A Study on The Extent to Which Block Chain Technology Prevents Counterfeit Medicine Distribution in the Indian Pharmaceutical Industry

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CANDIDATE DECLARATION:

This dissertation entitled "**A STUDY ON THE EXTENT TO WHICH BLOCK CHAIN TECHNOLOGY PREVENTS COUNTERFEIT MEDICINE DISTRIBUTION IN THE INDIAN PHARMACEUTICAL INDUSTRY**" submitted in partial fulfilment of the MSc in Pharmaceutical Business and Technology is my own; based on my own study and/or research, and I acknowledge that all material and sources used for the study purpose were cited appropriately. I further affirm that I have not plagiarised anyone else's work, whether in whole or in part, including other students.

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ABSTRACT:

When it comes to producing generic drugs, India dominates the market. More than half of all vaccines produced, as well as 40% of all generic drugs sold in the United States, come from India's pharmaceutical industry. By volume, India is the third-largest pharmaceutical producer worldwide, and by value, it is the fourteenth-largest. A counterfeit medicine or counterfeit medication is a drug or pharmaceutical product that has been produced and distributed with the goal to misrepresent its origin, validity, or effectiveness. Blockchain is the future of technology because of its distributed database structure and the unparalleled data security and integrity it provides to its users. Many industries, including the pharmaceutical, will benefit from blockchain technology's ability to speed up their digital transition. In this study, I intend to investigate the problem of counterfeit drugs in India, as well as their effects and potential technological solutions. The study will provide light on how blockchain technology can be used to stop the spread of counterfeit drugs, which, as is widely known, can have devastating effects on human health. In addition, this research looks at the difficulties of putting blockchain systems into practise. Quantitative and qualitative methods are used interchangeably in this investigation. The quantitative approach often involves an inquiry by use of a survey questionnaire. In order to get the necessary information, a questionnaire would be developed and sent electronically to workers at pharmaceutical firms in India. Interviews with a supply chain and production management from a well-known Indian firm are done for qualitative research. Both sets of data are combined to reach the ultimate conclusion. By using blockchain technologies in the Indian pharmaceutical sectors the distribution of counterfeit medications are prevented to about 20%-40%. From the interviews it was found that blockchain technologies are associated with many challenges. When all these challenges are tackle down blockchain can work with more efficiency and thereby we can completely avoid the counterfeit medicines distribution and issues related to it like health issues, mortality rate and so on. From the study conducted it was found that Indian pharmaceutical firms were among the few in the world to employ innovative technologies like blockchain to stop the distribution of fake drugs in the Indian pharmaceutical industry. Pharmaceutical companies employ blockchain technology to create a distinct digital identity for each product at the time of manufacturing. The product's digital identity is validated and recorded on the blockchain at every step of the supply chain. This ensures that the item is real and unaltered. This is how the blockchain

technology utilized by the Indian pharmaceutical sector prevents the distribution of fake pharmaceuticals.

KEYWORDS: Blockchain technology, counterfeit medicines, tracking and tracing, Indian pharmaceutical industries

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ABBREVIATIONS

CAGR	Compound annual growth rate
API	Active pharmaceutical ingredients
USFDA	US food and drug administration
AIDS	Acquired immune deficiency syndrome
GMP	Good manufacturing practices
WHO	World health organizations
FY	Financial year
FDI	Foreign direct investment
PLI	Production linked incentive
FTZ	Free trade zone
SCM	Supply chain management
GDP	Gross domestic product
IPI	Indian pharmaceutical industry
BCPW	Bengal chemical and pharmaceutical work
R%D	Research and development
BPPI	Bureau of pharma PSU's of India
IPFS	Inter planetary file system
IoT	Internet of things
GDPR	General data protection regulation
DSCSA	Drug supply chain act

CHAPTER 1: INTRODUCTION

1.0 INTRODUCTION

1.1 THE INDIAN PHARMACEUTICAL INDUSTRY

When it comes to producing generic drugs and inexpensive vaccines, India is unrivalled. The pharmaceutical business in India has risen at a CAGR of 9.43% over the past decade, placing the country third in the world in terms of pharmaceutical output. The Indian pharmaceutical business is particularly strong in vaccines, contract research and manufacturing, biosimilars, and biologics. Generic pharmaceuticals, over-the-counter medications, drugs in bulk, vaccinations, and the generic drug market are all key subsectors. About 8% of the global API market is produced in India, which is also home to 500 API producers. The country also has the highest concentration of FDA-approved pharmaceutical facilities in the world. More than half of the world's demand for vaccinations is met by the Indian pharmaceutical sector. This same business also supplies 40% of the US market for generic pharmaceuticals and 25% of the UK market overall. There are more than 3,500 pharmaceutical firms and over 10,500 manufacturing facilities in the United States' pharma business. India's pharmaceutical industry is among the world's most important. To take the business to new heights, the country has a wealth of talented scientists and engineers. Indian pharmaceutical companies presently supply over 80% of the world's antiretroviral medications used in the treatment of AIDS (Acquired Immune Deficiency Syndrome). India is appropriately referred to as the "pharmacy of the world" due to the affordable prices and superior quality of its pharmaceutical products.

India's pharmaceutical sector has huge potential as an export product. In addition, the Indian government monitors a sizeable number of factories that make generic drugs for millions of people at affordable costs (USFDA), all while adhering to the Good Manufacturing Practices (GMP) regulations set forth by the World Health Organisation (WHO). India has been at the forefront of the pharmaceutical industry for quite some time. India's healthcare spending is expected to increase by 9–12% per year over the next five years, placing it among the top 10 of all countries. Companies' capacity to refocus their product lines on chronic medicines, such as those used to treat cardiovascular disease, diabetes, depression, and various types of cancer, will be crucial to the future growth of domestic sales. The Indian government has implemented numerous reforms to increase the quality of healthcare while reducing costs. The opening of pharmacies selling cheap generic medications and other government initiatives, like the National Health Protection Scheme, which aims to provide healthcare to all citizens, should all help to strengthen India's pharmaceutical industry. The speedy introduction of generic drugs to the market has remained a primary priority, and it is one that could help Indian pharmaceutical manufacturers. Anticipatory immunisations, life-saving medications, and programmes to

enhance rural health are currently receiving a lot of attention, which is good news for the pharmaceutical industry.

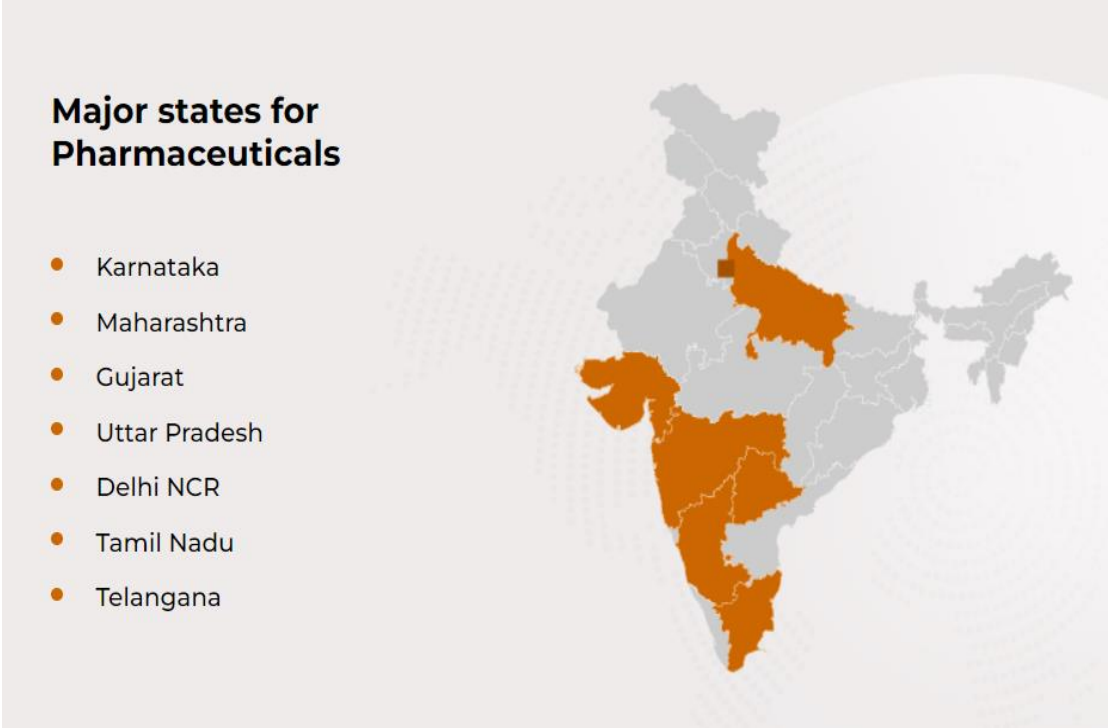

Figure 1:Location of Major Indian Pharmaceutical Companies, IBEF 2021

India exports 12.0% of the world's total medical goods. Indian pharmaceuticals are exported to over 200 countries, with the United States being the largest single market. Generic medications account for 20% of exports from this country, making it the world leader in this sector. Exports of Indian pharmaceuticals and medicines were valued at US$24.60 billion in FY(financial year) 22 and US$24.44 billion in FY21. The value of Indian pharmaceutical and drug exports in September 2022 was $2,196.32 million USD. According to the Indian Economic Survey 2021, the domestic market is expected to multiply by three over the next decade. The value of India's domestic pharmaceutical market is expected to increase from $42 billion in 2021 to $65 billion in 2024 and then to $120–130 billion in 2030. In India, the biotechnology industry encompasses pharmaceuticals, services, agriculture, manufacturing, and information technology. Values for the Indian biotechnology market range from $70.2 billion in 2020 to an expected $150 billion in 2025. A total of $10.36 billion was spent on healthcare technology in India in FY20. With a CAGR of 37%, the industry is expected to increase to $50 billion by 2025.

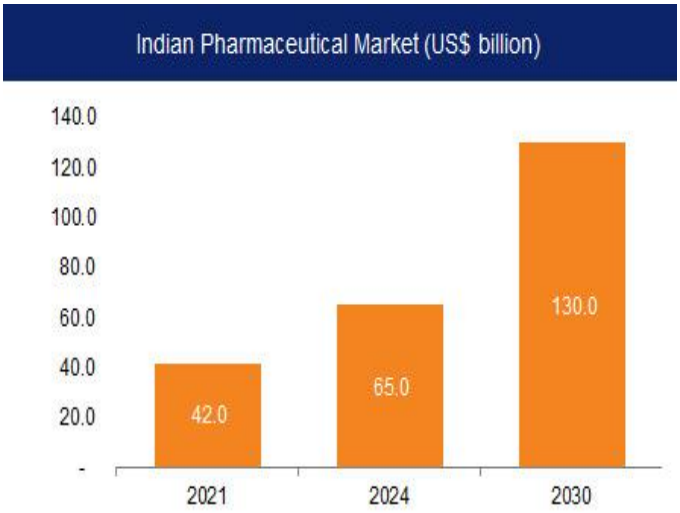

Figure 2: Growth of India's pharmaceutical industry, from the Indian Economic Survey 2021

The "Pharma Vision 2020" initiative is meant to make India a leader in the field of pharmaceutical research and development. Between April 2021 and December 2021, $1.206 billion in Foreign Direct Investments (FDI) went to India's pharmaceutical and medical sector. Between April 2000 and December 2021, a total of US$19.19 billion in FDI into the Indian pharmaceuticals and medicine industries was invested. North America accounted for 34 percent of India's pharmaceutical export market in FY21, and the region saw increases in shipments of 12.6%, 30%, and 21.4%. The Department of Pharmaceuticals initiated the Production Linked Incentive (PLI) scheme in FY21 with an initial cost of Rs. 6,940 crore (US$ 951.27 million) to promote domestic manufacturing by establishing greenfield plants with minimum domestic value addition in four distinct "Target Segments" to achieve self-reliance and reduce import dependency on the nation's essential bulk drugs. The pharmaceutical PLI plan will get an extra investment of Indian Rupees (Rs. 197,000 crore) (US$ 26,578.3 million) in June 2021 (Fig. 3), as approved by Finance Minister Ms. Nirmala Sitharaman. The investment will be spread across 13 key industries, some of which are: active pharmaceutical ingredients, pharmacological intermediaries, and critical raw materials. As of August31, 2021, the PLI programme had received 278 applications, indicating a positive response from the industry. Local and emerging markets are predicted to drive growth in the Indian pharmaceutical industry by ICRA's estimates of 9–11% for the years 2021–2022. The second quarter of FY22 was marked by moderate revenue growth for a sample of 21 Indian pharmaceutical companies, with ICRA reporting 6.4%, down from 16.4% in the first quarter of FY22.

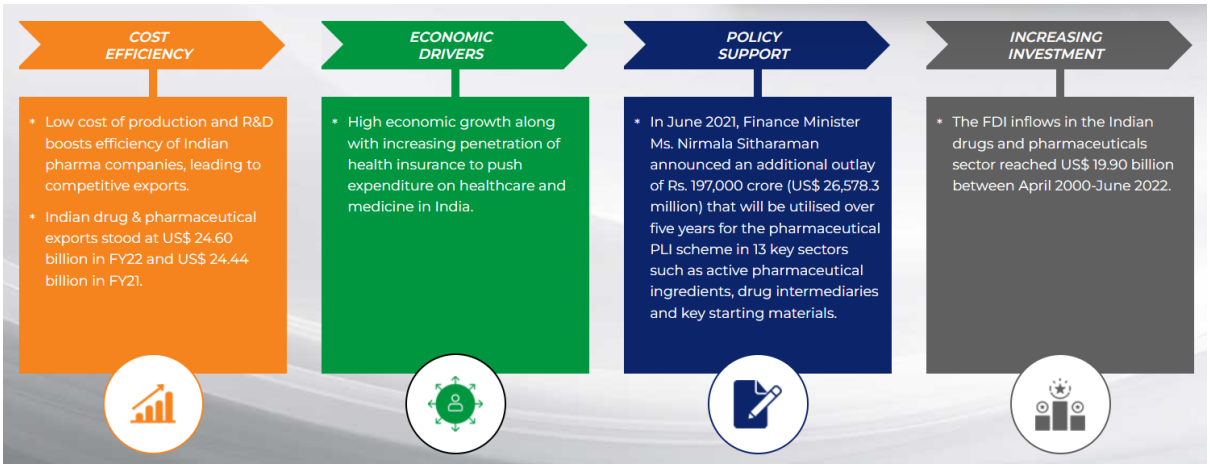

Figure 2:Pharma Vision 2020, IBEF 2020

1.2 COUNTERFEIT MEDICINES IN THE INDIAN PHARMACEUTICAL INDUSTRY

The Indian pharmaceutical industry is a knowledge-intensive sector with steady growth that contributes significantly to the Indian economy. In terms of industrial output, India's pharmaceutical industry ranks fourth globally, and more than 55% of its exports go to highly regulated regions. India exported drugs worth $14.6 billion (about Indian Rupees 82, 730 crore) in the financial year that ended on March 31, 2012. India is a perfect example of a developing nation with an efficient drug regulatory framework and a strong pharmaceutical industry. According to Rama Lakshmi research, between 12 and 25 percent of all medicines sold in India are reportedly counterfeit. India is one of the largest producers of substandard and counterfeit medications, and it also has a large market for them. According to the health ministry, 0.3% and 5.0% of Indian medications are counterfeit. Chandni Chowk in New Delhi, India, is known as the "Bhagirath palace" and is the main distribution point for counterfeit and illegal drugs in the country. 20% of India's $40,000 billion pharmaceutical sector is made up of counterfeit pharmaceuticals. Cough syrups, vitamin supplements, and medicines now contain ingredients that were formerly exclusive to exotic and expensive drugs like Viagra (Roger Bate, 2008). India is now a hub for counterfeit and illegal drugs because it is the largest supplier of generic medications worldwide. Bihar, West Bengal, Uttar Pradesh, and Gujarat were the states with the most instances of counterfeit and spurious medications being sold locally in India. China, the United Arab Emirates, and India are the main nations from which counterfeit goods are produced, according to European customs agencies.

Drug counterfeiting is a thriving industry in India for a number of reasons, including the expansive pharmaceutical sector, weak pharmaceutical regulation, high drug costs, value added

tax, the prescription of drugs without registration, a lack of public awareness, poor regulatory enforcement of laws, and the flexibility of the current legal system. In India, counterfeiting drugs is a highly profitable industry. India's reputation as a source for low-cost manufacturing has allowed counterfeiters to expand. Counterfeiters are able to make significant profits despite not contributing to the significant expenditures of research and development required by genuine producers. It can be expensive and difficult to identify counterfeit medications. The difference between an authentic product and a counterfeit one is sometimes undetectable to consumers and even to prescribing doctors. For instance, there would be no reason to suspect a counterfeit product if a patient consumed it and recovered naturally. By utilizing the most advanced technological tools in their illegal trade, drug counterfeiters are becoming ever more sophisticated. Researchers found that between 2001 and 2005, the ability of counterfeit makers to use advanced printing technology, including holograms, has significantly improved. The study examined the frequency of inactive components in counterfeit artesunate (an anti-malarial). Criminally inclined individuals frequently manufacture and distribute fake or spurious drugs as a replacement for real medications in cases where demand for drugs in the pharmaceutical business exceeds supply. Also, consumers who use medications improperly often create a demand for such medications, which may come from fake sources. For instance, weight-loss supplements have created a market for illegal steroid-containing pharmaceuticals. These medications are frequently sold illegally or on the black market for high rates. Several exporting nations do not hold drugs produced for domestic consumption to the same standards as those developed for sale.

Moreover, drugs are occasionally exported via free trade zones (FTZs), where drug regulation is difficult and repackaging and re-labelling occur. Even when the system is well regulated, this type of negligent trade system gives counterfeiters better chances to get illegal medications into the supply chain. Drug regulation is based on legislation and regulations. Control over the production, importation, distribution, and sale of medicines in the nation requires a capable national drug regulatory agency with the accompanying financial support. According to a WHO assessment, 20% of the 191 member states have drug laws and regulations that are well developed. The remaining 30% either don't have drug regulation in place or have it with very little power that barely works, while 50% are bringing drug regulation into practice at various levels. The spread of counterfeit medications in the legitimate distribution channels is caused by insufficient, inadequate, or weak drug regulatory supervision, which encourages unregulated drug importation, manufacture, and distribution (Saurabh Verma *et al.*,2014).

1.3 BLOCKCHAIN TECHNOLOGY TO PREVENT COUNTERFEIT MEDICINES IN PHARMACEUTICAL INDUSTRY

Security is the primary benefit of using Blockchain technology in a system like pharmaceutical supply chain management (SCM). The best alternative for 21st-century cyber-security is blockchain, and so far no fault has been discovered in it. As it is meant to prevent any one individual from changing the data or transactions, blockchain can boost confidence and help get rid of the bias present in conventional supply chain systems. Participants can exchange digital assets anonymously via blockchain, eliminating the need for third parties or other participants they don't know or trust. As a result, in a world where there is no trust, blockchain is the greatest option. The Smart contract is the biggest factor behind the use of blockchain in the pharmaceutical SCM system. A smart contract is a piece of computer code that contains the actual rights and obligations, including the terms and conditions for the payment and delivery of goods and services agreed upon by all signees and capable of being automatically carried out. Blockchain could get additional strength and intelligence from smart contracts. Modern, cutting-edge, tailored blockchain-based solutions can be created using them (Ijazul Haq *et. al.,* 2018).

The pharmaceutical sector uses blockchains for a variety of operations. Cryptographic technologies are employed to validate blocks of transactional data, hence addressing security, a significant concern. Serialization has addressed the security concern provided by counterfeit pharmaceuticals. In this method, serial numbers are checked and validated at multiple points along the supply chain. Consumers are able to check the legitimacy of pharmaceutical products by using security features like serialisation. Digital signatures are used for quality control, and medicine traceability has been improved to deter theft. The openness and code-based transparency of blockchain-based transactions also boosts safety. Since the counterfeiting industry thrives in the absence of confidence and openness in the pharmaceutical sector, consumers are put at risk by low-quality or fake medications. Safety is increased and lives are saved when blockchains are used for quality control and the detection of counterfeit drugs (Zakari et al., 2022).

Public registries based on cryptographic systems are used in blockchain technology. It is decentralized and based on open Internet services, and it keeps records of all system activities and changes. The main principles of the Blockchain system are decentralization, the exclusion of intermediaries, accessibility to the public (publicity), and participant consensus. Both during an independent procurement and while receiving inpatient care, the patient is unable to determine which drug is being sold to him yet. Although a patient has the right to request

certain documentation, such as a quality certificate for a medication, nobody is stopping a dishonest supplier or pharmaceutical institution employee from falsifying it. It will be able to track the complete chain, nevertheless, if all the data is kept in the blockchain starting at the point of clinical research, production, additional storage, and distribution to the pharmacy and/or its structural subdivision, including the medical institution. It is obvious that this system can be changed by including new functions, such as guidelines for the storage of medications and the care of inpatients. It is feasible to determine who received medications and how much of a need there is for them generally. For this purpose, the packaging of pharmaceutical products (for example) features a barcode that may be used to access blockchain through a specialized application. Additionally, Blockchain has another crucial feature that makes it irreplaceable. A major advantage over a single database, where data may be easily fabricated while concealing any changes to it, is that once information is saved there, it cannot be changed or destroyed. As a result, using the blockchain system, patients may be able to verify the accuracy of information about the effectiveness of drugs, their effectiveness, safety, and even adverse reactions (Pashkov and Soloviov, 2019).

1.4 RESEARCH PURPOSE

Counterfeit medicines are drugs or pharmaceutical products that have been produced and distributed with the goal of deceiving consumers about their legitimacy. Blockchain is the future of technology due of its distributed database structure, which provides users with unrivalled data security and integrity. Many industries, including the pharmaceutical one, will hasten their digital transformation with the help of blockchain technology. In this study, I intend to investigate the prevalence, effects, and potential solutions to the problem of fake drugs in India. Because the distribution of fake drugs is on the rise and can have devastating effects on human health, our research will shed light on how blockchain technology can be used to stop it.

1.5 SIGNIFICANCE OF THE STUDY

Distribution of counterfeit pharmaceuticals is seen as a global concern because of the harm it can do to patients. There are a number of reasons why counterfeit drugs could be dangerous. It's possible that these were fake or that the labels were mislabeled on purpose. Too little, too much, or no active ingredient at all is common with illegal substances. Some fake drugs have been found to include cement, rat poison, mercury, or arsenic. Counterfeiting pharmaceuticals is dangerous to the public's health and against the law. Counterfeit medications often have the correct ingredients but in inadequate doses; however, they may also contain the wrong API,

which could be hazardous, or no active ingredient at all. The widespread use of subpar drugs, especially antibiotics, can promote the development of resistant organisms and have negative effects on patients. Counterfeit drugs could prove lethal in extreme cases.

The study focuses on to reduce the marketisation of counterfeit medicines using anti-counterfeiting technology called as blockchain. Pharmaceutical companies make extensive use of anticounterfeiting technologies to make sure that only genuine products are delivered from the manufacturer to the sellers. Holograms, color-changing inks, and embedded codes, images are a few of the technologies employed by pharmaceutical companies. With these anti-counterfeiting technologies, pharmaceutical experts can identify suspect drugs as potential counterfeits.

1.6 RESEARCH OBJECTIVES

The main objectives of this research can be broken down into three main parts. They are as follows:

1. Firstly, to determine the current use of blockchain technology in the pharmaceutical industry.
2. Secondly, to review the use of blockchain technology have in the role of preventing the sale of counterfeit drugs in the pharmaceutical sector.
3. Thirdly, to study the challenges faced when implementing block chain technology to prevent distribution of counterfeit medicines.

1.7 STRUCTURE OF THE STUDY

Although mostly a qualitative investigation, this study will also have some quantitative inquiries in the form of a survey. The qualitative study will elaborate on the thoughts of knowledgeable professionals. As part of the quantitative research, we will conduct surveys with appropriate personnel from Indian pharmaceutical businesses. About 30 people working in the pharmaceutical industry in India will take part in the study. The application of blockchain technology in the pharmaceutical business to prevent the distribution of counterfeit medications can be better understood with the help of both quantitative and qualitative data. The primary benefit of these types of research projects is that they allow us to provide organised findings with minimal investment of time and money. As part of the quantitative strategy, we will conduct an investigation utilising a survey questionnaire. In order to gather the required information, a questionnaire will be developed and distributed electronically to eligible workers at Indian pharmaceutical businesses. The information will be sorted and analysed so that conclusions can be drawn. The data will be used to investigate whether or not blockchain

technology can effectively stop the spread of fake drugs. In this step, we analyse the raw data. Interviews with experts in the Indian pharmaceutical industry would be conducted via zoom meetings and phone calls within a certain time frame to facilitate qualitative research. The information will be analysed, and conclusions will be derived from the study.

1.8 CONCLUSION

Due to its rapidly expanding economy, aging population, expanding middle class, increasing number of chronic illnesses, cheap labor, and improved access to healthcare, India is being considered as a potential growth market by international pharmaceutical companies. Yet, the foreign investment crisis places India at risk of missing out on investment work. Investor sentiment might be greatly enhanced by changes to the regulatory environment and harsher penalties for those who produce counterfeit items. Without strong words and action, India runs the risk of losing significant pharmaceutical industry investment, which would subsequently compromise the population's health.

When we make a comparison of all the countries in the world it is found that in India, the availability of counterfeit drugs is at its peak. As a result, many deaths were reported. If the usage of counterfeit drugs are not controlled it can result in further complications. In addition to health issues, the revenue and reputation of the pharmaceutical companies are affected. In order to make all these under control we need a way, this is achieved by blockchain technology.

CHAPTER 2: REVIEW OF LITERATURE

2.0 LITERATURE REVIEW

Counterfeit and inferior medicines account for 10% of global trade, which is an issue for all nations. In India, it is widely accepted that counterfeit medications are common. Over 10.5% of medicines sold in low- and middle-income countries, including India, are defective and counterfeit, according to a 2017 WHO research. The possibility of counterfeiting increases with globalization and rising healthcare expenses. Up to 20–22% of all generic drugs are produced by Indian pharmaceutical companies, and counterfeiting poses a serious risk, complicating the issue for the pharmaceutical industry. There have been numerous unsuccessful attempts to eliminate this hazard in the past. An unstable supply chain arises when one counterfeiter is stopped because another one quickly begins elsewhere.

Worldwide, medication is used to treat serious illnesses and manage chronic conditions. But, even in developed as well as developing nations with highly controlled healthcare systems, people unintentionally take counterfeit pharmaceuticals every day. They risk their life for something they should have been able to count on. The pharmaceutical sector and global medication regulators are always seeking to remove any substandard and counterfeit drugs off the market. In 2000, it was reported that India accounted for 35.0% of global sales of counterfeit medicines, which primarily involved antibiotics but also included all therapeutic drug classes. There are many strategies to stop counterfeiting, including technological countermeasures, consumer education, legal action against counterfeiters, and enforcement department action. The most effective method of preventing and reducing counterfeiting is to implement anti-counterfeiting technologies.

2:1 INDIAN PHARMACEUTICAL INDUSTRY:AN OVERVIEW

Economically, society benefits greatly from the pharmaceutical business because of the jobs, supply chains, and infrastructure it builds. In terms of both output and value, India's pharmaceutical sector is among the world's largest and most advanced. The pharmaceutical industry anticipates a 10% contribution from the country and a 2% share of worldwide markets. It has made substantial investments over the years in its infrastructure and technological prowess, allowing it to manufacture a diverse selection of pharmaceuticals. The industry's bulk drug production currently covers all the key therapeutic areas. Many of the individuals it employs have technical training, and they excel at upstream processing and process development. Its capital investment is estimated to be $4.1 billion. It manufactured formulations worth $15.4 billion and bulk medications for 3.5 billion dollars in 2008. Pharmaceuticals in bulk expanded at a rate of about 14% in the 1990s, whereas formulation expanded at a rate of 24%. Research and development is receiving more funding and attention.

It has 29 million workers overall. The pharmaceutical industry accounts for 12% of the manufacturing sector's GDP and 2% of India's overall GDP (G. Akthar,2016). The history of the modern Indian pharmaceutical industry (IPI) dates back to the early 20th century, when burgeoning nationalism inspired a resurgence in interest in science, particularly pharmaceuticals. With the creation of two businesses that are still operating today, the modern pharmaceutical sector got its start. One of them is Bengal Chemical and Pharmaceutical Work (BCPW) Ltd., which Acharya PC Ray established in Kolkata in 1901. The other company was established in Vadodara in 1907 by TK Grajjar, Rajmitra, and BD Amin and is called Alembic Chemical Works Co. Ltd. Both companies underwent a significant shift away from outdated practices and toward a more scientific style of pharmaceutical creation, manufacture, and research. In their early phases of development, Indian pharmaceutical companies placed a large amount of reliance on foreign corporations to supply them with bulk medications.

It is the largest contract manufacturer, contract research organisation, clinical trial sponsor, and contract R&D organisation in the world, in addition to meeting domestic demand. Some of India's primary benefits include the country's enormous population and growing middle class, its low manufacturing costs while maintaining high standards, and its well-developed infrastructure. Many Indian pharmaceutical facilities meet international quality standards, such as those set by the US Food and Drug Administration and the UK's Medicines and Healthcare Products Regulatory Agency, even though China is seen as the biggest danger to the IPI.

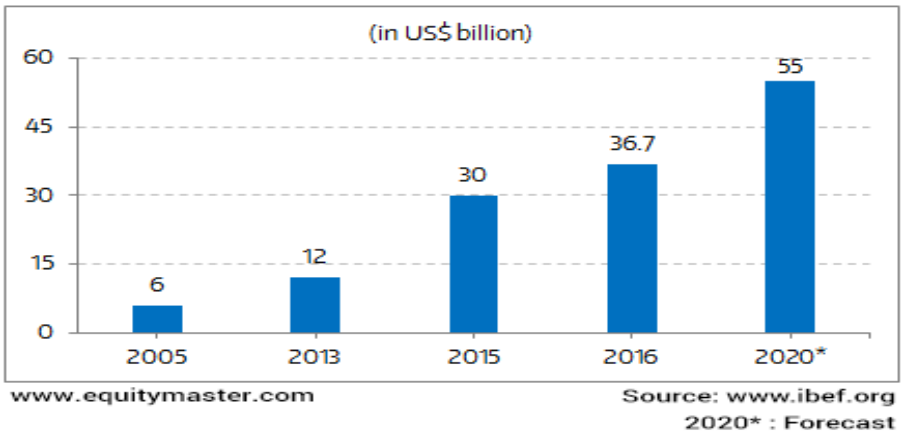

Figure 3:Growth of Indian Pharmaceutical Industry. (IBEF,2020)

2:2 COUNTERFEIT MEDICINES

Fake pharmaceuticals and their outcome have long been a problem in developing and low-income countries due to the widespread lack of access to standard medical care and resources. The lack of regulation in some areas has created a market for counterfeit goods. A counterfeit

drug or medication is one that has been intentionally produced and distributed with the intention of deceiving consumers as to its legitimacy, safety, or effectiveness. Drug efficacy and safety could be compromised if the formulation includes unanticipated compounds or excessive amounts of the active ingredients. In addition, problems may arise because of inaccurate labelling on medicinal products. Counterfeit drugs are immoral since they are made outside of the regulated pharmaceutical manufacturing system. Due to their similarity to legitimate drugs, it may be challenging to spot fakes. They are often ineffective since they are merely cosmetic replicas that seem like the real thing. However, they can include harmful or even fatal ingredients, and they often fail miserably at curing the condition or illness for which they were designed. Pharmaceutical drugs are used in every stage of healthcare, from diagnosis to treatment to prevention. The number of deaths attributed to counterfeit drugs is estimated to be between 100,000 and 1,000,000 per year (Jamil et al., 2019). The introduction of counterfeit drugs must be halted swiftly to safeguard patients and prevent further damage to legitimate pharmaceutical companies' brands and bottom lines. Some counterfeit drugs contain genuine antibiotics or antivirals,though at greatly reduced dosages compared to what is indicated on the product label. Antimicrobial resistance is a major public health problem, and this approach to illness treatment is insufficient since it allows germs a time to change and spread. Medicines that aren't supposed to be in fake pharmaceuticals can cause overdoses and even death (Pfizer, 2023) if they end up there. Fake pharmaceuticals are readily available online from any country in the globe, making everyone increasingly vulnerable. Everyone should know the dangers associated with buying and using drugs. Efforts are being made by public health professionals, law enforcement, and the pharmaceutical industry to lessen this threat.

2:3 IMPACT OF COUNTERFEIT MEDICINES

Increased morbidity and mortality, drug resistance, consequences for economic growth, adverse effects (such as toxicity) caused by inappropriate active substances, etc. are just some of the ways that the distribution of fake medications harms the pharmaceutical industry's standing in developing countries (Glass, 2014, OECD/EUIPO 2020). Those who choose to utilise counterfeit drugs do so at their own peril. False drugs are linked to between 72,000 and 169,0000 cases of pneumonia in children each year (WHO, 2017), and an additional 116,000,000 deaths may be attributable to fake anti-malarial tablets.

Fake or low-quality medications threaten human health, waste financial resources, and undermine public faith in the medical system worldwide. Numerous difficulties have arisen in the medical and life sciences due to the widespread trade in fake goods in India. The emergence

of counterfeit pharmaceutical products poses a threat to the market share and business opportunities of legitimate pharmaceutical product manufacturers. The estimated annual loss to the pharmaceutical industry due to the distribution of fake drugs is $46 billion. Branded generics are projected to make about 90% of the value of India's pharmaceutical market. The availability of counterfeits makes it difficult for certain governments to promote the adoption of cheaper unbranded generic pharmaceuticals to save healthcare expenses (Pratik Avhad, 2018). When the quality of counterfeit pharmaceuticals is low, the same risks to a company's reputation and the goods involved apply as with other forms of counterfeiting. Furthermore, the company's image for quality and safety is at risk, and litigation may occur, if consumers are hurt by counterfeit versions of the company's drugs. There are many ways in which counterfeits negatively impact legitimate manufacturers, including income loss, trademark protection costs, reputational damage, the potential cost of managing the disposal of counterfeits, and legal fees involving counterfeiters and maybe individuals who were accidentally damaged by counterfeits. The issues have been briefly mentioned in the company's reports. In its 2019 annual financial report, Pfizer, one of the top five pharmaceutical businesses, acknowledged counterfeiting as an issue. In many instances, legitimate pharmaceutical companies lose business to those peddling fakes. An estimated USD 1 billion in counterfeit revenue was earned in India's pharmaceutical industry in 2003 (OECD, 2016).

2:4 COUNTERFEIT MEDICINES-INDIA

India's economy, public health, and safety are all negatively impacted by the prevalence of counterfeit products, piracy, and smuggling. The majority of generic drugs are manufactured in India, and estimates suggest that anywhere from 12 to 25 percent of all medicines sold internationally are substandard, fake, or otherwise tainted. According to some estimates (McLaughlin, 2012), India may be the world's leading manufacturer of both finished pharmaceutical products and active pharmaceutical components. Some people worry that India's medicine isn't reliable because of how it's made. The World Health Organisation (WHO) found in 2002 that estimations from Indian pharmaceutical producers suggested that 20% of pharmaceuticals in major Indian metropolitan marketplaces were either substandard or unlawful. It has been shown that the standard of Indian medicines has an effect on markets worldwide. Approximately 35% of antimalarial drugs sold in pharmacies and private businesses across six major African cities failed to meet minimal quality control standards, a recent study found. According to research by Bate R et al. (2009), 31% of purportedly Indian

samples were found to be of low quality. Numerous reports have surfaced out of India detailing the distribution of substandard medicines. Indian pharmaceutical businesses have been in the spotlight recently due to the deaths of 66 children in the Gambia, which followed claims that the children's condition had worsened after they had been administered cough syrup made in India. India's Maiden Pharmaceuticals shipped four distinct varieties of its syrup to the African country. The World Health Organisation (WHO) issued a warning that the items were "contaminated" and could cause serious health problems, such as "abdominal pain, vomiting, diarrhoea, inability to pass urine, headache, altered mental state, and acute kidney injury which may lead to death" (Murali Krishnan, 2022). Over 30 percent of retail goods in India are found to be potentially dangerous, according to a report by the Central Drug Standard Control Organisation, which is part of the Ministry of Health and Family Welfare. Substandard pharmaceuticals are not a new issue in India, but they do have far-reaching consequences. For instance, in the previous four years, the Bureau of Pharma PSUs of India (BPPI) has recalled 106 batches of 52 goods and 632 medicines from Jan Aushadhi kendras in Karnataka due to a failure to meet a drug quality standard test (ETHealth world,2021).

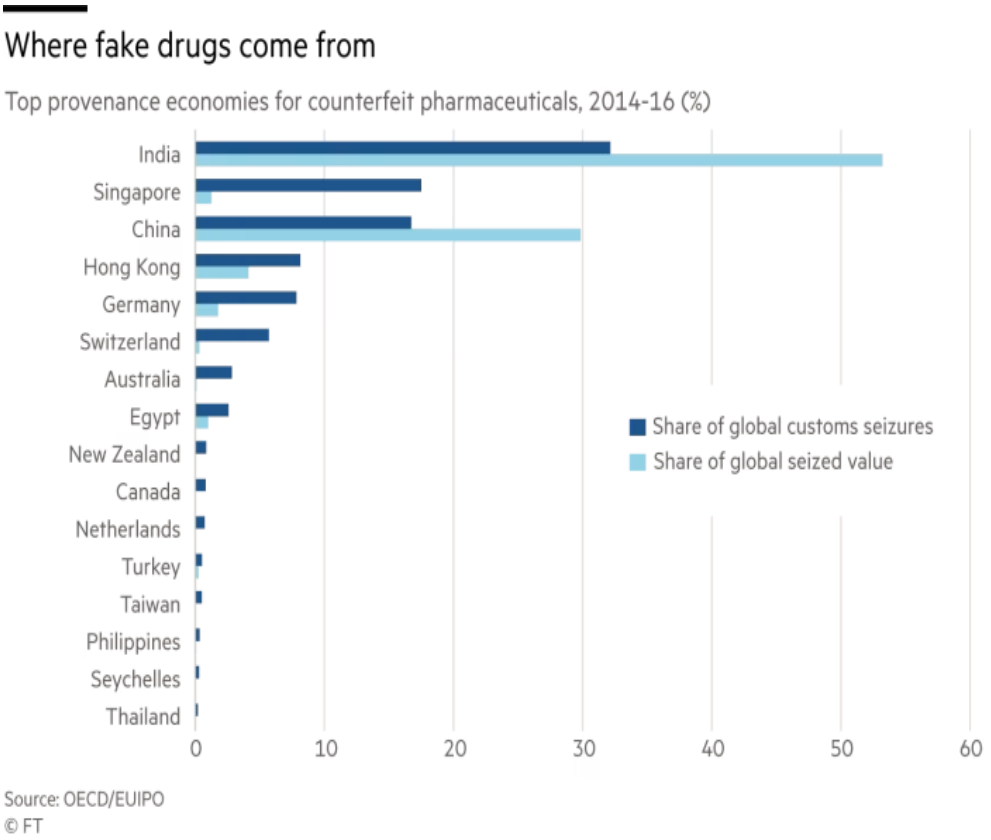

Figure 4:Top provenance economies for counterfeit pharmaceuticals (Stephanie Findlay,2021)

2:5 BLOCKCHAIN TECHNOLOGY

Technology countermeasures, consumer education, legal action against counterfeiters, and enforcement agency action are only some of the methods that have been used to combat this problem. Anti-counterfeiting technology is the most efficient means of minimising the prevalence of counterfeiting and preventing its occurrence. Pharmaceutical firms make use of blockchain technology in a number of contexts. Serialisation has mitigated the safety concerns associated with potentially dangerous counterfeit medications. Quality control is maintained via data miners from the factory to the pharmacy. (Alshahrani and Alshahrani, 2021) This is accomplished with the help of digital signatures, blockchain codes, and medical records.Anti-counterfeiting technology enables tamper-evident packaging, product verification, and track-and-trace systems. The implementation of blockchain technology has the potential to reduce mortality rates and improve drug safety by facilitating the detection of counterfeit pharmaceuticals. IPFS (Inter Planetary File System) and the Ethereum blockchain are powerful tools for putting many plans into action (Mani et al., 2022). In order to improve product traceability across the whole industrial supply chain, the Indian government has been steadily introducing new regulations. This ensures that the appropriate product is available through the appropriate channel at a fair price (Shiva Kabra, 2022). Security features, such as serial numbers, are added to pharmaceutical products so that buyers may identify genuine products from fakes. Through transparent blockchain-based transactions, blockchain technology also enhances safety. Lack of transparency, difficulties in monitoring medicines, and the delivery of expired pharmaceuticals are all concerns difficulty in the pharmaceutical industry. Using blockchain technology, some of these problems have already been solved (Sinclair et al., 2019, Zakari et al., 2022). However, the pharmaceutical industry has to accurately record the origins of raw materials in order to produce and distribute drugs. Adsul et al. (2020) note that adopting blockchains to monitor drug quality and spot counterfeits can increase safety and save lives. The pharmaceutical industry is only one of several sectors experiencing a rapid digital transition because to blockchain technology.

2:6 HOW IS BLOCKCHAIN CURRENTLY USED IN PHARMACEUTICAL INDUSTRY

It is possible to monitor the entire pharmaceutical supply chain, from raw materials to finished drugs, with a blockchain. Blockchain technology also reduces the number of pharmaceutical intermediates, which in turn lowers costs and improves safety (Huang, Wu, Long, et al., 2018).The blockchain is getting more and more study. Blockchain technology was initially

used in the financial industry, but is now also being used in the public sector, in the IoT, in reputation systems, and in security services. The pharmaceutical industry is one of the most recent to use blockchain technology, and one of the most significant applications of this technology is the elimination of the counterfeiting problem. It's fascinating to see the explosion of blockchain-related medicine research during the past three years. Some IT constraints, such as data management, accessibility worries, data redundancy, and data privacy, provide a number of challenges for blockchain technology's use. They face the same challenges in trying to manage operations and streamline patient safety, medical transactions, tracing, and tracking while also dealing with malpractice and inefficient supply chains. Therefore, modern approaches and algorithms for dealing with enormous amounts of data are required to manage blockchain data (Gürsoy et al., 2020). Each new product that comes out of a factory will be given a unique code. Using the item's code as its unique identifier (ID), the item will be added to the blockchain. As a digital asset, the product may be tracked at any time using its unique code using the blockchain system. Any additional product details can be kept either on-chain or off-chain, depending on the manufacturer's preference. Information stored off-chain will be integrated with data stored on-chain using an identifier. Typically, password analysis (such SHA-256) is used to create off-chain data and link it to on-chain data in blockchain-based applications. Therefore, the best practise is to store text data on the blockchain and large files (such as photos) off-chain. After the maker registers the product on the blockchain, the transfer of ownership to another participant will be quick and easy thanks to a user-friendly smartphone application. Let's say a drug distributor has expressed interest in purchasing some of the manufacturer's wares. After registering the transfer transaction on the blockchain, the producer would ship the medications to the wholesaler. Similar procedures are followed by the wholesaler and the distributor when handing out drugs to their respective distributors and pharmacies (Ijazul Haq et al., 2018). The blockchain could serve as a platform to increase confidence and transparency in the pharmaceutical industry by allowing customers to track medicines as they make their way through the supply chain. A bar code on the packaging of a pharmaceutical might be scanned whenever the drug is exchanged for another. Only trusted users are granted the authority to add new blocks to the blockchain. The record is distributed in real time over the blockchain. By scanning the bar code, both the manufacturer and the end user can access the information. In the case that illegal substances are identified, the platform must enable identification, tracking, verification, and reporting (Philipp Sandner, 2018).

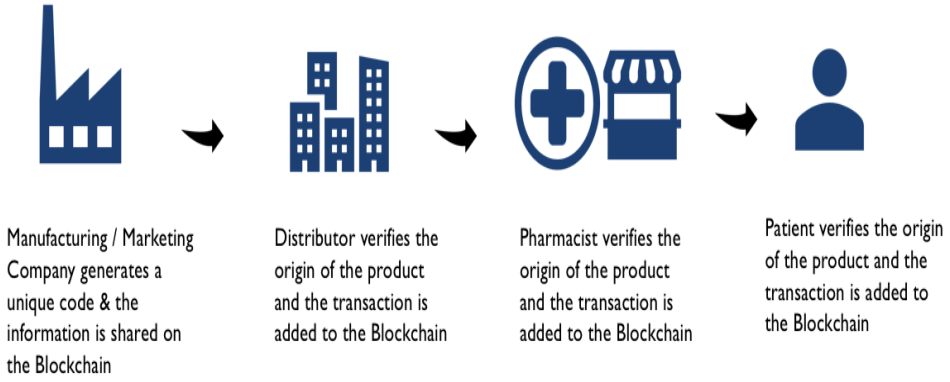

Figure 5:How blockchain technology used in the pharmaceutical industry (Ida Rachel, 2019)

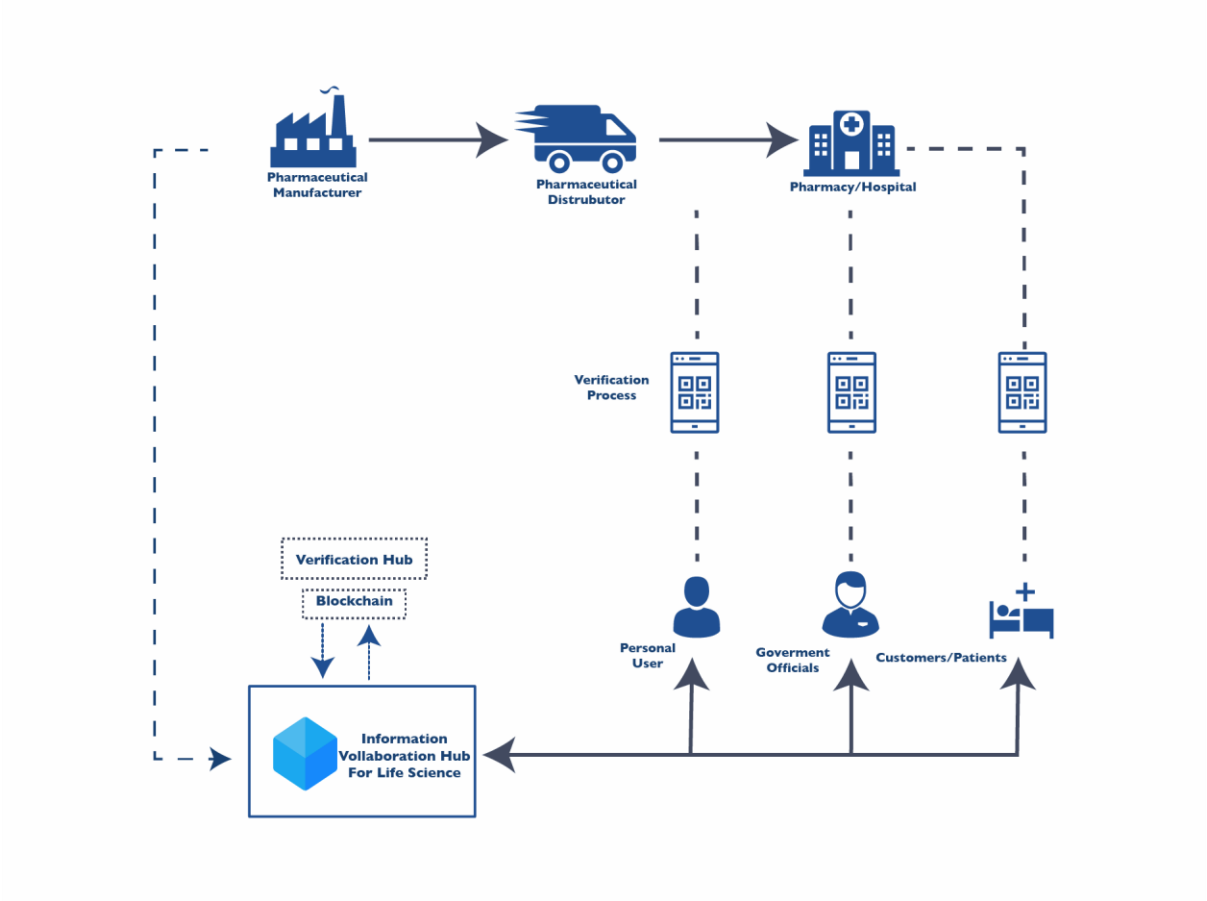

Figure 6:Blockchain technology to introduce traceability into the pharmaceutical supply chain (Devendra, 2018)

2:7 CHALLENGES OF ADOPTING BLOCKCHAIN TECHNOLOGY

One of the challenges with data is the continuous flow of information and materials throughout the production technology and supply chain. In such cases, data flows vertically, with one

partner higher and one partner lower. An end-to-end traceability would be requested by trading partners through the supply chain. The electronic compatible system is then sent back to the requesting business by each partner, which is slow, ineffective, and can be outdated by the time the information is received by the searching company. The systems used by different firms may be distinct and unable to communicate with one another as a result of issues with trust and supply chain security practices in exchanging data and access to systems with other organizations. Blockchain enables close to real-time data access since the details of each transaction or record are readily available to all participants in the supply chain. Additionally, as previously mentioned, blockchain has the advantage of not requiring a single central owner of all information, which enables organizations from having to reveal their internal systems or confidential information. Instead, only the record or transaction that needs to be verified needs to be shared publicly across all parties in the supply chain, developed to address any concerns about data and system trust and security. Drug regulatory agencies' responsibilities also include quality control, monitoring of pharmaceutical products' efficacy, safety, and post-market surveillance. They frequently supervise the production, sale, and storage of pharmaceutical goods so that illegal production and trading of counterfeit medications can be immediately identified and appropriately punished. As it becomes increasingly difficult for regulatory bodies to establish the legal parameters and environment for blockchain technology, their involvement in blockchain-based solutions becomes more important and complex. For instance, it is challenging for these authorities to precisely define the jurisdiction and proper legal obligations of the stakeholders involved when a new transaction is carried out in the network. Another difficulty is adapting to the demands of impending laws like the FDA DSCSA, sterilization, and GDPR in blockchain networks. As a result, blockchain technology continues to be incompatible with current legislation governing the pharmaceutical supply chain. Creating the ideal blockchain application is a difficult challenge because the majority of the current solutions are still in the development stage. This problem is also severely impacted by the privacy, scalability, and operational requirements. Most of the businesses, including those in the pharmaceutical supply chain, face one of the biggest difficulties in terms of implementation and energy costs. When it comes to transaction execution, the current platforms and legacy software systems are inefficient and centralized, which results in high implementation and maintenance costs. Due to its distinct consensus mechanisms, Hyperledger Fabric, for instance, can process more than 3500 transactions per second while using substantially less power than Ethereum (Uddin *et. al*.,2021).

CHAPTER 3: RESEARCH METHODOLOGY

3.0 RESEARCH METHODOLOGY

3.1 OVERVIEW

Research methodology chapters of studies provide in-depth descriptions of the research methods, approaches, and designs used throughout the study and provide justification for the selection of those methods, approaches, and designs by discussing their relative merits and shortcomings, as well as how well they apply to our particular research (Walliman & Walliman, 2011). Study validity and reliability can be evaluated by the reader in the section of a research report devoted to methods. The techniques section responds to two main concerns. How did you find this pattern or make this prediction? And how did they analyse it? Your research technique should outline the steps you'll take to complete your study. Methods like as data collection, statistical analysis, and the use of participant observations are all a component of this. Justifying your research strategy means providing evidence for your data collection, analysis, and other major conclusions, which is what you'll accomplish in your methodology section. Envision yourself creating an agenda or outline of your goals. It's easy to lose focus or vary from your usual procedure when you're doing research. You can keep your workload under control, improve your efficiency and output, and stay focused on your original goals and objectives with the help of a tried and true methodology. There are three distinct approaches, each defined by their emphasis on either words or numbers or both.

SERIAL NUMBER	PRIMARY DATA	PART A	PART B
1	Approach	Quantitative Analysis	Qualitative Analysis
2	Philosophy	Positivism	Interpretivism
3	Source	Questionnaire: Designed via Google forms and are distributed online.	Zoom interview
4	Structure	13 Questions	10-20 minutes of Zoom interview.
5	Subject	Qualified personnel working in the Indian Pharmaceutical companies	Production and Supply chain Managers

Table 1:Details on Research Methodology and primary data collection.

3.2 RESEARCH APPROACH

Quantitative and qualitative research methods will be utilised to learn how well blockchain technology stops the spread of fake drugs in India's pharmaceutical industry. The strengths of

one form of data can make up for the weaknesses of another when qualitative and quantitative data are combined, leading to a more robust assessment. I plan to employ survey questions and a zoom interviews to accomplish this. In order to collect this information, I will use Google form to create the survey and distribute it to the participants online. Statistical analysis will be performed with the collected data. The questionnaire was designed to elicit responses pertinent to these three overarching questions. The first step is to research how blockchain technology is currently being applied to the healthcare sector. The study's secondary objective is to learn how blockchain technology might be applied to the problem of fake pharmaceuticals making it to market. Finally, this research aims to shed light on the difficulties inherent in using blockchain technology to curb the spread of counterfeit pharmaceuticals. Finding areas of consensus and divergence among survey takers and then providing a solution that can be maintained over the long term will yield the most fruitful findings.

The qualitative strategy will involve conducting a zoom interviews with highly experienced production and supply chain managers to learn about their perspectives on production and distribution, as well as their thoughts on the latest strategies for preventing the sale of counterfeit medicines and their suggestions for overcoming the latest obstacles. Quantitative and qualitative data will be combined to produce the most reliable findings, after which a conclusion will be drawn.

3.3 RESEARCH PHILOSOPHY

The following are the four primary types of paradigms utilized in research:

- **POSITIVISM:** A research methodology that takes into account social realities is referred to as positivism. The research's conclusions would be in line with any relevant theoretical laws or principles. This paradigm helps to clarify the relationship between a hypothetical situation and the actual situation. It is primarily related to quantitative research.
- **REALISM**: Based on their feelings, scientists who practice realism hold the view that their way of thinking or reality is real or that it is the truth. They belong to the positivism subclass, however unlike positivism, they have thoughts. Realisticism is a key component of quantitative research methodology (Walliman, 2017).
- **INTERPRETIVISM:** Interpretivism is a method of interpreting data in which researchers rely on their own judgment and experience to do so. Most of the time, qualitative research employs this technique.

- **PRAGMATISM:** The use of several approaches to do research is known as pragmatism. These investigations typically employ a variety of methodologies, and the philosophy has little bearing on this paradigm. It is discussed that this is a type of interpretivism.

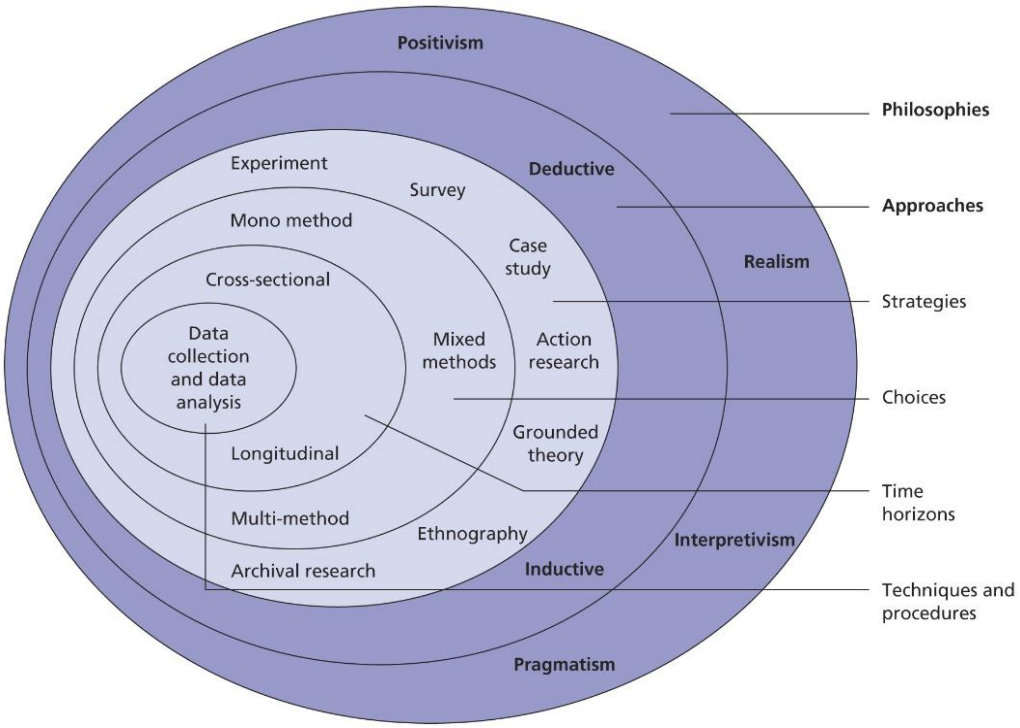

Figure 7:Research onion. (Source: Saunders and Thornhill, 2019)

This work will be primarily grounded in positivist and interpretivist philosophy. It will apply in this study to provide an explanation for the data collected from respondents, helping to project a proper research result. The research's application will be supported by a number of quantitative findings that helped with the statistical analysis of the information gathered from respondents. The ideas under investigation will be easily quantifiable, therefore the research tried to proceed through hypotheses and deductions, involving a sizable number of randomly chosen medical and pharmacy specialists. The evaluation of a research methodology will be essential since it ensures the validity and advancement of the investigation. By focusing on the research techniques utilized, it also helps the researcher understand the analysis (Saunders et al., 2009).

The research methodology or paradigm selected for this work was epistemology, which asks how we can know something (MacIntosh, 2016). As the study's results may be proven without further investigation, this paradigm is widely used in scientific research. In other words, the

data gathered through data collection and literature reviews have been found to be widespread. Research problems were investigated using the positivist philosophy.

Participants in the survey will be given a perfectly designed questionnaire, from which information was gathered, examined, and impartially assessed. The author, who only focused on the facts provided, will be unaffected by the study and had no need to include human intervention or personal interests in it. Instead of employing a face-to-face questionnaire, which ran the danger of subjectivity and bias, an electronic survey alternative will be used to preserve minimal interactions with research participants while the study will being done. This study primarily employs the deductive strategy since it has a positive impact on the research and helps to build a new phase of the investigation.

Zoom interviewing techniques will be used to collect data qualitatively, and the use of interpretivism produced primary data that will be influenced by the production and supply chain manager's individual beliefs and values. They had a tendency to be opinionated but honest, and as a result, people questioned their reliability and overall depiction. As a result of the increased degree of depth and expression achieved from highly experienced managers trusted by the philosophy of interpretivism, which will be necessary to obtain suitable study results, it will also link to a high level of validity.

3.4 RESEARCH STRATEGY

As part of the quantitative approach, will administer a survey questionnaire and conduct in-depth interviews.

In order to gather the required information, a questionnaire will be developed and distributed electronically to eligible workers at Indian pharmaceutical businesses. The data is organised and analysed so that conclusions can be drawn. The data will be used to investigate whether or not blockchain technology can effectively stop the spread of fake drugs. In this step, I analyse the raw data. In order to generate responses to the research questions, I shall employ the simplest questionnaire design possible. There are both open-ended and closed-ended questions in the poll for this reason. The length of the survey questionnaire is greater than 10. The researcher won't need to be present for the rest of the survey once the online questionnaire has been sent out. This is consistent with the tenets of positivism, which advocate for open and honest communication. The data collected through a survey has the potential to be extrapolated to the entire population because it is collected from a large number of people or events. Data in vast quantities can be generated rapidly and cheaply using surveys. Therefore, researchers could potentially improve both planning and delivery of study data by imposing a time

constraint on the duration of the investigation. Each analysis is crafted to integrate data in a way that is easy to comprehend and yields results that address the research objectives we posed. Interviews with experts in the Indian pharmaceutical industry would be conducted via zoom meetings and phone calls within a certain time frame to facilitate qualitative research. The analysis of the data is the next step before drawing any conclusions from the study. The interview process will be standardised and adaptable. The ideal interview question is one that can be easily answered by the individual being questioned and does not present any obstacles. Avoid asking the person too many questions or letting the interview go on for too long. Keep the interview to 30-60 minutes at the most and stick to direct questions. The setting and the degree of background noise should be checked before the interview begins.

An introductory letter will be sent with the first question in order to gain respondents' permission to utilise their responses in the research project. They were also made aware that the General Data Protection Regulation (GDPR) would control the processing of their survey responses and that their privacy would be strictly protected.

3.5 COLLECTION OF PRIMARY DATA

In order to find resources, any research endeavour needs to use a data gathering strategy. Either a quantitative or qualitative approach will be used. The quantitative technique involves gathering quantifiable data and applying statics and mathematical models to examine it. The qualitative method, on the other hand, relies on the participants' own data and will be very effective for fully understanding and exploring a small number of specific situations or illuminating intricate investigations. Thematic or document analysis will be the most popular types of analysis.

According to the research approach, only questionnaires will be used to collect primary data from the qualified individuals whose work will be being investigated for the study. All 13 questions will be designed to gather survey respondents' thoughts in order to efficiently achieve the research objectives without any noticeable gaps. The survey form will be made available online to qualified company employees using the Google forms platform. From 30 people, the author will be collecting the data. To analyse the data and produce pie and bar charts to explain and display the findings as well as to compare the outcomes, the author next used the Google Forms answer bar. Also, a zoom interviews with a production and supply chain manager with extensive expertise will be held to better understand the knowledge, awareness, challenges, and suggestions for production and distribution.

3.6 INCLUSION AND EXCLUSION CRITERIA

Participants in the study will be qualified employees of Indian pharmaceutical industries. A production manager with sufficient years of experience who worked for a reputed Indian pharmaceutical company participated in the interview. Everyone who refused to answer the questionnaire will be automatically disqualified from the study. No further explicit inclusion or exclusion criteria will be provided for this study's recruitment or subsequent data analysis aside from these. A request for their informed consent will be included in an introduction letter that will be linked to the survey questionnaire before it could begin. Participants in the survey had complete discretion over whether or not to take part. Professionals who will be hesitant to take part will be advised to disregard the sent link, however those who answered the questionnaire will be assumed to have done so voluntarily.

3.7 ETHICAL CONSIDERATIONS

The author will provide a brief overview of the study to all respondents to the survey and interviews as part of the course work for her master's degree. When designing the survey, we paid close care to ensure that no personal information was requested from respondents and that all questions were pertinent to the study's goals. It will be made clear that participation in the survey is voluntary at any point, and participants are under no obligation to do so.

The European Commission is dedicated to protecting your privacy and the confidentiality of your personal data. Protection of natural persons with regard to the processing of personal data by Union institutions, authorities, offices, and agencies, Regulation (EU) No 2018/1725 of the European Parliament and of the Council of 23 October 2018. Furthermore, the Commission's collection and use of personal data is governed by the free movement of such data (repealing Regulation (EC) No 45/2001). All information will be kept securely in compliance with the ethics policies of Griffith University.

This privacy notice will inform you of why, how, and where your personal information will be used, as well as the choices you have regarding its collection, storage, and disclosure. Take action with the help of this data by contacting the relevant Data Controller, Data Protection Officer, and European Data Protection Supervisor.

The following details the data processing practises of the Commission in relation to the EU Survey application, and more especially how your personal information is treated when you become a registered user of EU Survey and use the tool to generate surveys. If, for instance, your survey is going to gather and process respondents' personal information, you'll need to add a privacy statement to the survey itself. The privacy concerns associated with your survey creation are not addressed. I want to make it clear that I will not be asking any participants any

questions regarding their work or personal lives as part of my research. All aspects of the probe will adhere to the strict ethical guidelines set forth by Griffith College.

CHAPTER 4:FINDINGS AND ANALYSIS

4.0 FINDINGS AND ANALYSIS:

4.1 INTRODUCTION:

In this section, we examine the data gathered from the survey's questionnaire. In order to answer research questions about how well blockchain technology stops the spread of fake medicines in India's pharmaceutical business, we'll be collecting data via a survey questionnaire.

Interviews with experienced supply chain and production managers were analysed to see if their responses, the literature study, and the researcher's own perspective on the research subject overlapped in any way.

4.2 INTRODUCTORY QUESTIONS (QUESTIONS 1-5):

The initial five questions in the survey are introductory in nature. The sole purpose of these questions is to find out the background of people participating in the survey. Before we get into the questionnaire, the first question is asked in order to make sure that the participants clearly understand the purpose of the survey. If a participant, does not understand the motive behind the survey, then there is no point of completing the survey in the first place,

The second question aims at seeking the consent of the participants to take place in the survey. It is mandatory to seek the approval of participants before enrolling them for the survey. The third question is to know whether the survey participants are working in the Indian pharmaceutical companies. The survey aims at finding out the details of application of block chain technologies in pharmaceutical companies of India. So, the greater proportion of survey participants must be the people working in the Indian pharmaceutical companies.

The introductory questions in the survey made sure that only qualified participants took part in the survey. The responses obtained in the first three questions are as follows:

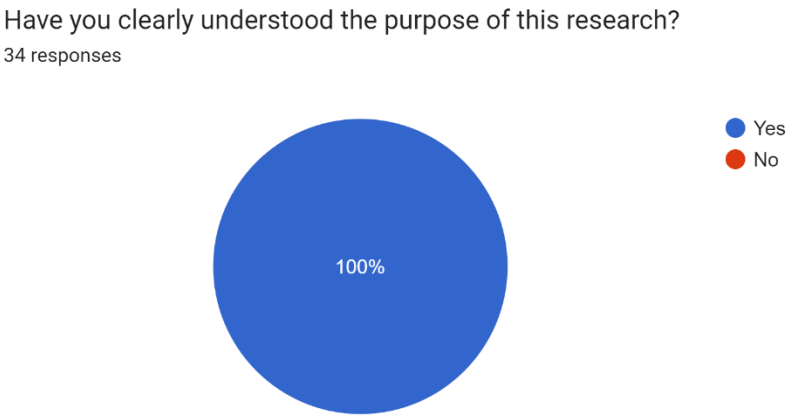

Figure 8:Response to the first question.

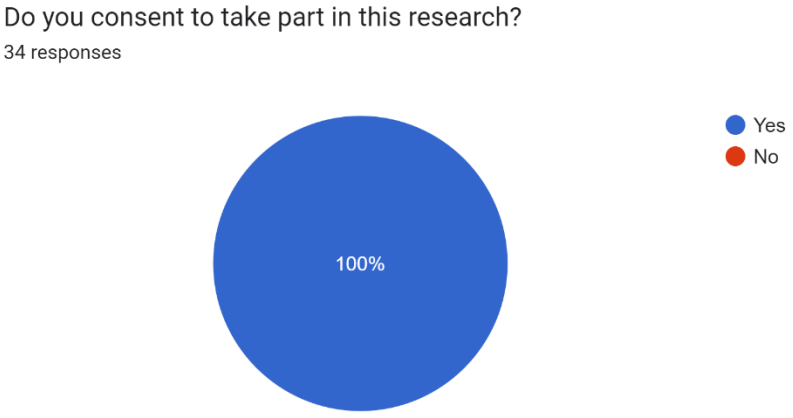

Figure 9:Response to the second question.

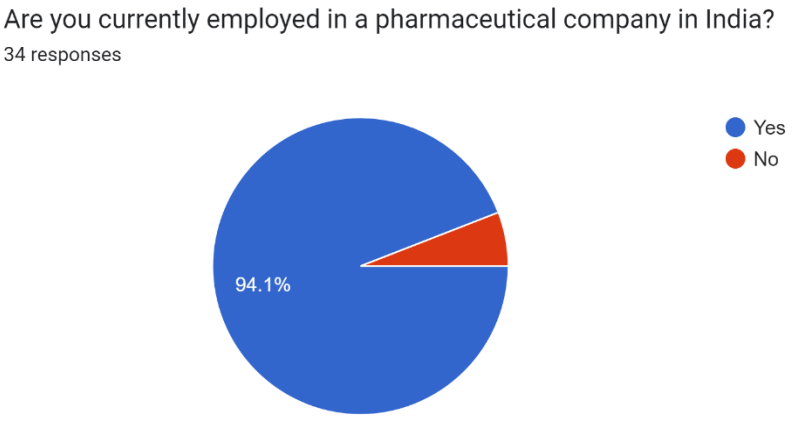

Figure 10:Response to the third question.

Only those who are eligible to participate in the survey should fill out the questionnaire. That's why it's crucial to screen for eligibility and invite only those who qualify to the survey. When looking at the data from the first three questions, it is clear that the vast majority of respondents gave favourable responses. As a result, it is clear that only people who were allowed to take part in the poll actually did so.

The purpose of the fourth survey question is to learn how long respondents have been in the workforce. The goal of this inquiry is to ensure that only respondents with adequate levels of relevant experience have taken part in the study. The data collected for the fourth question looks like this:

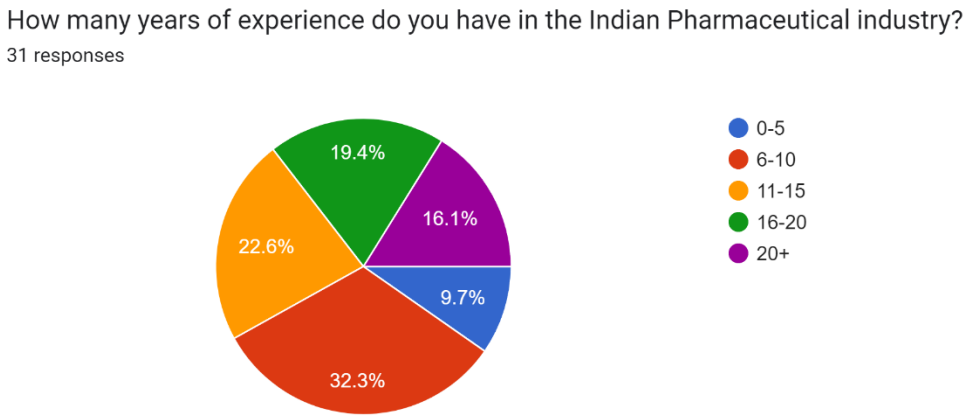

Figure 11:Response to the fourth question.

The data can be tabulated as follows:

YEARS OF EXPERIENCE	RESPONSES
0-5	9.7%
6-10	32.3%
11-15	22.6%
16-20	19.4%
20+	16.1

Table 2:Work experience of survey participants.

From the response obtained for the fourth question it can be seen that majority of the survey participants possess 6-10 years of work experience which is followed by people with 11-15 and 16-20 years of experience contributing to 22.6 % and 19.4% respectively. In addition to

that, 16.1% of survey participants are people with 20+ years of experience and remaining 9.7% of survey participants have about 5 years of work experience in the Indian pharmaceutical industry. It is crystal clear from the responses that only eligible participants took place in the survey.

The fifth question aims at finding out whether the survey participants are from reputable pharmaceutical companies and from the responses obtained it can be seen that all survey participants are currently working in reputed Indian pharmaceutical companies.

4.3 MAIN SURVEY QUESTIONS (6-13):

These questions are the core part of the survey and explains to what extent block chain technologies are being used in the Indian pharmaceutical industries.

The aim of sixth question is to find out whether survey respondents are aware of the cases reported in India regarding counterfeit or fake medications. It is very much clear from the response that survey participants are aware of the reported cases. The response obtained are as follows:

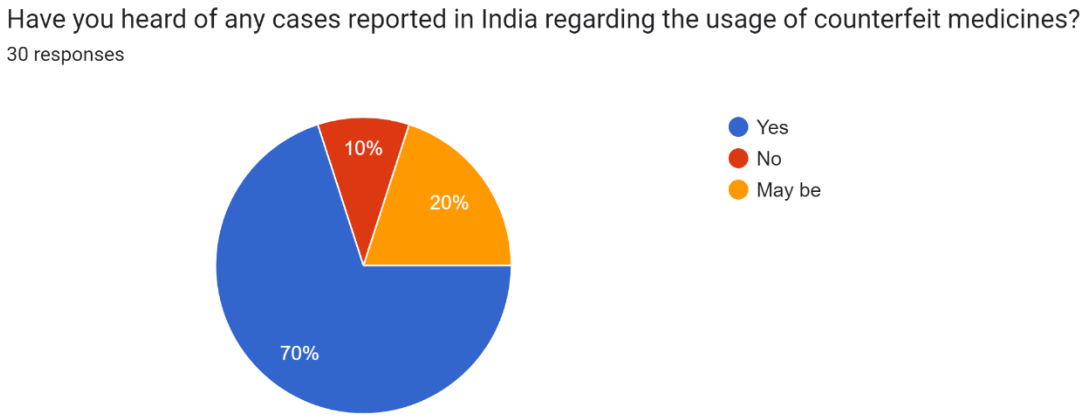

Figure 12:Response to the sixth question.

Around 70% of the survey respondents responded by saying yes to the question. This indicates how popular cases related to fake medications in India are. The rest of the responses together contribute to 30% indicating more people are aware of cases related to counterfeit medications. Since, cases related to fake medications are serious, real time preventive measures like blockchain technologies are to be implemented.

The next question aims at finding out how popular block chain technologies are. The response obtained for that question is as follows:

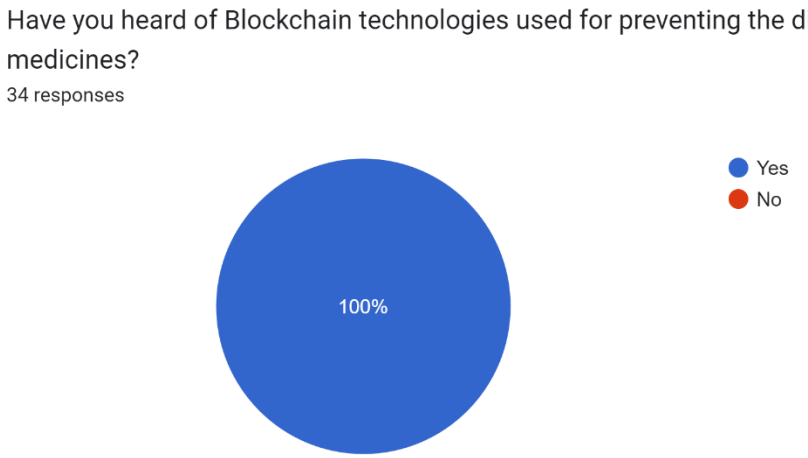

Figure 13:Response to the seventh question.

It is very evident from the response obtained that all survey participants are aware of the blockchain technologies. This shows how popular blockchain technologies are. Even though, blockchains are emerging technologies, they have already secured the popularity in the Indian pharmaceutical industries.

The eighth question aims at finding out whether the companies in India are making use of blockchain technologies to prevent distribution of counterfeit medications. This is achieved by directly asking the survey participants about this. The response to this question in as follows:

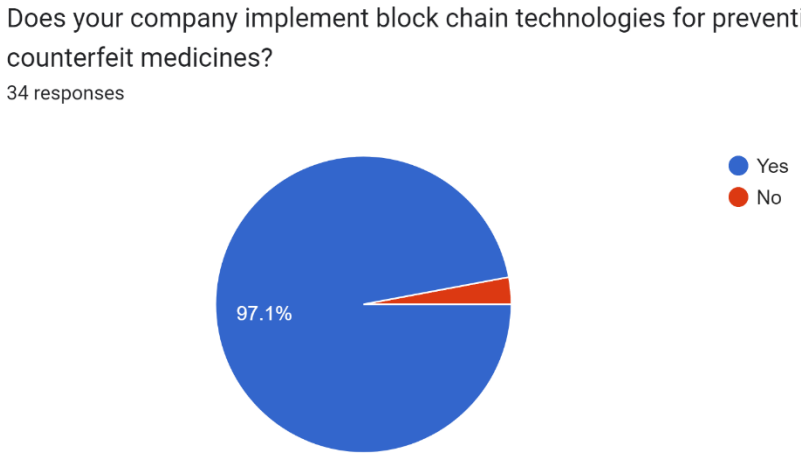

Figure 14:Response to the eighth question.

It is very clear from the responses obtained that the Indian pharmaceutical companies are making use of blockchain technologies to prevent the distribution of counterfeit medications.

About 97.1% of the responses were Yes to the question and only 2.9% of the responses came out as No. This also indicates how popular blockchain technologies in India are.

Drugs are developed and manufactured at manufacturing facilities, regularly moved to wholesalers, and finally delivered to patients. Blockchain technology provides a possibility to verify the dependability of the medication supply chain and enhance drug development by assisting and managing the drug development process. While the entry of fake and substandard medications into the legal supply chain poses a severe threat to public health, blockchain technology can improve the present systems by utilizing distributed ledgers, smart contracts, the transfer of assets, and proof of work.

The nineth question aims at finding out how long ago the Indian pharmaceutical companies started to implement blockchain technologies. The response obtained for this question is as follows:

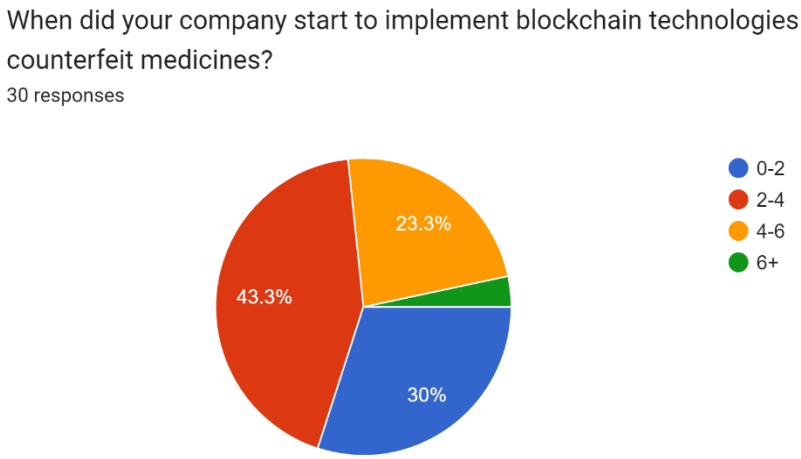

Figure 15:Response to the nineth question

From the responses obtained it can be clearly seen that majority of the pharmaceutical industries in India started to implement blockchain technologies recently. Around 40% of the respondents responded by saying that their company started implementing blockchain technologies 2-4 years back. It is followed by 30% of the responses saying that their company started to implement blockchain technologies within the last two years. Another 23.3% survey participants said that their company started implementing blockchain technologies 4-6 years back. Only less than 4% of the participants responded by saying that their company have been using blockchain technologies for past 6+ years. From this it can be concluded that blockchain technologies are really an emerging technology with many potential scopes of developments.

The next question aims at finding out to what extent the emerging technology, blockchain technology prevents the distribution and utilization of counterfeit medications in the Indian pharmaceutical industries. From the response obtained it can be seen that blockchain technologies play a major role in preventing the distribution of counterfeit medications in the Indian pharmaceutical industries, The response obtained from the survey are as follows:

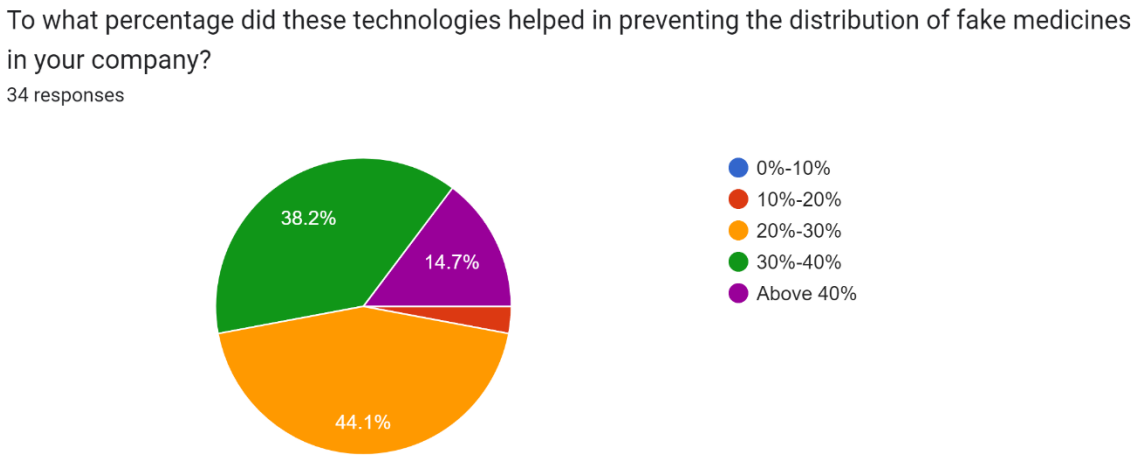

Figure 16:Response to the tenth question.

It can be seen that about 44.1% of the responses indicated that the blockchain technologies can prevent distribution of counterfeit medications to about 20%-30%. It is followed by 38.2% responses indicating 30%-40% prevention of distribution of counterfeit medications in the Indian pharmaceutical sector. In addition to that, it can be seen that 14.7% of responses responded by saying that blockchain technologies help in preventing distribution of fake medications to about 40% and above in the Indian pharmaceutical industries.

Even though blockchain technologies are emerging technologies it is surprising to see that majority of the Indian pharmaceutical industries have already made use of this and at the same time it is highly effective in preventing the distribution of counterfeit medications. From the survey responses it can be narrowed down by saying that blockchain technologies help in preventing distribution of fake medications by 20%-40%.

The next question aims at finding out the challenges faced by Indian pharmaceutical companies to implement the blockchain technologies for preventing distribution of counterfeit medications. Whenever a new technology is implemented, it is often associated with some challenges. When survey participants were asked about the challenges faced for implementing

blockchain technologies in Indian pharmaceutical industries, a wide variety of responses were obtained. Some of them were as follows:

Costly and time-consuming, due to the impossibility of erasing or changing data after it has been recorded via blockchain technology.

Lack of adoption: To work properly, blockchain ecosystems need mass adoption. In order to implement track-and-trace capabilities in supply chains, for instance, not only the corporation but also its suppliers would need to embrace a blockchain network. Without widespread acceptance, blockchains will be limited in their efficiency and scalability.

Lack of necessary skills: Because Blockchain is still in its infancy, not enough people have the knowledge and experience to develop and use it. Base salaries for blockchain developers have increased in line with the 500% year-over-year increase in demand for blockchain engineers reported by the Blockchain Council for 2019. The high price tag and high difficulty of recruiting experts in blockchain further add to companies' worries about using the technology and integrating it with existing systems.

Energy usage: The system employs a Proof-of-Work technique to validate transactions and instill trust prior to accepting them into the network. Processing, validating, and most importantly securing the entire network requires a lot of computing power in this system.

Lack of standardisation: It is currently unclear what kinds of standards Blockchain is supposed to follow. There is currently no established norm for networks despite the proliferation of numerous options. Issues with connectivity, increased costs, and difficult techniques all result from a lack of standards, making widespread adoption unrealistic. New developers and investors are discouraged by the lack of a standardised version of blockchain technology.

Cost Involvement: The majority of the current solutions are free, but there are still significant costs involved, such as hiring skilled software developers who focus on blockchain development, paying licence fees if switching to a for-profit software version, general management, and so on. It is one of the biggest challenges facing blockchain right now.

The absence of regulations is the next major problem. Scams and market manipulation have the potential to trigger a global financial collapse.

Implementation challenges centre on its inability to scale. Blockchain is impractical for widespread use at this time.

Shift in cultural norms: A blockchain represents a radical departure from conventional business practise, even for companies that have undergone radical transformation as a result of digital technology. It decentralises power and trust from a centralised entity to a network of

nodes. Most people may find this weakness quite unsettling. A blockchain, it is estimated, will require an 80% change in business operations and a 20% increase in technology. Consequently, a more creative strategy is needed to understand changes and how things will develop.

The next question is asking the survey participants whether the blockchain technologies helped in preventing the distribution of counterfeit medications in the Indian pharmaceutical industries. It was an open question and many positive responses were obtained. It is very much clear from the responses that blockchain technology plays a major role in preventing the distribution of counterfeit medications in the Indian pharmaceutical industry. Blockchain technology track the production of medicines as well as the purchasing of the basic ingredient, it is also minimising the number of intermediaries. By significantly improving the security and transparency of supply chains, blockchain can aid in the prevention of fake medications. It makes it simple to follow the movement of medical supplies from suppliers to consumers.

Blockchain, in a nutshell, is a shared ledger that generates a visible and tamper-proof record of transactions on blocks. The ledger, which is updated virtually in real-time, is kept on file by each member. Each block in the blockchain will include a timestamp that cannot be altered and a hash that connects it to other blocks. As a result, the data on the substance saved on blocks becomes unchangeable. It also indicates any attempts to change the data that has been saved. By using blockchain, pharmaceutical companies can create a tamper proof record of each drugs history including details such as where it was manufactured, when it was shipped and who handled it. This can help to identify any points in the supply chain where counterfeits drugs may have been introduced and enable targeted action to prevent their distribution.

Blockchain can significantly improve speed, transparency, and security in healthcare in addition to addressing the issue of counterfeit medications.

The last question in the survey aims at finding out whether the survey participants will recommend the application of blockchain technology in the Indian pharmaceutical sectors in the coming year. The response obtained for that question is as follows:

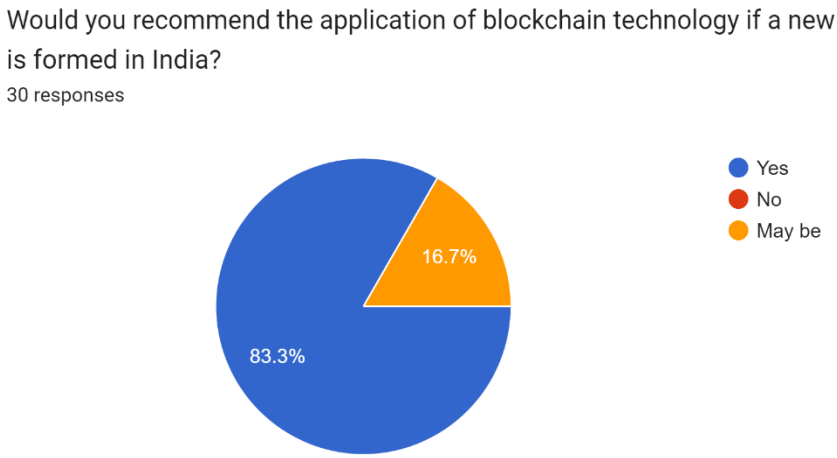

Figure 17:Response to the eleventh question.

It is very much clear from the responses that, the survey participants will surely recommend the application of blockchain technologies in the Indian Pharmaceutical industries in the coming years. Around 83.3% of the responses were yes and other 16.7% responses were maybe and not even a single participant responded by saying No. This clearly shows how promising the blockchain technologies are in the Indian pharmaceutical industries.

4.4 QUALITATIVE ANALYSIS

An experienced supply chain and production manager from one of India's leading pharmaceutical businesses was interviewed via Zoom for this qualitative study. The primary goal of the conversation was to gain insight into how the Indian pharmaceutical business is using blockchain technology to combat the distribution of counterfeit medicines. The questions in the interviews are meant to help identify potential stumbling blocks when introducing new technology.

The first question in the interviews aims at finding out what exactly is blockchain technology in the pharmaceutical industry. The response received was blockchain technology used in the pharmaceutical industry are a type of digital ledger that enables secure and clear tracking of pharmaceutical products in all parts of the supply chain. A distributed database called a blockchain is made up of data blocks that are securely and openly linked together using cryptographic algorithms. The data is permanent and cannot be changed since each block carries an encrypted version of the one before it.

The blockchain technology used in the pharmaceutical sector to trace the whole supply chain, from manufacturer to the patient, guaranteeing that the medications are genuine, secure, and efficient. One can track a product back to its source and spot any potential flaws or issues along the way since every transaction on the blockchain is logged and accessible by those with authorization.

The blockchain, for instance, used to track a drug's temperature and humidity during shipment, ensuring that it is maintained properly and is not tampered with. This can lessen the chance of drug diversion, restrict the entry of counterfeit drugs into the supply chain, and guarantee that patients are given the right medication. By increasing supply chain transparency, lowering fraud and counterfeiting, improving patient safety, and improving health outcomes, blockchain technology has the potential to completely transform the pharmaceutical industry.

The intention of the second question was to learn how it is possible to prevent counterfeit medicines distribution using blockchain technology. Product and transaction tracking can benefit from blockchain technology's distributed, immutable, and secure ledger system. This feature makes it useful for stopping the spread of fake medications. Pharmaceutical companies create a distinct digital identity for each product at the point of creation by utilizing blockchain technology. The movement of the product along the supply chain can then be followed using this digital identity, which is subsequently stored on the blockchain.

The product's digital identity is validated and recorded on the blockchain at every step of the supply chain. By doing this, it make sure that the product is genuine and unaltered. The blockchain is utilised to locate the root cause of any suspicious activity and take the necessary measures. Additionally, smart contracts that automate various aspects of the supply chain can be made using blockchain technology. A smart contract might be used, for instance, to guarantee that a product is only made available for distribution after its authenticity has been confirmed. In general, the usage of blockchain technology can offer a safe and transparent supply chain that aids in preventing the circulation of fake medicines.

The third question was aimed at finding out how is blockchain used in the pharmaceutical industry. When it comes to tracking and confirming the legitimacy of medications, blockchain technology has the potential to significantly improve the pharmaceutical sector. Here are a few instances of blockchain applications in the pharmaceutical sector:

- ***Supply chain management:*** By tracking the transfer of medications from the producer to the consumer, blockchain can provide transparency and visibility along the whole supply chain. In addition to ensuring the pharmaceuticals' purity and safety, this can assist prevent drug counterfeiting.

- ***Drug traceability***: Using blockchain, a record of a drug's journey through the supply chain, from manufacturing to distribution to the final consumer, may be made that cannot be altered. This can assist to maintain patient safety and stop the distribution of fake medications.
- ***Drug pricing:*** As an alternative to picking arbitrary numbers, blockchain technology might be used to calculate drug prices in a transparent and secure manner by factoring in the cost of manufacture and delivery, among other criteria.
- ***Management of patient data:*** Prescriptions, lab reports, and other sensitive patient information might potentially be stored and shared via blockchain technology. This can help improve patient outcomes by giving doctors and nurses access to the most recent and accurate data.

The fourth inquiry looks into the possible applications of blockchain technology in the pharmaceutical sector. Supply chain management, data security, transparency, and cost savings are just a few of the ways in which blockchain technology has the potential to revolutionise the pharmaceutical sector. Current applications of blockchain technology in the pharmaceutical sector include:

- ***IBM Blockchain:*** The "IBM Blockchain Platform" is IBM's take on the blockchain technology, and it simplifies the process of creating and deploying blockchain-based solutions for organisations. Companies like Merck have worked with IBM to create a blockchain-based solution for the pharmaceutical industry that will track the distribution of medicines and prevent the introduction of counterfeit versions.
- ***MediLedger***: San Francisco-based technology startup Chronicled created the MediLedger blockchain platform. Companies like Pfizer, Amgen, and McKesson utilize the platform, which was created to answer the unique demands of the pharmaceutical sector, to enhance supply chain management and boost transparency.
- ***TraceLink***: Blockchain technology is used by cloud-based platform TraceLink to give complete supply chain visibility and traceability. Pharmaceutical firms like Pfizer and Teva utilize the technology to trace medicine shipments and guarantee legal observance.
- ***PharmaLedger*** is a blockchain technology that seeks to advance the pharmaceutical sector by enhancing supply chain security, clinical trial transparency, and pharmacovigilance. The platform, which is supported by the European Union, is a

collaboration between pharmaceutical firms, tech businesses, and academic institutions.

These are only a few examples of blockchain technology being applied in the pharmaceutical sector at the moment. We can anticipate seeing even more innovative applications of blockchain technology in the pharmaceutical business and elsewhere as it continues to develop and mature.

The fifth question is focused more on things to consider while implementing blockchain technologies. To ensure the adoption of blockchain technology, strict thought and preparation must be put into place. Here are a few things to think about:

- ***Technical Requirements:*** Take into account the hardware, software, and network infrastructure needed to utilize blockchain technology. Choosing a blockchain that is public or private, permissioned or permissionless, depends depend on the company's demands.
- ***Security:*** Although the security characteristics of blockchain technology are well-known, it is still crucial to make sure that your blockchain implementation is safe. In order to safeguard your blockchain from hacking and data breaches, take into account security methods like encryption, access control, and authentication.
- ***Governance:*** To oversee the blockchain's functioning and decision-making procedures, blockchain implementations need a governance framework. You must decide who will be in charge of maintaining the blockchain and how decisions about its usage will be made.
- ***Regulatory Compliance:*** Depending on the type of organization, they might have to abide by laws governing financial transactions, data security, and privacy.
- ***User Adoption:*** Finally, think about how people will accept the blockchain implementation. To make sure that people comprehend how to utilize the blockchain and how it helps them, you might need to offer training and assistance. It's also crucial to think about how the blockchain fits into current company operations and whether major adjustments will be needed.

The sixth question is targeted at finding out the advantages and disadvantages of blockchain technologies.

4.4.1 ADVANTAGES:

4.4.1.1 Security: Because the blockchain is decentralized, it is very impossible for any one entity to modify the data that is kept there. It is practically hard for hackers to alter the data on the blockchain because to the cryptographic techniques employed to safeguard the data.

4.4.1.2 Transparency: All parties participating in a transaction on the blockchain can see the data. Greater trust among parties is made possible by this transparency, which also has the potential to stop fraud.

4.4.1.3 Efficiency: Blockchain technology may speed up transactions and simplify company operations by removing the need for middlemen. Faster turnaround times and cost reductions may arise from this.

4.4.1.4 Decentralization: Since blockchain technology is decentralized, there is no longer a need for a central organization to oversee transactions. Greater independence and self-governance may result from this.

4.4.1.5 Immutability: Data on the blockchain cannot be changed or removed once it has been saved. The blockchain is therefore the perfect tool for keeping data that has to be protected against alteration or erasure.

4.4.2 DISADVANTAGES:

4.4.2.1 Scalability: It is challenging to scale blockchain technology to accommodate massive volumes of data due to its present architectural design. This may lead to longer transaction delays and more expensive prices.

4.4.2.2 Energy consumption: The blockchain transaction verification process uses a lot of computer power, which might result in significant energy use. This has raised questions about how blockchain technology may affect the environment.

4.4.2.3 Regulatory issues: Governments may find it challenging to control blockchain technology because of its decentralized nature. When it comes to according to the law, this may create uncertainties and difficulties.

4.4.2.4 Lack of privacy: While the blockchain's transparency might be a benefit, it can also be an issue in terms of private data. All transactions on the blockchain are public, which may worry people or organizations who wish to protect the privacy of their data.

4.4.2.5 Complexity: Blockchain technology is intricate and challenging for anyone who are unfamiliar with it to comprehend. When it comes to acceptance and execution, this may provide problems.

The seventh question is aimed at finding out the challenges faced by the company for implementing the new technology to prevent counterfeit medicines. Companies may find it difficult to implement new technologies to stop the sale of fake medications for a number of reasons, including:

- ***Cost:*** Bringing new technology into use can be expensive, and businesses might not be able or willing to make the necessary financial investments.
- ***Integration***: If the new technology is incompatible with the company's existing systems, integrating it with existing systems and procedures might be challenging.
- ***Complexity:*** Some new technologies may be difficult to install and need extensive staff training, which may be expensive and time-consuming.
- ***Employee resistance to change***: If they are used to the current method of doing things, employees may be reluctant to adopt new technologies. This may result in a lack of enthusiasm for the new technology and poor adoption rates.
- ***Regulatory compliance:*** Companies must ensure that the new technology complies with regulatory requirements, which can be a time-consuming and expensive process.
- ***Data management:*** The new technology could call for managing massive volumes of data, which can be difficult for businesses without the required infrastructure.
- ***Technical expertise:*** Placing new technology into use needs technical skill, which may not be easily accessible within the organization and necessitates bringing in outside.

4.5 CONCLUSION

From the analysis and finding presented above, it can be concluded that the pharmaceutical companies in India are implementing blockchain technologies to a greater extent. Even though blockchain technologies are emerging technologies the Indian pharmaceutical sector is actively making use of blockchain technologies to prevent distribution of counterfeit medications.

In addition to that it was found that by making use of blockchain technologies, the Indian pharmaceutical industries were successful in controlling distribution of counterfeit medication to about 50%. Since blockchain technologies are an emerging technology challenges associated with implementing them are also discussed in this research.

CHAPTER 5:DISCUSSION AND CONCLUSION

5.0 DISCUSSION AND CONCLUSION

5.1 INTRODUCTION:

The purpose of this study was to find out to what extent the Indian pharmaceutical companies are making use of blockchain technologies and how it prevents the distribution of counterfeit medication in India. The study was carried out by using a combination of quantitative and qualitative methodology.

The survey questionnaire was used to get an idea about the extent to which blockchain technologies were used in the Indian pharmaceutical companies. The responses obtained from the survey were used to know the extent to which block chain technologies are used in the Indian pharmaceutical industries. The interviews conducted in the study was used to understand how blockchain technologies prevent the distribution of fake medications in the Indian pharmaceutical industries.

5.2 ANSWERING THE RESEARCH QUESTIONS:

To what extent does Indian pharmaceutical companies make use of blockchain technologies to prevent distribution of counterfeit medications in India?

The answer to this question was obtained by carrying out the survey. The survey questionnaire contained two sets of questions introductory questions and core questions. The purpose of introductory questions is to prove the eligibility of the survey participants. For all surveys to be successful, it has to be done by survey participants who are experts in the subject. The introductory questions are asking survey participants whether they are currently working in Indian pharmaceutical industries or not, their years of experience in the field and their knowledge on the blockchain technologies.

The core questions of the survey aim at finding out to what extent the Indian pharmaceutical companies make use of blockchain technologies to prevent the distribution of counterfeit medications. Firstly, the survey participants were asked about whether their company make use of blockchain technologies and very positive responses were obtained which clearly indicated that pharmaceutical companies of India have already employed blockchain technologies to prevent distribution of counterfeit medications. From the survey responses it was found that on average the Indian pharmaceutical industries were implementing blockchain technologies from the last two to five years.

In addition to that it was found out that the blockchain technologies implemented by the Indian pharmaceutical companies helped in preventing the distribution of fake medications by 20%-

40% and above. It is very interesting to note that an emerging technology was implemented and it has benefited the company to about 50% prevention in the distribution of counterfeit medications.

The survey participants were asked about challenges for implementing blockchain technologies and for that, a numerous numbers of challenges were highlighted. It was an open question and many responses were obtained. Some of the common responses are lack of adoption in which people found an unlikeness to adopt new technologies which are very much different from existing methods. A good proportion of people got used to traditional way of doing things and found it very difficult to change their daily routine.

Then the next big challenge was lack of skilled personnel to operate the blockchain technology. Since, these technologies are brand new only limited people were available who are trained on operating the blockchain technologies. It was one of the hardest challenges to overcome. It is associated with high cost and energy requirements for operating blockchain technologies. Large number of super computers and electronic equipment were required to operate block chain technologies resulting in high energy and cost consumptions.

The next set of challenges are lack of regulations and standardization. Since, blockchain technologies are a brand new there are only few regulations so far. In addition to that, there is no proper standardization either. For proper and uniform functioning of blockchain technologies worldwide strict regulations have to be designed and executed. It also requires proper standardization for following it in a same manner throughout the world.

The survey participants were asked about their viewpoints on how efficiently the blockchain technologies prevent the distribution of fake medications in India and highly positive responses were obtained. The responses obtained are by using blockchain, pharmaceutical companies can create a tamper proof record of each drugs history including details such as where it was manufactured, when it was shipped and who handled it. This can help to identify any points in the supply chain where counterfeits drugs may have been introduced and enable targeted action to prevent their distribution. Blockchain can significantly improve speed, transparency, and security in healthcare in addition to addressing the issue of counterfeit medications.

The responses obtained for the survey indicates that blockchain technologies are widely used in the Indian pharmaceutical industries to prevent distribution of fake medications and to a greater extent these technologies prevent the distribution of fake medications in the Indian pharmaceutical sector.

How does the blockchain technology prevent distribution of fake medications in the Indian pharmaceutical industries and the challenges associated with implementing blockchain technologies in the Indian pharmaceutical sectors?

To answer these questions an interviews was conducted on experienced pharmaceutical professionals working in the Indian pharmaceutical industries. This is the important part of the study and it answers the second research question. The interview participants were asked about a brief introduction on blockchain technology in the pharmaceutical industries and a clear idea on how blockchain technology works in the Indian pharmaceutical industries was obtained. Basically, blockchain technologies are a digital ledger that allows us to track a particular pharmaceutical product in all parts of the pharmaceutical supply chains. By making use of blockchain technology, a pharmaceutical product can be tracked from sourcing of its raw materials to the finished product.

The next question in the interviews was to explore how blockchain prevents distribution of fake medications in India and the answer to this question was obtained. Blockchain technology provide a digital ledger system for each pharmaceutical product. Pharmaceutical products can create unique identity for each product and movement of these products through the supply chain can be marked and monitored. This identity is validated at each stage until the product reaches the customer. This is how blockchain technologies are used to prevent distribution of counterfeit drugs in the Indian pharmaceutical industry.

The next question in the interviews was asked to find out other applications of block chain technologies in the Indian pharmaceutical industries. The blockchain technologies are also made use of in supply chain management where pharmaceutical products can be traced from origin to its final location. Drug traceability is yet another application of blockchain technology in which a drug's journey through the supply chain, from manufacturing to distribution to the final consumer, may be made and cannot be altered. This can assist to maintain patient safety and stop the distribution of fake medications. In addition to that, drug pricing can also be established in a transparent and safe way using blockchain technologies. Lastly, using blockchain technologies patient data can be stored safely. This includes patient prescriptions, test results and medical history.

The interviewees were asked regarding different types of blockchain technologies currently in use and answers were obtained. The most commonly used blockchain technologies are IBM block chains, Mediledger, Tracelink and Pharmalink.

The next question in the interview regarding the advantages and disadvantages of blockchain technology. The main advantages of blockchain technologies are security, transparency,

efficiency and so on. Since the blockchain is decentralised, it is impossible for any one entity to modify the data is kept there. It is practically hard for the hackers to alter the data on the blockchain. All parties participating in a transaction on the blockchain can see the data. Greater trust among parties is made possible by this transparency, which also has the potential to stop fraud. Furthermore, blockchain technology speed up transactions and simplify company operations by removing the need of intermediators. The disadvantages of this technology are scalability, lack of privacy, regulatory issues and energy consumption. It is challenging to scale blockchain technology to accommodate massive volumes of data due to its present architectural design. This may lead to longer transaction delays and more expensive prices. While the blockchain's transparency might be a benefit, it can also be an issue in terms of private data. All transactions on the blockchain are public, which may worry people or organizations who wish to protect the privacy of their data. The blockchain transaction verification process uses a lot of computer power, which might result in significant energy use. This has raised questions about how blockchain technology may affect the environment.

The last question of the interviews was asking the interview participants regarding the challenges faced while implementing the blockchain technology Like all other new technologies, the blockchain technologies are also associated with some challenges. Bringing new technology into use can be expensive, and businesses might not be able or willing to make the necessary financial investments. Some new technologies are difficult to install and need extensive staff training, which may be expensive and time-consuming. If the new technology is incompatible with the company's existing systems, integrating it with existing systems and procedures might be challenging.

5.3 CONTRIBUTIONS AND LIMITATIONS OF THE RESEARCH:

Despite the restricted time allocated for the study, the research was effectively and efficiently completed. The study was completed by making use of survey questionnaire and zoom interviews. The survey questionnaire was completed by using about 30-35 pharmaceutical professionals working in the Indian pharmaceutical industries. For interviews, Indian pharmaceutical professional/managers with 10+ years of experience were selected. The data obtained was analyzed and presented in tables and other graphical charts.

Since blockchain technologies are brand new technologies information on this topic was very hard to find. In addition to this, the survey and interviews participants were extremely hard to arrange. Only few people have the skills and proper trainings on blockchain technologies. So, it was a real task to arrange interviews and survey participants. Additionally, a number of other

variables, including respondents' biases and recollection reliability, may affect how the results are perceived. The findings may have been impacted by other non-responders and participants who did not complete the survey. The study's participants were more unevenly located. A more thorough comparison of perception among competent professionals was not feasible due to the small sample size. Participants' poor understanding led to an uninterested attitude toward the survey. Due to lack of prior publications on this subject, the review of the literature was quite constrained. Additionally, making optimum use of the time available, the study is conducted.

5.4 RECOMMENDATION FOR FUTURE RESEARCH:

The study can be conducted by using more participants for both survey and interviews. As mentioned above, since this is a new area, it was very hard to get survey and interview participants. This research is restricted to India alone, it can be further improved by including other Asian countries and comparative study can be made between how blockchain technologies prevent distribution of counterfeit medication in India and Europe.

In this research, I have included challenges faced by companies to implement blockchain technologies for preventing distribution of counterfeit medications. It can be further modified by including a part in which companies tackle these challenges to maximize the use of blockchain technologies.

5.5 FINAL CONCLUSION:

The research can be concluded by saying that the Indian pharmaceutical industries were among one of the few industries in the world to make use of an emerging technology like blockchain technology to prevent distribution of counterfeit medication in the Indian pharmaceutical sector.

To track and trace products and transactions, blockchain technology offers a distributed, immutable, and secure ledger system. It is ideally suited for preventing the distribution of fake drugs because of this capacity.

Blockchain technology may be used by pharmaceutical companies to establish a unique digital identity for each product at the time of manufacturing. Then, using this digital identity, which is then saved on the blockchain, the movement of the product along the supply chain can be tracked. At each stage of the supply chain, the product's digital identity is verified and stored on the blockchain. This guarantees that the product is original and unmodified. This is the working mechanism behind blockchain technology used for preventing distribution of

counterfeit medications in the Indian pharmaceutical industries. Since, it is a new technology, the challenges associated with blockchain are also discussed in this research.

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7.0 APPENDICES: SURVEY QUESTIONNAIRE

A study on the extent to which block chain technology prevents counterfeit medicine distribution in the Indian Pharmaceutical Industry

Dear Respondent,
I am Anju Susanna Alex, a post graduate student at Griffith College, Dublin, Ireland. I am carrying out a research to study the extent to which block chain technology prevents counterfeit medicine distribution in the Indian Pharmaceutical Industry as a part of completing my Masters degree in Pharmaceutical business and technology.

The survey is made up of some questions that aims at finding, blockchain technology to prevents counterfeit medicine distribution in the Indian pharmaceutical industry. Please answer all the questions by selecting your preferred option. The privacy of every participant is highly assured and high confidentiality is maintained. All data generated will be handled as per General Data Protection Regulation (GDPR).

Thank you for your participation.

Have you clearly understood the purpose of this research?

- ○ Yes
- ○ No

Do you consent to take part in this research?

- ○ Yes
- ○ No

Are you currently employed in a pharmaceutical company in India?

- ○ Yes
- ○ No

How many years of experience do you have in the Indian Pharmaceutical industry?

- ○ 0-5
- ○ 5-10
- ○ 11-15
- ○ 16-20
- ○ 20+

What is the name of the company in which you are working?

Short-answer text

Have you heard of any cases reported in India regarding the usage of counterfeit medicines?

- Yes
- No
- Maybe

Have you heard of Blockchain technologies used for preventing the distribution of counterfeit medicines?

- Yes
- No

Does your company implement block chain technologies for preventing the distribution of counterfeit medicines?

- Yes
- No

When did your company start to implement blockchain technologies to prevent distribution of counterfeit medicines?

- 0-2
- 2-4
- 4-6
- 6+

To what percentage did these technologies helped in preventing the distribution of fake medicines in your company?

- 0%-10%
- 10%-20%
- 20%-30%
- 30%-40%
- Above 40%

What are the biggest challenges to the success of blockchain at your organizations?

Long-answer text

In your opinion, do these technologies help in preventing distribution of counterfeit medicines?

Long-answer text

Would you recommend the application of blockchain technology if a new pharmaceutical company is formed in India?

- Yes
- No
- May be