Drug Traceability in Healthcare Supply Chain using block chain

[1]SANKARARAO GANAPATI   [2]G. RAJASEKHARAM   [3]Ch. KODANDARAMU
Miracle Educational Society Group of Institutions, Vizianagaram, Andhra Pradesh, India.

ABSTRACT

The healthcare supply chain is an intricate system that crosses many organizational and geographical barriers to provide essential services. Incorrect data, an absence of straightforwardness, and insufficient information provenance are only a couple of the debasements that might be presented by the intricacy of such frameworks. One consequence of these imperatives inside current inventory chains is the multiplication of fake medications, which imperils patient's wellbeing as well as costs the medical care framework huge amount of cash. Consequently, past examination has focused on the need of a thorough track and follow framework for the drug production network as a whole. For this reason, it is essential to have a comprehensive system for monitoring pharmaceutical products along the whole supply chain. Data privacy, transparency, and authenticity challenges in healthcare supply chains are exacerbated by the fact that most current track and trace systems are centralized. In this study, we provide a smart contract– and off–chain storage–enabled Ethereal block chain–based method for improving healthcare goods tracking. The savvy contract guarantees information provenance, getting rid of the requirement for go betweens, and gives all gatherings included a protected, changeless record of all transactions. We describe the structure of the system and the algorithms in detail that underpin our suggested solution. We conduct testing and validation, as well as give a cost and security analysis, to determine how well the system works to improve pharmaceutical supply chain traceability.

1. INTRODUCTION

The natural substance providers, producer, wholesaler, drug stores, medical clinics, and patients are all essential for the medical care production networks many-sided snare of interconnected associations. Absence of data, unified control, and clashing way of behaving among partners all contribute to make supply chain tracking in this system more difficult than it has to be. Because of this intricacy, inefficiencies arise, as shown with the COVID-19 pandemic [1], and it may be difficult to prevent the spread of counterfeit medications across the healthcare system. Products that are later found to be counterfeit have been created and/or labeled falsely to conceal their true identity or origins [2] [3]. Inactive pharmaceutical ingredients (API), API of the wrong quality, API of the wrong kind, contaminants, and repackaged expired pharmaceuticals are all examples of potentially dangerous medicines. It's possible that some fake drugs are made with inferior ingredients or follow an improper formulation [4].

Health Research Funding Organization estimates that up to 30% of pharmaceuticals marketed in low-income nations are fakes. Also, a recent research by the World Health Organization (WHO) found that children under the age of 15 make up the majority of those killed by fake pharmaceuticals

in third-world nations [7, 8]. Counterfeit pharmaceuticals not only endanger people's lives, in any case, they likewise cost the drug business truckload of cash. In such manner, it is assessed that the yearly monetary misfortune to the US drug sector owing to fake drugs is roughly $200,000,000.00 [9] [10].

The normal distribution procedure throughout the medication supply chain. When a regulatory body like the FDA requires certain ingredients for the production of an authorized medicine, it is up to API suppliers to provide those ingredients. The medicine is either packaged by the manufacturer themselves into Lot quantities, or shipped off a re-packager. The fundamental wholesaler gets a few Heaps of the items and is liable for dispersing them to the drug stores in accordance with the products demand or, in the event of a high amount of Lots, to secondary distributors who may distribute the product to the pharmacies. Afterward, patients [11] may pick up their medication at a pharmacy, usually in response to a prescription from their doctor. Distributors may also maintain their own fleet of trucks, but often use outsider strategic specialist co-ops like UPS or FedEx to move pharmaceuticals between points in the supply chain.

Because of the intricate nature of the healthcare supply chain, fake medications are able to make their way to the consumer market. Because of the many steps involved in getting drugs to patients, it is possible for them to slip through the cracks with hardly a paper trace [12]. Therefore, it is crucial to prevent counterfeits in the healthcare supply chain that monitoring, effective control, and tracking of goods be implemented.

Many nations have recently passed laws mandating drug traceability (track and trace) because of its critical necessity. Pharmaceutical companies in the United States, for instance, are required by the U.S. Drug Store network Security Act (DSCSA) [13] to make an electronic and interoperable framework for distinguishing and following physician endorsed meds across the distribution network in the country. A similar policy has been in place in China for the last eight years, whereby all parties engaged in the distribution of pharmaceuticals are compelled to utilize a specialized IT system to track the movement of specific items between storage facilities [14]. The capacity to verify medicines legitimacy and follow its journey through the supply chain from point of manufacture to final consumer is why drug traceability is so important.

It is the effective implementation of the data structure inside the Bit coin application that has led to the widespread adoption of block chain technology as a new paradigm for application development. A block chains underlying principle is like a connected rundown in that it is kept up with a the same time by all the organization hubs, with each node keeping a copy of the whole chains worth of blocks, from the genesis block forward [15]. Several recent examples of real-world applications may be found in fields as varied as e-Government [16], e-document management [17], and the Internet of Things [18]. The disseminated record of exchanges records in a distributed organization, which performs self-cryptographic approval among exchanges (by hashes), is made publicly available, and is therefore used in these applications. It is very difficult to falsify the records when they are stored in a chain of blocks connected by cryptographic developments (hashes), as displayed in [19], since doing so would require re-trying the work from the beginning to the latest exchange in blocks.

In [20], one of the first initiatives to use block chain technology for tracking the provenance of pharmaceuticals along the supply chain is described. In spite of the fact that our approach is similar to [20]s in that both address the issue of medication recognizability and the drug inventory network using block chains, we take a more extensive perspective on the drug inventory network and give a start to finish arrangement. As opposed to [20], which just includes the distributer, maker, and provider, our strategy effectively includes every one of the significant partners in the medicine production network: the Food and medication Administration, the manufacturer, the distributor, the pharmacy, and the patient.

Pharmacists are therefore portrayed as an independent third party, which is not the situation in the genuine medication supply chain. Second, unlike [20], we undertake concerted efforts to discover and characterize the linkages between partners, on-chain assets, brilliant agreements, and appropriated stockpiling frameworks. Due to the importance of stakeholder interactions, we have also added clear definitions to avoid confusion, while such interactions are not described in [20]. Finally, we leverage smart contracts to offer seamless, real-time traceability with push alerts, reducing the need for human involvement and, by extension, delays. To be more precise, a user of the DAPP will get a list of occurrences based on the drug Lots ownership history, which will be tracked by a smart contract that is exclusive to that Lot. The smart contracts in [20] are role- specific, so the suppliers, manufacturers, and wholesalers all need to verify the pharmaceuticals they get by hand. Such a procedure has the potential to cause mistakes and hold up the unchangeable data recorded on the ledger. We have also discussed how our suggested solution might be applied to various supply chains and done a cost and security study to assess its efficacy.

There have been many attempts to address the problem of drug counterfeiting, and it is generally known that obtaining traceability is difficult. A full use of block chain technology for drug traceability has yet to be described in the literature, although a thorough analysis reveals various holes and possibilities. Specifically, this study makes the following main contributions: We propose a block chain-based answer for the pharmacy store network that ensures the uprightness, certainty, and openness of medication related information provenance.

We foster a savvy contract for the drug inventory network that can accommodate a wide range of financial and other transactions. The smart contract that specifies our solutions operational principles is presented, implemented, and tested.

To quantify the adequacy of the proposed block chain-based arrangement, we do security and cost investigation.

2. LITERATURESURVEY

[1] Health professionals all around the globe are at risk due to a lack of proper safety gear https://tinyurl.com/v5qauvp. [Last Accessed: 3 June 2020]

The novel corona virus and other infectious illnesses are putting lives at danger, and the WHO has cautioned that a critical and heightening interruption to the overall inventory of individual defensive hardware (PPE) is seriously endangering lives. This disruption has been driven by increased demand,

panic purchasing, stockpiling, and abuse. Medical professionals and their patients both benefit from the use of PPE to prevent the spread of disease.

Clinical experts are seriously ill-equipped to really focus on Corona virus patients in light of the fact that to an absence of hardware such gloves, clinical veils, respirators, goggles, face safeguards, outfits, and covers. Without secure stock chains, the gamble to medical services laborers all over the planet is genuine, said WHO Chief General Tudors Adhanom Ghebreyesus, PhD. We need swift action from industry and governments to increase supply, relax export restrictions, and prevent speculation and hoarding. To combat COVID-19, we must ensure the safety of healthcare providers first. Job of the physicist in forestalling appropriation of fake prescriptions by William Chambliss, William Carroll, Michael Selvage, et al. Reference: J Am Pham Assoc. 2012;52(2):195-199.The healthcare supply chain is an intricate system that crosses many organizational and geographical barriers to provide essential services. Impurities such as false information, a lack of transparency, and a lack of verifiable source data may be introduced into such systems due to their intrinsic complexity. Because of these constraints within current supply chains, counterfeit medications are a major problem, with devastating effects on human health and substantial financial losses for the medical care area. The need for an extensive track and follow framework for drug supply chains has consequently been featured by past exploration. For this reason, it is essential to have a comprehensive system for monitoring pharmaceutical products along the whole supply chain. Information protection, straightforwardness, and credibility challenges in medical care supply chains are exacerbated by the fact that most current track and trace systems are centralized. In this work, we provide a method for using smart contracts on the Ethereal block chain. Contracts and distributed off-chain storage to improve healthcare supply chain product traceability. All parties involved will have access to a trustworthy, immutable record of all transactions thanks to the smart contracts assurance of data provenance and the removal of middlemen. We describe the structure of the system and the algorithms in detail that underpin our suggested solution. We conduct testing and validation, as well as give an expense and security examination, to decide how well the system works to improve pharmaceutical supply chain traceability.

[2]. Fiancé RJ. Roles for pharmacy in combating counterfeit drugs. Journal of the American Pharmacists Association. 2008; 48(e):e71-e88.

The medical services store network is a mind boggling framework that traverses various hierarchical and geological lines and offers an essential help framework for life's most fundamental need. The innate intricacy of such frameworks might make pollutions such slanted information, an absence of straightforwardness, and a limited wellspring of information. Comparative requirements inside the stock chains add to the creation of fake medications, which not just devastatingly affect human wellbeing yet additionally result in a significant financial loss for the healthcare sector. There is a growing body of research that highlights the need of a comprehensive tracking and tracing system for the pharmaceutical supply chain. In this regard, a comprehensive product shadowing system throughout the pharmaceutical supply chain is the icing on the cake in terms of assuring the quality and authenticity of the final product. The healthcare business is facing a growing problem in the form of counterfeit pharmaceuticals, which has major societal ramifications. With such serious confidentiality and integrity implications, protecting electronic health records is of the utmost importance. The healthcare system may suffer irreparable harm, perhaps death, if this issue is

ignored. Therefore, it is necessary to create a block chain based system that aids in the battle against counterfeit pharmaceuticals and improves the safety of electronic health information. The pharmaceutical sector is operating with an antiquated supply chain that does not provide enough visibility. In addition, the prevalence of requests for counterfeit drugs has grown over the years. Who estimates that around 10.5% of medications in poor and medium income nations are counterfeit, with potentially fatal effects for public health? Considering these repercussions, this research proposes a block chain-based architecture to monitor the distribution of pharmaceuticals. In order to lessen the possibility that a drug is a fake, and in case. The immutability of the block chain and the simplicity of reality-altering block chain shadows are two of the main reasons wave chosen to use this technology in our work. The suggested concept allows the pharmaceutical company to submit the relevant information about a drug before sending it out to be approved. Through our implementation, we show that the suggested block chain-based methodology can accurately identify any drug as counterfeit. People who abuse drugs and are harmed by counterfeit drugs will benefit from this. In addition, the suggested approach enables us to monitor the drugs journey from its point of production all the way to the patient who ultimately takes it.

[3].The Dangerous World of Counterfeit Prescription Drugs, by P. Tuscan. Located at http://usatoday30.usatoday.com/money/industries/health/drugs/story/2011-10-09/cnbc-drugs/50690880/1.Date Accessed: 6/3/2020

Some fake drugs may have the wrong ingredients or be manufactured in unsafe facilities, according to the FDA.5 Both name-brand and generic versions of drugs are vulnerable to counterfeiting.6 Generic pharmaceuticals have a potential barrier to broad usage and adoption since they are frequently confused with counterfeit medicines. The drug organizations in countries where nonexclusive prescriptions are created, like India, Europe, and Japan, may find this to be an especially difficult situation. Furthermore, any effect on the popularity of generic drugs might have far-reaching consequences. It is claimed that in the United States alone, for instance, authorized generic medications account for half of all prescriptions filled, with total annual spending in the billions.6 The Worldwide Epidemic of Fake Medicine Counterfeit pharmaceuticals have steadily increased over the last several years, making their way into respectable drug stores and at last patients homes. Assume a patient takes a medication for a possibly lethal illness, just to figure out later that the measurements didn't include any active pharmaceutical ingredients (APIs). Millions upon millions of individuals over the globe have reportedly been affected by this tragedy, and it continues even now. Patients, chemists, and drug manufacturers all have reason to worry about the rise of counterfeit pharmaceuticals. tough to put a number on the issue.7 The incidence of counterfeit medications is difficult to assess because of the delay between when the crime is committed and when the culprits are apprehended.7 According to the World Health Organization (WHO), counterfeit medications account for $10 billion (or 10%) of the pharmaceutical industries $21 billion annual revenue.7,12 The broad nature of drug counterfeiting in recent years has prompted increased alarm, despite the fact that it is not a new occurrence.8,9 About half of all instances of medication duplicating (48.7%) were kept in agricultural countries in the Western Pacific (China, the Philippines, and Vietnam),according to a survey conducted by the World Health Organization (WHO). Third place, with 13.6% of reported cases, went to the industrialized regions of the World Health Organizations Regional Office for Europe.10, 11 While just around one percent of fake drugs

are thought to be on the market in the US, that rate is supposed to increase each year.1Most fake drugs in the United States are acquired over the Internet, although some have made their way into official avenues of distribution.

[4]. T.Adhanom, Health is a fundamental human right, 2017. Available: https: //www.who.int/mediacentre/news/statements/fundamental-human-right/en/. Accessed: 26- May- 2020]

Through interviews with case manager volunteers and an examination of administrative limitations, this paper gives novel bits of knowledge into the real factors of displaced people, haven searchers, and undocumented transients in the Assembled Realm regarding admittance to medical care. Our examination of Opportunity of Data records from NHS trusts and subjective meetings with Specialists of the World case managers reveals insight into the snags that exiles, refuge searchers, and undocumented transients experience while looking for clinical consideration. Some examples of these problems include rules about fees, doctor's offices that won't accept new patients without identification, language hurdles, and confusing procedures. We discovered that these barriers cause

People to seek aid and health services more recklessly, leading to insufficient or no treatment and

Worse health outcomes. Policies such as charging rules were seen as unfair by DOTW caseworkers since they cause patients to incur substantial debt, which is then answered to the Work space and could bring about confinement or extradition for the patient and his or her family. The studies participants urged the British government to offer outcasts, haven searchers, and undocumented transients similar admittance to wellbeing and social administrations as English residents by laying out wellbeing as an essential basic liberty, creating comprehensive social strategy, and laying out a wellbeing framework with compassion. Some of them claimed that more specific rules should be established about access to healthcare and pricing laws in order to attain health for all. Suggesting that the current Work space measures and Division of Wellbeing and Social Consideration approaches is overhauled. Our examination reasons that it is important to address the social, financial, and ecological determinants of wellbeing, as well as give significant and socially suitable medical care and social help, to decrease the predominance of preventable medical conditions.

[5]. World Health Organization, Growing threat from counterfeit medicines, 2010. Even life-saving medications may be counterfeited and sold online.

The World Health Organization (WHO) is collaborating with Interpol to disrupt the criminal ring responsible for the billions of dollars in illegal profits generated by this industry.

3. PROBLEM STATEMENT

The term traceability refers to the capacity to follow the historical backdrop of a thing through its many incarnations by referring to its unique identifiers. Any item that can be traced back to its origin in the supply chain is known as a Traceable Resource Unit (TRU). The goals of traceability are to record past transactions and monitor the ongoing area of the TRU. For this situation, the TRU in the store network is the drug, and a traceability system requires knowledge of its identity and differentiation from other TRUs via the use of various identification methods. A technique for recognizing TRUs, a component for reporting the connections among TRUs, and a cycle for putting

away the properties of the TRUs are the main components of a traceability system [21]. Standardized identifications and RFID labels have been utilized as recognizable proof strategies, Remote Sensor Organizations (WSN) have been utilized to catch information, and the Electronic Item Code (EPC) has been utilized to distinguish, catch, and offer item data to work with following of merchandise through different stages in the store network [22].Smart-Track [23] uses barcodes compliant with GS1 standards to record information such as the products unique serial number, its Lot number, and its manufacturing and expiry dates.

The data encoded in a GS1 barcode is collected throughout the supply chain and used to keep a running tally of who owns what at any given time. With the use of a mobile app, the final consumer (the patient) may check the products validity by accessing the central data repository maintained as Global Data Synchronization Network (GDSN). By scanning the barcode, hospital and pharmacy departments farther down the supply chain can confirm the products identity and qualities. Similarly, the Information Lattice global positioning framework [24] creates an Information Grid for every medicine, which contains information, for example, the medications veritable code, the producer ID, the item ID, the interesting ID of the packaging, and any other metadata that the manufacturer chooses to provide. The patient may use the Data-Matrix to confirm the drugs country of origin.

Disadvantages:

If you don't use block chain strategies to preserve trust amongst data, your system is less secure. In the absence of a shared conceptual framework across fields including sociology, economics, psychology, computing, information science, and computer science, it is impossible to accurately represent the complexities of human interactions that underpin trust.

4. PROPOSEDSYSTEM

In contrast to [20], which only consider manufacturers and wholesalers as stakeholders, the proposed system applies a strategy that recognizes and involves the FDA, makers, wholesalers, drug stores, and patients as dynamic members in the drug supply chain. Because of this, the chemists are portrayed as an independent third party, which is not the situation in the actual medication supply chain.

Second, we undertake concerted attempts to fill a gap in [20] by defining the connections between partners, on-chain assets, shrewd agreements, and conveyed record capacity. We also incorporated clear definitions to avoid any confusion on the relevance of stakeholder interactions, which are not stated in [20].

The third way we avoid delays caused by human error is by using savvy contracts innovation to give continuous, consistent recognizability with push alarms. For each medication Parcel, a different brilliant agreement keeps track of ownership changes and notifies the Dap user with a list of such changes. Each party must verify which pharmaceuticals are received manually since the smart contracts in [20] are tailored to certain jobs like supplier, manufacturer, and distributor. This method may cause inconsistencies or delays in the changeless information kept in the record. Finally, we have evaluated the suggested systems performance in terms of cost and security and discussed how the approach might be applied to different supply chains.

Advantages:

The product proposes a block chain-based answer for the drug inventory network, which would further develop information provenance security, recognizability, changelessness, and openness. A savvy contract custom fitted to the necessities of the drug production network is created by the framework. Our suggested solutions underlying functioning principles are presented in the form of a smart contract, which is then implemented and tested by the system. To gauge how well the suggested block chain-based solution performs, the system analyses its security and associated costs.

5. SYSTEM ARCHITECTURE
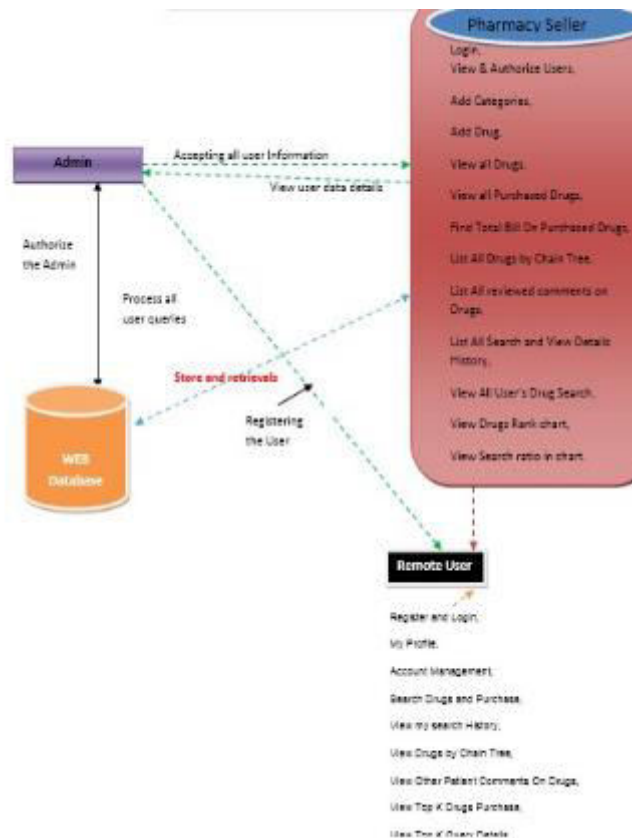
6. IMPLEMENTATION

6.1 Pharmacy Seller

The module requires the seller to provide their login details. Following a successful login, he will be granted access to features including viewing and authorizing users, adding categories and drugs, and more. Browse Medications, To get a list of all the Medications you've Bought, Find the Full Cost of the Medicines You Bought, Arrange All Drugs in a Chain Diagram, Compile a complete list of Drug Reviewer comments, Archive All Inquiry and Detail Perusal Search the Drug Databases of All Users, See the rankings for drugs and the ratio of searches in a chart.

6.2 View and Authorize Users

The buyer may see a list of registered users in this section. Here, the administrator may see the users information such username, email address, and physical address, and grant the user permissions.

6.3 View Chart Results

Here, the vendor has access to data visualizations for metrics like Search Volume, Drug Market Share, and more.

6.4 User

There are n participants in this section. Users need to sign up first before they can do any actions. When a user signs up, their information is added to a database. Once his registration has been approved, he will be able to log in using his unique user ID and password. After a successful login, the user may access features like My Profile and Account Management. Find Medicines and Buy Them, View Other Patients Opinions on Drugs, My Search History, and the Drug Chain Tree Check out the most searched for drugs and queries.

7. SYSTEM RESULTS
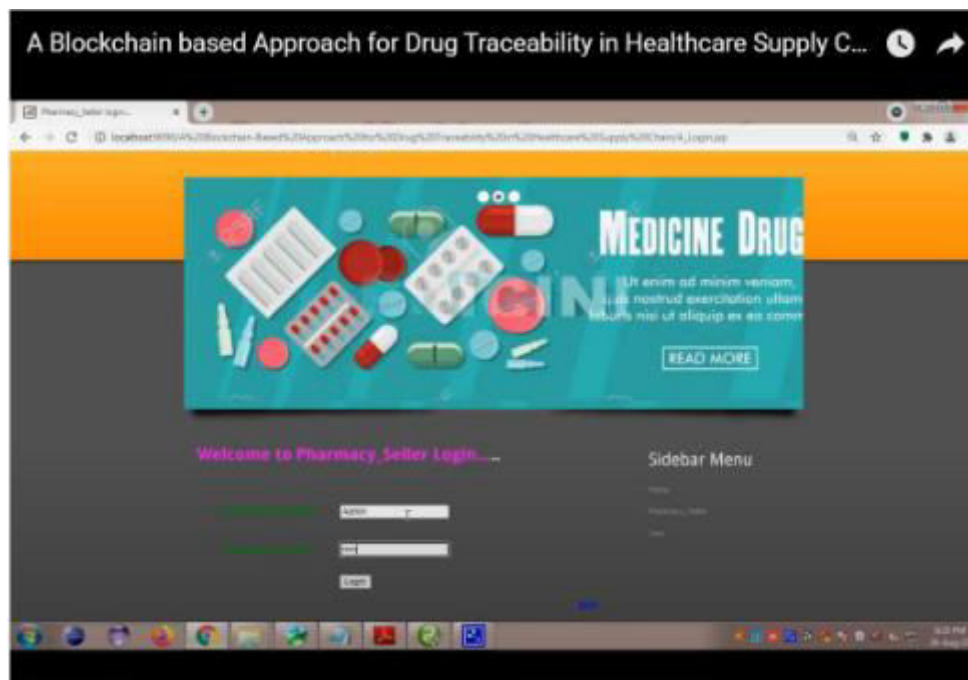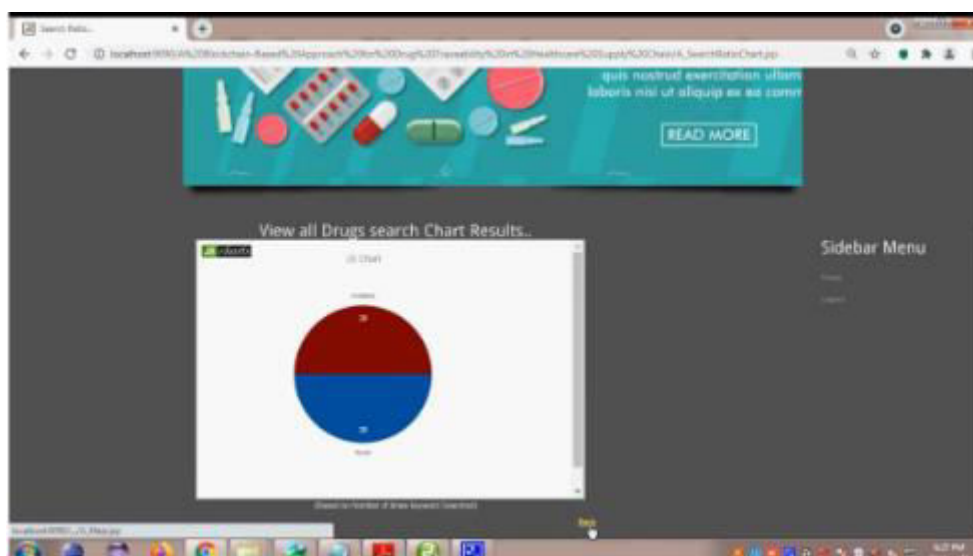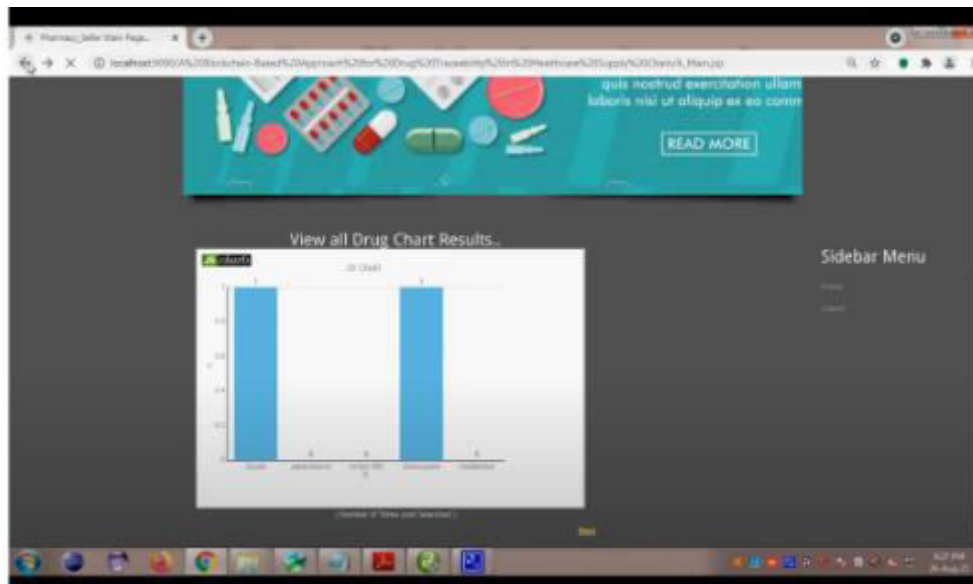
8. CONCLUSION

In this study, we look at the difficulty of tracing medications across pharmaceutical supply chains, emphasizing the need of this safeguard against fake medications. To ensure that pharmaceuticals can be tracked and traced in a decentralized fashion, we have created and tested a block chain-based solution for the store network. Specifically, we propose an answer that utilizes the cryptographic underpinnings of block fasten innovation to make permanent logs of production network occasions and that utilizes brilliant agreements inside the Ethereal block chain to make robotized recording of occasions that are accessible to all involved parties. We shown that our suggested method saves users money on the petrol required to run the various services activated by the smart contract. It is vital in complicated multi-party environments like the pharmaceutical supply chain that transaction data be protected from hostile efforts targeting its integrity, availability, and non-repudiation. Later on, we need to extend the recommended framework to accomplish start to finish straightforwardness and unquestionable status of meds utilization, the two of which will assist our endeavors to work on the adequacy of drug supply chains.

9. References

[1] Shortage of personal protective equipment endangering health workers worldwide https://tinyurl.com/v5qauvp. [Accessed on: 3-June-2020]

[2] Chambliss W, Carroll W, Selvage M, el al. Role of the pharmacist in preventing distribution of counterfeit medications. J Am harm Assoc.2012; 52(2): 195-199.

[3] Fiancé RJ. Roles for pharmacy in combating counterfeit drugs. J Amp harm Assoc. 2008; 48: e71-e88.

[4] Tuscan P. The dangerous world of counterfeit prescription drugs. Available: http://usatoday30.usatoday.com/money/industries/health/drugs/story/2011-10-09/cnbcdrugs/50690880/1. [Accessed on: 3-June-2020]

[5] T.Adhanom, Health is a fundamental human right,2017.Available:https://www.who.int/mediacentre/news/statements/fundamental-human-

Right/en/. [Accessed: 26- May- 2020].

[6] World Health Organization, Growing threat from counterfeit medicines, 2010.

[7] Daniela Boozy, C.L. 1 in 10 Medical Products in Developing Countries Is Substandard or Falsified. 2017. Available: https: //www.who.int/news-room/detail/28-11-2017-1-in-10-medical-products-indeveloping-countries-is-substandard-or-falsified. [Accessed: 3-June-2020].

[8] The Guardian. 10% of Drugs in Poor Countries Are Fake, Says WHO. 2017. Available: https: //www.theguardian.com/globaldevelopment/2017/nov/28/10-of-drugs-in-poor-countries-are-fakesays-who. [Accessed: 3-June-2020].

[9] Funding, H.R. 20 Shocking Counterfeit Drugs Statistics. 2017. Available: https: //healthresearchfunding.org/20-shocking-counterfeit-drugsstatistics. [Accessed: 3- June-2020].

[10] Blackstone, E.A.; Fur, J.P., Jr.; Pokies, S. The health and economic effects of counterfeit drugs. Am. Health Drug Benefits 2014, 7, 216–224

[11] U.S. Food and Drug Administration, A drug supply chain example. Available: https://www.fda.gov/drugs/drug-shortages/graphicdrug-supply-chain-example}.Accessed: 3-June-2020].

[12] Mar check, Ann; Geris, Noel; Mena, Carlos; Cain, Lining (November2011). Product safety and security in the global supply chain: Issues, challenges and research opportunities. Journal of Operations Management.29 (7–8): 707–720

[13] U.S. Food and Drug Administration, Drug Supply Chain Security Act. Available: https://fda.gov. [Accessed: 3-June-2020].

[14] State Food and Drug Administration of China, on suspension of drug electronic supervision system, Feb. 2016. Available: http: //www.sda.gov.cn/WS01/CL0051/144782.html. [Accessed: 3-June-2020].

[15] M. Andrychowicz, S. Dziembowski, D. Malinowski, L. Mazurka, On the Malleability of Bit coin Transactions in the proceedings of Financial Cryptography and Data Security, Pages 1—18 , 2015.

[16] A. Suleiman, Z. Husain, M. Abououf,M. Alblooshi, and Khalid Salah,Monetization of Iota data using smart contracts, IET Networks, issue 1,volume 8, pages 32-37, 2019.

[17] K. M. Khan, J. Arched and M. M. Khan, Simulation of transaction malleability attack for block chain-based e-Voting, Computers & Electrical Engineering, volume 83, pages 106583, 2020,

[18] N. Nizamuddin, K. Selah, M. A. Azad, J. Arched and M.H. Rehman, Decentralized document version control using ethereal block chain adapts, Computers & Electrical Engineering, volume 76, pages 183 - 197, 2019.

[19] S. Nakamoto, Bit coin: A Peer-to-Peer Electronic Cash System, Cryptography Mailing list at https://metzdowd.com, 2009

[20] Unhandy, M., & On Tzu Earn, G. (2019). Implementation of Pharmaceutical Drug Traceability Using Block chain Technology. Into Journal.Vol. 2019:035. eISSN: 2600-7920

[21] Olsen, P., Boris, M., The components of a food traceability system, Trends in Food science & Technology (2018), doi:10.1016/j.tifs.2018.05.004.

[22] Boudoir, A., Ahaitouf, A. and Akharraz, I. (2019), Conceptual framework for general traceability solution: description and bases, Journal ofModelling in Management, Vol. 15 No. 2, pp. 509-530.

[23] K. Al Huraimel, R. Jenkins, Smart Track, 2020. Available: https://smarttrack.ae/. [Accessed: 26-May-2020]

[24] GS1 Data Matrix: A tool to improve patient safety through visibility in the supply chain&quot Available: https://www.gs1.org/docs/healthcare/MC07_GS1_Datamatrix.pdf. [Accessed: 26-May-2020]