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Evaluating The Role of NEXUS Blockchain Technology in Preventing Counterfeit Drugs: A Task-Technology Fit and DEMATEL Approach

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ABSTRACT

Counterfeit drugs pose a significant threat to global public health and safety, including treatment failure, disease spread, and loss of public trust in healthcare systems. The pharmaceutical industry has acknowledged the importance of implementing novel technologies to improve the supply chain. Pharmaceutical industries have increasingly adopted innovative technologies to increase security and traceability within supply chains, especially Blockchain technology such as Ethereum and NEXUS Platform. Blockchain technology represents an alternative solution, and in this research study, the NEXUS blockchain technology's contribution to pharmaceutical supply chains by exploring its ability to combat counterfeit drugs is examined. Three primary methods were employed. First was an analysis of the literature using the PRISMA methodology, which identified counterfeit issues before considering what potential solutions blockchain technology could bring to address these issues. Second, this research employs the Task-Technology Fit (TTF) model to measure how effectively NEXUS supports pharmaceutical tasks, including inventory management, tracking & tracing, authentication, fraud detection, secure transactions, recall management, and bottleneck identification. Finally, we conduct a DEMATEL analysis to examine the cause-and-effect relationships among key blockchain features such as decentralization, immutability, smart contracts, data encryption, real-time monitoring, and transparency. Results demonstrate the efficacy of blockchain in combatting counterfeit drugs depends on the key factors of decentralization and data encryption while transparency and real-time monitoring require further refinement. NEXUS blockchain technology's potential is evidenced in these findings as it revolutionizes pharmaceutical supply chains with enhanced security, traceability, and transparency.

Keywords: *Counterfeit drugs, Blockchain technology, DEMATEL, TTF, Public health safety*.

1. INTRODUCTION

Counterfeit medications are a major problem for the pharmaceutical sector. Without the required authorization, these medications are produced and distributed. They are of poor quality and are typically offered at cheaper costs than the original medications. The pharmaceutical supply chain is complicated since it involves many different parties. For the pharmaceutical supply chain to overcome this enduring issue, transparency and traceability are required [1]. Using its characteristics of immutability and decentralization, blockchain has emerged as a potential remedy for this counterfeiting problem. In the pharmaceutical supply chain, this shared ledger makes it convenient and more efficient to track and record transactions [2]. Blockchain technology's decentralization, transparency, and immutability make it ideal for data-driven fields. Blockchain technology allows us to safely store data on a common platform that all parties involved can access but not change. There are several uses for blockchain in the medical field. Every day, a lot of data is generated by this domain. Clinical trials, medical insurance, electronic health records (EHR), access control, and billing may all be made more efficient with blockchain [3]. Blockchain is a more effective way to fight counterfeiting than the conventional centralized system because of its decentralized structure and unchangeable characteristics. NEXUS technology is a scalable, high-performance blockchain that effectively prevents the sale of fake medications. Because all nodes receive information about data transactions in the supply chain, using the NEXUS blockchain improves the efficacy of medication monitoring and tracking. All nodes will be notified in the case of malicious conduct, and remedial measures can be implemented to either block or remove the rogue node from the blockchain [4].

Without consent from every node, no inaccurate data can be added to the blockchain, so the NEXUS blockchain algorithms increase the reliability of data entry. Because only certain requirements must be fulfilled for a transaction to be completed, smart contracts increase the transparency and security of blockchain technology. NEXUS Blockchain and hyper-ledger fabrics offer great privacy and restricted data access. This makes it possible to exchange pharmaceuticals and medications in pharmaceutical supply chains using a safer network without worrying about data theft or alteration. Blockchain might help healthcare organizations deal with the issue of counterfeit medications.

Problem Statement

Despite using RFID tags and regulatory efforts, it is highly complex to prevent counterfeit drugs. These conventional methods rely on centralized control systems, which are vulnerable to data security. Blockchain technology represents an alternative to centralization that may provide secure transactions [5], but its efficiency in pharmacy supply chains, specifically NEXUS, has not been assessed in depth. Particularly its ability to meet requirements needed to protect against counterfeit drugs - tracking/tracing as well as secure transactions are not fully explored; hence this study seeks to address this by conducting Task-Technology Fit (TTF) analyses on NEXUS as well as using DEMATEL analysis for causal relationship determination between key blockchain features.

Significance of the Study

The significance of the study involves an investigation of NEXUS blockchain technology's key features and its effectiveness in preventing counterfeit drugs in pharmaceutical supply chains [6]. On considering the severity of counterfeit drug problems, proper implementation of blockchain technology can radically transform processes for managing supply chains to ensure only authentic medications reach patients [7].

2. METHODS

The objectives of this study are to: (1) use the PRISMA framework to conduct a systematic review of the literature; (2) assess the NEXUS project's task-technology fit (TTF); and (3) use the DEMATEL analysis to examine the connections between the main components of NEXUS blockchain technology in preventing counterfeit medications in the pharmaceutical supply chain. The primary objective is to conduct literature reviews using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework.

The initial goal is to gather relevant studies and the literature reviews are conducted using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework regarding blockchain's application to healthcare and pharmaceutical supply chains, with particular consideration for counterfeit medicines.

The keywords used in the search are:

- “BLOCKCHAIN TECHNOLOGY” or BLOCK CHAIN TECHNOLOGY
- “HEALTHCARE” or HEALTH CARE
- “PHARMACEUTICAL SUPPLY CHAIN” or PHARMACEUTICAL SUPPLYCHAIN
- “COUNTERFEIT DRUG or FAKE DRUG”

The search was conducted across databases including PubMed, IEEE Xplore, Scopus, Google Scholar, SpringerLink, and Elsevier ScienceDirect. Only peer-reviewed, English-language studies published between 2010 and 2024 were taken into consideration. This provided 1638 studies for initial review.

Inclusion and Exclusion Criteria:

Inclusion Criteria: Studies focusing on blockchain applications within healthcare or pharmaceutical supply chains that address tasks focused on counterfeit drug prevention or supply chain security.

Exclusion Criteria: Non-peer-reviewed articles, studies not related specifically to blockchain technology, and non-English publications will not be included.

The four steps of the study selection process were identification, screening, eligibility, and inclusion, as shown in the PRISMA flowchart. Overall 26 studies were chosen for a thorough analysis after duplicates were eliminated and inclusion/exclusion criteria were applied.

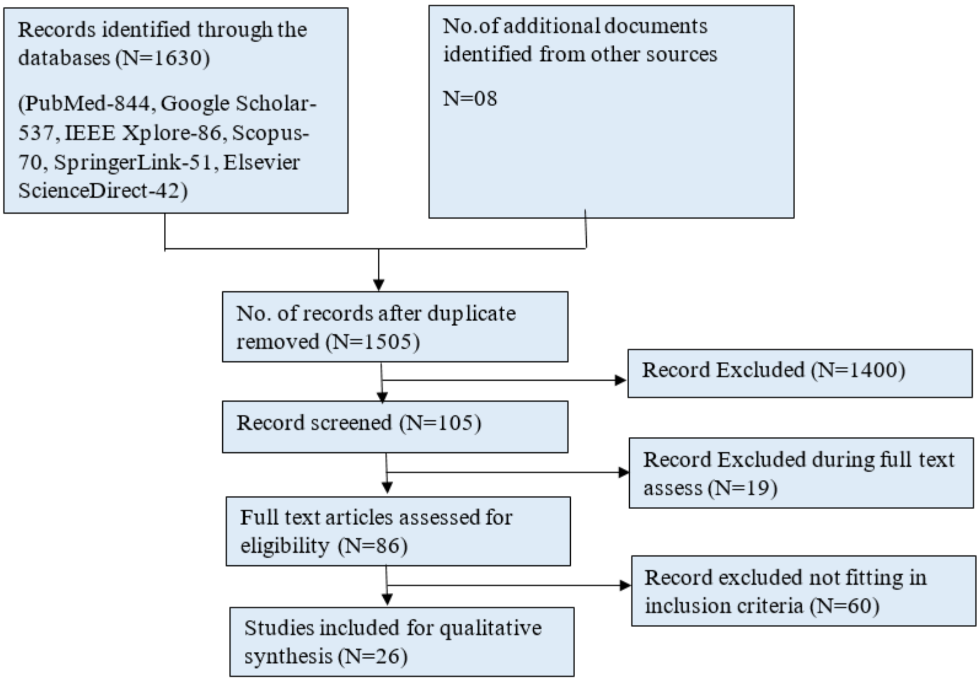

Figure-01 PRISMA framework for literature selection and analysis

Task-Technology Fit

The second objective is to assess Task-Technology Fit (TTF). TTF provides a framework that measures how effectively technology supports tasks it is meant to do. TTF was used to evaluate the performance of NEXUS technology in supporting key tasks reviewed in literature for combatting counterfeit drugs [8]. Tasks identified as essential to pharmaceutical supply chains include Inventory Management, Tracking & Tracing, Authentication, Fraud Detection, Secure Transactions, Bottleneck Identification, Recall Management, Data Safety, Security, Controlled Access, and Data Storage. NEXUS utilizes blockchain technology with key features such as decentralization, immutability, smart contracts, data encryption, real-time monitoring, and transparency to support tasks identified for completion. Each feature was carefully examined to ascertain its impact and support of identified tasks.

Evaluation Process: The Task-Technology Fit assessment focused on three criteria.

Functionality: Does Nexus meet each task within its supply chain adequately and efficiently (speed, accuracy, security improvements, etc)?

Efficiency: Does NEXUS enhance performance (such as speed, accuracy, security, etc)?

User Satisfaction: To gauge user satisfaction with NEXUS among stakeholders (manufacturers, distributors, and regulators), feedback was collected from those using it (manufacturers, distributors, and regulators).

Data was gathered through qualitative interviews with supply chain managers, and quantitative performance measures before and after implementation of NEXUS blockchain technology. The Figure 02 TTF analysis provided insights into how well the system supports supply chain operations, particularly in reducing counterfeit drugs.

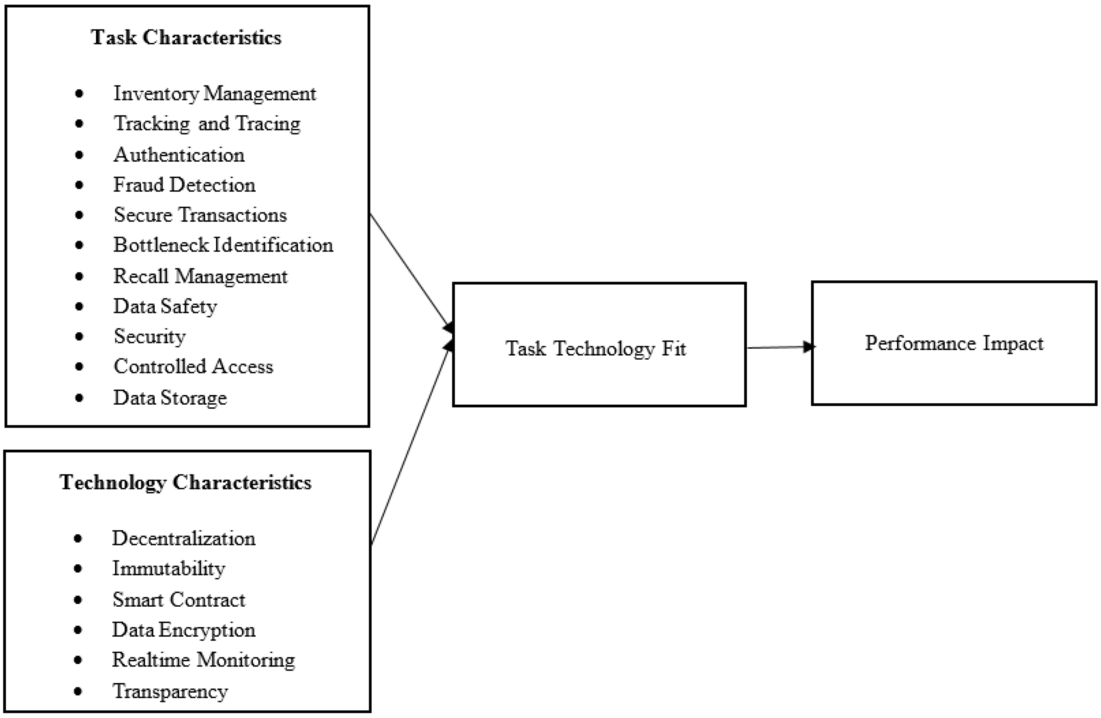

Figure 02: Task Technology Fit (TTF) for the study

DEMATEL Analysis

Our third goal is to use DEMATEL (Decision-Making Trial and Evaluation Laboratory) method to comprehend the cause-and-effect relationships among key features in the NEXUS system, using it to understand which elements act as drivers and which act as effects (dependent upon other features). DEMATEL provides insight into which features act as drivers versus effects when it comes to design decisions.

Step 1: Selection of Key features

The DEMATEL team identified six features of NEXUS that comprise its key characteristics for analysis, including

- Decentralisation
- Immutability
- Smart Contracts
- Data Encryption
- Real-time Monitoring
- Transparency

These features have been chosen due to their importance in safeguarding and guaranteeing traceability for pharmaceutical products within the NEXUS blockchain-based system.

Step 2: Gather Data and Establish the Direct-Relation Matrix

To evaluate relationships among features, an expert panel composed of 6 members (2 blockchain specialists, 2 pharmaceutical supply chain managers, and 2 healthcare professionals) was convened. Each expert was then asked to rate how influential each feature had on another feature using a 5-point Likert scale [9],

0 = No Influence,

1 = Very low Influence

2 = Low Influence

3 = High Influence

4 = Very High Influence

The experts provided pairwise comparisons that allowed for the construction of the Direct-Relation matrix (A). In this matrix, a_{ij} represents the i feature had more influence over the j feature [10].

Step 3: Normalizing the Direct-Relation Matrix.

To ease the comparison of impact levels, each element in the matrix was normalized by dividing it by its greatest row sum [11]. Normalized matrix N may be readily calculated using the following equation:

$N = 1/\max(\sum a_{ij})$

Step 4: Calculation of Total Relation Matrix (T)

To understand both direct and indirect influences between the key features, the Total Relation Matrix (T) was calculated [12]. This matrix takes into account not only the immediate influences one feature has on another but also indirect pathways through which features interact.

The Total Relation Matrix T was calculated with this equation:

$T=N (I-N)-1$

Where I is the identity matrix and N is the normalized Direct Relate Matrix; matrix T includes both direct and indirect relationships among features [13].

Step 5: Computing Dispatch, Receive, Net Effect and Total Effect

Using the Total Relation Matrix, it was calculated that these values [14]:

Dispatch (D): A feature's influence over others can be represented as its total sum in this row of the matrix [14]

$Di=\sum jTij$

Receive (R): Each column in a Total Relation Matrix represents how influential one feature is over another [14].

$Rj=\sum iTij$

Net Effect (D - R): The difference between dispatch and receive values that indicates whether an object acts more as a causing agent (positive value) or as an effect (negative value).

$D-R=Di-Rj$

Total Effect (D+R): D+R indicates the cumulative involvement of features within a system and comprises both dispatch and receive values. When combined, they provide a significant influence on that system [14].

$D+R=Di+Rj$

Step 6: Interpretation of DEMATEL Results

DEMATEL analysis provided insight into how key features in NEXUS interacted. Decentralization emerged as a primary cause, having significant effects on Immutability, Smart Contracts that provide security automation across pharmaceutical supply chains as well as Transparency and Real-time Monitoring which depended on other features for proper functioning [15].

Step 7: Visualization of Impact-Relation Map (IRM)

To further examine our findings, the IRM was utilized as an effective representation of causal relationships within the NEXUS system, providing a visual depiction of nodes representing features and directed edges representing strength of influence between them; edge thickness was proportional to magnitude as determined in Total Relation Matrix; this visualization offered clear representations of causal relations within its system for decision making in improving supply chain security and decreasing counterfeit drug production.

3. RESULTS AND DISCUSSION

TTF Analysis Results

The Task Technology Fit (TTF) analysis from the literature reviewed provides a correlation between the NEXUS technology features and the tasks needed in blockchain technology in the prevention of counterfeit drugs. Table 01 shows that Decentralisation, Smart Contracts, Data Encryption, and Real-time Monitoring have high significant fit with the tasks needed, considerably improving operational effectiveness and efficiency [16]. Decentralization improves stakeholders' transparency, trust, and cooperation by diminishing a central authority that depends on shared accountability in the pharmaceutical supply chain. Smart Contracts are essential for the processes executed with accuracy and speed for specific transactions and enforce agreements without intermediaries, which reduce the chances of delaying the tasks [17].

Real-time monitoring is crucial for operations that require immediate feedback and quick decisions to ensure that there is no disruption to operations. In any case, data encryption is necessary for all operations of a confidential nature or those concerning sensitive information since it guarantees no leakage of information, also ensuring the pharmaceutical industry complies with its regulatory conditions.

Whereas, Immutability and Transparency show moderate fit to TTF. Immutability is to support integrity, and its effectiveness depends on supporting technologies, inclusive of data encryption and data security. Transparency is essential for developing stakeholder confidence, and proper integration with other key features is essential to ensure data quality and security [19].

The Task Technology Fit analysis provides insights into the significance of key features such as decentralization, smart contracts, and data encryption. By optimizing these key features in blockchain technologies, stakeholders can improve operational performance in the pharmaceutical supply chain, enhancing the performance of technology and task needs in the prevention of counterfeit drugs [20].

NEXUS Technology Features Task	**Decentralization**	**Immutability**	**Smart Contract**	**Data Encryption**	**Realtime monitoring**	**Transparency**
Inventory Management	✓		✓		✓	
Tracking & Tracing	✓	✓	✓		✓	✓
Authentication		✓		✓		
Fraud detection		✓			✓	✓
Secure transaction		✓	✓	✓		
Bottleneck identification	✓		✓		✓	✓
Recall management			✓		✓	✓
Data safety & security		✓		✓	✓	✓
Controlled Access	✓	✓		✓		
Data storage	✓	✓	✓			

Table-01 Task Technology Fit (TTF) Analysis of NEXUS blockchain technology in the prevention of counterfeit drugs

	Decentralisation	**Immutability**	**Smart Contracts**	**Data Encryption**	**Real-time Monitoring**	**Transparency**
Decentralisation	0	3.8	3.6	2.1	4	3.2
Immutability	1	0	1.6	2	2	3.2
Smart Contracts	3	2.2	0	1.2	3.2	3.8
Data Encryption	3.2	4	1.4	0	3.4	1.6
Real-time Monitoring	2	2.4	1.3	3.2	0	2.1
Transparency	1	2	2	1	2	0

Table-02 Direct influence matrix (A) for the study

	Decentralisation	Immutability	Smart Contracts	Data Encryption	Real-time Monitoring	Transparency
Decentralisation	0.0000	0.2235	0.2117	0.1235	0.2352	0.1882
Immutability	0.0588	0.0000	0.0941	0.1176	0.1176	0.1882
Smart Contracts	0.1764	0.1294	0.0000	0.0705	0.1882	0.2235
Data Encryption	0.1882	0.2352	0.0823	0.0000	0.2000	0.0941
Real-time Monitoring	0.1176	0.1411	0.0764	0.1882	0.0000	0.1235
Transparency	0.0588	0.1176	0.1176	0.0588	0.1176	0.0000

Table-03 Normalized direct influence matrix (N) for the study

	Decentralisation	Immutability	Smart Contracts	Data Encryption	Real-time Monitoring	Transparency
Decentralisation	0.30876985	0.61144748	0.48606345	0.41996615	0.62439896	0.58676001
Immutability	0.24335796	0.25764863	0.27035546	0.28983355	0.36290984	0.4150833
Smart Contracts	0.40172847	0.46388013	0.25770382	0.32124007	0.51335196	0.53772031
Data Encryption	0.42206158	0.56583265	0.34099592	0.27017766	0.53681041	0.44803718
Real-time Monitoring	0.32517429	0.43130981	0.28812067	0.38067745	0.30513585	0.40385158
Transparency	0.21596193	0.3225269	0.26231878	0.21609682	0.32494145	0.22047692

Table-04 Total direct influence matrix (T) for the study

Factors	D	R	D-R	D+R
Decentralisation	3.0374059	1.91705408	1.12035182	4.95445998
Immutability	1.83918874	2.6526456	-0.81345686	4.49183434
Smart Contracts	2.49562476	1.9055581	0.59006666	4.40118286
Data Encryption	2.5839154	1.8979917	0.6859237	4.4819071
Real-time Monitoring	2.13426965	2.66754847	-0.53327882	4.80181812
Transparency	1.5623228	2.6119293	-1.0496065	4.1742521

Table 05 Summary matrix for the DEMATEL

Factors	D	R	D-R	D+R	IDENTITY
Decentralisation	3.0374059	1.91705408	1.12035182	4.95445998	Cause
Immutability	1.83918874	2.6526456	-0.81345686	4.49183434	Effect
Smart Contracts	2.49562476	1.9055581	0.59006666	4.40118286	Cause
Data Encryption	2.5839154	1.8979917	0.6859237	4.4819071	Cause
Real-time Monitoring	2.13426965	2.66754847	-0.53327882	4.80181812	Effect
Transparency	1.5623228	2.6119293	-1.0496065	4.1742521	Effect

Table-06 Factor identity table for the study

4. DEMATEL ANALYSIS

The DEMATEL analysis provides the significant relationships between Decentralisation, Immutability, Smart Contracts, Data Encryption, Real-time Monitoring, and Transparency of blockchain technology. Through a series of matrices—Direct Influence Matrix (A), Normalized Direct Influence Matrix (X), Total Direct Influence Matrix (T), and the Summary Matrix—each factor's role as either a cause or effect is identified [21]. Figure 03 utilizes colors to signify the influence strength and intensity of relationships between these key factors.

Table 02 displays the direct influence values between each factor. Decentralization exerts the highest direct influence on Real-time Monitoring (4.0) and Transparency (3.2). On the other side, Immutability exhibits lower influence values across most factors, showing that it plays a major indirect role in the blockchain system [22]. The highest direct influences are seen between Decentralisation and Real-time Monitoring. The direct influence matrix indicates that Decentralisation is a crucial driver of blockchain technology in the prevention of counterfeit drugs. The higher direct influence value shows that improving the particular key factor, Decentralisation could significantly enhance other factors, which results in improving monitoring and transparency within the blockchain. Immutability shows a lower level of influence, showing that it relies more on other key factors for its effective functionality rather than being a driver itself [23].

In Table 03, the normalized matrix value provides comparative influences among key factors, to identify the dominant relationship. Decentralization has a large impact on Real-time Monitoring (0.2352) and Transparency (0.1882), although Transparency has little effect on the other aspects. Following normalization, decentralization has a significant impact on its interactions with real-time monitoring and transparency [24]. Transparency's low influence ratings indicate that it serves as a result or impact rather than a driver inside the system. This lends credence to the theory that decentralization has a significant upstream impact on system behavior.

Table 04 displays the direct and indirect effects of variables impacting blockchain technology. Data Encryption has a strong influence on Real-time Monitoring (0.5368) and Decentralisation (0.4221). Decentralization and Smart Contracts also have a big overall impact on a variety of other issues, making them critical components for technological advancements [25].

The entire influence matrix stresses that Data Encryption is indirect yet important in enabling both surveillance and decentralized operations. This suggests that, while it is not necessarily the primary driver, Data Encryption facilitates efficient and secure operations. Decentralization has a substantial total effect over other critical elements, implying that any enhancements will improve the overall functionality of blockchain technology [26].

Table 05 summary matrix emphasizes the D (Dispatchers) and R (Receivers) values for each component, allowing us to determine if they are influencers or impacted entities. Decentralization has the greatest D - R value (1.120), indicating its importance as a major factor.

Transparency and Real-time Monitoring, with negative D - R values, are identified as effect factors. The summary matrix confirms that Decentralisation is the system's primary driver, exerting significant influence on other factors with minimal susceptibility to being influenced. Transparency and Real-time Monitoring are effective factors as they are more dependent on other factors, particularly Decentralisation and Smart Contracts, to function effectively. It suggests that any impacts on the cause factors will result in changes in the effect factors [27].

In Table 06, all the key factors are kept under two categories, either cause or effect based on the D-R Value. Factors such as Decentralisation, Data Encryption, and Smart Contracts are indicated as causes, while Immutability, Real-time Monitoring, and Transparency are categorized as effects. This table makes it clear that the system is primarily driven by Decentralisation, Smart Contracts, and Data Encryption. These cause factors can influence multiple downstream factors, making them the primary focus for any improvement efforts. The effect factors Immutability, Real-time Monitoring, and Transparency heavily rely on the strength and functionality of the cause factors [28].

Figure 03 shows how strongly these factors influence one another. Stronger relationships are represented by more vivid colors, whereas weaker relationships are represented by lighter hues. Because of their close ties to other elements, which are shown by deeper color intensity, decentralization, smart contracts, and data encryption are visually identified as the main influencing aspects in this graphic representation. Decentralization, smart contracts, and data encryption as the main affecters, the figure graphically supports the system's hierarchical structure [29]. Immutability, Real-time Monitoring, and Transparency are all effectors which are strongly influenced by these aspects, as indicated by the more intense colors surrounding them. In the absence of guiding arrows, the emphasis switches to the strength of relationships, enabling us to identify the most important elements. The color scheme makes it obvious which locations will benefit from system enhancements.

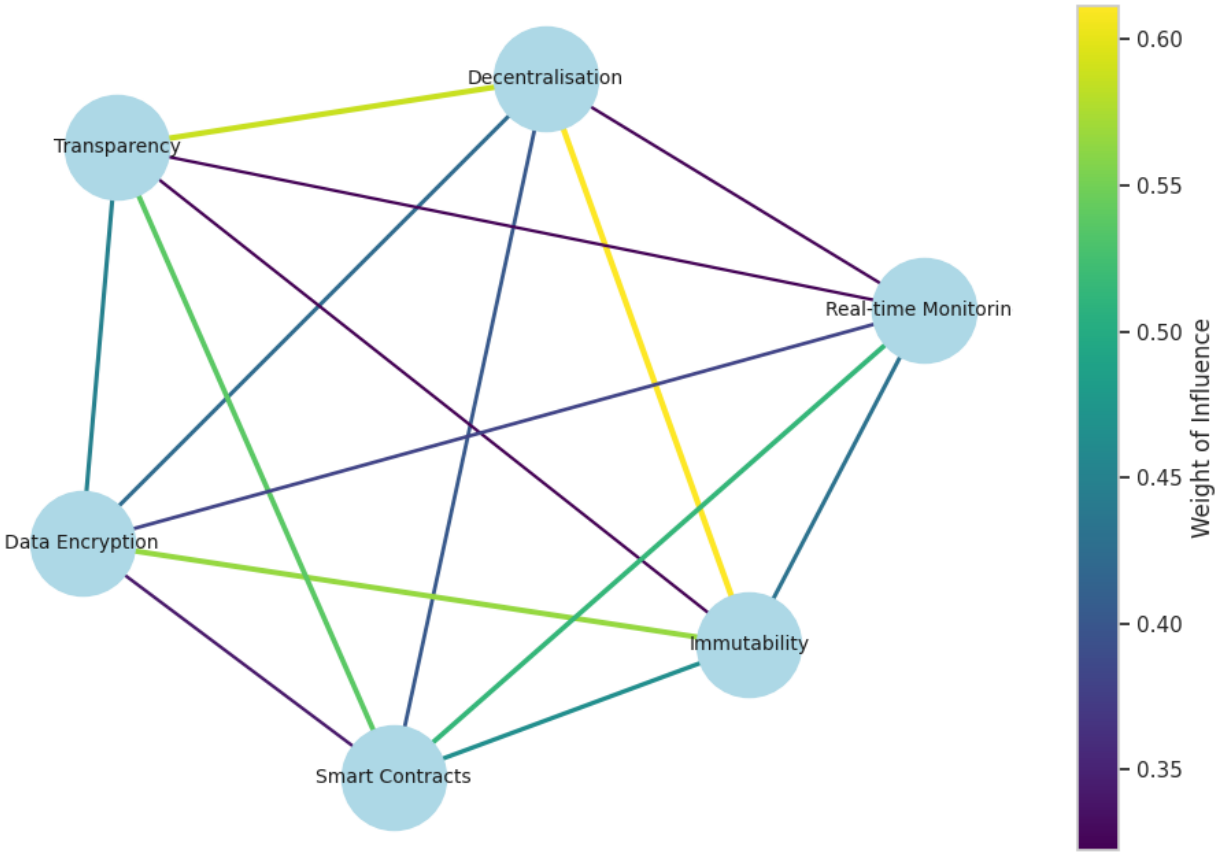

Figure 03: Impact Relationship Map for analyzing cause and effect relationship

5. CONCLUSION

In this study, an extensive assessment was executed with the help of DEMATEL and Task Technology Fit (TTF) for factors that will contribute to optimizing NEXUS technology in pharmaceutical supply chains. The technology's key features such as decentralization, immutability, smart contracts, data encryption, real-time monitoring, and transparency were considered primary factors that were investigated. This study focuses on the casual relationship and provides an in-depth understanding and responsibilities of blockchain technology. According to these findings, the principal catalysts for change are decentralization, smart contracts, and data encryption, with considerable association with other factors such as real-time monitoring, immutability, and transparency. This indicates that optimizing the cause factors that have high Total Flow (D - R) values results in relevant changes in the overall dynamics of the blockchain system. The cause traits that influence Immutability, Real-time Monitoring, and Transparency are effect traits. By improving the cause traits, the effect variables can function efficiently and the overall performance in the entire blockchain system can be achieved. This study highlights the integral approach in the NEXUS blockchain system by sorting changes in cause traits, which results in increased efficiency, security, and confidence to prevent counterfeit medications in the pharmaceutical supply chain. The findings offer a structured framework for administrators, to focus on the most important areas, resulting in a more robust and successful operational environment. Further, this study could examine their practical consequences in real-world contexts, thereby improving our understanding of complex pharmaceutical supply chain systems.

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Abbreviations

NEXUS - Network for Ensuring exemplary and Unblemished Safety

PRISMA - Preferred Reporting Items for Systematic Reviews and Meta-Analyses

TTF - Task-Technology Fit

DEMATEL - Decision-Making Trial and Evaluation Laboratory

REFERENCES

[1] Haq I, Esuka OM (2018) Blockchain technology in the pharmaceutical industry to prevent counterfeit drugs. Int J Comput Appl 180(25):8–12

[2] Mishra V (2022) Applications of blockchain for vaccine passport and challenges. J Glob Oper Strateg Sourc 15(3):345–362

[3] Siyal AA, Junejo AZ, Zawish M, Ahmed K, Khalil A, Soursou G (2019) Applications of blockchain technology in medicine and healthcare: Challenges and future perspectives. Cryptography 3(1):1–16.

[4] Hölbl M, Kompara M, Kamišalić A, Zlatolas LN (2018) A systematic review of the use of block- chain in healthcare. Symmetry 10(10).

[5] Yadav NK, Singh HP, Verma R, Singh KK (2021) Pharmaceutical supply chain management block- chain. Lect Notes Netw Syst 150(LNNS):181–190.

[6] Alzahrani N, Bulusu N (2018) Block-supply chain: A new anti-counterfeiting supply chain using NFC and blockchain. CRYBLOCK 2018 - Proceedings of the 1st Workshop on Cryptocurrencies and Block- chains for Distributed Systems, Part of MobiSys 30–35.

[7] Abbas K, Afaq M, Khan TA, Song WC (2020) A blockchain and machine learning-based drug sup- ply chain management and recommendation system for smart pharmaceutical industry. Electronics (Switzerland) 9(5):1–31.

[8] Jamil F, Hang L, Kim KH, Kim DH (2019) A novel medical blockchain model for drug supply chain integrity management in a smart hospital. Electronics (Switzerland) 8(5).

[9] Prisma-statemen (2019) PRISMA. Prisma-Statemen. http://www.prisma-statement.org/. Accessed 20 May 2022

[10] Mishra V, Sharma MG (2022) Digital transformation evaluation of telehealth using convergence, maturity, and adoption. Health Policy Technol 11(4):100684

[11] Hawash B, Mokhtar UA, Yusof ZM, Mukred M, Gaid ASA (2021) Factors affecting Internet of Things (IoT) adoption in the Yemeni oil and gas sector. Int Conf Technol Sci Admin ICTSA 2021:1–7.

[12] Si SL, You XY, Liu HC, Zhang P (2018) DEMATEL technique: A systematic review of the state-of- the-art literature on methodologies and applications. Math Probl Eng 2018:1–33

[13] Omar I, Debe M, Jayaraman R, Salah K, Omar M, Arshad J (2020) Blockchain-based supply chain traceability for COVID-19 PPE. Preprint 1–17.

[14] Agbo C, Mahmoud Q, Eklund J (2019) Blockchain technology in healthcare: A systematic review. Healthcare 7(2):56.

[15] Chang SE, Chen YC, Lu MF (2019) Supply chain re-engineering using blockchain technology: A case of smart contract-based tracking process. Technol Forecast Soc Chang 144(March):1–11.

[16] Casino F, Dasaklis TK, Patsakis C (2019) Enhanced vendor-managed inventory through blockchain. South-East Eur Des Autom Comput Eng Comput Netw Social Media Conf SEEDA-CECNSM.

[17] Cole R, Stevenson M, Aitken J (2019) Blockchain technology: Implications for operations and supply chain management. Supply Chain Manag 24(4):469–483.

[18] Ajao LA, Agajo J, Adedokun EA, Karngong L (2019) Crypto hash algorithm-based blockchain technology for managing decentralized ledger database in oil and gas industry. J 2(3):300–325.

[19] Mohana M, Ong G, Ern T (2019) Implementation of pharmaceutical drug traceability using block- chain technology. Inti J.

[20] Kassab MH, DeFranco J, Malas T, Laplante P, Destefanis G, Neto VVG (2019) Exploring research in blockchain for healthcare and a roadmap for the future. IEEE Trans Emerg Topics Comput 6750(c):1–16.

[21] Li H, Zhu L, Shen M, Gao F, Tao X, Liu S (2018) Blockchain-based data preservation system for medical data. J Med Syst 42(8):1–13.

[22] Velmovitsky PE, Bublitz FM, Fadrique LX, Morita PP (2021) Blockchain applications in health care and public health: Increased transparency. JMIR Med Inform 9(6).

[23] Hasselgren A, Kralevska K, Gligoroski D, Pedersen SA, Faxvaag A (2020) Blockchain in healthcare and health sciences—A scoping review. Int J Med Inform 134(May 2019):104040.

[24] Uddin M, Salah K, Jayaraman R, Pesic S, Ellahham S (2021) Blockchain for drug traceability: Architec- tures and open challenges. Health Inform J 27(2).

[25] Pandey P, Litoriya R (2021) Securing e-health networks from counterfeit medicine penetration using blockchain. Wireless Pers Commun 117(1):7–25.

[26] Kumar R, Tripathi R (2019) Traceability of counterfeit medicine supply chain through blockchain. Int Conf Commun Syst Netw COMSNETS 2061(1):568–570.

[27] Sahoo M, Singhar SS, Sahoo SS (2020) A blockchain based model to eliminate drug counterfeiting. Adv Intell Syst Comput 1101(March):213–222.

[28] Yadav NK, Singh HP, Verma R, Singh KK (2021) Pharmaceutical supply chain management block- chai. Lect Notes Netw Syst 150(LNNS):181–190.

[29] Mishra V, Singh J (2022) Health technology assessment of telemedicine interventions in diabetes management: Evidence from UAE. FIIB Bus Rev.