JISR management and social sciences & economics
2022, VOL. 20, NO. 2, 111–130, e-ISSN: 1998-4162, p-ISSN: 2616-7476
https://doi.org/10.31384/jisrmsse/2022.20.2.7

Adoption of Blockchain Technology in Pharmaceutical Supply Chain to fight Counterfeit Medicine Market

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ABSTRACT

Blockchain Technology (BT) is recognized as a technology with multiple applications in many industries due to the nature of its utilization. In the pharmaceutical industry, an effective supply chain is crucial to mitigate the counterfeit medicine market, which is currently a big challenge, especially for the low or middle-income countries. This research investigates the possibility of implementing blockchain technology solutions in the Pakistan's pharmaceutical industry by introducing blockchain Application Software. The pharmaceutical industry and General Practitioners from hospitals and clinics were interviewed in the public and private sectors to understand this possibility. Data coding was conducted on the data gathered from the interviews, and from these codes, categories were extracted, these categories were then further refined to extract the final themes. Finally, the paper discusses that based on the need of the current situation, the proposed BT system would present a solution for making the pharmaceutical supply chain more transparent.

Article Type: Original

OPEN ACCESS

Received:
5 October, 2022
Revised:
16 November, 2022
Accepted:
10 December, 2022
Published:
31 December, 2022

Keywords: *pharmaceutical industry, counterfeit medicine markets, supply chain, blockchain technology*

JEL Classification: *G32, E51, F30, Q13, Q1*

How to cite this article (APA): Zulfiqar, S., Lakho, A., Nizam, K., & Fayyaz, B. (2022). Adoption of Blockchain Technology in Pharmaceutical Supply Chain to fight Counterfeit Medicine Market. *JISR management and social sciences & economics*, *20*(2), 111–130.
https://doi.org/10.31384/jisrmsse/2022.20.2.7

INTRODUCTION

The supply chain is a lifecycle practice in which substances or items move from the producer to the position of utilization and collection of money, such as retailer and wholesaler dealers (Chopra & Meindl, 2007; Tseng, 2010). The producers and distributors, medical service providers, medical clusters, indemnity companies, public sector organizations, corporations, government watchdogs, and customers of health care services are the main participants of the medicine supply chain (Mackey et al., 2015). Protecting the integrity and genuineness of the supply chain of drugs appears to be one of the leading and sophisticated issues in today's world due to the comprehensiveness of health and care delivery (Mackey et al., 2015). Notorious criminal groups are engaged in selling hazardous forms of medicines, which are putting the safety of patients at stake. The illegitimate global trade of counterfeit medication is huge and deep-rooted, including health products of simple therapy use in life-saving drugs (Elmuti et al., 2013; Mackey et al., 2015).

Blockchain technology or blockchain is a decentralized data storage system (data stored in multiple storage units instead of a single centralized unit or server) that can be spread across millions of small data storage units so, hacking blockchain would mean hacking millions of servers simultaneously, and that's the real challenge for hackers (Ali et al., 2021). Blockchain technology provides a way to know exactly where a piece of knowledge originated. If evidence is put into an appropriately sustained blockchain, it is permanent, unalterable, and time-framed. This shows a definite validity for a particular piece of data created at that specific moment highlighted in the blockchain (Brennan, 2017). Applicants who wish to store information on the blockchain are granted digital Identities and confidential keys; further, any evidence or documentation they keep on the blockchain is electronically signed (Brennan, 2017). This technology bears no fee for the transaction**.** There is a likelihood of setup cost but no cost of the transaction. This blockchain technology is an uncomplicated but creative mode of transiting data from one point to another in a completely mechanized and secured style.

A block in the blockchain is created when a blockchain stakeholder starts a transaction, that particular block is then validated by hundreds or even thousands of workstations spread across the network (Khan, 2016), then the block, that was, validated is subsequently enlisted to a string which is piled throughout the network, resulting not only distinctive record but a distinctive chain of past events; this makes that block unique. Forging one record would result in developing the whole sequence comprising thousands of events, making it almost impractical. Bitcoin technology works on this methodology for transactions related to financial and economic markets, but it can be applied

to many other areas, including health, privacy, and information sharing (Khan, 2016).

Blockchain technology became prominent through the swift growth of the Bitcoin currency, and the organizations giving financial services were quick to understand its significance. Still, Blockchain technology is advancing in different fields, including health services (Bhutta et al., 2021), manufacturing, legal services, financial services, and electronics (Bhardwaj & Kaushik, 2018). For Example, Wikipedia is one of many instances depicting Blockchain technology's working. Wikipedia is decentralized and can be accessed entirely by anyone. The only access to an internet connection and anyone can make traceable amendments to the Wikipedia page that are visible to the common person. The BT is extremely protected which makes it impossible to corrupt any transactions.Blockchain users have fully acknowledged the movement of their funds. Blockchain technology is a completely protected genuine instrument that can operate as a check and balance method for transactions; hence, documenting and specifying all transactions that have been performed (Zheng et al., 2018).

LITERATURE REVIEW

There are different type of technologies for the blockchain. These different types of applications of Block Chain technology have been briefed in the appended literature. Generally, the applications of said technology are categorized into finance, the Internet of Things, public and social services, reputation system, and security and privacy. In Financial services, the crisis of blockchain technology, for example, Bitcoin (Nakamoto, 2014) has resulted in a vast effect on conventional financial and trade facilities (Parlikar, 2015). Peters and Panayi (2015) proposed that blockchain technology could potentially disturb the universe of banking services. Blockchain technology can be functional in numerous fields comprising trade of financial resources etc. Moreover, in enterprise transformation, the development of financial and trade facilities, blockchain technology can aid conventional corporations to accomplish venture conversion effortlessly (Javaid et al., 2021). In Risk management, the risk mitigation structure performs a significant job in FinTech, and currently, it may be merged with blockchain technology to work better. Pilkington (2016) offered a new risk-mitigation structure where the said technology is practised to scrutinize investment uncertainties in the Luxembourgish situation.

The most prominent technology Internet of things (IoT) which is Information and Communication Technology (ICT) is speeding up these days. The IoT technology combines the things commonly known as smart objects into networking and

facilitates the subscribers with many facilities (Atzori et al., 2010; Miorandi et al., 2012). In Safety and privacy, Security and confidentiality maintenance is another essential apprehension for IoT businesses, and Blockchain technology can also assist in increasing confidentiality in IoT workflows. Hardjono and Smith (2016) suggested a confidentiality-saving process for onboarding an IoT machine into a cloud system. In land registration, one of the distinctive blockchains practiced in municipal services is the registration of property, i.e. land (Togawa, 2015), where the land data, including the bodily position and associated privileges, can be recorded and revealed on the blockchains. Also, any amendments made on the land, like the shifting of land or the development of a mortgage, can be registered and administered on the blockchain, as a result, enhancing the competence of local communal services. In Energy-saving, Apart from that, blockchain technology can be practised in pollution-free fuel resources. Gogerty and Zitoli (2011) suggested the solar coin to support the practice of reusable energies. The particular solar coin is an electronic currency facilitating sun energy creators. Blockchain technology is initially designed to enable currency trade to be worked out in an uncertain atmosphere. Though we remark on the knowledge and learning phase as the currency, blockchain technology can be functional in the web-based educational marketplace (Devine, 2015).

There is an increasing amount of instances of individual repute of document forgery, such as, in electronic trade, several facility providers register an enormous figure of bogus clients to attain a high reputation, blockchain technology may help resolve this dilemma. Status is essential to academia. Sharples and Domingue (2015) proposed a blockchain-affiliated scattered structure for educational documentation and repute. Initially, each organization and scholar member would be provided with a primary honour of academic reputation money. An academic institute could grant a membership by transmitting some status documentation to the members. Since these trades are recorded on blockchain technology, all the repute changes could be discovered comfortably.In Web community, the capacity to judge a worker's reputation in a web society is extremely significant. Carboni (2015) suggested a reputation-based model related to the blockchain. Since businesses are recorded on blockchain technology, reputation documentation is almost impossible to corrupt.

In security enhancement, blockchain technology can most likely assist in improving the safety of the dispersed system. Noyes (2016) suggested a new malware-free atmosphere called BitAV where subscribers may allocate the virus outline on the blockchain, and it in that way may improve the error patience. As it is exhibited by Noyes (2016) that BitAV may progress the scanning momentum and increase the error dependability, reducing vulnerability to besieged denial-of-service assaults. Blockchain technologies may also be practiced to improve

the reliability of the safety system. In privacy protection, blockchain technology has the prospect to make the safety of security susceptible information. Zyskind and Nathan (2015) suggested a delegated system of individual data management that guarantees the client possession of its data. This structure is based on blockchain technology (Lim et al., 2021).

The use of blockchain technology is becoming prominent in international organizations globally, where tracking is necessary to maintain records on the whereabouts and quality of products (Yiannas, 2018). Walmart, which operates globally and has a hypermarket chain, uses blockchain technology to ensure quality food products by tracking and recording the whole procedure of the supply chain from the farms to the final customer (Tan et al., 2018). Using this approach, the customers can transparently investigate the origin of products (where and when it was manufactured) (Yiannas, 2018). Blockchain technology is also being used in America for global trade due to the purpose of export and import that is implemented and managed by the organization "Gliding Eagle". It has reduced the complexity of the trade process and provides transparency to the customer like never before (Duan, 2018).

Blockchain technology is the time-bound sequence of indisputable informative documentation administered by a group of workstations not possessed by any particular corporation. All these chunks of information, which are blocks, are protected and restricted to one another, exercising cryptographic standards. Three attributes of the said technology may help interrupt the logistics management system i.e. first is decentralization, the second is immutable, and the last is transparency. Some logistical networks are already using the blockchain technology, and professionals propose that this technology may soon become a common operating system in the supply chain. This blockchain technology may help improve some procedures, which are documenting the amount and relocation of resources like pallets and containers as they travel between different points of the supply chain, tracking purchased orders, and other records related to trade. Conveying or validating documentation or different attributes of products such as deciding, if an edible good is a natural or reasonable deal, connecting material products to serial figures, electronic signatures such as RFID (Radio-frequency identification), allocating data related to production course, assembling, maintaining, and delivering to vendors and suppliers (Vorabutra, 2016).

Irrespective of the form, blockchain technology provides transporters different benefits such as improved clearness by recording a good's voyage across the logistical network, disclosing its actual foundation and key points; hence, increasing reliance and assisting in the elimination of the prejudice witnessed in the supply chain networks these days. Producers may also lessen summon up

by informing about history logs with Original Equipment Manufacturer (OEMs) and supervisory body, approaching from any amount of touch-nodes, is likely, enhanced safety by giving out ineradicable ledger with encrypted principles may potentially eradicate the examination mandatory by in house systems and procedures and better novelty offering prospects thrive to build innovative, dedicated usage for the said technology as a product of the decentralized structure (Vorabutra, 2016).

Blockchain and Pharmaceutical Supply chain

The medicine business has a specifically sophisticated supply chain structure involving different parties in the production and supply of a particular medicine. Blockchain technology gives a prospect to shorten the supply chain procedures and facilitate the quality management across the same. Further, it also validates that the responsible people have pursued and performed the accurate production procedure, for example, ensuring that the product has not been done at an unauthorized or unregistered facility. Malfunctioning has been observed in China concerning food safety, as a result, Walmart is operating blockchain tech to make the tracking of food better (Tan et al., 2018). Many industries, following blockchain technology, can be benchmarked and replicated in the pharmaceutical industry (Blomfield & Ghhogra, 2019).

Countries worldwide are monitoring serialization (allocating a serial number to every package) to make follow-up better in the supply chain area due to fears of bogus drug markets. It has been advised to all the stakeholders in the field of the supply chain to facilitate electronic follow-up capability as proposed by the US Act on Drug Supply by the year 2023. The directives on counterfeit drugs, i.e. falsified medicine directives (FMD) in Europe, have required all medicine corporations to incorporate security attributes on their medicines and drugs and become part of the central data warehouse of the European Union. Blockchain technology drives away the obstacles of intrusion across suppliers and equipment and gives a supportable modification log maintained in a protected cyber atmosphere. Big players in the pharmaceutical industry like Pfizer and Genentech, are operating on a blockchain-framed design to accomplish their needs (Blomfield & Ghhogra, 2019).

The most important concern for the end-user in the drug industry is the quality of medicine, this concern can be addressed through BT in multiple ways (Bocek et al., 2017). An organization MODEM.IO is using BT to ensure that the quality of medicine is not compromised on the long routes by monitoring its temperature and securely recording exchange data between buyer and seller (Bocek et al., 2017). Because the information stored on BT is immune to hacking, it helps fight

the problem of counterfeit medicine, this has been ensured with respect to more transparency of medicine whereabouts, better privacy protection, and extended information security (Choun & Nasr, 2018; Haq & Esuka, 2018). So it enables the end-user to know the exact source of origination. The interface of such a BT-based system is shown in Figure 1.

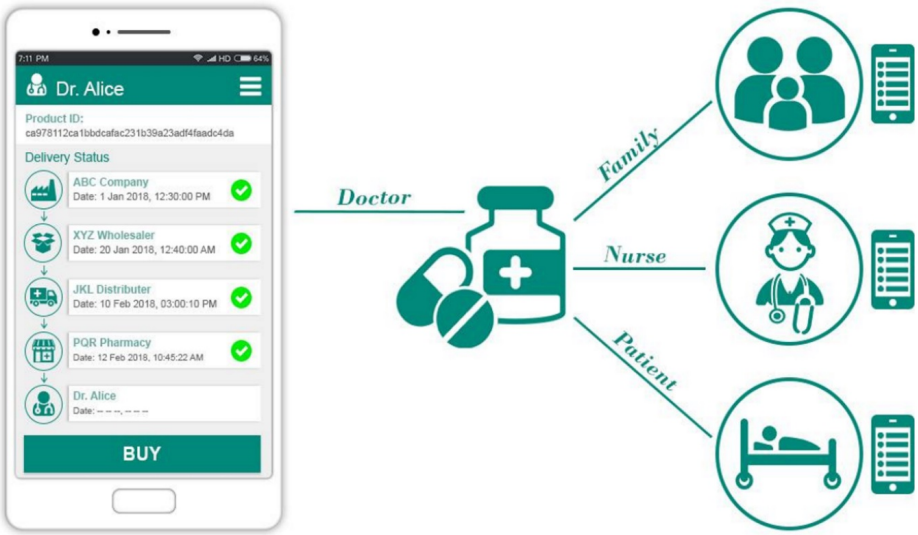

Figure 1: *Proposed BT Software Application frontend layout (Haq & Esuka, 2018)*

Technology Acceptance Model (TAM) as a theoretical foundation

The Technology Acceptance Model (TAM) can be applied as a theoretical conjuncture. It implies that two factors which determine the acceptance of a computer system by its determined users are perceived usefulness and perceived ease of use (Skare & Soriano, 2021). This model has emphasis on the word "perception", thus it primarily focuses on the perceptual positioning of the need of the product and the degree to which the product is useful and its convenience of use. TAM describes that it is essential for potential users of a computer system to perceive that the system is highly useful to them and the system is easy to use and doesn't seem complex (Sharma & Ahmad, 2022). We have used TAM as our theoretical foundation in this particular paper because both these features of TAM have been highlighted in the literary findings related to block chain (Arbaiza et al., 2021).

METHODOLOGY

We used a qualitative approach that involved interviewing pharmaceutical and health experts from all over the Pakistan using distinct organizational, professional, and disciplinary contexts. Interviews were conducted, face to face in Karachi city and via phone calls to the respondents in other cities of Pakistan. A qualitative method was considered most suited as we aimed to study the counterfeit medicine market in Pakistan's context. About the philosophical underpinning, interpretive research philosophy is followed as it argues that studying social constructs is the only way to access reality; that also includes the interview approach. Using Purposive sampling, we constructed a sampling matrix of pharmaceutical professionals (sales/supply chain/operations), drug regularity authority of Pakistan (DRAP) officials, and doctors (general practitioners). Participants were voluntarily selected individuals and were sent an invitation for participation on leaflets, topic guides, and consent forms. None of the respondents were sent more than three reminders. Following interpretivism research philosophy, the final sample size was purely selected based on saturation point attainment. The final sample size for this purpose was 12.

The sampling framework was examined throughout the data collection and was implemented to make sure of the breadth and depth of coverage. Here, we kept on interviewing until data saturation was reached, as suggested by Guest and Bunce (2006). Interviews lasted for a median of 12.5 minutes. Interviews were conducted from February 1, 2019, to March 31, 2019. Interviews were undertaken in Urdu and English following respondents' preferences. Some interviews were conducted in a mixture of both languages. Written or recorded verbal consent/permission was obtained before the conduct of all the interviews. A topic guide was used, although interviewees were given the liberty to speak freely and; hence, the topic guide itself evolved during the research period. Interviews were digitally recorded in audio along with the written field notes and then transcribed manually. An analysis was undertaken continuingly to allow emerging themes to inform the topic guide for successive interviews to ensure the robustness of the study by removing any possible deviants. During data collection, we took special care that our backgrounds do not impact the findings of this research.

Table 1.
Sampling Framework

Sampling Framework consists of the following domains:
Pharmaceutical Experts (PE)

Continued on next page

Table 1 continued

DRAP Govt. Officials (GO)
General Practitioners (GP)

Table 2.
Areas Covered in Interviews

Counterfeit Market-related challenges
Current technologies being used to overcome these challenges
Awareness about BT Pharmaceutical and Health Experts
Perceived Usefulness of BT in Pharmaceuticals
Path and barriers to the implementation of BT in Pharmaceuticals
Room for improvement in proposed ideas for implementation of BT in Pharmaceuticals

Table 3.
Characteristics of Interviewees

Interviews	Domains	Influence on Counter-feit	Gender	Location	Interview Method
PE_1	Pharma Supply chain	Medium	Male	Karachi, Sindh	In-person
PE_2	Pharma Sales	Medium	Male	Karachi, Sindh	In-person
GO_1	DRAP Audit	High	Male	Hyderabad, Sindh	Mobile
PE_3	Pharma Market-ing/Sales	Medium	Male	Karachi, Sindh	In-person
PE_4	Pharma Supply chain	Medium	Male	Karachi, Sindh	Mobile
GO_2	DRAP	High	Male	Lahore, Punjab	Mobile
PE_5	Pharma Quality Assurance (QA)	Medium	Female	Karachi, Sindh	Mobile

Continued on next page

Table 3 continued

GP_1	General Practitioner	Low	Female	Karachi, Sindh	In-person
GP_2	General Practitioner	Low	Male	Karachi, Sindh	Mobile
GP_3	General Practitioner	Low	Male	Karachi, Sindh	Mobile
GO_3	DRAP Operations	High	Male	Karachi, Sindh	Mobile
GP_4	General Practitioner	Low	Male	Karachi, Sindh	Mobile

(See Table 1 for Keys to column 1)

Table 4.
Summary of Results

Themes		
Challenges due to Counterfeit Medicine Market		Huge counterfeit medicine market in Pakistan The role of Govt. in the prevention of counterfeit medicine is minimal so far High market share drugs are most affected Negatively affects customer loyalty due to which, organizations lose customers Import of raw materials is highly unregulated DRAP has been unable to implement its standard operating procedures (SOP) regarding control of counterfeit medicines market
Current Systems being used to mitigate challenges		Barcode System (Package verification) Website Portal (Provides company drug information) Coding System (Information imprinted on every package in text form) Packaging (Logo, Font, Color, Box, Packaging Technology) Hologram Packaging and Stickers Suspected samples are sent to Central Drug Testing Laboratory Karachi (by FIDs) and Provincial Drug Testing Laboratories (by Provincial Regulators) for analysis Tamper-resistant packaging Radio-frequency Identification (RFID) System Track and Trace System (serialization and aggregation)
Knowledge about BT		BT is a Supply chain tool BT is a technology that is famous for crypto-currency Blockchain is a decentralized digital ledger BT records and transfers data in a fast, secure and transparent manner BT is a technological tool for information sharing
Role of BT to mitigate these challenges	Perceived Usefulness	BT will increase authenticity and reduce counterfeit It's good for the transparent exchange of information, such a system may enable better product knowledge Improve supply chain efficiency to disseminate verifiable medications across the planet

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Table 4 continued

	Barriers to Implementation	More field research needs to be done No firm would be willing to discuss their Supply chain details, such as the source of raw material. Pharma companies prefer cheaper raw materials while compromising on quality. DRAP is starting to ask for the source of raw material in SOP Form 2 It would take hours for the shopkeeper to check each package of every batch through BT and simply won't do it unless forced by DRAP DRAP won't go with BT's idea as they are already working on implementing Barcode technology (G1 Standard)
	Suggested Improvement	Randomly selected packets could be checked through BT to save time only in cases where there is doubt Incorporate the idea of BT with the Barcode System

DISCUSSION

For data collection, we approached 20 potential participants at 12 places (60%). We decided that our sample size was satisfactory because the responses started to be repetitive after 8 to 9 interviews and findings got saturated after 12 interviews. Twelve separate interviews were conducted. Table 2 discusses the details of our participants including their influence, profession, and the interview methods applied for each interview. The following themes emerged, and are arranged accordingly: i). Challenges due to the counterfeit medicine market; ii). Current Systems are being used to mitigate these challenges; iii). Knowledge about BT; and iv). Role of BT to mitigate these challenges

Challenges of Counterfeit Medicine Market

PE_1 suggests that there is a huge market for counterfeit medicine in Pakistan and one of the primary reasons for it is the lower manufacturing cost. So far, the role of government has been minimal in terms of attempts in controlling counterfeit drugs.

"Counterfeit medicine is made with only 20-25% cost compared to original medicine" PE_1

"These are $1-2 Billion brands" PE_3

"… People can only afford low-cost alternative and so the market of such medicine is huge …" GP_2

DRAP (Drug Regulatory Authority Pakistan) is working on developing and implementing new systems and technologies to mitigate this issue.

"... Federal Inspectors of Drugs (FIDs) are visiting medicines markets vigilantly to curb the menace of spurious/unregistered/counterfeit medicines etc. A National Task Force was constituted comprising of Federal Drug Inspectors and Provincial Regulators for the same ..." GO_2

The medicines and brands with a larger market share have a higher probability of being counterfeit as they have more market share.

"... Rizek is very popular, the more popular a product is, the faster counterfeit medicine for it comes." PE_1

"... low volume high-cost products are the ones most affected by it ..." GO_3

These counterfeit medicines damage brand equity for these brands as they negatively affect customer perception and loyalty towards them.

"... Company reputation and business is damaged as patients using counterfeit do not have a positive impact on their health ... they lose business ..." PE_1

"... Directly hits business, value, customer satisfaction, and loyalty ..." PE_2

"... majority of these counterfeit medicines are sold in rural areas where there is almost no regulation to quality control ..." PE_1

The counterfeit medicine market can only be mitigated through the active participation of the government, as the corporates are primarily focused on the market competition. Also, the role of medical institutions in fighting this menace has been helpful.

"... This is a higher level management decision, and their primary concern is profits ..." PE_2

"... Kachi-Gali fake medicines are sometimes financed by the organizations itself as well ..." GO_1

Current Systems being used to mitigate these Challenges

Currently, packaging technologies play an important role in mitigating this challenge. Special Logo, Font, and Color schemes are used to differentiate from others.

"... Packaging techniques may include Logo, Font, Color, Box, Packaging Technology, Packaging Sheets ..." PE_2

"... Primarily Counterfeit is recognized through packaging ..." PE_4

Package information (Coding System) is printed on the box; this information is verified by the organization to confirm if the package is counterfeit or real. Special Hologram stickers are used on the packaging that is not easy to replicate.

"... Hologram Packaging and Stickers are expensive to check ..." PE_2

"... Coding packets with serial numbers ..." GP_2, GO_3

A Barcode system is also used, where a barcode is printed on every package. This barcode contains all the information that is printed in the package information. Currently, the use of barcodes is almost close to none.

"... good companies are using the barcode (It's new for the market) ... Barcode is new and used by one a few companies ..." PE_1, GO_3

The Track and Trace system is used to track any package throughout the supply chain. For this, RFID technology is used in developed countries.

"... Track and Track Technologies is used to manage pharma supply-chain ... Packaging includes overt and covert technologies like barcodes, holograms, sealing tapes, and radio frequency identification devices to preserve the integrity of the pharmaceutical product ..." PE_5, GP_1, GP_4

DRAP sends suspected samples to Central Drug Testing Laboratory Karachi and Provincial Drug Testing Laboratories for analysis.

"...Suspected samples are sent to Central Drug Testing Laboratory Karachi (by FIDs) and Provincial Drug Testing Laboratories (by Provincial Regulators) for analysis ..." GO_2

Knowledge about Blockchain technology

Blockchain Technology is a Supply chain tool.

"... BT is a Supply chain tool ..." GO_1

Blockchain is primarily famous for its application in the implementation of cryptocurrency.

"... BT is a technology that is famous for crypto-currency ..." PE_5

"... BT software-based digital technology ..." GP_3

Blockchain is a decentralized digital ledger that records and transfers data in a fast, secure and transparent manner.

"... It's a safe transaction ledger that is shared by everyone taking part in an established distribution network of computers. BT keeps a record of all the transactions which take part in the network. ..." GP_1

"... Blockchain is a decentralized digital ledger that records and transfers data in a fast, secure and transparent manner ..." GP_4

It's primarily for information sharing.

"... It's a technological tool for information sharing ..." GP_1

BT in Pharmaceuticals

BT may increase medicine authenticity and reduce the risk of counterfeiting. It's good for the transparent exchange of information and may enable better product knowledge.

"... BT will increase authenticity and reduce counterfeit ..." PE_1

"... It's good for the transparent exchange of information, such system my enable better product knowledge ..." GO_2, PE_5

"... Improve their efficiency and disseminate verifiable medications across the planet ..." GP_4

Barriers to Implementation

To ensure the implementation of such technology, more market research needs to be conducted.

"... More field research needs to be done ..." PE_2

The majority of pharma companies in Pakistan would prefer to hide their supply chain details because much of it may be unregulated.

"... No firm would be willing to expose their Supply chain details ... Pharma companies prefer cheaper raw material while compromising on quality. DRAP is starting to ask for a source of raw material in SOP Form 2 ..." GO_1

DRAP is developing SOPs to ensure such supply-chain details are shared with the government. Such a BT application would be difficult to use as it is time-consuming to check and verify each package.

"... It would take hours for the shopkeeper to check each batch of every order through BT and simply won't do it unless forced by DRAP ..." PE_3

DRAP is currently working on implementing Barcode System so, BT's idea would take time to implement even if DRAP decides to.

"... DRAP won't go with BT idea as they are already working on implementing Barcode technology (G1 Standard) ..." GO_3

Suggested Improvement

Such a BT application would be difficult to use as it is time-consuming to check and verify each package. The right way would be to randomly select packages from the stock to be checked through the BT application.

"...But instead of all packets, randomly selected packets could be checked to save time only in cases where there is doubt. This will save time. This way it might bring a good impact ... Randomly selected packets could be checked through BT to save time only in cases where there is doubt ..." PE_3

"... Incorporate the idea of BT with Barcode System ..." GO_3

The issue of counterfeit medicine exists in Pakistan due to the involvement and negligence of many private and public sectors including DRAP, pharmaceutical companies, hospitals, and clinics. The counterfeit market has a huge share in Pakistan due to the low-cost manufacturing and high demand. Due to the use of counterfeit medicine, pharma companies are losing customer loyalty and their market share. Government intervention in this matter so far has been minimal. The majority of respondents believed that the role of DRAP has not been significant in mitigating this issue, but a change is expected soon as DRAP is developing news SOPs to implement the necessary policies.

Currently, many packaging and tracking techniques are being used to minimize the counterfeit medicine market. These techniques have not been very effective so far. The majority of the respondents including DRAP professionals believed that many pharma organizations are benefiting from these unregulated systems, this is the reason why many organizations would not let the systems get regulated effectively. Unregulated imports of raw materials for medicines could be an example of it. So, it primarily becomes the responsibility of the government to develop systems to fight this menace.

The majority of the respondents had partial knowledge about blockchain technology and its potential role in making Supply chain systems effective. After letting them know about the possible impact of BT on the pharma supply chain and our proposed BT Application, the majority believed that the idea may be very beneficial for the industry. Along with that, there were concerns about the dynamics of the current market and the possibility of implementation of such technology due to challenges related to the current market systems.

It was suggested by the respondents that such a technological tool could be only effective if implemented by the government itself, as they would be the ones to enforce it. The right set of SOPs and enforcement departments need to be developed. Also, DRAP is working on implementing barcode systems throughout Pakistan, respondents suggested the inclusion of BT into the barcode system to

enhance data integrity and increase public transparency.

CONCLUSION

Strong government intervention is needed to implement BT-based systems that may regulate the supply chain processes for pharma in Pakistan. Both federal and provisional governments would play an important role in implementing it. DRAP is currently working on developing newer SOPs', BT may enable them to enhance their systems at a technological level. But this can't be implemented just now, as the healthcare system in Pakistan faces disparity across different regions of Pakistan in terms of development. DRAP is currently focusing on implementing packaging technologies such as barcode systems, these technologies enable package authentication through imprinted information and barcode. The supply chain transparency remains an issue and the proposed BT software application may be the right solution for it, provided that DRAP enforces its implementation.

STRENGTH AND LIMITATIONS

The primary strength of this study is the sampling strategy with maximum variation (respondents are from different domains of the industry of public and private sectors with different levels of significance and influence). A response rate of 60% was achieved. The iterative approach was exercised for data analysis following the theory of deductive and inductive reasoning. To ensure the validity of the data, interviews were conducted until the point of saturation was reached. At the end of each interview, respondents were welcomed to raise any other concern that was not raised in the interview questions.

Even with the sampling strategy that was considered and the high response rate, there is always the possibility of some point of view being missed during the interviews. To minimize this risk, we interviewed the respondents until saturation was reached, to ensure that any new piece of information that is relevant to the study is gathered. Due to the barriers of distances and availability, some of the interviews were conducted telephonically. Related literature reveals that face-to-face interviews are more effective in terms of information gathering (Irvine et al., 2013). It's hard to find the female participants in this industry so, equally-weighted gender opinion was hard to maintain. Many respondents were short on time due to availability issues, so time constraints may have prevented some information from being recorded. In the end, the concern of transferability of findings to other settings is another concern. However, we believe that these findings apply to the context of other low-middle-income countries (LMIC) too.

Our findings of this research are broadly in keeping with the existing literature on the pharmaceutical industry which demonstrates that the current issue of counterfeit medicine can only be suppressed through the proactive role of government intervention. Along with that, the market for counterfeit medicine primarily exists due to non-transparent supply chain systems for pharmaceutical medicines, starting from raw material to the end product (Bocek et al., 2017). BT has the potential to make the whole supply chain transparent which would allow the end consumer to be sure about the authenticity of the end product they use (Tan et al., 2018).

IMPLICATIONS FOR POLICY, PRACTICE, AND RESEARCH

The role of government in implementing systems such as BT is even more important in low or middle-income countries (LMIC), as there is no systematic way to enforce such processes. To implement such a system, the analysis of the need of the people is essential to be understood, this would ensure that the intervention that we introduce are interlinked with the needs of the people. In the process of implementing such a system, partnership with international and local healthcare institutions would be needed to establish centers for training and spread awareness to the general public regarding the use of this system and its need. However, it might be difficult to forecast the learning curve and implementation rate in different regions of Pakistan due to the disparity in education and healthcare facilities.

We believe that many of the findings of this research apply to other LMICs' as they face the same barriers compared to Pakistan (Lewis et al., 2012). To some extent, the findings of this research are culturally influenced and future research in other LIMCs' may prove to be beneficial in this context. For example, general practitioners tend to recommend the drugs to the patients based on their networking with the pharma industry, instead of judgment based on quality.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interests.

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