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## Blockchain and Big Data Analytics in the Optimization of Nigeria Vaccine Supply Chain

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### Abstract

Temperature excursion, cold chain maintenance and the attendant issues of maintaining vaccine integrity across the supply chain network till the last mile remain a critical bottleneck to immunization and vaccine coverage. This study takes a pragmatic approach to understand supply chain professionals' perspective regarding their awareness, acceptability, feasibility, and preparedness to take up innovations to optimize the vaccine supply chain and immunization coverage. Internet-based questionnaire was used to reach different public health supply chain professionals in Nigeria. A community of professionals whose works relates to the supply chain of public health commodity was selected as the sampling frame. This community includes some supply chain professionals in Nigeria who have identified as part of the International Association of Public Health Logisticians, IAPHL. There 200 valid responses of which 70.5% were males, and 29.5% were females. The knowledge of respondents on the vaccine supply chain was as high as 100% among all professions. All also had good awareness on the use of blockchain in vaccine supply chain with the least value of 50.0% for financial/business and project professionals. Blockchain recorded 100.0% acceptability and feasibility among most professions such as IT, financial/business project management and regulatory with minimum acceptability of 88.9% among health/public health development professions. Acceptability and feasibility of blockchain were also very high regardless of respondents' position or year of experience. Preparedness to take up blockchains was rated highest (96.0%) for international political will and least (54.0%) for national political will. This study found that the majority of participants had good knowledge of vaccine supply chain as well as a good awareness of blockchain though it is a new technology to developing countries. The overall acceptability and feasibility of blockchains were generally high. Preparedness of Nigeria vaccine supply chain to take up blockchains was rated high across all sectors. We, therefore, conclude that blockchain and big data analytics can be adopted to optimize the Nigeria vaccine supply chain.

**Keywords: Blockchain, vaccine, supply chain, acceptability, feasibility, preparedness**

## **1.0. Introduction**

Due to the current accelerating rate of innovation, many industries face disruptions that could leave the present business models obsolete. Failure to adapt to the continuously changing competitive environment can have dire consequences most notably with a faster pace of innovation in 2018. The challenge has not become easier for companies. A significant challenge for companies is to foresee disruptive technologies making an impact in their industry and what the consequences of the disruption could end up being.

### **1.1. Blockchain, Big Data, and Cloud Computing - Data and Visibility**

Blockchain technology, popularized by Bitcoin cryptocurrency, is characterized as an open-source, decentralized, distributed database for storing data and transaction information [1]. Rather than relying on centralized intermediaries (e.g., banks) this technology allows two parties to transact directly using duplicate, linked ledgers called blockchains [2]. This approach makes transactions considerably more transparent than those provided by centralized systems [3]. Blockchain technology is also defined as a distributed ledger technology that uses a distributed, decentralized, shared and replicated ledger [1,2], which may be public or private, permission or permission less, or driven by tokenized crypto economics or token less [4]. Beyond Bitcoin and cryptocurrency, blockchain technology holds exciting potential as game-changer in any industry in a similar way the internet did [5].

The first appearance of Blockchain technology was in 2008 through whitepaper for *Bitcoin*, a digital currency built on principles such as cryptography and decentralization [6]. Recently, blockchain technology has started moving from solely fintech to some other applications. Today blockchain technology has already been identified as a potentially disruptive innovation for the supply chain management. A few innovative companies, such as Walmart and Boeing, have identified the benefits of using blockchain technology in their supply chains, and are exploring their opportunities with the technology [7,8]. A major hurdle for companies that do not typically follow the behaviour of early adopters is to identify disruptive innovations as beneficial to their supply chain management or operations. Therefore, this study takes a pragmatic approach to understand supply chain professionals' perspective regarding their awareness, acceptability, feasibility, and preparedness to take up innovations to optimize the vaccine supply chain and immunization coverage. The principal aim is to determine the possibility of optimizing Nigeria vaccine supply chain with Blockchain and big data analytics.

### **1.2. Blockchain in the supply chain, (the Potentials)**

Supply chains are believed to be one of the next big beneficiaries through applying the technology to increase consumer confidence and quality assurance through, amongst other properties, increased traceability. Supply chain management has become a prime focus for both industry and academia. For industrial players, especially as a consequence of increased global trade and competition [9], cost related to supply chain processes have become a significant share of the overall costs. This process has resulted in increased scientific work in the fields of supply chain strategy and process optimization [10].

The emergence of innovations such as blockchain technology leads to disruptions in both traditional operations and competitive environment [11]. Blockchain technology might be a prime example of such a situation, and it is highly likely that future innovations might grow in complexity and be more challenging to identify as useful in specific industrial settings.

The scientific community has started to give blockchain technology serious attention and nearly a decade after its first appearance, academic work on blockchain technology is beginning to appear in fields besides computer

science and finance, such as supply chain management. This development raises the question if the technology could have been applied to these new fields earlier if decision-makers had a more straightforward way of assessing the strategic fit of blockchain to their specific situation [12].

Underwood (2016) in her report, opined that blockchain is expected to revolutionize industry and commerce and drive economic change on a global scale. She maintained this position based on the attributes of blockchain as immutable, transparent, secure, fast and trustworthy and its potential public or private ownership. Among others, Underwood [13] submitted that blockchain would be beneficial to developing countries, healthcare programs, and supply chain. One of the key benefits in developing countries like Nigeria is the 'Trust element' of the blockchain [13]. Trust element means that supply chain data, information and transactions in developing countries can benefit from the trust attribute of the blockchain technology. The issue around data to support the vaccine supply chain in Nigeria can, therefore, be tamed by with blockchain's reliable data that are reliable, accessible and incorruptible [14].

The blockchain-based supply chain could be more interoperable and simplify the capture and description of events that are written against smart contracts through the supply chain network for visibility and traceability [15]. Maersk and Walmart had respectively used the blockchain technology to track the shipment of their containers and livestock through their intercontinental supply chain [16]. In the supply chain of temperature-sensitive products like vaccines, blockchain holds some potential that would enhance quality. Gemalto has piloted this potential in transporting thermolabile medicines from manufacturers to hospitals [16]

### **Challenges of Blockchain and Big Data Analytics**

Though blockchain is a classic disruptive technology that no industry or society can ignore, it still presents with some challenges [4,13,14]. Therefore, for any industry to benefit from the technology, it must pay attention to how the challenges can be addressed. As identified by Walch [4], some of the regulation-related challenges include; inconsistency, confusing, misleading and hazy vocabulary in blockchain technology. These make regulating the technology complicated as such impeding the adoption of the blockchain [4]. Our survey is therefore addressing strategies to mitigate some of these challenges.

#### **1.3. Going forward**

Blockchain technology is novel to the world's economy, and it as such requires adequate investment for proper adoption [17]. This investment includes purchasing the technology and securing the interest of user/decision-makers with relevant and convincing benefits. A report suggests that blockchain technology could solve some the toughest pharma supply chain problems and up to 83% of top executives interviewed in June 2017 opined that blockchain technology would be adopted in life-science within the next five years [18].

## **2. Methods**

We conducted an electronic survey using an internet-based questionnaire to collect data from different professionals who have good experience of Nigeria supply chain of vaccines. The respondents were drawn from different levels of operation, geography, and areas of practice. At the time of this study, the estimated population size of professionals in Nigeria's development/health public health was above 5000. A number of professionals whose works are related to the supply chain of public health commodities was recruited as the sampling frame in accordance with the method of Easterby-Smith *et al.* [19]. Sample size calculator was used to estimate the expected sample size. At a 95% confidence interval and P-value of 0.05, the estimated sample size was 281 [20].

The questionnaire was shared on the listserv of the IAPHL and other smaller internet-based social network (Whatsapp, Telegram and LinkedIn) and opened for one (1) calendar month after which it was closed to further responses. At the end of one-month time horizon, (December 3, 2017, to January 2, 2018) a total of 200 valid responses were received and the questionnaire closed to further responses using the switch on the Google form. Following this stage, the data were harvested for onward analysis. We improve the response rate by assuring confidentiality and providing a concise introduction to the survey and how responses will affect a smoother supply chain. We also ensured that questionnaires were easy to use and understandable and only took 5-10 minutes of a participant's time. The permission and support of the administrator of the different platforms were also secured to give the process speed and credibility. This approach follows the strategy by Easterby-Smith *et al.* [19]. on how to improve the response rate [19]. The data analysis combined SPSS version 25 and Microsoft Excel. With SPSS, we better managed data with case selection, file reshaping, and creating derived data. A metadata dictionary was stored with the data. Statistical analysis tasks performed with the base package include the generation of descriptive statistics, prediction of numerical outcomes, and prediction of identifying groups.

### **3. Results**

#### **3.1. Background information**

The study comprised 200 valid responses, of which 141 (70.5%) were males, and 59 (29.5%) were females (male: female; 2:1). The most frequent age group was 31 – 40 (113, 56.5%) followed by >40 years (48, 24.0%) while 21 – 30 recorded the least value of 39 (19.5%). Majority of respondents were Health/Public health development professional (81, 40.5%) followed by 52 (26.0%) supply chain professional only, 49 (24.5%) were into the supply chain and health/public health development. There were 8 (4.0%) financial/business and project managers, 7 (3.5%) were regulatory and safety professionals while the IT profession had the least number of 3 (1.5%). Respondents were from various specialties including technical/executive officers (82, 41.0%), middle managers (59, 29.5%), consultants (26, 13.0%), senior managers (25, 12.5%) and regulatory/policymakers (8, 4.0%). Fifty-seven percent of the respondents had maximum of 5 years' experience in Nigeria supply chain/development, 57 (28.5%) had between 6 – 10 years' experience, 26 (13.0%) had between 11 – 20 years' experience while only 3 (1.5%) had more than 20 years' experience in Nigeria supply chain/development (Table 1).

**Table 1: Demographics with professional experience**

Parameter	Frequency	Percentage
<b>Gender</b>		
Male	141	70.5%
Female	59	29.5%
<b>Age category</b>		
21 - 30	39	19.5%
31 - 40	113	56.5%
41 and above	48	24.0%
<b>Profession</b>		
Supply Chain Professional Only	52	26.0%
Health/Public Health/Devt Professional Only	81	40.5%
Supply Chain and Health/Public Health/Devt	49	24.5%
IT professionals Only	3	1.5%
Financial/Business and Project Mgt	8	4.0%
Regulatory and Safety Professionals	7	3.5%
<b>Specialization</b>		
Consultant	26	13.0%
Middle Manager	59	29.5%
Regulatory and Policy Maker	8	4.0%
Senior Manager	25	12.5%
Technical/Executive Officer	82	41.0%
<b>Year of experience</b>		
≤ 5	114	57.0%
6 – 10	57	28.5%
11 – 20	26	13.0%
>20	3	1.5%

### 3.2. Knowledge of supply chain with an awareness of blockchain in supply chain

The knowledge of respondents in the vaccine supply chain and level of awareness of blockchain were examined. All (100.0%) Information Technology (IT) and regulatory and safety professionals had good knowledge of vaccine supply chain, 98.0% of supply chain and health/public health development, 92.3% of supply chain professionals, 91.8% of health/public health/development professional only while the least value of 62.5% was seen among financial/business and project managers. All IT professional had good (100.0%) awareness of blockchain, 85.7% of regulatory and safety professionals, 61.7% of health/public health/development professionals, 71.2% of supply chain professionals, 75.5% of supply chain and health/public health/development professional and 50.0% of Financial/Business and Project management profession had good awareness of the use blockchain in vaccine supply chain.

All consultants (100.0%) had good knowledge of the vaccine supply chain, and 84.6% were aware of the use of blockchain in the vaccine supply chain. Most middle managers (91.5%) had good knowledge of the vaccine supply chain, and 72.9% had a good awareness of blockchain. Regulatory and policymakers had 87.5.0% and 37.5%, senior managers; 92.0% and 72.0% while technical/executive officers had 91.5% and 62.2% good knowledge of vaccine supply chain and a good awareness of blockchain respectively. Knowledge of vaccine supply chain was 92.1% for those who had a maximum of 5 years working experience, 89.5% form 6 - 10 years while all (100%) those who had above 10 years' experience had good knowledge of vaccine supply chain. On the other hand, 62.3% of those who had a maximum of 5 years' experience had a good awareness of blockchain, 73.7% for 6 – 10 years, 80.8% for 11 – 20 years and none for those who had over 20 years' experience (Table 2).

**Table 2: Experience of vaccine supply chain with an awareness of blockchain**

Profession/Experience	Knowledge of Vaccine Supply Chain			Awareness of Blockchain		
	Good Knowledge	Poor Knowledge	p	Good Awareness	Poor Awareness	p
<b>Profession</b>						
Supply Chain Professional Only	48 (92.3%)	4 (7.7%)	<b>0.020</b>	37 (71.2)	15 (28.8%)	<b>0.251</b>
Health/Public Health/Devt Professional Only	74 (91.8%)	(8.6%)				
Supply Chain and Health/Public Health/Devt	48 (98.0%)	1 (2.0%)		37 (75.5%)	12 (24.5%)	
IT professionals Only	3 (100.0)	-		3 (100.0%)	-	
Financial/Business and Project Mgt	5 (62.5%)	3 (37.5%)		4 (50.0%)	4 (50.0%)	
Regulatory and Safety Professionals	7 (100.0%)	-	6 (85.7%)	1 (14.3%)		
<b>Specialization</b>						
Consultant	26 (100.0%)	-	<b>0.644</b>	22 (84.6%)	5 (15.4%)	<b>0.064</b>
Middle Manager	54 (91.5%)	5 (8.5%)				
Regulatory and Policy Maker	7 (87.5%)	1 (12.5%)		3 (37.5%)	5 (62.5%)	
Senior Manager	23 (92.0%)	2 (8.0%)		18 (72.0%)	7 (28.0%)	
Technical/Executive Officer	75 (91.5%)	7 (8.5%)		51 (62.2%)	31 (37.8%)	
<b>Year of experience</b>						
≤ 5	105 (92.1%)	9 (7.9)	<b>0.372</b>	71 (62.3%)	43 (37.8%)	<b>0.114</b>
6 – 10	51 (89.5%)	6 (10.5%)				
11 – 20	26 (100.0%)	-		21 (80.8%)	5 (19.2%)	
>20	3 (100.0%)	-		-	3 (100.0%)	

**3.2. Acceptability and Visibility of Blockchain technology in Nigeria Vaccine Supply Chain**

Participants were surveyed about the acceptability and feasibility of blockchain technology in Nigerian vaccine supply chain. This survey was conceived to overcome the cold chain challenges in the country. Blockchain recorded 100.0% acceptability among IT, Financial/business project management and regulatory and safety professions, 93.9% among supply chain/health/public health development, 92.3% supply chain and 88.9% health/public health development professions. Similarly, the feasibility of blockchain was 100.0% among IT and regulatory/safety professionals, 93.9% for supply chain/health/public health development, 92.3% supply chain, 87.5% Financial/business project management and 84.0% health/public health development professions (Figure 1).

Acceptability of blockchain was 96.2% among consultants, 96.0% from senior managers, 94.9% among middle managers, and 75.0% among regulators and policymakers. Feasibility was also 96.0% among senior managers, 94.9% among middle managers, 92.3% among consultants and 82.9% among technical/executive officers (Figure 2).

For respondents who had more than 20 years of experience, acceptability and feasibility recorded 100.0% each while 11 – 20 (92.0% and 100.0%), 6 – 10 (93.0% and 87.7%) and for ≤5 (91.0% and 87.7%) for acceptability and feasibility respectively (Figure 3).

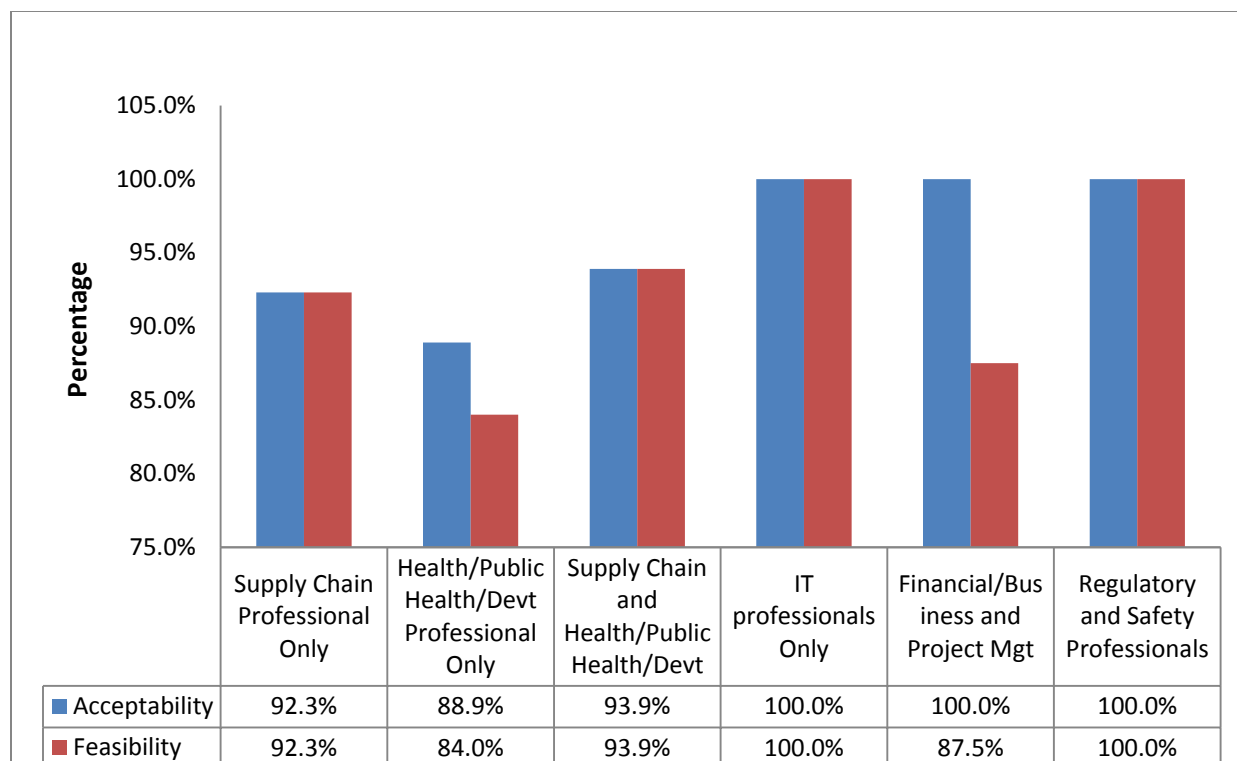


Figure 1: Acceptability and feasibility of blockchain across different professions

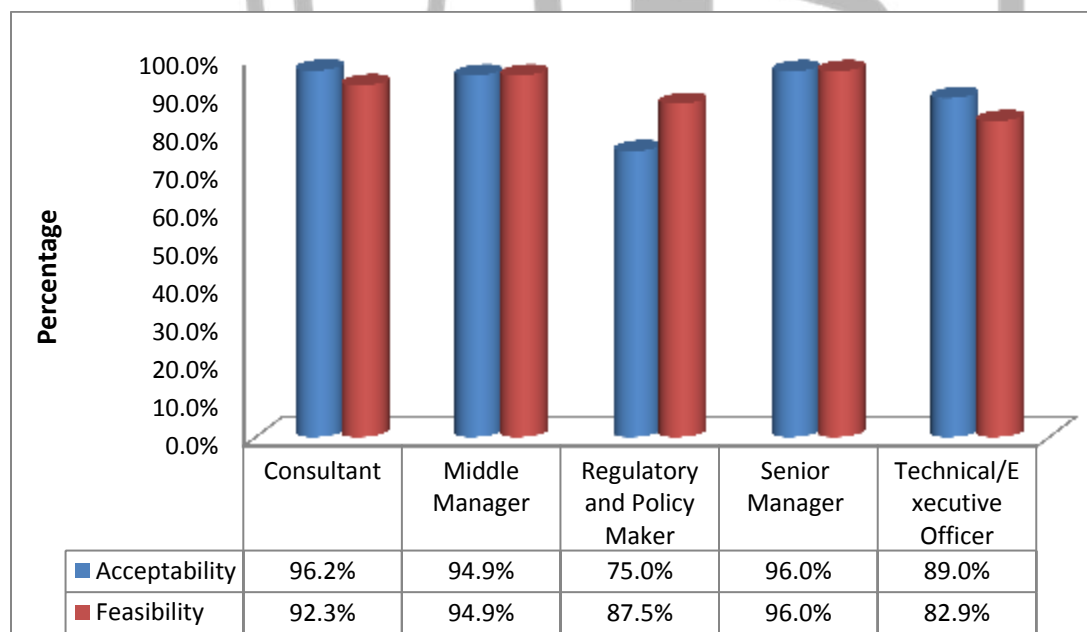


Figure 2: Acceptability and feasibility of blockchain across various specialization

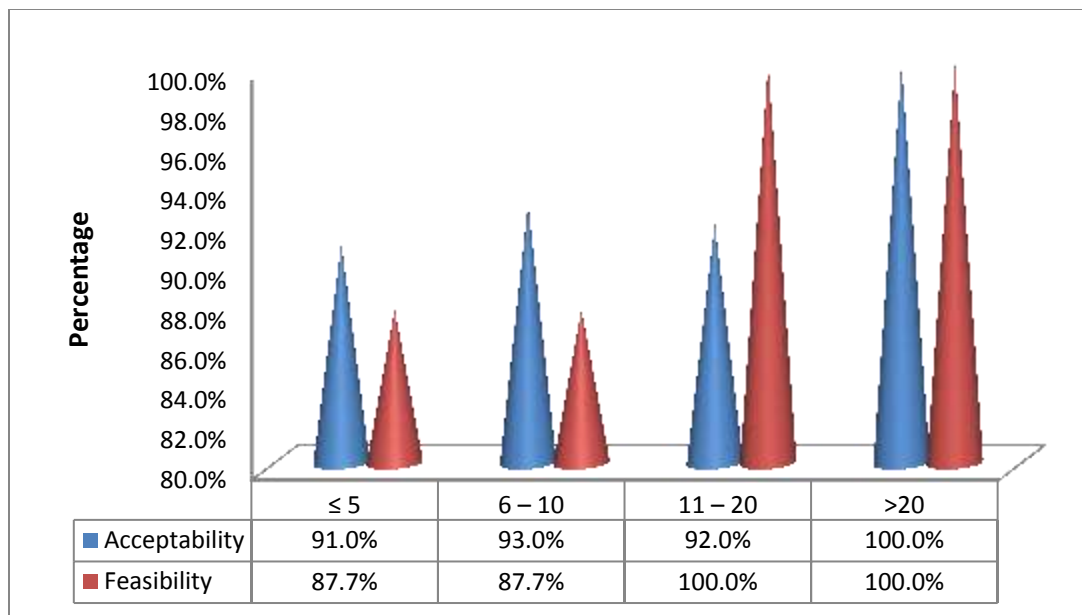


Figure 3: Acceptability and feasibility of blockchain with years of experience

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### 3.3. Preparedness to take up new technological innovations in Nigeria vaccine supply chain

International political will was rated with the highest (96.0%) preparedness to take up new technologies/innovations in Nigeria vaccine supply chain followed by private sector involvement and collaboration (82.0%). Readiness in regulatory and policy was rated 76.5%, workforce know-how 73.0% while the national political will was rated 54.0% (Table 3).

**Table 3: Preparedness to take up new technological innovations in Nigeria vaccine supply chain**

Parameter	Preparedness (%)
Political Will (National)	54.0%
Technical/Technological Infrastructure	60.0%
Workforce/Know-how	73.0%
Regulatory and Policy	76.5%
Private sector involvement and collaboration	82.0%
Political Will (International)	96.0%

### 4.0 Discussion

Blockchain may bring supply chain transparency to a new level, but presently academic and managerial adoption of blockchain technologies is limited by our understanding, for this reason, we carried out this study to assess the acceptability and feasibility of blockchain in Nigeria vaccine supply chain as well as to determine the level of preparedness of Nigeria vaccine supply chain to take up innovations.

Majority of respondents in this study (70.5%) were males, and most were of active age group 31 – 40. Respondents were drawn from various professions including health/public health development professional, supply chain profession, supply chain and health/public health development. Others include financial/business and project management profession, regulatory and safety profession as well as the information technology profession. Respondents' positions include technical/executive officers, middle managers, consultants, and senior managers. The knowledge of respondents on the vaccine supply chain was as high as 100% among all professions. All also had good awareness on the use of blockchain in vaccine supply chain with the least value of 50.0% seen among financial/business and project professionals

Blockchain acceptability was 100.0% among most professions such as IT, financial/business project management and regulatory with minimum acceptability of 88.9% among health/public health development professions. In a similar trend, blockchain was seen to be 100.0% feasible among most respondents. Acceptability and feasibility of blockchain were also very high regardless of respondents' position or year of experience.

The level of preparedness of Nigeria vaccine supply chain to take up innovations/technologies was also very high across all sectors with international political being the highest in rating with (96.0%) preparedness. Other areas of preparedness listed include private sector involvement/collaboration (82.0%), readiness in regulatory and policy, workforce know-how as well as readiness in national political will. Gartner (2016) identified blockchain as one of the vital platform-enabling technologies to track. Nonetheless, while there is currently no standard in the blockchain space, there is a growing consensus that blockchain is entering its peak of inflated expectations. The report anticipated that it would take 5 to 10 years for blockchain technology to get mainstream adoption [21].

Further, most of nowadays blockchain efforts, mainly when applied to business environments, are still in a nascent state [22]. The time is ripe for the database community to get more deeply involved in solving open problems about data management and analytics in a permission blockchain network for business applications [23]. The assertion of Mohan justifies the basis for this research. Our findings revealed that Nigeria vaccine supply chain is ready to adopt blockchain even though Gartner research showed that it would take 5 – 10 years for blockchain to get full adoption. Early adoption blockchain by Nigeria, vaccine supply chain, will benefit the country to get

