THE USE OF BLOCK CHAIN TO FIGHT DRUG COUNTERFEITING IN THE PHARMACEUTICAL INDUSTRY

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Abstract

Drugs can cause major health problems, counterfeit medications are widely considered as the biggest concern facing the pharmaceutical business. Counterfeit medications are defined by the World Health Organization (WHO) as unregulated and mislabeled medicines whose source and identity is either misrepresented purposefully and deceitfully. One of the most significant challenges facing the pharmaceutical sector today is combating the distribution of fake medicines. Research findings show that the suggested method helps to preserve market equilibrium by ensuring there is enough demand while preserving supply. The medication supply chain's vast amounts of data must be handled properly using the system proposed to better manage market forces and prevent manufactured shortages from inflating medicine costs. There are plans to employ blockchain to verify consumers and monitor the whole Drug Distribution Process (DDP), which will be controlled by Drug Regulatory Authority (DRA), according to the planned framework. Results show that even though the system is computationally expensive, it gives a reliable solution to the issue of counterfeit medications. Blockchain technology (BCT) is widely used in the pharmaceutical industry to improve the distribution of medicines, prevent counterfeiting, manage data and supply chains, assure security, and monitor medication, as the following description indicates.

Keywords: *Drug Regulatory Authority (DRA), Drug Distribution Process (DDP), Blockchain Technology (BCT), Counterfeit pharmaceutical.*

1. Introduction

Medicine production is costly with a single type of drug costing almost two billion dollars to produce. Substitute of these pharmaceuticals with counterfeit drugs is a common challenge that costs the pharmaceutical industry roughly $150 billion each year. In addition to causing financial damage, counterfeit pharmaceuticals endanger lives and ruin well-known brand

names [1]. The problem of counterfeit pharmaceuticals is exacerbated by the lack of medication traceability in the pharmaceutical supply chain. It is also a complicated and branching network in which many actors are engaged in getting medicine from point A to point B [2]. There is no mechanism in place to track the actual flow of pharmaceuticals, counterfeiters join the supply chain and swap authentic medications with fakes. Drug Security Chain Act, enacted by the Food and Drug Administration (FDA) in 2013, demands for a computerised supply chain management system and an interoperable to be in place by 2023 in order to fight counterfeit drugs [3]. Furthermore, modern solutions include putting non-human readable barcodes, QR codes on packaging, and Radio Frequency Identification (RFID) tags, however, these tactics don't avoid drug counterfeiters from substituting a fake drug within the box [4]. Furthermore, mechanism for confirming medicine and brand identity utilising the dose identification of tablets and capsules rather than their packaging is required[5].

Tablet printing machines have been in use for more than 60 years and function on the same principles as inkjet printers or rubber rolls to print tiny QR codes into the medications. It is possible for a manufacturer to encrypt the messages included in these tiny QR codes so that anybody, including patients, can verify them by scanning the codes [6]. These microcodes, which can be printed on medications using Oggic's software, can be dynamic and unique for every batch of drug production. The blockchain can be used to keep track of every drug transaction and shipment, making it impenetrable to tampering, decentralized, and time stamped for maximum security[6].

It would be much easier to track where the counterfeiting occurred since every supplier would have to sign and scan the message as the medicine moved by the supply chain. The use of tiny QR codes printed on pharmaceuticals to track the drug in real-time as this is being sent might better avoid drug counterfeiting in the future [7]. One out of every ten medical items in nations is substandard or fabricated which demonstrates the prevalence of counterfeit pharmaceuticals in the healthcare business. Fake drugs can include erroneous components and quantities or no active ingredient at all. This implies that millions of patients are oblivious to the fact that these are taking medications that do not operate as intended [8]. Counterfeits are a large commercial drain on individuals, healthcare systems and they can also result in an additional financial strain on the system in some situations if the patient needs treatment as a result of the counterfeit [9]. Figure 1 shows the Pharmaceutical supply chain [9].

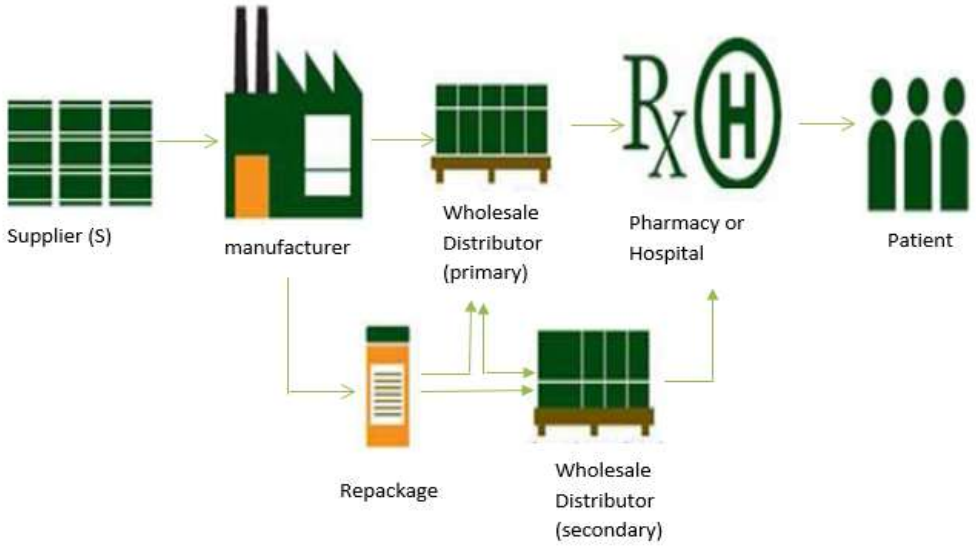

Figure 1: Pharmaceutical supply chain [9]

In pharmaceutical research and development, the process begins with the discovery of a novel medication and takes several years to complete. Once all the steps have been completed and a standard product has been established, distributing a product in its original form assures that clients get a genuine product from a licenced producer rather than a counterfeiter [10]. Suppliers and regulatory bodies in the pharmaceutical industry are unable to access or oversee the delivery of medicines because of antiquated Supply Chain Management (SCM) systems [11]. As a result of the current state of SCM, counterfeit medications are being produced, distributed, and consumed. Counterfeit medications have become a particularly hazardous public health threat and a growing global concern, particularly in underdeveloped nations [12].

These fake pharmaceuticals have a negative impact on people's health, both directly and indirectly. Drug-resistant strains and the inability to use the initial therapies are both directly and indirectly caused by the absence of active components in these drugs [13]. Specifically, these fakes can also include active ingredients, but in an insufficient or excessive amount, or it can be made in an impure manner, resulting in hazardous compounds, which can result in major health concerns. Counterfeit medication makers have been known to imitate the brand logos of real drug companies to create less hazardous counterfeit goods [13].

However, it frequently impacts cancer treatment medicines, cardiovascular diseases, painkillers, antibiotics, contraceptives, and other prescription drugs, which can have extremely dangerous consequences. Counterfeit medicines account for up 10 to 15% of the global medication supply, according to estimates. Counterfeit medications account for 30% of all pharmaceuticals sold in underdeveloped nations [14]. According to the World Health Organization (WHO), counterfeit anti-malarial medications are responsible for 0.2 million of the 1 million fatalities caused by malaria each year [15]. One million people die each year from counterfeit TB and malaria drugs. Counterfeiting is one of the oldest and most profitable enterprises due to technical improvement [15]. Counterfeit pharmaceuticals are those that are

not genuine and have been created with improper amounts or components in order to diminish or eliminate the potency of the drug, and the same is true of food counterfeiting [16].

The addition of dangerous chemicals might lead to counterfeiting and have catastrophic health consequences for patients. Counterfeit pharmaceuticals have grown more difficult to identify as counterfeiters have expanded their operations across borders, posing a public health danger to individuals living across communities and boundaries. Food and medicine counterfeiting has been an economic and social concern for decades, as it directly affects human beings owing to the essential significance of food and drugs for survival [17]. The WHO has detected a rapid increase in food and drug faking, particularly in poor countries which have resulted in an alarming incidence of illness and mortality among people of all socioeconomic levels. The majority of governments have devised ways to combat rising food and medication counterfeiting [18]. The SMS verification approach was recently proven to be effective, however, it was not adopted on all pharmaceuticals in certain underdeveloped nations. Furthermore, food counterfeit is virtually completely ignored in the battle against counterfeit, posing a bigger threat to society [19].

A counterfeit drug is one that is manufactured and sold with the goal of misrepresenting its origin, validity, or efficacy. It can include insufficient amounts of active components, be incorrectly processed inside the body or include ingredients not listed on the label, and be packaged and labeled in an inaccurate, erroneous, or fraudulent manner. Drug counterfeiting is a relatively new topic, having been recognized as a developing concern by the WHO in 1985 [20]. Since then, the issue has grown in scope to the point that it is now believed that counterfeit medications account for more than 10% of all drugs sold worldwide, with counterfeit drugs accounting for more than 50 percent of drug supply in some countries. Until of late, new, pricey lifestyle drugs like hormones, steroids, and antihistamines were the most often counterfeited pharmaceuticals in rich countries. Medicines utilized to treat life-threatening illnesses like malaria, TB, and HIV/AIDS have been the most counterfeited in underdeveloped nations [21].

As the problem increases, more medicines are being counterfeited, containing expensive ones like anticancer therapies and high-demand ones like antivirals. In 2006, a shortage of active components was discovered in the authorized supply of Lipitor, a cholesterol-lowering medicine in the United Kingdom [22]. In 2007, Xenical, an obesity medicine, was offered in the United States via internet sites maintained outside of the United States with no active components. Viagra and Cialis, both used to treat erectile dysfunction, were smuggled into Thailand in 2008 from an unknown source in an unknown nation [23].

An antidiabetic conventional medication in China (2009) utilized for decreasing blood sugar was found to have 6 times the normal quantity of glibenclamide, resulting in the deaths of two persons and the hospitalization of nine others. Many more instances are being reported, not only in underdeveloped nations but also in wealthy countries [24]. The purpose of this study is to provide an overview of the available literature, address a few important problems, and discuss the implications for the Indian pharmaceutical business. However, just stating a collection of issues without discussing alternative remedies is unsatisfactory [24].

1.1. Fake Drugs and Supply Chain

A counterfeit medicine has the incorrect active components, the right active elements at the incorrect dose, or none of the active ingredients at all. Forgeries of prescription drugs have found their way into almost every stage of the pharmaceutical distribution system. As much as one-third of all counterfeit drugs are produced in India [25]. This harms India's international image. How did counterfeit medications get such a large part of the market? There are several insecure and unverified points of contact that can have served as an entrance route for counterfeit medications. A variety of plausible explanations have been suggested [25]:

- The worldwide medicine supply chain is so complicated that selecting pharmaceuticals or medicinal components is extremely challenging.
- A disjointed supply chain.
- The supply chain can be tainted by one or more members: In the supply chain, items are adulterated, replaced, or mislabeled.
- Uncertified raw material source (A reputable producer can be ignorant that the materials come from an unknown source).
- Absence of high price and consumer awareness of genuine medicine.
- Weak enforcement of anti-corruption legislation and modern counterfeiting methods[24].

1.2. Blockchain in Health Industry

Blockchain technology has attracted a large number of academics, organizations, and businesses, especially when it comes to the use of the digital currency bitcoin. In a blockchain, transactions are stored in a peer-to-peer network securely in a decentralised ledger. Furthermore, this ensures that transactions are both transparent and verifiable. The basic goal of blockchain technology is to permit 2 groups to perform safe transactions without the need for a third party to intervene [24]. Healthcare professionals and patients now have better access to information thanks to the use of the blockchain technology. The use of many names and identities, and the fact that these data are spread over different networks, the volume of healthcare records is increasing, but optimization is still lacking due to duplication.

Health care security is also necessary in order to secure data and stop criminals from accessing it [26]. Patients personal information can be accessed by anybody with access if unlicensed users have access to patient data. Effective healthcare management relies on protecting the privacy of patients' information. Industry 4.0's blockchain technology can be used to solve these issues and concerns, ensuring the integrity of data and preventing manipulation and collapse at any time [27]. Figure 2 shows the Blockchain in Healthcare [28]. The blockchain is not the only smart machine that has transformed a wide range of industries and sectors, such as engineering, computers and electronics, automotive, business, aerospace, accounting, finance, health care and military. These include machine learning and IoT as well.

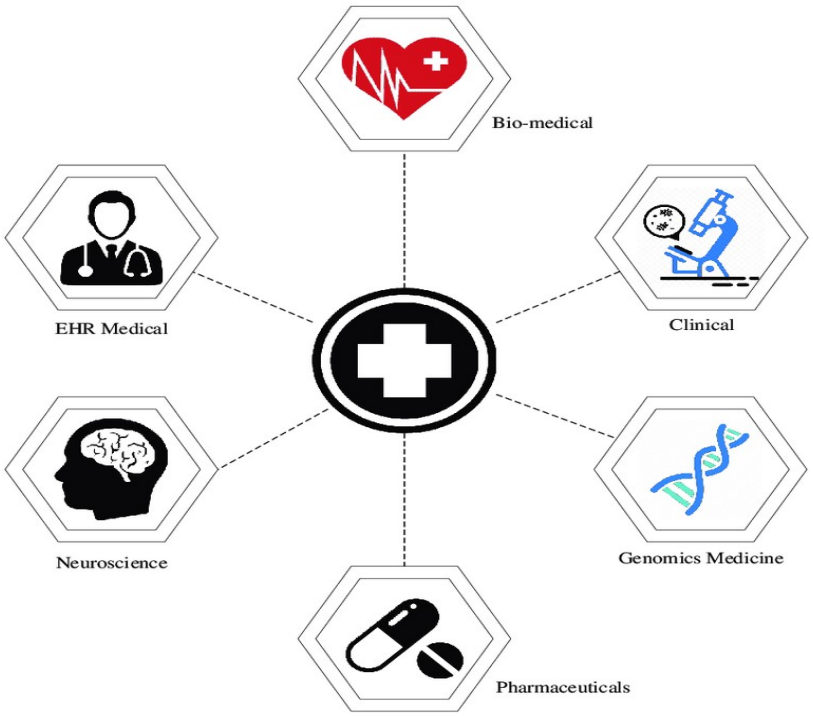

Figure 2: Blockchain in Healthcare [28]

1.3. Unique Node Key

A unique node key is used to avoid all the malicious activities between the process from level 1 to level 3. Key_level 1 demonstrates the level at the Manufacturer side, Key_level 2 demonstrates the level at various intermediate nodes like wholesalers, retailers, distributors, etc. Key_level 3 demonstrates the level at the customer side or patient side [29].

2. Literature Review

This section contains the related work done by the different authors in the different years some of them are given below:

Zakari et al., (2022) [30] described that the pharmaceutical business was one of the many sectors that was benefiting from the acceleration of digital transformation brought about by BCT. The pharmaceutical sector was plagued by problems such as a lack of transparency, difficulties in tracing medicines, a lack of trust, and the distribution of medications that have beyond their expiration date. The blockchain technology has already been put to use to find solutions to numerous of these issues. A comprehensive literature study of blockchain usage in the pharmaceutical business was presented in the research. The author collected, analysed, categorised, and debated pertinent research. The examination of data governance, data quality, pharmaceutical turnover, and prescription medication monitoring began with the usage of seven databases. Author go through the pros and cons of each of these subjects and experiments, as well as their strengths and weaknesses.

Zoughalian et al., (2022) [31] demonstrated that bkockchain technology (BCT) has promise for a more transparent pharmaceutical supply chain because of the present system's lack of openness. The purpose of the research is to investigate the current notions for

blockchain-based distribution systems. There has not been any consideration for the system's data privacy or its nodes' reputation in decision making, according to a survey of the literature on presently suggested solutions. In the planned prototype, the integrity of distributed data is ensured using a zero-knowledge proof approach. Markov models were used to compute reputation scores for each node, and these scores were used to predict the nodes reliability in a consensus decision-making process. The results show that a dependable distribution system must take into account the decision procedure.

Humayun et al., (2022) [32] explained that research in the area was aimed at resolving coordination issues and enhancing overall security in the drug distributiom market (DDM). The lack of a centralised monitoring system was another fundamental problem in drug market coordination management, since it does not supply real-time pricing, availability, and authentication data. There is a big global market for counterfeit pharmaceuticals because to DDM tampering, which was one of their primary problems. The distribution system would be under danger because of the huge counterfeit medication market. Coordination failure, secure medicine distribution, and pharmaceutical authenticity have been some of the issues addressed in the research. The medication supply chain's vast amounts of data must be handled properly using the system suggested to better manage market forces and prevent manufactured shortages from inflating medicine costs. The Drug Regulatory Authority (DRA) must authenticate users on the blockchain and maintain track of the whole command chain for the DDP to operate.

Sabah et al., (2022) [33] examined that counterfeit pharmaceuticals were an real and growingly important concern throughout the supply chain. They were produced and circulated there as well. Everyone, including patients, would be able to see and monitor the authenticity of the medicine thanks to the blockchain-based distributed system. The Hyperledger Fabric technology has been used to build peer-to-peer distributed applications for the supply chain of medicines in an effort to speed up the process. The supply chain management system was also made more resilient and transparent via the use of smart contracts, making it easier to identify counterfeit pharmaceuticals and ensuring that patients get only authentic goods from reputable manufacturers. Hyperleadger Fabric platform the suggested system operates smoothly and each transaction can be handled effectively by the distributed smart contracts, as shown by the experimental analysis

Islam et al., (2022) [34] studied about medicines that were fake or counterfeit were always a danger to people's health all around the globe. A Systematic Literature Review (SLR) technique can be used to assess all relevant papers on preventing or decreasing counterfeit and counterfeit medications via digital intervention. The findings of the review were future research potential to assist with current efforts to prevent the counterfeiting of medicines, including an investigation into the consequences of new technological developments. Locating the contaminated link in the medication supply chain and looking into the lesser-known issue of fake and fraudulent medications. The creation of a system for the reporting of counterfeit and falsified medication events and the investigation of all possible use cases or features of any digital solution to reduce counterfeit and falsified pharmaceuticals.

Arumugam et al. (2021) [35] suggested an increasing number of nations throughout the globe were plagued by counterfeit medicine manufacture and distribution. The annual

counterfeit pharmaceutical market price is in the tens of billions of dollars. These were claims that blockchain technology was being employed in the pharmaceutical supply chain to ensure the safety and monitoring of the provider. The suggested method is utilized to monitor the drug from the moment it is made to the time it reaches the patient. Each drug's outcome is saved in the database for future reference. Only trustworthy parties can access the network and transfer data in the blockchain which is stored on an approved blockchain.

Raijada et al. (2021) [36] suggested advanced design ideas for emerging goods like interactive tailored therapy, which would combine the pharmaceutical and digital worlds. This also examines recent advances in Pharmaceutical Supply Chain (PSC) management, as well as the present mass manufacturing model's constraints. Consider the current state of the art, as well as possible future development pathways and areas of growth.

Pandey et al. (2021) [37] suggested a strategy that relies on the blockchain network to record pharmaceutical logistical demands from the manufacturer to the patient. It is possible to stop the spread of counterfeit medication if it is introduced into the system at any stage. The performance of a hyper ledger fabric platform was compared to that of other contemporary techniques in order to simulate the system. The findings show that although the system is computationally expensive, it offers a reliable solution to the counterfeit drugs issue.

Ratta et al. (2021) [38] suggested using cutting-edge computer technologies like the Internet of Things (IoT) and Blockchain, healthcare systems can be made more efficient and effective. IoT and Blockchain fundamentals were laid out from the beginning, as a result of the presentation. Three major applications of IoT and Blockchain are being studied when it comes to healthcare medication traceability, remote patient tracking, as well as the administration of health records. In the end, the difficulties of using Blockchain and IoT in healthcare are brought to the forefront.

Ahmadi et al. (2020) [39] examined IoT and Blockchain-based pharmaceutical governance frameworks were also developed. The Internet of Things (IoT) uses a distributed ledger (DLT) based on blockchain to maintain an immutable record of all transactions. The record was open to all participants and cannot be tampered. Implementing a blockchain-based IoT system would assist the pharmaceutical sector improve supply chain drug governance, hence making healthcare more effective and trustworthy.

Haq et al. (2020) [14] described how blockchain technology can be used to enhance the pharmaceutical supply chain Tracking pharmaceuticals from the point of manufacturing to the point of distribution can be accomplished using the developed model. Once a drug has been administered to a patient, the results can be saved in a database for future research. Permissioned blockchains can only store data if only reputable parties are permitted to join the network and add it to the blockchain.

Saxena et al. (2020) [9] suggested counterfeit medications on the healthcare supply chain are examined, as well as the existing remedies in place to limit the amount of counterfeit on the market. Discussing Blockchain in the pharmaceutical supply chain must serve as a way to learn more about the opinions of specialists in the field. PharmaCrypt, a Blockchain-based programmed, could be developed with the help of the feedback received. It can be used to track

and verify the validity of medications as they move through the supply chain and upload the data to a distributed Blockchain ledger. A device prototype was built to illustrate how this technology could be used in a corporate setting using the Amazon Web Services Blockchain platform.

Sami Ullah et al. (2020) [40] performed research on current applications and growths in the healthcare industry using blockchain technology discussed, a few robust applications and numerous companies which are utilizing blockchain solutions for data security and also present challenges and upcoming standpoints. The blockchain would undoubtedly advantage of the storing of brain data with immutability and transparency because brain data is more delicate and must be handled with care. As a result, corporations and individuals use blockchain technology in healthcare applications to enhance their quality of life while maintaining privacy and dependability.

Monalisa Sahoo et al. (2020) [12] suggested that counterfeit drugs are not only harm patients' health but also cause legitimate manufacturers to lose money. The intricacies of medication counterfeiting as well as its influence have been discussed. A number of blockchain-based counterfeiting methods have also been suggested. Blockchain technology can be used to improve the drug supply chain's traceability, security, and visibility. This suggested system can trace pharmaceuticals from the source, the producer, to its destination and the user.

Kumar et al. (2019) [41] suggested that the greatest risk of medicine safety because of how they created when counterfeit pharmaceuticals enter the supply chain. Tracking the correct and active pharmaceutical components during actual manufacture is a difficult task to avoid patient damage or death. Medications can be tracked from the maker to the end user, and counterfeit drugs can be detected using the blockchain's advanced capabilities. Blockchain and encrypted Quick Response (QR) code security would be used to solve the problem of pharmaceutical safety in this research project.

Sylim et al. (2018) [42] suggested a blockchain-based pharmaceutical monitoring system was evaluated. Counterfeiting of pharmaceuticals is a global issue that poses major dangers to customers and the broader public. In the Philippines, substandard/spurious/falsely-labeled/falsified/counterfeit medications were discovered in 30% of examined drug shops in 2003. The cost of medication expenditures on the people and governments is significant. The Philippines food and drug administration (FDA) invites the public to verify product registration certificates and report any counterfeiting incidents. A specific task squad of the Philippine National Police responds to such reports. In spite of this, there was no evidence that it had an impact on the distribution of these drugs. As a result of repeated sequential hashing and a consensus process, blockchain technology claims to be immutable and fault-tolerant. These efforts were aimed at developing and testing a blockchain pharmacy monitoring system that can share data throughout the whole official medicine distribution network.

Mehdi et al. (2017) [43] presented an unique and revolutionary medledger system that employs chain codes to make advantage of the Hyperledger Fabric blockchain technology. Medicine supply chain transactions are supported by the Medledger system in a fabric-enabled private permissioned distributed network embracing a wide range of pharmaceutical

companies. The drug supply chain ecosystem can keep track of and manage interactions between all of its constituent parts using sequence diagrams and chain codes. This technology, which was also based on decentralised file systems like the Interplanetary File System (IPFS) file currency, Swarm, and many more, was designed to preserve and record every activity, an immutable record of every transaction and event on the Medledger blockchain. The hyper ledger fabric platform's continuing implementation challenges should also be discussed in more detail here. Finally, outline open problems that can be used to guide future research to enhance medication traceability solutions. Blockchain technology was initially popular when it came to adopting cryptocurrencies and other financial services. Smart contracts, which made blockchain more powerful, were proposed for use in a variety of different sectors later on. Several concepts have been offered to include Blockchain's capabilities in the sphere of medical and healthcare, because of its tremendous versatility.

Benchoufi et al. (2017) [44] described how clinical research can be improved by using blockchain technology. However, they didn't go into depth about how blockchain can be utilized in the medication supply chain, which would be an area where the technology has great potential. Medical data can be transmitted from one institution to another in an untrusted environment using MedShare, a new idea based on blockchain technology. Healthcare data is extremely important and vulnerable to numerous forms of assaults. Researchers can use the MedRec white paper to learn more about a new approach for archiving patient medical records and making them accessible to others for research. It suggested the use of blockchain technology to store patient data safely and provide simple access to such data in the future[10].

C. Edward et al. (2017) [45] found that the use of blockchain in the pharmaceutical supply chain has also been discussed, although he does not go into depth on how it is implemented. Aside from that, various papers and academic publications on the subject have been published; interested readers might read.

Liang et al. (2016) [46] stated that using a crawler to convert unstructured data from a pharmacological website into structured data and save it to a local database. It also suggests an information retrieval module and an image recognition module are presented as part of an integrated fake drug identification technique. The fraudulent drug websites are not only recognized one by one using this technology but the hidden links across numerous platforms are also extracted. Experiments show that the utilized technology is capable of detecting a huge number of phoney drug websites. Table 1 shows the summarized table of the Literature review.

Table 1. Summarize table of Literature Review

References	Technique	Aim	Outcome
Zakari et al., (2022) [30]	Blockchain	Use to find solutions to numerous of these issues.	A look into some of the challenges and possibilities of employing blockchain technology in the pharmaceutical industry was conducted

Zoughalian et al., (2022) [31]	Blockchain and Markov model	The study's goal is to look at current ideas for blockchain-based platforms for distribution.	A zero-knowledge proof technique can be used to ensure the integrity of distributed data in the suggested prototype.
Humayun et al., (2022) [32]	Drug distribution process	The aim of the research is resolving coordination issues and enhancing overall security in the drug distribution market (DDM).	The suggested method is used to manage better market forces and prevent manufactured shortages from inflating medicine costs.
Sabah et al., (2022) [33]	Hyperledger fabric	Peer-to-peer distributed applications built on the Hyperledger Fabric platform have been utilised to speed up the pharmaceutical supply chain.	Hyperledger Fabric platform the suggested system operates smoothly, and each transaction can be handled effectively by the distributed smart contracts, as shown by the experimental analysis.
Islam et al., (2022) [34]	Systematic literature review (SLR)	A SLR technique can be used to assess all relevant papers on preventing or decreasing counterfeit and counterfeit medications.	The suggested method was used to prevent the use of counterfeit and falsified medications in the research.
Arumugam et al. (2021) [35]	Blockchain	Distribution and production of counterfeit drugs	The suggested method is utilized to monitor the drug from the moment it is made to the time it reaches the patient.

Raijada et al. (2021) [36]	Pharmaceutical supply chain (PSC)	Suggested advanced design ideas for emerging goods like interactive tailored therapy, which would combine the pharmaceutical and digital worlds.	The pharmaceutical supply chain (PSC) has made significant progress in recent years.
Pandey et al. (2021) [37]	Blockchain and Hyperledger fabric	Suggested a method which is based on documenting pharmaceutical logistical	The findings show that although the system is computationally expensive, it offers a reliable solution to the counterfeit drugs issue.
Ratta et al. (2021) [38]	Blockchain and IoT	Suggested and improve the operation of healthcare systems	Medical records management, remote patient monitoring, and medicine traceability were just a few of the applications for IoT and Blockchain in the healthcare industry.
Ahmadi et al. (2020) [39]	IoT and blockchain	Examine new pharmaceutical governance models based on IoT and Blockchain technologies	Implementing a blockchain-based IoT system would provide the pharmaceutical sector with the tools it needs to strengthen drug governance across the supply chain, making healthcare more efficient and dependable.
Haq et al. (2020) [14]	Blockchain	In the pharmaceutical supply chain, the usage of blockchain technology can be	Make it easier for people to find and track down products.

		of advantage.	
Saxena et al. (2020) [9]	Blockchain	Suggested counterfeit medications on the healthcare supply chain	An Amazon Web Services Blockchain-powered gadget prototype was built to illustrate how the technology could be used in a corporate setting.
Sami Ullah et al. (2020) [40]	Blockchain	Performed research on the current application	Growths in the healthcare industry using blockchain technology
Monalisa Sahoo et al. (2020) [12]	Blockchain and counterfeiting methods	Suggested that counterfeit drugs are not only harm patient's health	This suggested system can trace pharmaceuticals from the source, the producer, to its destination and the user.
Kumar et al. (2019) [41]	Blockchain	Suggested the biggest difficulties with medication safety	Blockchain and encrypted QR (quick response) code security would be used to solve the problem of pharmaceutical safety in this research project.
Sylim et al. (2018) [42]	Blockchain and food and drug administration (FDA)	In a simulated network, tested the blockchain-based pharmaceutical surveillance system.	For the purpose of this project, it is hoped that a blockchain-based system for pharmacosurveillance would be developed and tested.
Mehdi et al. (2017) [43]	Hyperledger fabric, blockchain and Interplanetary File System (IPFS)	Presents a new and innovative blockchain-enabled Medledger system	The suggested Medledger system aids in the effective and safe execution of medication supply chain transactions
Benchoufi et al. (2017) [44]	Blockchain	Tell us about the benefits of using blockchain	A method for securely storing and accessing patient data has been

		technology in clinical research.	developed using blockchain technology [10].
C. Edward et al. (2017) [45]	Blockchain	The use of blockchain in the pharmaceutical supply chain has been addressed here.	As a consequence, healthcare personnel often have difficulty correctly identifying patients, increasing the likelihood that incorrect patient information would be associated with medical data.
Liang et al. (2016) [46]	Integrated fake drug identification (IFDI)	Using a crawler to convert unstructured data from a pharmacological website into structured data	Experiments show that the utilized technology is capable of detecting a huge number of phoney drug websites

3. Background Study

This research investigates the impact that fake medications have on the supply chain for healthcare, includes an analysis of the many methods that are currently being used to cut down on the number of bogus imitations that are available for purchase. The conversations are being held with the goal of gaining an understanding of the opinions held by professionals working in the pharmaceutical industry about the use of Blockchain technology within the supply chain. PharmaCrypt, a Blockchain-based programme, is being developed with the help of the feedback received. This technology can be used to monitor and track medications as they make their way through the supply chain. The information that is acquired is then recorded to a distributed Blockchain ledger, which verifies that the drug is in compliance with the law. The author built a tool prototype to illustrate how this technology could be used in the real-world using Amazon Web Services' Blockchain platform [2].

4. Problem Formulation

In recent years, a range of industry sectors has found methods to incorporate blockchain technology's capabilities into their operations, demonstrating its versatility. Other service-related sectors like healthcare are starting to observe changes that signal the beginning of a shift in this direction while the financial services industry has received most of the attention thus far. This study examines a range of starting points for Blockchain technology in the healthcare industry. Fake medicines are a rising issue throughout the globe.. One in ten medicines sold globally is fake, and the rate rises to 30 percent in underdeveloped countries. Fake medications impact a wide range of medications, including those prescribed for the

treatment of heart disease and cancer, as well as weight-loss aids, antibiotics, painkillers, and other prescription medications [11]. Counterfeits can contain the proper active component, but they are frequently created with an inaccurate dose or in an unclean process. As soon as the active ingredient is missing from the falsified medication, it is very hazardous to the human body. To identify counterfeit pharmaceuticals, the method outlined in this article is the most successful.

5. Prospective of work

In the current time, Pharmacology is the most important concern in counterfeiting drugs. As stated by the Health Research Funding Organization, between 10 and 30 percent of the pharmaceuticals in developing countries are fraudulent. It is not the major issue itself but rather, then it is the fact which as compared to regular medications, these counterfeiting drugs create distinct adverse effects on human health. The growth of contemporary pharmacies has made it more problematic to regulate drug safety. The pharmaceutical industry's supply chain mechanism is to blame for medicine counterfeiting. There are many people involved in this chain of ownership before the final buyer receives the product.

6. Hypothesis

As per the current secure digital era blockchain is the preferred solution to resent the traceable secure solution. *Blockchain is a dispersed network of computers that exchange a reliable record of transactions among the network's users without the need for a central server. This saves every transaction that happens in the network and removes the requirement for a third party. The primary goal of the current study is to offer a blockchain-based traceable supply chain system for authenticating and protecting pharmaceutical products. The first step in the research process is to determine the number of supply chain intermediaries, such as producers, wholesalers, distributors, pharmacies, and patients. At initial nodes, the manufacturer generates a unique code and passes it as transactional data for blockchain and asks all intermediary nodes to generate the unique code of them and keeps on processing to the next level in the supply chain. At the user level, the prefinal node unique code and unique code at the initial stage are matched for sequencing if matching then the system product is free for* counterfeiting.

7. Materials and Methods

The implementation of the research methodology over python language the python version which is used to implement the results is python 3.7.1. In this methodology, the whole technique is simulated in the Jupiter Notebook 5.7.4. and python 3.7.1.

7.1. Research Methodology

The following Methodology is highly effective and useful to fight drug counterfeiting in the pharmaceutical industry. In the proposed methodology two techniques (blockchain and Unique node key) are used. Figure 3 shows the key at a different level.

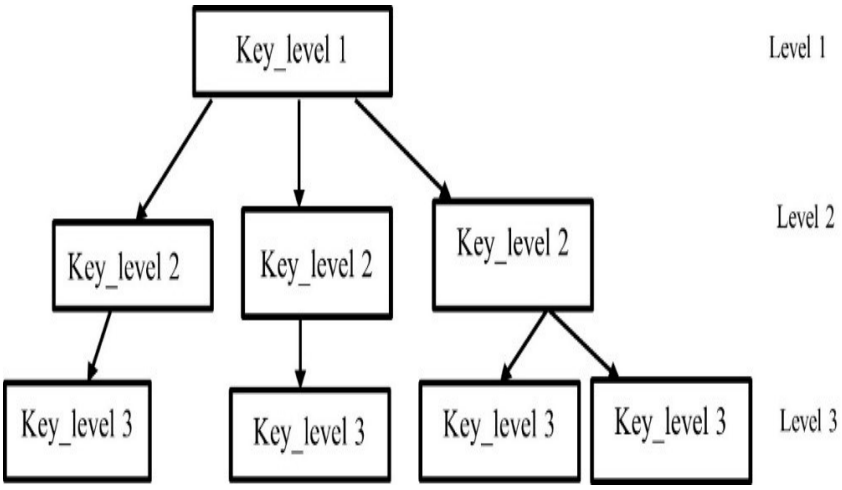

Figure 3: Key at different level

The steps of the proposed methodology are as follows:

Step 1: It shows the Intermediate nodes for example wholesalers, retailers, distributors, etc. which is worked as input for the manufacturer's unique key.

Step 2: The Manufacturer generates the unique code and stores the code into the block. The unique code is generated to remove the malicious activities between the whole process.

Step 3: It followed to the next level of distribution.

Step 4: It checks if follow-up for the block is Okay i.e., the correct key is used. After checking, if it is correct then it proceeds to the next level and finishes at the patient's level (level 3), otherwise, if it is not correct then it reports for error to be manufactured. The designed methodology has been shown in figure 4.

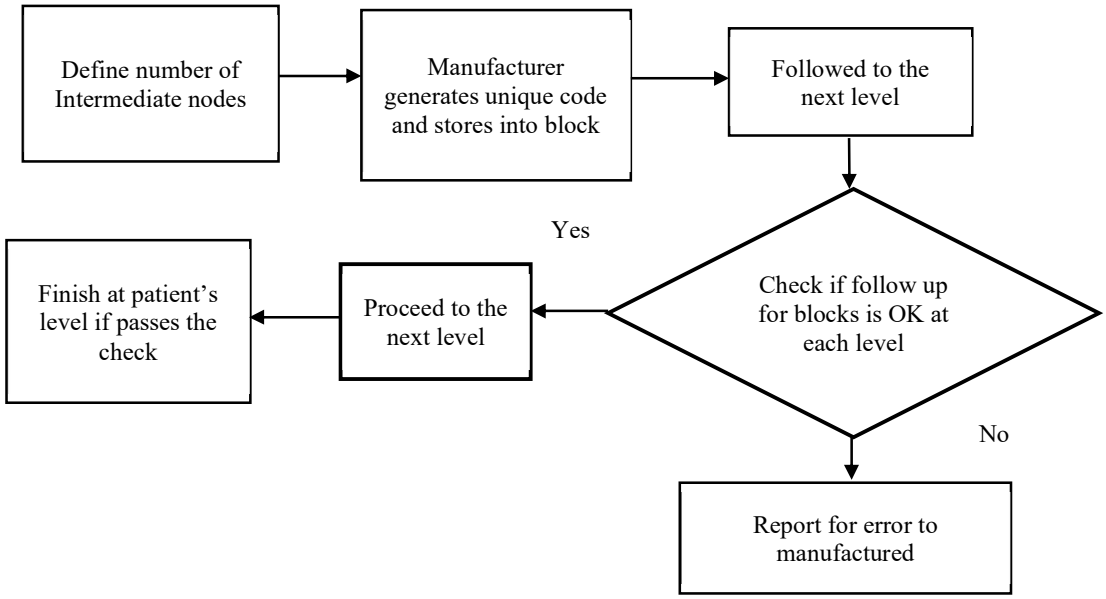

Figure 4: Designed methodology in a pictorial representation

7.2. Results

This section shows the results of the proposed Methodology. Time-consuming and inefficient, the application needs additional hardware and protocol implementation. Tampering, spamming, physical layer attacks, and preferential treatment can all be defeated using the techniques outlined in the proposed tool. A prescription drug's journey to the patient is facilitated by the pharmaceutical supply chain. Before arriving at the final formulation, medicine's ingredients are often gathered from a number of sources.

- **Result 1**

The medicine can be sold after its final formulation has been completed. At various points along the supply chain's lifespan, the drug's supply will be exchanged between manufacturers and patients. Falsified products can enter the supply chain and the industry at any point in the process. Figure 5 depicts a server, which is used for transaction of drugs by their IP addressed.

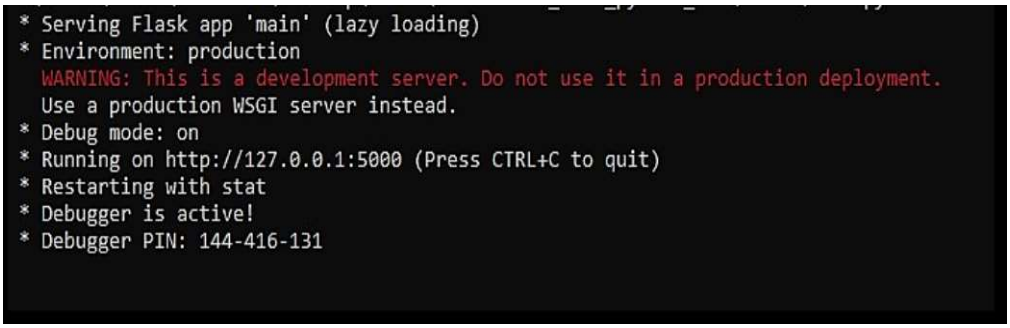

Figure 5: A localhost server.

Prescription drugs are provided to patients via the supply chain of the pharmaceutical industry. Medicinal ingredients are often collected from a number of sources before they are combined into a final recipe. The medicine is passed from one entity to another throughout the supply chain, from the producer to the end user.

- **Result 2**

On the top page, there are three levels: manufacturers, distributors, and pharmacies, which provide the pharmaceuticals. There is a levelled supply chain shown on the top page of Figure 6.

Figure 6: Front page for drug supply chain.

Figure 7 depicts the five blocks, which has been needed to conduct medication transections free of mischievous attacks All of them are acceptable methods of obtaining the medications.

- **Result 3**

The Ordering service chronologically orders multiple drug transactions into blocks, chaining the blocks' hashes to previous blocks. This phase is called the ordering phase.

Figure 7: -drug transection blocks.

There are five blocks for medication transection as in Figure 8, but the third one has been compromised by mischievous attacks.

- **Result 4**

All the blocks are checking the mischievous attacks, block 1, 2, 4 and 5 are ok but in block 3 an integrated breached is detected.

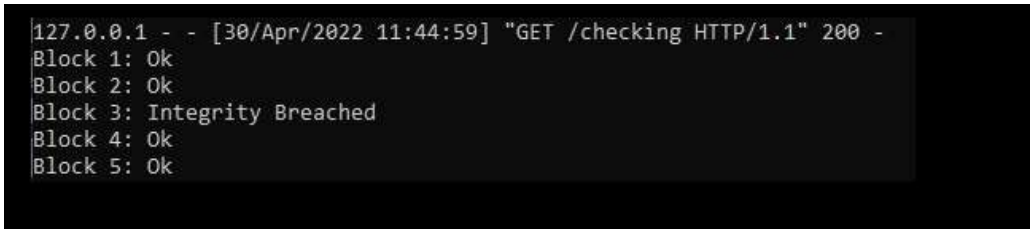

Figure 8: Drug supplying blocks with a mischievous attack in Block 3.

Compared to Drugledger, the suggested consumer-oriented application solution offers better controllability, a user-friendly interface, increased security via groups, and private

network virtualization. The suggested tool has a lower overhead than the Drugledger. Figure 9 shows a thorough comparison between PharmaCrypt, Drugledger [9], and proposed blockchain. The application is both time and resource intensive. Anti-tampering, spam-blocking, physical layer assault and preferential treatment can all be thwarted by the suggested technology due to the need for additional hardware and protocol implementation. If they want to use the Drugledger, they must have a Certificate Service Provider (CSP), Anti-attack Service Provider (ASP), and Query Service Provider (QSP). In other words, compared to the Drugledger, the suggested tool has reduced overhead. If there are 10, 50, or even 200 blocks, the average time for each block is shown in Figure 9(a). Figure 9(b) compares the average block duration for PharmaCrypt, Drugledger and proposed blockchain when the number of blocks is 10, 20, 30, 40, and 50.

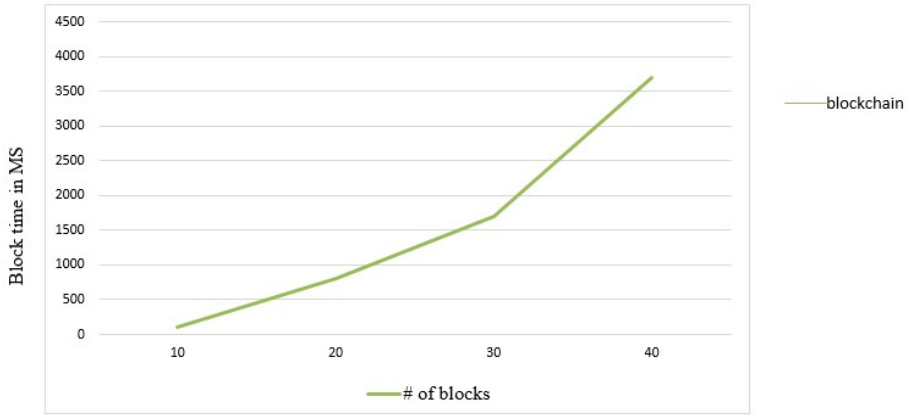

Figure 9 (a): -blockchain average block time where # of blocks range from 10 to 200.

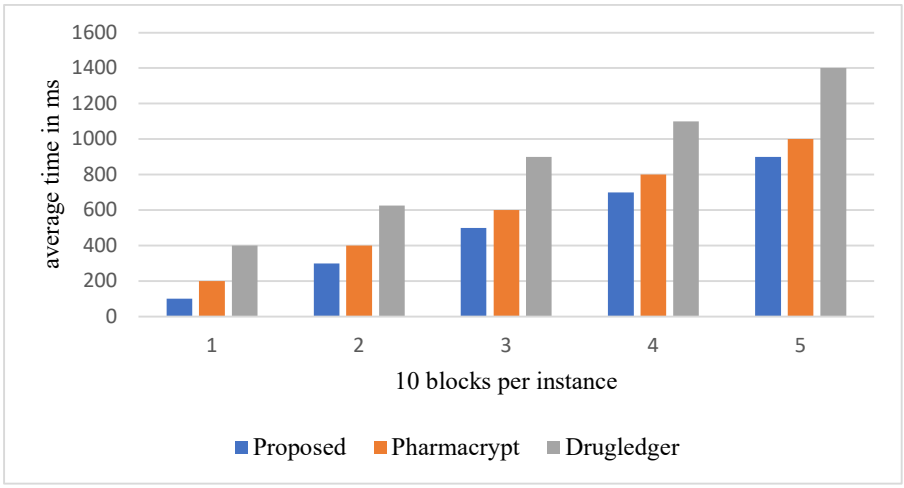

Figure 9 (b) : PharmaCrypt, blockchain vs. Drugledger block time where # of blocks range from 10 to 50.

A decentralised anti-counterfeiting supply chain based on unique node key and blockchain technology, and a decentralised consensus system were presented in BlockSupply. The protocol's utility in blockchain-related applications like PharmaCrypt, on the other hand, remains ambiguous. Health data can be shared, medical records can be reviewed, and treatment

can be audited using both upcoming Blockchain technology and parallel healthcare systems. From this comparison it is clearly shown that the results of the proposed methodology outperformes the state-of-the-art technique [9].

8. Conclusion and Future Scope

Analyzed and evaluated in this study are current solutions to the issue of counterfeit pharmaceuticals. The input of relevant industry specialists working in both medicines and BCT has been explored for the suggested application tool 100% of the pharmacists questioned in the main study were aware of the counterfeit medication problem, demonstrating how pervasive and serious the problem is in the healthcare profession. More investigation is needed on how they must attain this goal for the shortest period possible. Supply chain management can also be integrated into a larger solution. Patients' information can now be stored on a blockchain thanks to ongoing efforts to create an Electronic Patient Record system. Up until recently, RFID technology has been the most effective means of combating this issue. The compliance rules can be included into the Blockchain solution so that the tool records and tracks the information required to comply with the directive. Several challenges pertaining to the management of the medication supply chain are addressed in this study. Blockchain technology is discussed as a way to avert problems in a transparent and safe manner. The model of the blockchain framework that has been developed is not only restricted to preventing the falsification of pharmaceuticals. It can be used for real-time tracking, such as planning for the delivery of goods, the transfer should be signed digitally by both the manufacturer and the distributor using their distributed ledger private keys, and then the transaction is added to the block. In the future, the results of the review were potential to assist with current efforts to prevent the counterfeiting of medicines, including an investigation into the consequences of new technological developments. Researchers have highlighted research gaps as well as potential future research efforts focused on Information and Communication Technology (ICT) to combat the widespread use of fake and counterfeit pharmaceuticals. The use of tiny QR codes printed on pharmaceuticals to track the drug in real-time as this is being sent might better avoid drug counterfeiting in the future. All entities should validate the transaction to ensure that it cannot be denied or tampered with in the future by anybody and before adding another transaction to the blockchain.

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