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# Beyond Traceability: Evaluating the Challenges and Opportunities of Blockchain Integration in India's Pharmaceutical Supply Chain to Combat Counterfeit Drugs

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**Abstract**

This study investigates how Blockchain technology might be used to solve one of the gravest issues faced in the Indian pharmaceutical supply chain : the fight against counterfeit drugs. A thematic analysis of the interviews of 10 industry veterans was carried out, and several important topics, reasons, and ideologies emerged. One important revelation was that Blockchain's adoption, specifically in the Indian pharma industry, has been affected by a lack of knowledge and instruction about it among the working professionals. The participants were confident about Blockchain's capabilities and were of the strong opinion that it would play a very important role in revolutionizing the Indian pharma scenario. However, despite these positive remarks, the participants stated that challenges like the fragmented nature of the industry, legal and supply chain restrictions, and financial limitations were considered to be major adoption impediments. Participants argued for infrastructure development, financial incentives, and clear legal frameworks as key components of the government support for removing these obstacles, thus enabling mainstream adoption of this technology. The study also highlighted the reluctance to invest in blockchain due to uncertainties around its returns, especially in a price-sensitive market. While there is optimism about blockchain's future role, participants suggested a phased adoption approach, starting with high-value drugs. Ultimately, the paper concludes that while blockchain holds promise, successful implementation in India's pharmaceutical sector requires both industry education and substantial government support.

**Keywords:** Blockchain, Pharmaceutical Supply Chain, Indian Pharma Sector

## 1. Introduction

### 1.1 The Growing Threat of Counterfeit Drugs in India's Pharmaceutical Supply Chain

A serious and well-recognized threat to the pharmaceutical supply chain is the infiltration of the combined category of substandard and falsified (SF) medicines (Mackey et al., 2015). The recent growing prevalence of counterfeit drugs poses a significant threat to both the pharma supply chain and global health. Not only does it create grave mistrust in the pharma sector and its functioning, but it also affects sales and prosperity in the long run. According to the World Health Organization (WHO), almost one out of every ten medical items in the developing regions of the world is either poor or fraudulent. Drugs belonging to different therapeutic categories are counterfeited across the globe. Different reports corroborate that the anti-

infective drug category, which consists of antibiotics, antivirals, antifungals, antimalarials, etc., makes up the bulk of drugs being counterfeited, with the percentage ranging anywhere from 10% to as high as 50% (Newton et al., 2006). Further, in this category, antibiotics are the most falsified anti-infective with a staggering 28% share of the entire global counterfeit medicines market (Bougdira et al.,2019).

Asia, specifically India, leads in the production of counterfeit medicines, with approximately 35–75% of fake medicines being produced in India (Pathak et al., 2023)**.** The country has also witnessed an alarming surge in counterfeit medicines flooding retail markets, a spike of nearly 50 percent over and above the estimated figures from the COVID-19 years, according to the AIOCD (All India Organisation of Chemists and Druggists).

Efforts to combat counterfeit medicines have led to various proposed solutions, including that of blockchain technology. Blockchain is a growing list of linked records, named blocks, which are connected and secured using encryption algorithms (Zyskind et al., 2015). In simple words, it offers distributed ledgers that create a permanent and shared record of every transaction. All recorded transactions are visible to authorized participants, traceable within the ledger, immutable and irrevocable, which prompt the increasing usage of blockchains for data sharing in supply chains. (Chamblis et al., 2012)**.**

### 1.2 Blockchain Technology: A Potential Solution for Pharma Supply Chain Security

Blockchain has demonstrated its usefulness through the widespread use of cryptocurrencies and its support for the operations needed to achieve digital currency. However, the same features are promising to enable and support other industrial applications in many domains. A wide range of industrial domains are starting to adopt or consider adopting blockchain to facilitate their operations in hopes of streamlining processes, enhancing security and data sharing, increasing efficiency, and ultimately reducing costs to gain a competitive advantage(AL-Jaroodi & Mohamed, 2019). But its application and implementation, especially in the Indian pharma sector, has been subpar and not efficient.

### 1.3 Research Scope and Key Questions: Evaluating Blockchain's Role and Challenges

This paper examines the application of blockchain technology in combating counterfeit medicines. The research is based on interactions with industry decision-makers, policymakers, and CXOs of pharmaceutical companies. This paper is an attempt to find out why blockchain technology hasn't been implemented yet in the Indian pharma sector, what the future opportunities and how they can be accessed. Also, what are the challenges that the staff and the employees face in the implementation of these technologies and the reasons for such challenges?

The paper also takes into account the challenges that pharma company employees in the field face while putting this technology into practice. The paper analyzes various blockchain-based models, current solutions that major industry players have embraced, and the framework for blockchain's future in the Indian pharma sector.

With a focus on well-known brands, traditional companies, and industry trendsetters, the paper attempts to develop a precise vision of the future of blockchain in this field by examining the responses and performance of some of India's leading pharma companies. It does this by analyzing their ideas and opinions and determining whether or not this technology has the potential to tackle counterfeit drugs and help revolutionize the Indian pharma supply chain.

## 2. Literature Review

### 2.1 Existing Anti-Counterfeiting Measures in India's Pharmaceutical Supply Chain

The Indian pharma sector has come up with its own set of reforms to combat counterfeit drugs. Existing

solutions within supply chain management have traditionally used barcodes and RFID tags as identification techniques, Wireless Sensor Networks **(WSN)** to capture data, and Electronic Product Code **(EPC)** to identify, capture, and share product information to facilitate tracking of goods through different stages. **(Bougdira et al., 2019)**

In India, the Drugs Controller General of India **(DCGI)** made it mandatory for companies to ensure compliance with printing QR codes on top-selling brands to curb counterfeiting. The top Indian pharma companies welcomed the regulator's mandate and said that they were on track. They also view it as a positive step to ensure patient safety. **(Business Standard, 2024)**

However, disadvantages like technical issues, affordability, usability, reliability, and accuracy often overpower the advantages. **(McCathie,2004)**

Some disadvantages include

- Security Concerns: Vulnerable to phishing if not encrypted.
- Tech Dependency: Requires a smartphone with a camera and internet access.
- Connectivity: Needs a stable internet connection to complete transactions.
- User Familiarity: Some customers may not understand how to use QR codes.
- Design Impact: QR codes might disrupt store aesthetics.

Moreover, **(**although barcode accuracy rates are near perfect, they typically have one weakness - they require operators to perform the scan, which can often lead to human mistakes. (Singer,2004)

**2.2 Evaluating Blockchain Models for Pharmaceutical Supply Chain Security**

Developing an understanding of the different blockchain models can prove to be quite helpful in the quest to select the most efficient blockchain model for our research purpose. Extensive research throughout the world has come up with several blockchain models that can be implemented in the pharma sector.

**1) Ethereum**

Ethereum is an open-source, public, blockchain-based distributed computing platform featuring smart contract functionality. Ethereum blockchain-based approach **(Musamih et al., 2021)** leverages smart contracts and decentralized off-chain storage for efficient product traceability in the healthcare supply chain. The smart contract guarantees data provenance, eliminates the need for intermediaries, and provides a secure, immutable history of transactions to all stakeholders. The proposed solution is developed using the Ethereum blockchain platform. The deployed smart contracts define the details of the manufactured drug lot. The smart contract features mappings for authorized entities—manufacturers, distributors, and pharmacies—along with functions for the manufacturing and sales processes, all of this explained with the help of 3 algorithms.

2) Hyperledger **Fabric**

Hyperledger Fabric is an implementation of private (permissioned) blockchain technology that is intended as a foundation for developing blockchain applications for a wide variety of industries. **(Jamil et al., 2019)**, proposed a Hyperledger-based solution for drug traceability in the pharmaceutical supply chain The authors reported an increase in the performance in terms of throughput. This effort also highlighted the challenge of achieving scalable solutions with blockchain, which has received significant attention in recent literature, such as (**Bougdira et al., 2019).**

**3) Private Blockchain**

A private blockchain is a restrictive or permissioned blockchain operative only in a closed network. **(Hulseapple,2015)** developed a private blockchain concurrently with Bitcoin, which is used as a ledger to hash certain data to secure the transactions in the chain. Every product has its own permanent record on

their blockchain, making it impossible to manipulate with the private keys. The system was designed to protect every stage of product transfer in the supply chain, creating a trustful system of transparency.
Research on these blockchain models and their implementation in the pharma sector has been undertaken, but these researches are more theoretically oriented and fail to take into consideration their practical application in the present scenario. They have failed to analyze the rate and ability of the adoption of these blockchain models in order to combat drugs, which fails the purpose of a research paper.

**2.3 Challenges in Blockchain Adoption: Industry Barriers, Regulatory Hurdles, and Unexplored Root Causes**

Various vital participants, including manufacturers, wholesalers, and retailers, are engaged in the production, transportation, distribution, and sale of medications traversing a supply chain **(Bryatoy & Borodinov, 2019)**. Although the implementation of blockchain technology shows great potential for fostering sustainable development in the pharmaceutical industry, and despite an increasing amount of research regarding the hurdles linked to its adoption, a thorough comprehension of the potential challenges regarding embracing blockchain is still in its infancy. **(Riedel, 2024)**. Even as research on the challenges of adopting blockchain technology has been growing, previous studies have illuminated multiple obstacles to its adoption, despite stakeholders' recognition of its potential capabilities **(Toufaily et al., 2021)**. Certain studies, like **(Neumever et al ., 2021) , (Queiroz & Wamba, 2019), (Upadhyay, 2021)** focus on specific countries and industries, whereas others embrace a broader scope. Thus, in adopting blockchain technology, in addition to universally applicable challenges like awareness and understanding, there may also be industry-specific, as well as country-specific, challenges, such as specific laws and regulations. In addition to these, **(Yadav et al., 2020) , (Sahebi et al., 2020) ,** and **(Sharma et al., 2021)** have emphasized that the principal barrier to blockchain adoption in India is the "lack of government regulations and support." Although researches like **(Riedel,2024)** provide a detailed list of challenges faced in the implementation of the technology, the authors have failed to highlight the reason behind such issues. Simply listing down issues won't solve problems, as issues can be addressed only after identifying the root cause of these challenges. A detailed study of the challenges and the root cause will be done in the later sections.

**2.4 Blockchain Adoption in the Pharmaceutical Supply Chain: Industry Initiatives and Research Insights**

Pfizer has partnered with other industry stakeholders and has developed a blockchain-based platform for securely sharing and managing healthcare data. Through its blockchain initiatives, Pfizer has enhanced data security, integrity, and interoperability, leading to improved patient outcomes and regulatory compliance. **(Median, 2024)**. Pfizer has also launched a counterfeit awareness campaign to detect, disrupt, and deter leading producers and sellers of their drug imitations. **(Counterfeit awareness campaign, 2023**). All these developments come at a crucial time after a study conducted by the global security department of Pfizer for its blockbuster PDE5i, Viagra, showed that 77% of the tablets ordered online were counterfeit **(Campbell et al ., 2019).**

In addition to this, several tech companies like Blockverify , Chronicled, and IBM Blockchain are some of the companies also exploring blockchain for health supply chain management **(Clauson et al., 2024)**.
Also, leading the thought process around this development is **The Center for Supply Chain Studies**, a non-profit organization created to help explore the feasibility of blockchain adoption through a virtual pilot study with the participation of various stakeholders from across the pharmaceutical supply chain

**(Center for Supply Chain Studies. C4SCS. 2017)**.
Surveys are the best way to know about the current trends. While there are several good survey papers on blockchain **(AL-JAROODI & MOHAMED, 2019)**, examples of surveys on general blockchain concepts, opportunities, and applications are **(Zheng et al,. 2016),(Kaushik et al., 2017) and (Lu et al.2018)** . Other papers focused on surveying specific aspects of blockchain, such as security, consensus protocols, and algorithms **(Sankar et al., 2017), (Mingxiao et al., 2017)** and **(Nguyen & Kim ., 2018)** and healthcare **(Rabah, 2017), (Nguyen & Kim.,2018)** and **(Mingxiao et al ., 2017)** found that in their studies that blockchain has played a very important role in preserving and protecting important personal information.

## 3. Methodology

This research paper utilizes a qualitative case study design to study the subject matter. First, a systematic review is conducted to identify the relevant components. The existing literature is then carefully analyzed to determine these components.

### 3.1 Search strategies and data sources

Research papers available on digital databases were selected as the source of study given their extensive coverage of peer-reviewed journals. Searches were performed using keywords like “Blockchain,” “Supply Chain,” and the Indian Pharma Sector” with various spellings and semantically related concepts. The article screening process and identification of relevant works was based on the criteria that articles must discuss either blockchain technology, trends observed in the Indian pharma supply chain, counterfeit drugs, and the entire global pharma chain for analysing the differences. Initially, the initial list of 50 articles was examined to eliminate papers from unrelated areas such as engineering, finance, and ecology, resulting in a total of 38 articles that were therefore selected for a comprehensive review.

### 3.2 Criteria to Select Population-Company Selection

A list of about 15 companies was prepared, which was then shortened to 10 companies depending upon an analysis of their recent market performances along with the ease with which the interviews could be conducted with the top people at these companies.
The 10 companies are as follows :
1) New: Akumentis , Corona Remedies, Celagenix LLC.
2) Mid—Zydus , Intas, and Bharat Serum Vaccines.
3) Old: Sun Pharma, Cipla, CADILA, Sanofi India.

### 3.3 Procedure of data collection

The mode of conducting the interviews was online, and all the interviews were recorded after getting the required confirmation from all participants involved with informed consent.

### 3.4 Criteria to develop structured interview questions

Selection of questions was done on the basis of analyzing important themes related to the research.
Themes identified for the purpose are as follows:
1. Background and Familiarity with Blockchain
2. The perceived potential of blockchain in combating counterfeit drugs
3. Barriers to Blockchain Adoption in Indian Pharma
4. Feasibility and Government Support
5. Timeline and Future Outlook

## 4. Results

The Thematic analysis of interviews with 10 industry veterans were analysed, which revealed several key themes about the potential and challenges that Blockchain faces in the Indian pharmaceutical supply chain, particularly in countering counterfeit drugs.

Theme 1: Lack of Awareness and Education About Blockchain

A significant challenge was the lack of awareness about blockchain, with 5 out of 10 participants stating little to no knowledge about the technology. One participant shared, "I've heard the term blockchain, but I don't know how it relates to our supply chain." Those who were familiar with blockchain described it vaguely, often as a "secure way to send data." As a result, all the participants were asked beforehand to read up about Blockhain Technology. After the preparation time being given, the participants showed greater interest, thus indicating the need for more education within the sector to understand its application and benefits.

Theme 2: Perceived Benefits of Blockchain in Combating Counterfeit Drugs

Despite limited awareness, 'blockchain's potential benefits' were widely acknowledged. Nine participants believed that blockchain could enhance "traceability" in the pharmaceutical supply chain, thus helping in reducing counterfeit drugs. One respondent, however, stated, "Blockchain can make sure every transaction from manufacturing to retail is recorded and verified." The ability to track products and ensure authenticity was seen as a major advantage. However, one participant expressed skepticism, stating, "If blockchain were so effective, it would have already been implemented in the Indian pharmaceutical sector", thus suggesting doubts about blockchain's applicability in India's complex pharmaceutical landscape.

Theme 3: Barriers to Blockchain Adoption

Participants identified several barriers to Blockchain adoption in the Indian pharma sector. Cost was highlighted as the major issue, mainly because of India's price-sensitive market. One participant commented, "Pharmaceuticals are already priced at a low margin. Implementing blockchain will require a huge financial investment." A respondent noted, "Blockchain may work for larger companies, but smaller ones may not have the infrastructure to adopt it." In addition to all this, "regulatory hurdles" and the fragmented nature of the supply chain were also identified as obstacles.

Theme 4: The Role of Government Support

Every panelist concurred that "government support" is essential to India's adoption of blockchain. As one respondent put it, "The government should guide the adoption of blockchain, much like they did for the Aadhar system," several participants felt that the government should take the lead in establishing a "clear regulatory framework" for blockchain use." There was also agreement that the government might promote the use of blockchain by providing "financial incentives" to businesses that invest in the technology, such as "tax holidays" or "subsidies." To speed up deployment, "infrastructure support" was also suggested, including a centralized blockchain database.

About 50% of participants pointed out a lack of understanding of technological terms, especially among the senior pharma executives of companies in India. The reason for this was that the participants strongly felt that lack of familiarity with digital breakthroughs such as blockchain was probably caused by their limited exposure to new technologies. Age and industry expertise may not always be associated with the ability to adjust to change brought by technology, according to one interpretation.

Because they haven't used new systems previously, many older professionals lack the confidence to use them (suggested by participants).

While other participants alluded to a lack of conviction, indicating that technical knowledge alone wasn't

the main obstacle. In addition to all this, some also blamed the issue on a lack of abilities. These participants believed that because of a deep-rooted dependence on conventional procedures, people frequently oppose embracing technology, even when they do have access to or understand it, thus, fearing change.

"People don't see the need to change what has been working for decades, not because they don't understand digital tools."

This difference highlights a more fundamental behavioral and cultural issue facing the sector: a reluctance to abandon tried-and-true practices due to comfort, habit, and perceived risk.

Theme 5: Timeline for Blockchain Adoption

Given the complexity of the supply chain and associated costs, half of the respondents who were asked about the adoption timescale for blockchain predicted that it would take "5 to 10 years" for complete deployment. "It's a big system, and implementing blockchain will require time and resources to train stakeholders," said one participant. Two other participants proposed a "phased adoption approach" that would start with "high-value products" such as patented drugs and then progressively transition to more affordable pharmaceuticals. For addressing beginning costs and operational challenges, this incremental approach was seen to be more realistic.

Theme 6: Industry Readiness and Investment Hesitancy

Many players were reluctant to commit because of financial limitations, even though some thought that "the sector is ready" for blockchain. "The technology is available, but the industry is cautious about spending money on it without clear returns," one participant clarified. " When faced with conflicting financial priorities, Indian businesses are hesitant to invest in technology that might not pay off right away. Nonetheless, several bigger businesses, such as Ertigas India, indicated that they would be open to implementing blockchain, as they have already done so in their overseas branches and were thinking about doing so in India, given the availability of government assistance.

## 5. Discussion

A thorough analysis of the responses of all the respondents helped summarize the overall discussion.

1. Since digital technologies have not yet fully diffused into the Indian pharmaceutical industry, the majority of participants' unfamiliarity with Blockchain or any other alternative technology as a whole is an indication of a larger problem. While global sectors like finance are basking in the success of blockchain technology, the pharma sector hasn't been able to reciprocate the same level of success. The participants' eagerness to learn more about the technology indicates that industry experts' education and upskilling could use some work. This result is consistent with the global trend that prior to successful technological adoption, knowledge gaps must be filled (Kshetri, 2018).
2. Blockchain technology can help to a great extent with clarity in the supply chain, identification of the journey of the drug, and ensuring the originality of the drug, in turn ensuring high-quality standards. Furthermore, with its end-to-end verification process, it arrests harmful medications in the system, thus playing a crucial role in countering counterfeit drugs.
3. The results show that cost is still a significant deterrent to blockchain implementation, particularly in the low-profit pharmaceutical sector in India. This is in line with earlier studies that indicate the high upfront costs of blockchain deployment may discourage adoption, especially in industries where prices are crucial (Francisco & Swanson, 2018). Furthermore, a decentralized system like Blockchain needs broad support from all supply chain participants, which could be challenging to accomplish given the

large variety of participants in India's pharmaceutical sector. Therefore, it is impossible to ignore the difficulties posed by the supply chain's fragmentation and the regulatory environment's complexity.

4. Investment of considerable revenue for the implementation, training time required for acceptance of the system, fear psychosis of change, which can claim existing jobs, lack of understanding at the decision-making level, scalability, and India being a low-price model are some of the major challenges that the Indian pharma companies feel are the main reason for the lack of implementation of this technology.
5. While the timelines for adoption varied, the general consensus was that blockchain adoption would take several years. This is in line with other studies, which suggest that the integration of complex technologies like blockchain often requires a phased approach, starting with high-value or high-risk products before expanding to lower-cost items (Saberi et al., 2019). However, the suggestion that blockchain could be implemented immediately with proper regulatory intervention indicates that with the right conditions, adoption could be accelerated.
6. The government should lead from the front and should make the implementation of The authors suggest that Blockchain technology in the pharma sector is a must by providing several benefits. Investing in the technology and research, granting funds, awareness programs, and reforming educational programs like B Pharm, M Pharm, etc with technological courses could go a long way in the successful incorporation of this technology in our Indian pharma scenario.
7. Although several participants believed their companies were technically ready to adopt blockchain, most acknowledged that the hesitation to invest in the technology was a significant barrier. This reflects a broader challenge in the pharmaceutical industry, where the financial incentives for adopting blockchain are not immediately clear. However, as counterfeit drugs continue to be a major issue, companies may eventually recognize that blockchain is not just an investment in technology but an investment in trust and market positioning.

## 6. Limitations

It should be noted that even though this study provides insightful information about how blockchain technology might be used to combat counterfeit medications in India's pharmaceutical supply chain, a few limitations are ought to be noted. While 11 industry veterans were interviewed, which might be enough for a qualitative research paper, all the participants interviewed had a pharma background and held high positions at their respective companies. The opinions of other significant stakeholders, like IT developers, might not have been heard largely because the authors wanted to provide the center stage to Pharma understanding. Additionally, because of a lack of awareness, I was required to give background information before the interview and also had to ask them to read up about the topic before the interviews. While this helped move the conversation forward, it may have influenced how some opinions were shaped in real-time. Additionally, the study is focused entirely on the Indian pharma context, where infrastructure, regulation, and investment attitudes are quite unique—so the findings may not directly apply to other countries.

## 7. Conclusions

With an emphasis on how Blockchain technology can help in countering counterfeit drugs, this research paper examined the opportunities and difficulties of incorporating this technology in the Indian pharmaceutical supply chain. Through the thematic analysis of all the interviews, it was found that the

industry professionals strongly believed that Blockchain might improve supply chain transparency, traceability, and trust. However, there are still many obstacles to overcome, like lack of technical knowledge and preparedness, high implementation costs, and a general reluctance to reform long-standing customs in the pharma sector.

In addition, the findings suggested that while the technology itself shows promise, it can be successfully adapted only when the following factors are followed: education and awareness among stakeholders are present, there is constant and clear regulatory support from the government, and a phased, practical approach to implementation. Moreover, the study also highlighted the need for an industry-wide collaboration between different pharma companies and a shift in mindset, especially in the sector, where people have long been dependent on traditional systems and mindsets, for a greater cause.

Ultimately, it also needs to be understood that Blockchain is not a silver bullet, but it could very well become a powerful tool in improving supply chain integrity, if backed by the right policies, incentives, and leadership. As the Indian pharma industry continues to evolve, further research and investments will play a key role in the united fight against counterfeit drugs.

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