Jain, "Making drug supply chain secure traceable and efficient: a Blockchain and smart contract based implementation," *Multimed Tools Appl*, Nov. 2022, doi: 10.1007/s11042-022-14238-4.