

Challenges of Adopting Blockchain Technology to Pharmaceutical Supply Chain – A Case Study From Sri Lankan Health Sector

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Abstract — Ensuring the transparency of pharmaceutical supply chains is an important task to control the adverse health effects of counterfeit drugs. Blockchain technology has been widely recognized among supply chain researchers as a useful emerging technology to enhance transparency and security of various supply chains. However, the adoption of the blockchain technology in pharmaceutical supply chains is still in its infancy with only a handful of research reported to date. This paper presents the details of a conceptual model developed to explore the challenges of adopting blockchain technology to manage pharmaceutical supply chain while combatting against the flow of counterfeit drugs. The proposed conceptual model, which is based on a comprehensive review of literature, encapsulates the complex linkages between seven influencing factors namely 1) Relative advantage 2) Upper management support 3) Human Resource 4) Compatibility 5) Cost 6) Complexity, and 7) Technological Infrastructure and Architecture. The factors evaluated in the framework interact and impact one another. The proposed framework can be utilized as a starting point for implementing blockchain applications in the pharmaceutical supply chain as well as by academics to develop, refine, and assess blockchain based research. As factors have been identified, practitioners will be able to develop a strategy for implementing blockchain in the pharmaceutical supply chain

Keywords — *Blockchain Technology, Blockchain Adoption, Drug Counterfeiting, Pharmaceutical Supply Chain*

I. INTRODUCTION

Counterfeit and pharmaceuticals are a widespread issue that has a negative impact on public health. It has become a worldwide problem hence, counterfeit pharmaceuticals are on the rise, making it difficult to keep track of them. Counterfeit pharmaceuticals are common in developing countries including Sri Lanka. According to the World

Health Organization WHO, counterfeit medications account for 25% of all medicines in developing countries and 10% of all medicines worldwide [1]. Supply management is a critical issue in all industries, but it is especially important in healthcare because of its increasing complexity. This is because any disruption in the healthcare supply chain has an impact on a patient's health. As the complexity is high, pharmaceutical supply chains are insecure and contain openings for fraudulent attacks.

The deletion of sensitive information from the Sri Lankan Government Cloud is a severe data loss recently occurred at National Medicine Regulatory Authority, NMRA. The unexpected deletion of sensitive data held by the Drug Regulatory Authority is a contradiction of rules and regulations. It was one of the most serious data corruptions in Sri Lanka, as there was no data backup. These circumstances develop as a result of a lack of transparency and a centralized structure. These situations arise as a result of a lack of transparency and the lack of a decentralized system. Currently By bringing better data transparency and improved product traceability, blockchains enable a safe and secure platform to solve this problem and, in some situations, prevent fraud from occurring. Thus, the aim of this research was to explore all of these challenges and giving insights about the feasibility of adopting blockchain technology to Sri Lankan Pharmaceutical Supply Chain. Built on the findings of this research, a conceptual framework was proposed to be used in the future as well in order to develop strategy for implementing blockchain in pharmaceutical supply chain.

A. Why Blockchain

Blockchain technology came into the world with the introduction of Bitcoin. With the invention of this technology (blockchain platform), it stated that it could be used to perform peer to peer transactions without going through a trusted party [2]. Blockchain is a decentralized and distributed ledger technology that maintain transactional data and is governed by a consensus mechanism. In the blockchain, users can make and verify transactions instantly without the need for a central authority.[3] In general, transaction validation is done by

network members coming to an agreement. It has blocks, which are a collection of transactions linked together by a cryptographic hash. Data that is significant to all parties can be updated in real time, eliminating the need for time-consuming and eliminating fraud. As a result, each member of the network has a far better and more timely view of what is going on in the network.

Blockchain technology is increasingly being used in innovative ways that are relevant to the challenges posed by the COVID-19 pandemic. The inadequacy of traditional systems to provide dependable and effective solutions to challenges caused by the global crisis has increased the value of blockchain applications. It becomes much easier to instantly see the origin of items and to search for complete supplies of an item without developing a centralized database by keeping suppliers and buyers on a shared ledger and recording all transactions on the chain as immutable records. Not only are centralized databases difficult to keep up to date, but they can also be easy targets for hackers [4]. The blockchain's trustless system can help tremendously in decreasing supply chain failures, especially when the epidemics like Covid-19 progresses.

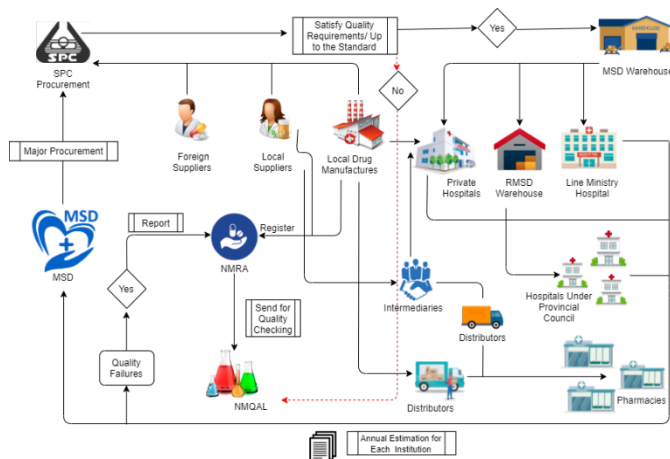


Fig.1. Pharmaceutical supply chain in Sri Lanka

B. Pharmaceutical Supply Chain and Reasons for increase in counterfeit drugs

Fig. 1 depicts the pharmaceutical supply chain in Sri Lanka. The National Medicines Regulatory Authority (NMRA), which is part of the ministry of health, nutrition, and indigenous medicine, as well as the State Pharmaceutical Corporation (SPC), Medical Supply Division (MSD), National Medicines Quality Assurance Laboratory (NMQAL) are in charge of overseeing the procurement, quality assurance, and distribution of pharmaceutical products, including medicines, in Sri Lanka. Under the Ministry of Health, the NMRA and NMQAL are separate authorities. Only drugs that have been registered with the NMRA can be manufactured, imported, and sold in Sri Lanka, according to the NMRA Act. To increase the quality, efficacy, and safety of the

medication, there are acts and several health institutes in place. Local manufacturers are inspected by a team of officials linked to the Office of Medical Technology & Supplies and the NMQAL, while overseas manufacturers are evaluated by assessing their company profiles. Counterfeit medicine can enter the pharmaceutical supply chain through foreign suppliers, local suppliers, local drug manufacturers, and supply chain intermediaries, as shown in Fig. 1

C. Improve Pharmaceutical supply chain with blockchain

As there are information losses and barriers at every step of the supply chain, it is extremely difficult to track the supply chain to investigate issues. Buyers and sellers require a trusted way to verify the real value of a product or service. [8]. Through the use of immutable records of data, distributed storage, and regulated user accesses, blockchain technology has the potential to improve traceability and transparency difficulties within the manufacturing supply chain. It would be possible to not only track the production and location of drugs using blockchain as an approach, but also to improve the traceability of falsified drugs [9]. Medical data sharing, privacy, and security can be considerably improved amongst healthcare professionals and the pharmaceutical industry by adopting blockchain technology [10]. Other than that blockchain can face cyber attacks/threats, which improve the reliability of the pharmaceutical supply chain. According to a statistical survey conducted by Statista, the financing investment in blockchain technology has increased dramatically worldwide since 2014 [11].

II. OBJETIVES

The pharmaceutical sector needs an effective supply chain management system to prevent counterfeit pharmaceuticals, and blockchain technology is the best available strategy for developing a faultless supply chain management system. When data security and privacy are the most crucial factors, it is the best alternative. This study aims to provide a thorough understanding of the numerous barriers to blockchain adoption in the Sri Lankan pharmaceutical sector. The study's findings will allow practitioners to better understand problems and their impact on the adoption process. Researchers and practitioners will be able to better grasp problems and their solutions as a result of the study's findings. This study aims to contribute to two different areas. Firstly, the existing pharmaceutical supply chain in Sri Lanka and potential usage of blockchain technology on supply chain will be identified. In second phase of the study barriers for the adoptability of blockchain will be identified. To the best of the knowledge, no research papers evaluating the adaptability of blockchain technology to the Sri Lankan context have been published. This study attempts to fill the current research gap about the adoptability of blockchain technology to the Sri Lankan Pharmaceutical Supply Chain

III. METHODOLOGY

A. Data Collection

The initial step of the analysis was to search the articles relevant to the study. The search criteria included keywords like “Blockchain”, “Supply Chain”, “Pharmaceutical Industry”, and the like. 155 related articles were found through the investigation. This search strategy was needed because the studies on pharmaceutical industry and supply chain management have appeared in a narrow range of publications. A comprehensive literature review was done to discover the knowledge available in the related fields. In databases like as Web of Science, Business Source Complete, Scopus, and Google Scholar, a simple search for the keywords "blockchain" and "adoption" generated many papers. Each paper was thoroughly examined to filter the irrelevant content to the work and finally, 78 articles were selected for the analysis. After analyzing the abstracts of each of the articles, it was discovered that only few of the of them have focused on the adoptability of blockchain. The important parameters were discovered after reading all those papers. At the end 27 papers were selected for the final review

In terms of data collection, the data is gathered through a survey approach and interviews. When it comes to examining a phenomenon of interest, the survey approach and interviews are appropriate (in our case, blockchain adoption in pharmaceutical supply chain). This study incorporated extra items from the existing literature and changed them to match our research environment, similar to other recent studies that employed a survey technique approach and interviews to collect data. Interviews and questionnaires had been conducted among six groups who are pharmaceutical product manufacturers, pharmaceutical companies (importers), Medical Supply Division, NMRA, Sri Lanka Chamber of the Pharmaceutical Industry (SCLPI), Ministry of Health, and Technical experts. Employees at the director, manager, and executive levels with more than one year of experience were chosen for the data gathering.

B. Data Analysis

A 7-point Likert scale (range from "strongly disagree" to "strongly agree") is used to assess all constructs. Both qualitative data analysis techniques and quantitative data analysis techniques will be carried out to analyze the data precisely in a “Mixed Method Approach”. The developed hypothesis is tested using PLS SEM. The sample is gathered to meet the ten times rule's minimum sample size criterion for performing the PLS-SEM analysis. The respondent groups for the data gathering are chosen according to their areas of competence.

C. Model Development

To build the conceptual framework, the authors went through existing technology and literature to determine the most important aspects of blockchain technology. Expert

opinions were taken by conducting structured interviews with professionals in the fields of pharmaceutical manufacturing industry and government organizations. Formed on the analysis of the data collection and the systematic literature review of the literature, the conceptual model was developed by obeying to all those discoveries. Based on the data collection and the systematic review of the literature, the factors which may have an influence towards the adoption of blockchain technology to Pharmaceutical Supply Chain have been identified as the following. This research shows a number of different elements/factors that need to be considered when evaluating the adoptability of blockchain technology.

- Cost
- Complexity
- Compatibility
- Architecture
- Human Resources
- Relative Advantage
- Technological Infrastructure
- Upper Management Support

D. Factors affecting adoption of Blockchain Technology

The factors that affect the adoption of blockchain in the pharmaceutical supply chain have been compiled based on a survey of published literature and answers from professionals with 1-20 years of experience in the pharmaceutical industry. A number of researchers have discovered substantial links between supply chain performance and other crucial characteristics, according to a recent study.

Upper Management Support

Managerial roadblocks have a significant impact on adoption decisions and are frequently linked to a company's strategic goals, particularly during technological implementation. Upper management commitment, on the other hand, can help spread technology, but it must remain active in order to accomplish the necessary results [12]. The provision of training facilities is an important component in this context, as it ensures that employees have access to appropriate training in order to adapt to blockchain technology within the sector. [13].

Human Resources

Completely digitizing all supply chain activities utilizing multiple data transmission systems is a significant decision. This will alter the entire way of operation, exacerbating the fear of change is a major reason why businesses are hesitant to accept 'new' technologies. This implies that once the owners believe in change, they will be able to guide their workforce toward effective blockchain adoption [14]. Additionally, management and employee reluctance to change might hinder blockchain technology adoption. Furthermore, organizational culture, which is

defined as the pattern of people's behaviors and practices inside the supply chain, is a crucial component that can impact the adoption of blockchains for performance enhancement [15].

Compatibility

Compatibility, which may be described as the ease with which blockchain technology can be integrated on essential platforms, is a key feature in this context [16]. With blockchain's growing popularity and the benefits it can provide to supply chains, pharmaceutical companies might be able to integrate it into their existing infrastructures [17].

Cost

One of the most common causes for adoption resistance is financial concerns [18]. Hardware, software, recruitment, and in-house training are just a few of the essential aspects that might affect implementation costs, which include both opportunity costs and accounting costs [19]. Although it has cost-cutting benefits, blockchain is thought to be a technology with high up-front investment costs. Blockchain technology is regarded as an investment because it necessitates the purchase of new gear and software [20].

Complexity

From the standpoint of adopters, a blockchain is tough to comprehend in practice. Algorithms may make mistakes that people are unaware of until it is too late to correct. Potential adopters' hesitancy due to concerns about blockchain's complexity may exacerbate opposition, outweighing implementation intentions [21]. In pharmaceutical supply chain operations, supply chain performance is crucial, and achieving it has become increasingly difficult due to the growing complexity of operations in the digital age [22].

Relative Advantage

Blockchain has recently attracted a lot of researchers and practitioners' interest and is seen to have the potential to disrupt a variety of industries [23]. "A decentralized, encrypted electronic distributed ledger that operates as an immutable, incorruptible linear event database of information/ transactions shared across networked participants," according to the definition of blockchain. [24]

Technological Infrastructure

The availability of infrastructure is another crucial aspect that might influence blockchain adoption, as it ensures that existing technologies are maintained and capable of meeting current infrastructure requirements [26].

Architecture

The technology's decentralized nature, as well as its potential for transparency and accountability, can create new environments in which people are less reliant on centralized, sometimes inefficient services provided by related and intermediary service providers [27]. The application of blockchain in supply chain is still in its early stages of acceptance, requiring a protracted deployment lifetime and a lot of unknowns about its significance for business processes.

Information transparency is a major benefit of blockchain in the supply chain. Once data is uploaded to the blockchain, it cannot be withdrawn from the chain and remains accessible for the duration of the blockchain. Despite the fact that blockchains create a decentralized network, they are nevertheless managed by service providers, raising worries about possible illegal spying and data misuse [28].

B. Conceptual Framework

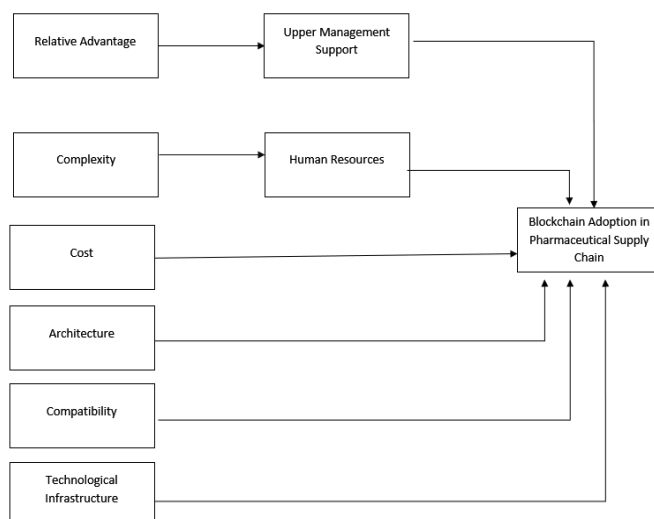


Fig .2. Conceptual Framework

Fig. 2 depicts the conceptual framework. The authors of this study created a conceptual framework for blockchain technology adoption in sri lankan pharmaceutical supply chain based on the literature (Table 1) and the insights from the experts of the Pharmaceutical Industry. The factors affecting the adoption of blockchain technology was examined through systematic literature review and interviews with experts and consultants.

Table 1. Summary of main factors affecting adoption of blockchain

Factors affecting adoption of blockchain		References
Relative Advantage	Increase traceability of supply chain	[5] [6] [9] [10]
	Increase transparency of supply chain	[11] [13] [14] [16]
	Enhance the visibility and privacy of supply chain	[17]
	Enhance trust with decentralized nature	
Upper Management Support	Upper managers actively respond and pay attention when blockchain based supply chain management project is initiated	[1] [5] [9] [14]
	Upper managers support by providing labour resources, materials for blockchain based supply chain project	[13] [15] [16]
	Upper managers are willing to accept risks when adopting Blockchain to supply chain	
Human Resource	Existing knowledge gap	[5] [9] [13] [14]
	Mindset of people	[16]
	Fear of change	
	Organization culture	
	Lack of understanding of blockchain technology	
Compatibility	Compatible with the way we work	[1] [13] [9][15]
	Compatible with our operations in supply chain	[16]
	Compatible with the supply chain management process	
	Compatible with the other information systems used (ERP)	
Cost	High investment cost	[1] [13] [14] [15]
	High cost for training and recruiting	[16]
	Maintenance Cost	
	Hardware and Software facility cost	
Complexity	Blockchain is difficult to understand from a technical perspective	[1] [3] [5] [15]
	Blockchain is conceptually difficult to understand from supply chain management perspective	[16]
	Interacting with the system does not require a lot of mental effort	
Technological Infrastructure	The current technological structure adequate for blockchain	[1] [9] [11] [15]
	Current internet service is efficient enough for blockchain	[16]
	There is sufficient infrastructure to adopt blockchain	
	Sufficient large computing power	
Architecture	Lack of Technological maturity	[3] [5] [6] [9] [10]
	Data Security	[11] [14]
	Performance and Scalability	
	Immutability Challenge	

When addressing blockchain implementation in the pharmaceutical supply chain in Sri Lanka, the conceptual framework suggested in Fig. 2 is a complete conceptual framework that provides an overview of components and their relationships. The framework can be utilized by government bodies and pharmaceutical companies to gain a better understanding of blockchain technology. It emphasizes the need of understanding the factors that influence technology adoption. This highlights the need of comprehending the interaction of factors and materiality during the transformation process, which ultimately influences the adoption of blockchain technology. The framework can be used to comprehend the ramifications of adoption on a larger scale.

AWARENESS ABOUT COUNTERFEIT DRUGS

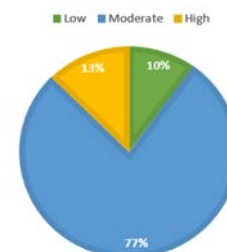


Fig. 3. Awareness about the prevalence of counterfeit drugs in Sri Lanka

EFFECTIVE USE OF TECHNOLOGY WILL CURB DRUG COUNTERFEITING

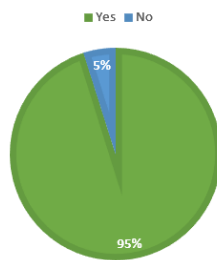


Fig. 4. Effective use of technology will curb counterfeit drugs in Sri Lanka

EFFECTIVE USE OF BLOCKCHAIN WILL CURB DRUG COUNTERFEITING

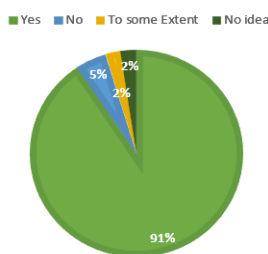


Fig. 5. Effective use of blockchain will curb counterfeit drugs in Sri Lanka

Reasons for the prevalence of counterfeit drugs



Fig. 6. Reasons for the prevalence of counterfeit drugs in Sri Lanka

In addition to the factors identified for the adoption of blockchain technology to the Sri Lankan pharmaceutical supply chain, 90 % of respondents believe that the availability of counterfeit drugs is moderate/ high in Sri Lanka, according to the investigation (Fig. 3). Moreover, according to the fig. 6, most of the respondents have identified “Lack of monitoring by the regulatory agencies” is the main reason for the prevalence of counterfeit drugs in Sri Lanka. Other than that, “Lack of political will to build a proper management system”, “lack of infrastructure”, “Corrupted government officers less support to change the system”, and “Lack of rules and regulations” are the major reasons for the prevalence of counterfeit drugs. As fig. 4 depicts 95% of the respondents believe that effective technology will curb the counterfeit drugs in Sri Lanka and according to the figure 4, 91% of the people believe that

blockchain technology will curb drug counterfeiting. Only 5% of people believe that blockchain technology will not be able to curb drug counterfeiting in Sri Lanka. All of these findings, and the factors identified, can be taken into account when developing a high-quality strategy to combat counterfeit pharmaceuticals from Sri Lanka.

IV. CONCLUSIONS

In contrast to earlier research that focused on blockchain adoption from larger supply chains and sustainable supply networks, the findings of this study provide a better knowledge of the characteristics that promote/enable blockchain adoption in the pharmaceutical supply chain in the context of Sri Lanka. The availability of specific blockchain tools, supporting infrastructure, and government regulation and support for the freight logistics business all influence adoption and implementation. Adoption factors in the pharmaceutical supply chain are discussed in the research as an important part of blockchain technology adoption. This research proposed a new framework of essential criteria that drive blockchain technology adoption in the pharmaceutical supply chain. These constructs could be used as a starting point for more in-depth theoretical research into the elements that influence blockchain adoption in the pharmaceutical supply chain.

From a managerial standpoint, the findings of this study are expected to aid the Sri Lankan pharmaceutical sector, blockchain service providers, and government agencies in focusing on the elements identified in this study in order to successfully implement blockchain. Furthermore, the findings of his research could be applied to other companies in emerging and developing economies and environments that are interested in digitizing their processes to improve transparency and competitiveness, reinforcing their utility. Future and further research into the area will benefit from these additional research avenues.

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