



The Nigerian Pharmaceutical Supply Chain: Blockchain Adoption, Counterfeit Drugs and Successful Deployment of COVID-19 Vaccine in Nigeria

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Authors' contributions

This work was carried out in collaboration between both authors. Author MJL designed the research, conducted the interviews and wrote the first draft of the manuscript. Author MHA structures the writing and revised the entire work. Both authors read and approved the final manuscript.

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ABSTRACT

Aim: Critically investigating the possibility of adopting blockchain technology within the Nigerian pharmaceutical supply chain to curb the supply of counterfeit drugs.

Study Design: The study is qualitative in nature and the primary data were fetched through interviews.

Place and Duration of the Study: Conducted within Nigeria for a period of 3 months.

Methodology: A qualitative method of data collection was adopted in the study, where some stakeholders were interviewed. The interviews were conducted with employees from different pharmaceutical companies and some drug regulatory agencies in Nigeria.

Result: Firstly, this study has ascertained the current prevalence of counterfeit drugs and the reasons for that. The study discovers a very high level of counterfeit drugs and some reasons behind that. Secondly, this study has also found some barriers to blockchain adoption, including the fact that the level of awareness of blockchain technology among stakeholders within the Nigerian pharmaceutical supply chain and the regulatory agencies is very low.

Conclusion: It was concluded that the efforts put in developing a viable COVID-19 vaccine could be undermined due to the current nature of the Nigerian pharmaceutical supply chain, the nature of porous borders in place, absence of an apparent drug distribution system, among others. This study also concludes that the supply chain's current structure needs more regulatory and structural interventions by the Nigerian government than blockchain technology. In other words, with the current nature of the supply chain, blockchain technology adoption would not be effective in delivering the said benefits reported by scholars because the atmosphere is not conducive for successful blockchain adoption.

Keywords: Blockchain adoption; counterfeit drugs; COVID-19 vaccine; Nigeria; supply chain.

1. INTRODUCTION

1.1 Background

Due to the heightened number of intermediaries between manufacturers and end-users, supply chains' manufacturing of goods and products is becoming complex [1]. Market expansion and globalisation continuously push companies to expand product life cycles and portfolios to reach new markets [2]. Thus, because of the complexity that market expansion and globalisation bring, little is known about the origins of products, shipment, and entire processing. This, therefore, poses a massive challenge for supply chains, particularly in terms of traceability and data management system [3].

In the pharmaceutical supply chain, globalisation has improved access to medicines to a more significant percentage of the world's population more than ever before. Still, unfortunately, the worldwide reach of pharmaceutical supply chains has -on the other hand- facilitated the opening of numerous gaps and points of entry for the introduction of counterfeit drugs [4]. As Adsul and Kosbatwar [5] argue, the opening of these numerous gaps in the supply chain that allows drug counterfeiting is because the contemporary approach in managing the pharmaceutical supply chain is outdated, lacking visibility and control for manufacturers as well as regulatory authorities over the distribution of drugs. The researchers added that this state of affairs in the pharmaceutical supply chain gives birth to the manufacturing, distribution and consumption of counterfeit drugs.

According to Raj et al. [6], counterfeit drugs are pharmaceutical products that are manufactured and pushed into the market to deceptively represent the origin, effectiveness and authenticity of a drug. According to the WHO as Raj et al. added, counterfeited versions of different drugs worth 80 billion dollars are traded annually worldwide. Up to fifty percent (50%) of the drugs traded on online pharmacies are believed to be counterfeited. Woosley and Schwartz [7] also added that according to the WHO estimates, about a hundred thousand people die in Africa every year because of counterfeit drugs.

The countries hit more by the torrent of counterfeited versions of drugs are mainly the third world countries, i.e., some parts of Asia and numerous African countries [8]. Seiter [9] analysed the negative impact of the counterfeited versions of antimalarial drugs in Sub-Saharan Africa (SSA) to depict this issue's severity. The researcher claims that, in each country of the sub-region, about 400,000 children get afflicted with Malaria every year without having access to effective treatment; this is because those children are administered either counterfeit or substandard anti-malarial drugs. In the year 2008, a study was conducted by the WHO on anti-malarial drugs in circulation to ascertain the quality of the drugs. It is maintained that 64% of such drugs in circulation in the Nigerian markets were either substandard or fake (counterfeited) [10].

Enyinda and Tolliver [11] claim that Nigeria has been acknowledged to be a notorious destination for counterfeit drugs for a number of reasons; such reasons -as the researchers asserted- arguably include weak regulatory and legal

oversight, lack of well-defined pharmaceutical supply chain, corruption and bribery, etc. Therefore, expelling counterfeit drugs from the pharmaceutical supply chain in Nigeria, they added, has been a concern of the highest priority to safeguard the wellbeing of the populace. Fatokun [12] believes that avoiding counterfeit drugs from being induced into the Nigerian pharmaceutical supply chain is a tough task; this is large because more than 70% of drugs circulating in Nigeria are imported either from India or China. And the duo are believed to be the biggest sources of counterfeit drugs.

Governments alongside pharmaceutical companies are continuously faced with increasing pressure to secure their pharmaceutical supply chain's reputation and, above all, patients' safety. Verily, alleviating the risk of counterfeit drugs in the pharmaceutical supply chain could be a matter of life and death [11]. Many researchers have studied the issue of drug counterfeiting in Nigeria and proffered solutions to help mitigate it. In the Nigerian context, Enyinda and Tolliver [11] proposed solutions by leveraging on Multilayer Mitigation Approach encapsulating a cocktail of policy/enforcement and the use of technology. In a broader perspective (not particular to Nigeria), Raj et al. [6] proposed a solution by adopting block chain's proof of ownership to increase visibility and transparency in the pharmaceutical supply chain.

Block chain was in the first place applied in crypto currencies providing a secure and anonymous way for the transfer of wealth from one person to another or even organisations across national boundaries [13]. Block chain is a decentralised database that stores business transactions in blocks on a peer-to-peer network [6]. Block chain makes it possible for firms to monitor transactions transparently across their supply chains [14]. Therefore, block chain enhances the recording of transactions throughout supply chains in an irreversible way, thus, giving partners supply chain access to this transaction history [15]. Another feature of block chain technology is that it allows consumers to trace the source and track any subsequent modifications to products, thereby alleviating customer's perceived risks [16].

Raj et al. [6] asserted that, for the fact that the blocks in a block chain are cryptographically bounded together, blockchain gets from this its characteristic nature of being an immutable

ledger where all transactions are registered and stored in blocks on a block chain which is bonded together to form a chain of blocks, thus the name block chain. The researchers added that many scholars in various fields of study had proposed block chain adoption because of its characteristic impact on supply chains to tackle drug counterfeiting and improve food supply chains, among others. Thus, this investigation intends to be achieved through the establishment of the prevalence of counterfeit drugs and issues associated with curbing their supply in Nigeria; ascertain the level of awareness of block chain technology among stakeholders in the Nigerian pharmaceutical industry; ascertain the level of knowledge of block chain among stakeholders in the Nigerian drug regulatory and enforcement agencies in Nigeria; ascertain the barriers to block chain adoption in the context of Nigerian pharmaceutical supply chain; and establish the feasibility of block chain adoption in the Nigerian pharmaceutical supply chain.

1.2 Highlights on Global Efforts towards a Viable Vaccine

To respond to the current corona virus disease 2019 (COVID-19) pandemic, governments have resorted to implementing some aggressive strategies that include contact tracing, case identification, social distancing, quarantine and isolation [17]. Experts have developed models suggesting that the rebound of transmission will speedily become apparent when current strategies are relaxed. Therefore, the priority for bringing an end to this pandemic is developing vaccines that would have a global reach [18].

Developing a viable vaccine involves coordinating a collective effort from governments, biotechs, pharmaceutical companies, military researchers and the academia. This is very expensive; for example, Johnson & Johnson, on the 30th of March 2020, announced its COVID-19 vaccine project and claimed it could cost up to a billion dollars [19]. Developing up to three COVID-19 vaccines within twelve to eighteen months requires an investment of a minimum of 2 billion USD apart from costs of manufacture or delivery, according to the Coalition for Epidemic Preparedness Innovations (CEPI) [18]. Other challenges faced by researchers trying to develop the COVID-19 vaccine, as noted by Peoples [20], include scientific and logistical challenges.

1.3 Background on the COVID-19 Situation in Nigeria

The COVID-19 index case in Nigeria was reported on the 27th of February 2020. According to the Nigeria Center for Disease Control (NCDC), there were 288 cases of COVID-19 in Nigeria with 7 deaths and 51 discharges, as reported by Olapegba et al. [17]. Currently, as of the 22nd of February 2021, the NCDC has reported 1,839 COVID-19 deaths, 152,074 confirmed cases and 21,567 active cases. Also, according to the NCDC, the number of samples tested as of the 22nd of February stands at 1,489,103 [21].

To contain the spread of the virus, the Federal Government of Nigeria, on 30th of March 2020, introduced different strategies like the closure of the border and airspace, public places, schools and worship centers. The central government also imposed a lockdown on three (3) states for 4 weeks initially [17].

Most Nigerians earn a living through the informal economy, so with lockdown imposed, their livelihood is under threat in a situation where the social safety net is not adequately available. Unemployment benefits or access to food stamps aren't available, and most people are earning their living daily [22]. Abati [23] reported that many Nigerians, due to ignorance and superstitions relating to the pandemic, resorted to the usage of talisman, herbs, anointing oils or rituals to prevent from contacting the virus without taking major health precautions identified by public health professionals. He added that other sets of people were busy on various social media platforms spreading fear and fake news concerning COVID-19.

1.4 Challenges Encountered in the Efforts Made to Contain COVID-19

A challenge that might be encountered in the global deployment of successful vaccines is that the COVID-19 vaccines are needed globally with the urge distributed differently among populations [24]. On this note, high-income countries, therefore, shouldn't monopolise the global supply because, during the 2009 influenza (A/H1N1) pandemic, large advance orders of vaccines were negotiated by wealthy countries leaving behind the poorer countries [18].

Due to the unfriendly and inevitable economic situation brought about by imposing lockdowns, a

lot of experts have opined that lockdown, social distancing and self-isolation measures are un-African [23]. Soludo [25] believes that lockdowns in Africa that Nigeria belongs to, is problematic without a credible exit strategy. He added that it is simply not affordable and can potentially worsen Africa's health and economy. The author also highlighted that there is going to be a massive under-reporting of cases and under-testing due to the realities of the African health systems (which Nigeria is not excluded). There was a similar claim reported that Africa at large has a testing problem. This can arguably be justified from the number of tests conducted as of 5th August 2020 (304,221) in Nigeria since the beginning of the pandemic, which is not up to a daily COVID-19 testing target of one of the developed countries.

Other scholars like Adepoju [26] and Reuben et al. [27] have also highlighted challenges faced by the Nigerian healthcare system in the face of the pandemic. This is the presence of viruses already at community infection levels which puts Nigeria's already convulsive healthcare system in grave danger. Such viruses that hinder the fight against COVID-19 include the Lassa virus, which is a deadlier zoonotic and viral haemorrhagic fever [27]. The same concern was also raised by Oladele et al. [28], stressing that HIV hinders the campaigns against COVID-19 in a similar fashion as Lassa.

1.5 Nigerian Pharmaceutical Supply Chain

According to Klantschnig and Huang [29], domestic manufacturing of drugs in Nigeria has declined since the late 1980s, and a system of private importation [12] claims that 70% of drugs in Nigeria are imported), manufacturing and distribution of drugs has been adopted in Nigeria since then. Furthermore, the researchers added that about 300 importers of pharmaceutical products were registered in Lagos alone in 2012 who mainly import from Europe and the US and more recently from India and China. These importers are of different categories ranging from multinationals to big Nigerian importers as well as smaller entities.

Both importers and local manufacturers of drugs in Nigeria mainly distribute their products via wholesale markets such as the Idumota market in Lagos, Agbeni in Ibadan or Bridgehead market in Onitsha. These wholesale markets in different parts of Nigeria are the nerve centres of the

pharmaceutical drug trade in Nigeria, where every importer or manufacturer wants to be represented, including larger pharmaceutical corporations. Every retailer, including pharmacies, hospitals, drug patent dealers, among others in the supply chain, relies on these wholesalers because there are no alternative suppliers that can provide the wide range of drugs available at their disposal [29].

Fatokun [12] also mentioned the notable open drug markets previously in Nigeria, referring to the wholesale markets identified by Onyebuchi [30], which include Idumota, Sabon-Gari and Bridgehead markets located in Lagos, Kano and Onitsha, respectively. Fatokun [12] added that Lagos's Idumota market has been considered one of the world's largest markets, where manufacturers directly sell their products to traders. Such products are sold to the rest of the West African sub-region and to as far as Kinshasa in Central Africa.

Onyebuchi [31] claims that Nigeria is the biggest country in West Africa that manufactures pharmaceutical products. Concurring with the assertions made by Klantschnig and Huang [29], Fatokun [12] and Onyebuchi [30] also mentioned the presence of the open drug markets, adding that the pharmaceutical drug distribution network in Nigeria is in a state of chaos. This claim by the researcher was also a claim previously made by Li [31]. Handling drugs is very poor because they are often displayed under direct sunlight. Sadly, pharmaceutical drugs are sold on the streets, roadsides, inside buses and so on [30].

Fatokun [12] believes that the open drug markets highlighted previously create the opportunity for counterfeit drugs to get into the legitimate pharmaceutical supply chain in Nigeria. On the contrary, Enyinda and Tolliver [11] believe that less defined pharmaceutical supply chains and loose regulatory activities encouraged the easy entry points for counterfeit drugs.

1.6 Prevalence of Counterfeit Drugs

It is difficult to obtain a valid figure or percentage of the global scale of counterfeit drugs trade because of the business's underground nature, therefore, estimates have to be treated with caution [30]. Halabi and Gostin [4] also believe that no estimates can be tagged as accurate regarding the prevalence of counterfeit drugs because, as the researchers put it, the trade occurs in global grey and black markets. There is

an apparent discrepancy in the estimates published regarding the scale of counterfeits which vary between 1 to 50% of the global pharmaceutical products [32]. According to Webb [31], even the data quoted by reputable international organisations are based on little more than guesswork; The International Medical Products Anti-Counterfeiting Taskforce (IMPACT) estimates that the global trade in counterfeits is between 10-30%, while the WHO put the figure to be at 10% although neither of the two is based upon published scientific research the researcher added.

Towards the end of the twentieth century, Nigeria had the biggest market for counterfeit pharmaceutical drugs [33]. According to Bird [34], 70% of Nigeria's pharmaceuticals were found to be counterfeited in 1987 after a nationwide study of the quality of pharmaceutical drugs. After the paracetamol syrup disaster in 1990 that caused the death of 109 children in Jos-Nigeria, the worldwide media's attention was drawn, which in turn made the Nigerian government respond by establishing 'The National Agency for Food and Drug Administration and Control (NAFDAC)'. Primarily to combat the spread of counterfeit drugs [31].

In 1998, the Nigerian government took steps to limit counterfeit drugs' manufacture and sale by implementing legislation that would make it a criminal offence [35]. Bate [34] notes that these initial efforts lacked widespread political support or enforcement, so they were ineffective in their objectives, with 50% of drugs in Nigeria still being counterfeit by 2001. Only when focused on government commitment, revised infrastructure processes and the total overhaul of NAFDAC resulted in an 80% drop of counterfeit drugs circulating in Nigerian markets by 2006 [35]. This suggests that effective government engagement can impact the extent and volume of counterfeiting operations. This is something that this work will explore further by reviewing methods such as technology (Blockchain) adoption alongside government engagement in a multi-faceted and multilayered approach for attitudes towards their effectiveness. This supports what Enyinda and Tolliver [11] believe that a multilayered mitigation approach that employs technology alongside effective government processes results in the successful mitigation of counterfeit drugs.

More recently, the Nigerian policymakers affirmed their commitment to combat the

circulation of counterfeit drugs in the country at the 66th session of the WHO Regional Committee for Africa, which took place in Addis Ababa, Ethiopia [12]. Even though Nigeria had in the past reported some progress in getting the number of counterfeit drugs in circulation down, the problem still poses a considerable challenge, most especially with regards to drugs that are of public health importance like antimalarial drugs [12]. 64% of antimalarial drugs in Nigeria were counterfeited in 2011 [36].

1.7 Barriers to Fighting Counterfeit Drugs in Nigeria

According to Klantschnig and Huang [29], one of the explanations that are often given (most especially in policy circles) is that counterfeit drugs are prevalent because most consumers are uneducated and poor, so they are ignorant of the risks consumption of counterfeits poses. Fatokun [12] argues that one of the main barriers to battling counterfeit drugs in Nigeria is highly unregulated open drug markets across major cities of Nigeria where drugs are traded on streets, in the open at kiosks and stalls. He added that preventing counterfeit drugs from the Nigerian market is difficult because more than 70% of the drugs in circulation in Nigeria are imported from either India or China, and these two are the world's biggest sources of counterfeits, according to the researcher. This statement claimed by Fatokun [12] was also made by Aminu and Gwarzo [10] that the majority of pharmaceutical drugs in circulation in the Nigerian markets are imported mainly from India and China, with the former being accused of contributing between 12-25% of global supplies of counterfeits, contaminated or substandard drugs.

According to Akiny [35], the public laboratories in Nigeria that are set up for quality control and assessment of drugs are not adequately equipped to handle the magnitude of drug quality test requests for the analysis of imported drugs. Generally, the researcher asserted that the barriers to tackling counterfeits in Nigeria as well as the factors that promote their preponderance had been reported as follows: the high cost of genuine drugs, ineffective enforcement of existing laws, loose control systems (at the borders), non-professionals in the pharmaceutical drug business, ignorance (from the side of consumers), greed, corruption, chaotic drug distribution network, illegal importation, supply not meeting demand, among others.

Aminu and Gwarzo [10] listed some barriers. There is some degree of agreement between their assertion and that of [35], where they also mentioned demand exceeding supply, greed, ineffective enforcement of existing laws, corruption, loose border control, chaotic drug distribution network, high cost of genuine drugs, ignorance and illegal importation. Aminu and Gwarzo [10] added that insufficient enactment of drug laws, lax penalties, poverty and internet commerce also serve as barriers. Ubajaka et al. [37] listed corruption and conflict of interest, insecure and unfriendly environment, poor health-seeking behaviour, high taxes and tariffs on pharmaceutical products, demand exceeding supply, heightened global campaigns on tackling narcotics, inappropriate/inadequate legislation, sophistication in the clandestine manufacture of drugs, unordered drug distribution system, false declaration by importers at the borders, insufficient cooperation among government agencies and discriminatory regulation by exporting countries as the barriers to tackling drug counterfeiting.

1.8 Blockchain Technology for the Pharmaceutical Supply Chain

When developing technology-driven solutions, the pharmaceutical supply chain is often considered [38]. The global market for counterfeit, fake, substandard and grey market drugs, for instance, account for up to 200 billion dollars per year. Numerous studies have disclosed several pharmaceutical products subject to counterfeiting in different countries worldwide, indicating that drug supply chains are prone to transnational pharmaceutical crime [39].

As a result of global pharmaceutical drug sales that was facilitated by the international growth of the pharmaceutical market, numerous solutions using various forms of technologies have been proffered to solve supply chain problems like counterfeiting [38]. Therefore, technologies such as Radio Frequency Identification (RFID) and different mobile applications for tracking drug pedigree alongside other product verification solutions have been adopted to secure and modernise the supply chain [39].

Numerous organisations have explored blockchain in pharmaceutical supply chain management through the development of use cases, prototyping of blockchain solutions and simulation modelling, according to Clauson et al. [39]. The Centre for Supply Chain Studies has

been doing that in conjunction with different stakeholders across the pharmaceutical supply chain. IEEE Standards Association has convened numerous workshops and seminars in an effort to explore frameworks that aid in terms of interoperability between blockchain and other existing systems to boost safety in the pharmaceutical supply chain. A lot of companies are currently working towards the same goals, specifically through the exploration of similar projects with manufacturers in other sectors while extending blockchain models used in those industries to the pharmaceutical supply chain [39].

2. METHODOLOGY

According to [40], data is collected as either primary or secondary data. The techniques of data collection are decided by the researcher based upon the researcher's comprehension of research philosophy, choice of methodology, research strategy and time horizon [41]. Thornhill et al. [42] argue that data collection is crucial when conducting high-quality case study research. Different data collection techniques identified by scholars include interviews, questionnaire survey, document reviews [43], group discussions, observations [44], etc. Ji and Hussey [45] asserted that the techniques highlighted could be further categorised into primary or secondary techniques.

They added that primary data could be quantitative (numerical) or qualitative (nominal). It is the form of data collected from sources like the data collected through interviews and questionnaires. On the other hand, secondary data is the data gathered from sources other than the ones used in obtaining primary data, such as the data gathered from journals, the internet, magazines, textbooks [46], etc.

In qualitative research like this one, Wahyuni [40] asserted that primary data is mainly gathered through semi-structured interviews conducted with experts in the observed topic from the case organisation, industry or sector. Parker [47] suggested that qualitative researchers should communicate with experts or practitioners from the 'organisational coal-face' so that the researchers have a better understanding of the current state of the real-world practices in their industry, sector or organisation of interest (case study). Consistent with the assertion made by Parker [47], the aim and objectives of this research could best be achieved through

effective communication with experts from the sector under investigation so that a better understanding of the current practices would be obtained, and ultimately, the research questions get answered.

2.1 Research Interviews

According to Moriarty [44], interview is the commonest data collection method in qualitative research. Sekaran and Bougie [48] describes it as the purposeful tapping into the experiences, perspectives and opinions of research participants. This is done by asking 'how', 'why' and 'what' questions [49] to gather valid and reliable data relevant to the research questions and objectives [42]. Ji and Hussey [45] asserted that interviews are conducted either via a face-to-face, screen-to-screen or voice-to-voice medium, while McNamara [50] believes it can be conducted via email.

Despite the flexibility and richness of data in research interviews, research interviews are criticised as being time-consuming, prone to biases, having confidentiality issues, and facing challenges in gaining access to information or participants [44]. Yin [49] also believes that such flaws attributed to research interviews include the difficulty of getting the interviewee to cooperate fully in sticking to answering the researcher's questions.

Based on the work of Gall and Borg [51], Turner [52] stated three types of research interviews, namely informal conversational interview, general interview guide approach and standardised open-ended interview. Other researchers have also identified different classifications of research interviews; Moriarty [44] mentioned in-depth interviews and semi-structured interviews. Ji and Hussey [45] mentioned unstructured interviews, Sekaran and Bougie [48] mentioned structured interviews, and Saunders et al. [42] stated standardised and non-standardised interviews among other types of research interviews.

In this research, the preferred interview method is the standardised open-ended (semi-structured) interview proposed by Gall and Borg [51].

2.2 Sampling of Participants

Since it is practically impossible to gather data from each member of a population, sampling

becomes necessary [42]. Saunders et al. [42] explained that the sample involved in research represents a specified number of selected persons out of a larger population that serve as data providers. In this research, non-probabilistic sampling (snowball sampling) is adopted since, according to Moriarty [44] this method of sampling encourages iteration and flexibility. The participants in this research that would represent the sample include five persons, three from amongst industry players within the Nigerian pharmaceutical supply chain, while the other two came from the Nigerian drug regulatory agencies. Table 1 presents the demography of the interviewees for a clearer demonstration of their strength in providing quality and reliable information.

This sample size may be considered low in some circumstances; however, the in-depth knowledge of the industry and its supply chain is paramount in this case. The quality or reliability of data source is more important than the quantity.

2.3 Research Questions

In this research, some objectives to achieve the aim of this study have been outlined. Based on these research objectives, the research questions are designed as presented in Table 2.

3. RESULTS AND DISCUSSION

3.1 Critical Discussions

This section focuses on analysing data obtained from the interviews conducted in this research, presentation and critical discussions around the investigation's findings.

A total of five interviews was planned to be conducted, and all the five were conducted. Two employees from the main drug regulatory agency in Nigeria were interviewed alongside three employees from various pharmaceutical companies in Nigeria, including some multinationals. Interviews were performed via Skype and voice calls.

Interviewees' consent to record the conversations was obtained, assuring them that utmost confidentiality of their identity and that of their respective organisations would be maintained.

3.2 Presentation and Data Findings

To achieve the objectives of this research, nine (9) research questions (RQ1-RQ9) were coined in line with the outlined objectives, and on the basis of these questions, the findings of the research are presented as follows:

RQ1: What do you think is the current prevalence of counterfeit drugs in Nigeria, and why do you think the scale of the prevalence is as you reveal?

3.3 The Current Level of Prevalence

There seems to be a disagreement between respondents on the current level of prevalence of counterfeit drugs in Nigeria. Three of respondents argue that the prevalence is currently very high (Interviewee 2, Interviewee 3 and Interviewee 4), while two of respondents believe it is low (Interviewee 1 and Interviewee 5). The argument in terms of the current level of prevalence being low could be explained due to the fact that the two interviewees who uphold this opinion comes from a regulatory agency and strongly believes that they are doing their jobs. But then, their claim is synonymous with what Akiny [35] asserted of the drop (around 2006) in counterfeit drugs in Nigeria after NAFDAC's leadership was reshuffled and revised infrastructure processes were put in place. On the other hand, the argument presented by the three interviewees is upheld by the assertions made by Fatokun [12] and Blackstone et al. [36] that the level of prevalence was still high even after the said changes to the regulatory activities.

Scholars have reported the above arguments among professionals about the level of prevalence of counterfeits in Nigeria. Researchers Webb [31], Halabi and Gostin [4], Newton et al. [32] have noted the disagreement and discrepancy in estimating the prevalence of counterfeits even at a global level.

3.4 Reasons for the Current level of Prevalence

Two respondents (Interviewee 1 and Interviewee 5) believe that the current level of prevalence of counterfeits in Nigeria is low as stated earlier, arguing that "the regulatory activity of NAFDAC had improved drastically over the years", stressing that there were some efforts by the regulatory agency of "adding one or two technological approaches in tracking fake and

counterfeit medicines” and “the policy of going to the source of fake and counterfeit medicines, ...addressing the root cause by partnering and collaborating with those countries to ensure that those drugs don't come into the country in the first place”. Interviewee 5 also attributed the low prevalence to some reasons he identified saying: “The reason of it going down is because of track and trace, the use of Truscan and mini-labs for on-the-spot checks and then the increased pharmacovigilance and post-market surveillance activity”. These claims made by Interviewee 1 and Interviewee 5 are in harmony with what Ubajaka et al. [37] had asserted.

Interviewee 2 argues that the current level of prevalence of counterfeits in Nigeria is very high (60-70%) simply because, as in his words, “the authorities are not doing their work, due diligence and the medication comes into the country”. This claim coincides with what Akiny [35] noted that

“loose control systems” mainly at the borders are why counterfeits are still high in Nigeria. Although Interviewee 5 argues that prevalence is currently low but has attested to the claim made by interviewee 2, saying: “...like at the customs or even some of the NAFDAC staff and you pay them some money and they pass these products, they let them enter the country”.

Interviewee 3, in a claim that coincides with the one made by Aminu and Gwarzo [10], also argues that it is very high and has attributed that to having porous borders, greed from the part of merchants, stating that “some people understand that it is a fake and counterfeit product, but they rather buy that and sell because they make more margins on that”. He added that a lack of education/awareness on the part of the end-users is one of the reasons that encourage drug counterfeiting.

Table 1. Demographic profile of the interviewees (Author generated)

Interviewees	Years of experience	Organisation size	Organisation role	Location
Interviewee 1	23 years	1000-1500 employees	Director of research	Abuja-Nigeria
Interviewee 2	8 years	500-1000 employees	Pharmaceutical Sales Rep.	Abuja-Nigeria
Interviewee 3	12 years	500-1000 employees	Regional Pharm. Rep.	Abuja-Nigeria.
Interviewee 4	20 years	1000-1500 employees	Regional Pharm. Rep.	Abuja-Nigeria
Interviewee 5	6 years	1000-1500 employees	Pharmacist	Abuja-Nigeria

Table 2. Research questions

Research objectives (ROs)	Research questions
RO1	RQ1. What do you think is the current prevalence of counterfeit drugs in Nigeria, and why do you think the scale of the prevalence is as you reveal? RQ2. What are the problems associated with tackling counterfeits in Nigeria? RQ3. What steps do you suggest to be taken in tackling the supply of counterfeits in Nigeria?
RO 2 & RO3	RQ4. How effective would the use of technology be in curbing drug counterfeiting in the context of the Nigerian pharmaceutical supply chain? RQ5. Have you heard of Blockchain technology? RQ6. How possible is blockchain technology able to help in curbing counterfeits supply in Nigeria?
RO4 & RO5	RQ7. How feasible is the adoption of blockchain technology within the Nigerian pharmaceutical supply chain, and why do you think it is feasible or not? RQ8. What are the likely barriers to be faced in adopting blockchain technology within the sector, and how can the barriers (if there is any) be overcome? RQ9. What is the level of readiness of the Nigerian pharmaceutical supply chain to blockchain adoption?

Poverty is another reason, as claimed by the respondent, arguing that due to that, people "actually ask for the cheaper brand," and that encourages counterfeiting, as he opined. The claims made by interviewee 3 were also made by Interviewee 5 attributing the prevalence to poverty and corruption, and these claims by the duo are in accordance with the assertions made by numerous researchers Aminu and Gwarzo [10]; Akiny [35]; Ubajaka et al. [37]; Klantschnig and Huang [29] as the literature reviewed depicted.

Interviewee 4 believes that the reasons for the current high level of prevalence is because of the presence of an open market and the absence of a well-defined distribution system (although this was disputed by interviewee 5), noting that "the distribution system is poor that everybody can bring the drug to the market and sell easily". Other reasons cited by the respondent include the lack of political will to expel open drug markets, lack of monitoring by the regulatory agencies "because they don't have a lot of systems on ground or mechanism to checkmate that", lack of "after-market test... where they will go and pick the product randomly and be checking". Interviewee 5, coming from the regulatory site, has agreed that they have coverage issues, their activities don't reach to some remote locations due to reasons beyond their control, he said: "it is not every place that NAFDAC can reach because of unforeseen or because of situations beyond their control, it's not everywhere that the agency can reach to enforce the regulatory requirements". The claims made by interviewee 4 are similar to those made by Fatokun [12] on the open drug markets, Akiny [35] and Aminu and Gwarzo [10] on lack of monitoring capacity by the regulatory agency and chaotic drug distribution network, respectively.

RQ2: What are the problems associated with tackling counterfeits in Nigeria?

The problems associated with tackling counterfeits in Nigeria as identified by the respondents include high level of illiteracy, unemployment, over dependence on medicines importation (more than 70%) (Interviewee 1) (these claims were also made by Akiny [35]), deficient regulatory activities, open drug markets, lack of political will (Interviewee 2, interviewee 3) (Fatokun [12] and Aminu and Gwarzo [10] also reported the same), cumbersome regulatory processes in terms of genuine drugs registration, corruption amongst regulators and border control

personnel, lack of domestic production of drugs, lack of infrastructure, electricity supply for example, lack of government incentives to encourage domestic manufacturing (Interviewee 3, Interviewee 5) [37] also reported these except "lack of infrastructure", chaotic distribution system, absence of a befitting technology to detect the originality of drugs after sales, lack of regulatory agencies' presence in remote locations (Interviewee 4, Interviewee 5) (Aminu and Gwarzo [10], Ubajaka et al. [37] and Klantschnig and Huang [29] also reported these).

RQ3: What steps do you suggest to be taken in tackling the supply of counterfeits in Nigeria?

The respondents suggested some steps to be taken in tackling the supply of counterfeits in Nigeria. Interviewee 1, when asked this question, said: "So local research and development, local drug manufacturing is the ultimate solution. This on the middle and long term, but in the immediate term, the use of technology to track, appropriate technology to track is something that the regulatory agencies cannot but do with" these claims made by the respondent are in harmony with the assertions made by numerous researchers (Akiny [35], Ubajaka et al. [37], Aminu and Gwarzo [10], among others). The respondent added that capacity building among personnel of the regulatory agencies would also help.

Interviewee 2, when asked this question, he said: "I think the regulatory body should be further strengthened; for me, we need to strengthen the regulatory body to make sure drugs remain in the hands of the professionals... you have people who take pharmaceutical business as pure business, they are not interested in what they are selling", this argument of his is in line with what Akiny [35] noted of having non-professionals in the business and what Aminu and Gwarzo [10] identified of the need for a more strengthened regulatory activity. Interviewee 2 added that more stringent legislation on drug importation and the use of technology to verify the authenticity of drugs would go a long way in tackling counterfeits (These suggestions were also made by Ubajaka et al. [37]).

Interviewee 3 believes that having an end-to-end tracking system that tracks products from manufacturing to consumption would help, and this is also suggested by interviewee 5; the same was suggested by Enyinda and Tolliver [11]. Interviewee 3 also added that reducing

bureaucracy in the relationship between manufacturers/importers and the regulatory agency will help, he said describing the situation: "In some cases, people cannot even have access to them directly, the regulatory bodies, you have to go through what they call consultants, so going to those consultants, those consultants would charge you, and then that's another financial burden, and those consultants would now go to NAFDAC". The respondent also suggested making the process of registration of genuine drugs easier, government incentives for manufacturers and importation waivers for importers of genuine medications, end-user awareness by the government on the defects of counterfeit and fake drugs, end-user awareness by companies on how to identify counterfeits and transparent drug distribution channels. These suggestions were also given by Enyinda and Tolliver [11], Aminu and Gwarzo [10], Ubajaka et al. [37], among others.

Interviewee 4 suggested in a statement synonymous with that made by Fatokun [12] and Onyebuchi [30], that the introduction of a central distribution system and effective monitoring of the distribution system by the regulatory agencies would help, the respondent said:

"The number one measure to be taken is to introduce a central distribution system in Nigeria... NAFDAC to be monitoring whether the wholesalers are particularly using the central distribution system". Onyebuchi [30] stated the establishment of MDDCS by the Nigerian government before 2016, but interviewee 4 claimed that these distribution centres are yet to be established.

Interviewee 5 believes that implementing a robust track and trace system, having stiffer penalties for counterfeiters, establishing a joint task force among enforcement and regulatory agencies, encouraging domestic production and waiver on some regulatory fees would help in curbing counterfeits. These suggestions presented by the respondent coincide with what Enyinda and Tolliver [11] suggested of having a robust technology, Ubajaka et al. [37] on having synergy among regulatory and enforcement agencies, Onyebuchi [30] on increased domestic manufacturing, Webb [31] and Aminu and Gwarzo [10] on the need for waivers and incentives.

RQ4: How effective would the use of technology be in curbing drug counterfeiting in the context of the Nigerian pharmaceutical supply chain?

All the five interviewees believe that technology would go a long way in curbing drug counterfeiting in Nigeria; Interviewee 2 added that technology "will help, everybody has a Smartphone these days, so for me I think technology is really the way to go about it". Interviewee 3 also claims that the use of technology "is going to be very useful, it is really going to impact excellently". Interviewee 4 also shares the same opinion as the rest of the respondents noting in the affirmative that "the new dimension to everything is the technology, technology has helped with a lot of things" and that technology would help in terms of end-to-end traceability of drugs from active pharmaceutical ingredients sourcing to the end-users. These assertions by the respondents are in harmony with what other researchers asserted on the use of technology to curb drug counterfeiting in Nigeria [31,53,11].

RQ5. Have you heard of Blockchain technology?

It is important to ascertain the level of acquaintance of blockchain technology among stakeholders in the supply chain because their knowledge of the technology gives them insights in terms of what the technology can offer, thus, adoption becomes more feasible. It is obvious that the majority of the respondents have no or limited prior knowledge of blockchain technology with two of the five (Interviewee 2 and Interviewee 4) getting to hear about it for the first time during the interviews. Only Interviewee 1 exhibited a fair acquaintance with the technology. This could be a barrier to blockchain adoption as it is asserted by Raj et al. [6].

RQ6. How possible is blockchain technology able to help in curbing counterfeits supply in Nigeria?

A brief introduction was given to the majority of respondents of what blockchain is, its features and how supply chains can leverage on the technology which is consistent with the assertions made by Chang et al. [54]. Based on this introduction, Interviewee 2 suggested that the technology can help in terms of tracking drugs especially since Nigeria imports 60-70% of its drugs and this is consistent with what Montecchi et al. [55] noted. The respondent showed some scepticism on the possibility of the technology to help in the context of the Nigerian pharmaceutical supply chain, he added: "So it might take a while, I don't know if we have what it takes technologically, I don't know much about it like I said, I don't know whether we have the

technology and infrastructure on the ground to make it work" (Interviewee 2). Interviewee 5 also believes that it would help and specifically said: "so the major thing that this blockchain technology would do is really to ensure product security". This assertion by interviewee 5 is similar to the one made by Olapegba [17].

Interviewee 3 also believes that the technology can help, he said: "But I think the technology behind the blockchain is logically scientific and which I am sure any manufacturer who wants to protect the integrity of his business would want to adopt blockchain technology", this statement is consistent with that of Montecchi et al. [55] of blockchain's ability to add provenance to products and by extension to manufacturers. Another issue raised by the respondents (Interviewee 2, Interviewee 3) to be taken into consideration before the technology can serve the purpose is that many stakeholders are not aware of the technology. Interviewee 4 noted that the technology would help in curbing counterfeits but added that "it depends on the cost of the implementation and how easy, fast and simple is the technology" (Interviewee 4). This issue of cost and the question of how easy it is to implement the technology was also noted by Hughes et al. [13].

Interviewee 1 also believes that the technology can help in curbing counterfeits; the respondent explained how this can happen, saying: "If in a drug that is not supposed to be in a distribution chain found its way into the chain, ...if you are operating a blockchain technology it will be easier to trace and solve the problem" (Interviewee 1). This is also captured by Montecchi et al. [55].

Furthermore, the submissions by the respondents of how possible blockchain technology can be able to help in curbing counterfeits' supply in Nigeria agree with the confidence some researchers Clauson et al. [39]; Adsul and Kosbatwar [5] have regarding the technology to help pharmaceutical supply chains tackle the issue of counterfeits.

RQ7. How feasible is the adoption of blockchain technology within the Nigerian pharmaceutical supply chain, and why do you think it is feasible or not?

All respondents, with the exception of interviewee 5 argued that blockchain adoption is feasible within the Nigerian pharmaceutical

supply chain, Interviewee 5 noted: "I will be honest, right, uhmm... it is not something that can happen now because the infrastructure does not exist, the technical know-how does not exist". Although all other respondents strongly believe that blockchain technology adoption is feasible, they have also identified some conditions before that becomes possible. Interviewee 4 argued that it's only when the government establishes a law to mandate it on companies that adoption would be effective. Interviewee 3 backed his argument of strongly believing that adoption is feasible because the issue of counterfeit "is a challenge for most of the manufacturers in the country, so once they see it as addressing most of the issues they have, so the feasibility of adoption is very easy" (Interviewee 3).

RQ8. What are the likely barriers to be faced in the adoption of blockchain technology within the sector, and how can the barriers (if there is any) be overcome?

The respondents highlighted some possible barriers to be faced in the course of adoption of blockchain technology within the pharmaceutical supply chain that include knowledge gap -as supported by Montecchi et al. [55] among professionals (about the technology), long period of time needed for implementation (Interviewee 1, Interviewee 5), acceptability, resistance to change (consistent with Hughes et al. [13]), regulatory implications, cost implication, difficulty in coordinating all players in the supply chain (Interviewee 2, Interviewee 5), cost of deployment, lack of awareness among stakeholders (Interviewee 3, Interviewee 5), lack of infrastructure (electricity, internet, etc.) and difficulty in understanding the concept of the technology (Interviewee 4). Hughes et al. [13] support the assertion that high costs and regulatory/governance issues are barriers to blockchain adoption. Chang et al. [54] also highlighted legal issues regarding blockchain adoption. Raj et al. [6] argued that one of the barriers is the knowledge gap because the technology is not well understood.

RQ9. What is the level of readiness of the Nigerian pharmaceutical supply chain to blockchain adoption?

The respondents didn't unanimously believe that the Nigerian pharmaceutical supply chain is ready to adopt blockchain technology. Interviewee 2 believes that the supply chain is not ready yet; he noted that: "I think we are not

very ready, I might say, we still need to put a lot of things in place" (Interviewee 2). Interviewee 5 also upholds this opinion by interviewee 3, he said: "so I am looking at five years from now, then Nigeria will be ready to embrace blockchain". Interviewee 3 believes that until a proper awareness of the technology and what it can offer is made, the readiness level is still not high. On the contrary, Interviewee 4 argues that they are ready because they need to "survive in the market and control their brands". Even though Interviewee 4 believes strongly that they are ready to adopt the technology, he buttressed the importance of how easy and cost-effective is blockchain in terms of adoption, he said: "So they are ready if the system is very easy to implement and the cost is not so much." (Interviewee 4).

4. DISCUSSION

According to the assertions made by the majority of respondents, the level of prevalence of counterfeit drugs in Nigeria is still very high. The researcher finds this argument to be stronger because those arguing that it's still high have raised some issues that support their claim and which sound more convincing to the researcher compared to the argument presented by the minority, which is based on comparative assessment rather than the actual current level of prevalence (so they simply compare the current level to that prior to the said reforms). Although one of the respondents argued they don't exist, the open drug markets and chaotic drug supply system as raised by respondents and contained in the literature reviewed are still in existence. The plan to establish a central distribution system before 2016, as reported by Onyebuchi [30], is yet to be put in place, as most respondents noted. Therefore, it is fair to say that these claims revealed by research participants support the claim that the current prevalence of counterfeit drugs in Nigeria is still high.

This research has found that the problems associated with tackling counterfeits in Nigeria include a high level of illiteracy, unemployment, over-dependence on medicines importation, deficient regulatory activities, open drug markets, lack of political will, cumbersome regulatory processes of new drugs registration, corruption amongst regulators and border control personnel, lack of domestic production of drugs, lack of infrastructure, lack of government incentives to encourage domestic manufacturing, chaotic distribution system, absence of a befitting

technology to detect the originality of drugs after-sales and lack of regulatory agencies' presence in remote locations.

To tackle the issue of drug counterfeiting in Nigeria, this research has found that a lot of steps need to be taken mainly by the government that include encouraging local drug manufacturing, local research and development, capacity building among personnel of the regulatory agencies, regulatory agencies should be strengthened, pharmaceutical drug business should strictly be in the hands of professionals, more stringent legislation on drug importation, making the process of registration of genuine drugs easier, reducing bureaucracy in the relationship between manufacturers/importers and the regulatory agency, government incentives for manufacturers and importation waivers for importers of genuine drugs, more stringent penalties on counterfeiters, synergy among regulatory and enforcement agencies, waivers on some regulatory fees for genuine manufacturers, end-user awareness by the government on the defects of counterfeit and fake drugs, transparent drug distribution channels, introduction of a central distribution system and effective monitoring of the distribution system by the regulatory agencies. Pharmaceutical companies in Nigeria also need to take some steps that include using appropriate track and trace technology, the use of technology to verify the authenticity of drugs, end-to-end tracking system and end-user awareness on how to identify counterfeits.

This research has also found that there might be a lack of awareness and knowledge of blockchain technology among stakeholders in the Nigerian pharmaceutical supply chain as well as the regulatory agencies, and this poses a barrier to the adoption of the technology. Despite their scepticism and near-zero level of knowledge of the technology, the majority of respondents have shown confidence in the feasibility of blockchain adoption, and its possibility to help in curbing counterfeiting in the Nigerian pharmaceutical supply chain.

Some possible barriers to be faced when adopting blockchain within the Nigerian pharmaceutical supply chain as found by this research include knowledge-gap among professionals, long period needed for implementation, acceptability issues and resistance to change, regulatory implications, cost implication, difficulty in coordinating players

in the supply chain, cost of deployment, lack of awareness among stakeholders, lack of infrastructure and difficulty in understanding the technology. The researcher is of the opinion that the above-mentioned barriers pose an enormous challenge to blockchain adoption within the sector which makes adoption very difficult. The issue of infrastructure, for example, is not something that can be achieved within a short period of time, hence, making blockchain adoption difficult at the moment.

This research has found respondents to exhibit scepticism on the level of readiness of pharmaceutical companies for block chain adoption, this research has found respondents to exhibit scepticism on the level of readiness, adding that the sector is not ready unless some conditions are met. Based on the interviewees' conditions, it is fair to conclude that a lot of companies within the Nigerian pharmaceutical supply chain are not ready for block chain technology adoption at the moment.

5. CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

This study aimed to critically investigate the potential of blockchain technology adoption within the Nigerian pharmaceutical supply chain to curb the supply of counterfeit drugs. Some objectives were set out to achieve the aim, and a qualitative method of research was assumed where interviews were conducted. To some extent, the objectives of the study were achieved, as demonstrated by the findings of the research.

To satisfy the first objective of this study, it can be concluded that the current level of prevalence of counterfeit drugs in Nigeria is still high, as the findings of this study suggest. This conclusion is consistent with the literature's revelation that the level of counterfeit drugs prevalence is still high due to some reasons, which the findings of this study also uphold.

Ascertaining the level of awareness of blockchain technology amongst stakeholders in the Nigerian pharmaceutical supply chain and the regulatory agencies were the second and third objectives this study set to achieve. Therefore, it can be concluded that a knowledge gap exists among stakeholders about the technology, with the majority of them exhibiting limited or zero knowledge of blockchain. This is undoubtedly an

enormous barrier to blockchain adoption in the Nigerian pharmaceutical supply chain context, as the literature reviewed entailed.

To fulfill the fourth objective of this study, some barriers were identified that might hinder blockchain technology adoption in Nigeria. Interestingly, the barriers found by this study are in accord with those identified by various researchers in the literature reviewed. Based on these barriers and to fulfil the fifth objective of this study, a conclusion could be drawn on how feasible blockchain technology adoption is within the Nigerian pharmaceutical supply chain. Therefore, it is fair to conclude after receiving all the information as depicted in the data collected, and the literature reviewed that the Nigerian pharmaceutical supply chain is not yet ready for the adoption of blockchain technology. This conclusion is drawn after a careful review of the barriers to adopting blockchain within the Nigerian pharmaceutical supply chain, as revealed by findings this research, and after ascertaining how the supply chain's current structure is. Adding all these together, there are many pre-requisites the Nigerian government needs to achieve, like establishing a clear distribution system, having a broader coverage of the regulatory agencies' activities, etc., before blockchain technology can successfully be adopted within the Nigerian pharmaceutical supply chain. Therefore, the supply chain's current structure needs more regulatory and structural interventions by the Nigerian government than blockchain technology. In other words, with the current nature of the supply chain, blockchain technology adoption would not be effective in delivering the said benefits reported by scholars because the atmosphere is not conducive. It can also be concluded that the efforts put in developing a viable COVID-19 vaccine could be undermined due to the current nature of the Nigerian pharmaceutical supply chain, the nature of porous borders in place, absence of an apparent drug distribution system, among others.

6. LIMITATIONS AND RECOMMENDATIONS

This study has limitation in the number of participants (interviewees) involved in fetching the research data. Though, the quality and reliability of the research data were not compromised. Based on the research output, the following recommendations are made:

- The government needs to expel open drug markets in Nigeria and establish a central drug distribution system.
- There is need for effective border security and control to avoid counterfeits getting into the country through the porous portions of the borders.
- The government should intensify efforts to tackle corruption among border control personnel and staff of drug regulatory/enforcement agencies to halt the passage of counterfeits through the borders.
- Government and actors within the Nigerian pharmaceutical supply chain should jointly establish a befitting track and trace system that would serve as a skeleton for future blockchain adoption.
- There is need for increased awareness and capacity building on emerging technologies like blockchain among professionals within the pharmaceutical industry and drug enforcement agencies.

Due to the lack of studies like this one, researchers need to conduct studies on blockchain technology adoption within the sector, its benefits and how it works, and the findings of such should be communicated to the government and the pharmaceutical companies.

CONSENT

As per international standard or university standard, respondents' written consent has been collected and preserved by the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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