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Perception on Cold Chain Service Delivery in Relation to the Service Delivery of COVID-19 Vaccine among Healthcare Workers in Abakaliki, Ebonyi State

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Abstract

The purpose of this study was to explore the perception regarding cold chain service delivery about the service delivery of COVID-19 vaccine among healthcare workers in Abakaliki, Ebonyi State, Nigeria. An exploratory survey approach was used and entailed the collection of quantitative data from forty-five (45) healthcare workers selected from forty-five health centres in fifteen (15) study districts. The findings reveal that a greater number of the respondents have a good knowledge of the usefulness of cold chain practices in managing the logistics system and cold chain supply from the beginning to the end of the process. The respondents perceived efficient cold chain delivery practices to have a significant impact on COVID-19 service delivery hence if strengthened will in turn lead to the availability of high-quality vaccines. A greater number of the respondents perceived inadequate storage facilities or cold chain capacity; transportation delays; absence of other sources of power and lack of dependable transportation as the greatest challenges that affect the cold chain provision of COVID-19 vaccines. Nigeria should sustain its vaccination efforts as an effective way to eliminate the burden of COVID-19 infection by strengthening its supply chain system using evidence-based interventions aimed at revamping and upgrading the cold stores' infrastructures; ensuring regular power supply/providing backup power supply to maintain the quality of vaccines during storage; strengthening inventory management system at the state and local government areas and training/retraining of key officers on supply chain management of COVID-19 vaccine.

Keywords: *Cold Chain, COVID-19, Last-Mile, Pandemic, Service Delivery, Supply Chain, Vaccine.*

Introduction

The COVID-19 infection was declared a global pandemic by the World Health Organisation (WHO) on March 11, 2020 [1]. The outbreak brought political instability, distorted the cultural and social norms and disabled the healthcare systems worldwide [2]. It was one of the greatest disastrous events in latest human history, which greatly influenced the world's economy, overwhelmed the healthcare systems, disrupted the global supply chains [3], and altered people's lifestyles. Over 198 million cases and 4 million deaths were officially confirmed as at August 2021, with a fatality rate of 2.1% [4].

To curtail the pandemic, numerous interventions were established universally. Non-pharmaceutical interventions, which include travel bans, nose mask usage, regular hand washing, social distancing, and lockdowns [5], helped ease the COVID-19 spread globally [6, 7]. However, despite the non-pharmaceutical interventions and to achieve herd immunity, there is a necessity for pharmaceutical interventions like vaccines [8]. Vaccination, the most effective form of public health intervention in curbing the problem of disease spread, helps prevent and eliminate

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contagious diseases and is also effective in reducing the mortality rate of disease [9]. To bring back normal lives, mass vaccination is considered the most effective way to control the disease spread [10] and minimize the associated deaths. The WHO estimates that, by mass vaccination and immunization, approximately two to three million deaths can be prevented [11].

Nigeria commenced it's COVID-19 vaccination program in March 2021 and aligned its objectives with the goals of the global COVID-19 eradication program of vaccinating 40% and 70% of the population by the end of 2021 and 2022, respectively [12]. Only 15% of the Nigerian populace had received a complete vaccination as of 21 September 2022 [12]. The low rate of vaccination is as a result of the challenges encountered in the vaccination program, including inadequate cold chain management, mistrust in the government, and communication breakdown in the course of running the program [12]. This largely has had effects generally on the achievements of the vaccination program [12].

Accessibility of vaccines globally relies on the transportation of doses to the last mile through distribution chains, uncompromised quality controls, multifaceted production processes, and availability of raw materials [4]. The efficacy depends not only on the supply chain that distributes the final product but also on all the supply chains that support the whole manufacturer [4].

In the health setting, a cold chain is a temperature-controlled supply chain, with procedures and rules that ensure the proper storage and distribution of vaccines to national and local health services. Also, the cold chain is important given that most of the vaccines must be at a specific temperature from manufacture to its vaccination point to maintain it's expected efficacy and safety (Peter et al., 2023, Introduction Section, Para 1 & 2) [4]. The cold chain aims to maintain vaccines in proper conditions during transport, storage, and distribution until the moment of dose administration at the last-mile stage. Reference [13] defined the last mile stage – vaccine administration as the final stage of the delivery process, often being the most expensive and least efficient supply chain segment. The final stage is very important for the supply chain as it involves providing the product to the end user in a medically compliant way (Peter et al., 2023, "COVID-19 Vaccines Supply Chain", Section) [4].

One of the major targets of the United Nations' third Sustainable Development Goals (SDG), is to ensure access to safe, effective, quality, and affordable essential medicines and vaccines, for all [14]. This target is critical to achieving universal healthcare coverage just as effective health product supply chains are indispensable in ensuring access to quality medicines and vaccines [15]. The availability of high-quality vaccines, health products and medicines at the service delivery points and in a timely and cost-effective manner is assured by the supply chain of health products [16] as cited in Olutuase et al., 2022). The mainstay of quality healthcare services is a functional health product supply chain system [17]. It not only guarantees the delivery of appropriate health products to the end-users, but also ensures that health system designers receive critical information on the need, demand, and consumption of products, thereby, contributing to better service delivery [17]. Though, the importance of supply chain management is widely recognized, access to quality essential medicines in developing countries including Nigeria continues to be a challenge [17]. Nigeria has implemented some strategies to mitigate some of these challenges and improve the efficiency of medicines supply chains [17]. However, the supply chain system remains weak and inefficient despite these strategies [17].

Vaccine supply chain is a network of activities involved in implementing vaccines

from the procurement stage. It includes proper management of vaccine inventory, cold chain, transportation, training of the healthcare workers and adequate management of vaccine distribution [18]. The main goal is to ensure that high-quality vaccines are always available between producers and the service provision points so that vaccination opportunities are not missed due to non-availability [19].

The COVID-19 vaccine cold chain is complex and highly challenging, mainly due to the global-scale demand [4]. Also, the immunization process is confronted with challenges in production, distribution, and even the acceptance of the vaccine which emerged as barriers to the process [4].

This study is an exploratory survey aimed at reviewing the perceptions of stakeholders on cold chain practices in COVID-19 service delivery and the challenges that are related to the cold chain delivery of COVID-19 vaccines. Assessment of perceptions in a study is a way of getting useful insights from stakeholders whose experiences might include both positive and negative feedback that are needed both for growth and improvements. It is a way of getting honest feelings, opinions, and thoughts as well as vital facts from the stakeholders thus, they are valuable in the designing of policies and strategies. The findings of this study will enhance the development of evidence-based guidelines and interventions to strengthen the COVID-19 vaccine delivery system to ensure availability of quality vaccines.

Literature has it that one of the effective ways for the prevention of the disease is through vaccination [19]. Hence, vaccination is taken by millions of people to prevent diseases [19]. Vaccine supply chain involves manufacturing, storage, packaging, cold chain transit, domestic and global shipping, distribution strategies and storage [19]. Vaccine supply chain also depends on individuals' attitude towards vaccination and Government plays a very key role both on the supply and demand sides [19].

For immunization programmes to be successful, they have to be built on a well-ordered supply chain and logistics systems as shown in Fig. 1 [20]. These systems enable efficacious vaccine storage, distribution, handling, and management as well as ensure strong temperature control in the cold chain. It leverages logistics management information systems to promote robust and efficient system performance. The main goal is to ensure constant availability of quality vaccines from the manufacturer to the service-delivery points so that opportunities to vaccinate are not missed because vaccines are not available [20].

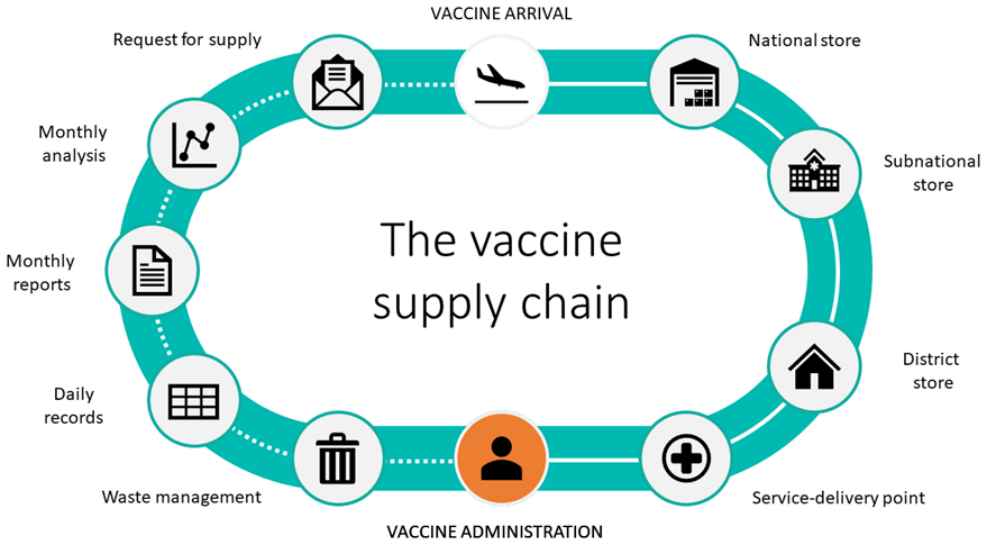

Fig 1. Vaccine Supply Chain. Adapted from: WHO, 2022 [20]

Delivering vaccines to all corners of the world is a complex undertaking. It takes a chain of precisely coordinated events in temperature-controlled environments to store, manage and transport these life-saving products (UNICEF) [21]. This according to UNICEF is called a cold chain.

UNICEF noted that vaccines must be continuously stored in a limited temperature range - from the time they are manufactured until the moment of vaccination. This is because extreme (too high or too low) temperatures can cause the vaccine to lose its ability to protect against disease and this cannot be regained or restored once it is lost (UNICEF, "What is a Cold Chain", para 1 &2) [21].

Equipment used for storing and transporting vaccines such as cold rooms, refrigerators, freezers, cold boxes and vaccine carriers must conform with the World Health Organization (WHO) performance standards. Also, stock management procedures for each type of vaccine must follow WHO guidelines (UNICEF, para 5) [21].

Methods and Materials

A structured questionnaire (*Adapted from Danso, 2021*) [22] was used to gather quantitative data from healthcare workers on the objectives of the study. The sample for the healthcare worker's questionnaire was forty-five (45) participants selected from forty-five health centers in the fifteen (15) study districts in the ratio of three (3) health centers per district. Other inclusion criteria were that the persons must be a healthcare worker from a Primary Health Centre in the 15 selected districts and be willing to participate in the survey and must be willing to sign informed consent. This helped to ensure adequate representation of every health center in the selected study area.

Direct questionnaire administration was adopted. The perspectives of the respondents regarding COVID-19 vaccination supply chain system was measured in three layers using the perceptions of healthcare workers on cold chain practices in COVID-19 service delivery, impacts of efficient cold chain practice on COVID-19 service delivery and challenges that are related with the cold chain delivery of COVID-19 vaccines. Their responses were graded on a 5-point Likert Scale. Data collected was analyzed using frequency distribution tables and percentages. The entire study lasted for twelve weeks from April to June 2023.

Results

Forty-five (45) questionnaires were distributed to the healthcare workers with a return rate of 100%. Of the forty-five (45) participants who responded to the questionnaire, 25 (55.6%) were males, and 20 (44.4%) were females. The socio-demographic profile of the respondents is shown in Table 1 below.

Table 1. Socio-demographic Profile of Respondents (Healthcare Workers) n = 45

	Male	**Female**	**Total**
	n =25 (55.6%)	n = 20 (44.4%)	n = 45
Occupation			
Nurse	0 (0%)	8 (100%)	8 (17.8%)
Midwife	0 (0%)	12 (100%)	12 (26.7%)

Cold Chain Officer	23 (92%)	2 (8%)	25 (55.5%)
Years of Experience			
Less than 5 years	0	0	0
5-10 years	2 (40%)	3 (60%)	5 (11.1%)
11-15 years	12 (66.7%)	6 (33.3%)	18 (40%)
16 – 20 years	10 (52.6%)	9 (47.4%)	19 (42.2%)
Over 20 years	1 (33.3%)	2 (66.7%)	3 (6.7%)
Educational Attainment			
Higher National Diploma (HND)	0 (0%)	7 (100%)	7 (15.6%)
Bachelor's Degree	24 (64.9%)	13 (35.1%)	37 (82.2%)
Masters	1 (100%)	0 (0%)	1 (2.2%)
PhD	0 (0%)	0 (0%)	0 (0%)
Knowledge of Cold Chain Delivery System			
Yes	25 (55.6%)	20 (44.4%)	45 (100%)
No	0 (0%)	0 (0%)	0 (0%)

Source: adapted from Danso, 2021

The Table 1 shows that the male respondents (25 [55.6%]) were slightly more than the female (20 [44.4%]) respondents. The occupation of the respondents shows that 25 (55.5%) were Cold Chain Officers, 12 (26.7%) respondents were Midwives, and 8 (17.8%) respondents were Nurses. For years of experience, it revealed that 19 (42.2%) respondents were ages 16-20 years, 18 (40%) were ages 11-15 years 5 (11.1%) and 3 (6.7%) of respondents had 5-10 years and over 20 years of experience respectively. Educational attainment showed that a greater number of the respondents (37 [82.2%]) attained bachelor's degree, 7 (15.6%) attained higher national diploma and 1 (2.2%) had master's degree. On knowledge of Cold chain delivery system, all (100%) the respondents had knowledge.

Perception on Cold Chain Practices in COVID-19 Service Delivery

The perceptions on cold chain practices in COVID-19 service delivery were measured from the respondents' experiences on how useful the cold chain practices are in managing the cold chain delivery system in their workplaces. Other dimensions measured were their opinions on the impacts of efficient cold

chain practice on COVID-19 service delivery and challenges that are related with the cold chain delivery of COVID-19 vaccines.

On cold chain practices in COVID-19 service delivery, Table 2 above shows that 100% of the respondents agreed on the following practices as being useful in cold chain delivery system: Use of temperature logging charts; Training of staff in cold chain; Use of inventory book for cold chain; Supervision and monitoring; Timely maintenance of cold chain equipment; Presence of cold chain officers; Presence of emergency power supply; Use of appropriate refrigeration (storage) equipment; Adequate storage capacity; Storage of products at required temperatures; Presence of backup equipment for emergency; Use of the principle of earliest expiry first out (EEFO) and Use of requisition forms for ordering and reporting. In the same vein, all the respondents (100%) disagreed that storing medical products with non-medical products is a useful practice.

Table 2. Perspectives on Cold Chain Practices Usefulness in Cold Chain Delivery System. n = 45

Cold Chain Practices	**Responses (Useful)**				
	Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
Use of temperature logging charts	0 (0%)	0 (0%)	0 (0%)	30 (66.7%)	15 (33.3%)
Training of staff in cold chain	0 (0%)	0 (0%)	0 (0%)	45 (100%)	0 (0%)
Use of inventory book for cold chain	0 (0%)	0 (0%)	0 (0%)	40 (88.9%)	5 (11.1%)
Supervision and monitoring	0 (0%)	0 (0%)	0 (0%)	31 (68.9%)	14 (31.1%)
Timely cold chain equipment maintenance	0 (0%)	0 (0%)	0 (0%)	41 (91.1%)	4 (8.9%)
Storing medical products with non-medical products	11 (24.4%)	34 (75.6%)	0 (0%)	0 (0%)	0 (0%)
Use of fridge tags or functional thermometers	0 (0%)	21 (46.7%)	20 (44.4%)	4 (8.9%)	0 (0%)
Presence of cold chain officers	0 (0%)	0 (0%)	0 (0%)	32 (71.1%)	13 (28.9%)

Possession of policies, procedures and guidelines on cold chain	0 (0%)	8 (17.8%)	0 (0%)	34 (75.5%)	3 (6.7%)
Presence of emergency power supply	0 (0%)	0 (0%)	0 (0%)	38 (84.4%)	7 (15.6%)
Use of appropriate refrigeration (storage) equipment	0 (0%)	0 (0%)	0 (0%)	42 (93.3%)	3 (6.7%)
Adequate storage capacity	0 (0%)	0 (0%)	0 (0%)	39 (86.7%)	6 (13.3%)
Storage of products at required temperatures	0 (0%)	0 (0%)	0 (0%)	45 (100%)	0 (0%)
Presence of backup equipment for emergency	0 (0%)	0 (0%)	0 (0%)	45 (100%)	0 (0%)
Use of the principle of earliest expiry first out (EEFO)	0 (0%)	0 (0%)	0 (0%)	33 (73.3%)	12 (26.7%)
Use of requisition forms for ordering and reporting	0 (0%)	0 (0%)	0 (0%)	45 (100%)	0 (0%)
Regular cleaning and defrosting of refrigerator ice	9 (20%)	21 (46.7%)	10 (22.2)	5 (11.1%)	0 (0%)

Source: adapted from Danso, 2021

On use of fridge tags or functional thermometers, 21 (46.7%) respondents disagreed on its usefulness, closely followed by the respondents who had no opinion on the issue - 20 (44.4%) and those that agreed with the issue 4 (8.9%). Similarly, a greater number of the respondents (30 [66.7%]) disagreed that regular cleaning and defrosting of refrigerator ice is useful in managing the cold chain delivery system, 10 (22.2%) respondents had no opinion on the issue and 5 (11.1%) respondents agreed. On possession of policies, procedures and guidelines on cold chain, 34 (75.5%) respondents out of the 45 agreed on the issue while 8 (17.8%) disagreed.

The implication of the above findings is that a greater number of the respondents have a good knowledge of the usefulness of cold chain practices in managing cold chain delivery,

however, there still exists gaps in the areas of storage and equipment maintenance.

Perceptions on Impacts of an Efficient Cold Chain Delivery Practice on Covid-19 Service Delivery

On impacts of efficient cold chain delivery practice on COVID-19 service delivery, Table 3 above shows that all (100%) the respondents agreed on the following statements as impacts of an efficient cold chain delivery on COVID-19 service delivery: Reduced patient waiting time; Increased vaccination coverage; Increased responsiveness; Reduced risk of a long-term potential outbreaks of diseases; Optimal use of healthcare resources; Patient satisfaction; Adequate stock of pharmaceutical products; Enhanced performance or efficiency and Improved healthcare services. On reduced mortality rates as an impact of an efficient cold chain delivery practice on COVID-19 service delivery, 43 (95.6%) respondents out of the 45 agreed on the statement while 2 (4.4%) had no opinion on the issue. Similarly, 39 (86.7%) respondents agreed that reduced wastage of cold chain products is an impact, and 6 (13.3%) respondents had no opinion. On cost-effective delivery of COVID-19 service as an impact of an efficient cold chain delivery practice on COVID-19 service delivery, 28 (62.2%) respondents agreed with the statement, 12 (26.7%) respondents disagreed, and 5 (11.1%) respondents had no opinion on the statement.

The implication here is that the respondents perceive efficient cold chain delivery practices to have significant impact on COVID-19 service delivery. It can be interpreted to mean that the efficacy of COVID-19 service delivery is dependent on an effective cold chain system.

Table 3. Opinions on Impacts of an Efficient Cold Chain Delivery Practice on COVID-19 Service Delivery. n = 45

Impacts	**Responses**				
	Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
Reduced mortality rates	0 (0%)	0 (0%)	2 (4.4%)	43 (95.6%)	0 (0%)
Reduced patient waiting time	0 (0%)	0 (0%)	0 (0%)	45 (100%)	0 (0%)
Increased vaccination coverage	0 (0%)	0 (0%)	0 (0%)	41 (91.1%)	4 (8.9%)
Increased responsiveness	0 (0%)	0 (0%)	0 (0%)	44 (97.8%)	1 (2.2%)
Cost-effective delivery of COVID-19 service	0 (0%)	12 (26.7%)	5 (11.1%)	28 (62.2%)	0 (0%)
Reduced wastage of cold chain products	0 (0%)	0 (0%)	6 (13.3%)	39 (86.7%)	0 (0%)
Reduced risk of a long-term potential outbreaks of diseases	0 (0%)	0 (0%)	0 (0%)	40 (88.9%)	5 (11.1%)

Optimal use of healthcare resources	0 (0%)	0 (0%)	0 (0%)	45 (100%)	0 (0%)
Patient satisfaction	0 (0%)	0 (0%)	0 (0%)	42 (93.3%)	3 (6.7%)
Adequate stock of pharmaceutical products	0 (0%)	0 (0%)	0 (0%)	45 (100%)	0 (0%)
Enhanced performance or efficiency	0 (0%)	0 (0%)	0 (0%)	37 (82.2%)	8 (17.8%)
Improved healthcare services	0 (0%)	0 (0%)	0 (0%)	35 (77.8%)	10 (22.2%)

Source: adapted from Danso, 2021

Perceptions on Challenges that are Related with the Cold Chain Delivery of Covid-19 Vaccines

Perceptions of COVID-19 cold chain delivery challenges were measured with the respondents' opinions and knowledge regarding statements on challenges that are related to the cold chain delivery of COVID-19 vaccines in Nigeria.

On challenges that are related to the cold chain delivery of COVID-19 vaccines that affect service provision, Table 4 above reveals that all the respondents (100%) agreed that the following are the challenges that are related to the cold chain delivery of COVID-19 vaccines that affect the service provision: Inadequate storage facilities or cold chain capacity; Inadequate temperature control systems; Erratic electric power supply; Lack of current technology or 'optimal' equipment; Inadequate financing; Transportation delays; Absence of other sources of power; and Lack of dependable transportation. On non-uniformity in storage temperature guidelines on labels, a greater number of the respondents 42 (93.3%) disagreed with it being a challenge related to cold chain delivery and 3 (6.7%) were undecided. In the same vein, on the absence of trained personnel and lack of information/consumption data as challenges 41 (91.2%) and 63 (95.6%) respondents disagreed while 4 (8.9%) and 2 (4.4%) respondents were undecided respectively.

Table 4. Challenges that are Related to Cold Chain Delivery of COVID-19 Vaccines. n = 45

Challenges	**Responses**				
	Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
Lack of a comprehensive list of cold chain materials and equipment	0 (0%)	36 (80%)	5 (11.1%)	4 (8.9%)	0 (0%)
Inadequate storage facilities or cold chain capacity	0 (0%)	0 (0%)	0 (0%)	41 (91.1%)	4 (8.9%)

Inadequate temperature control systems	0 (0%)	0 (0%)	0 (0%)	39 (86.7%)	6 (13.3%)
Erratic electric power supply	0 (0%)	0 (0%)	0 (0%)	8 (17.8%)	37 82.2%
Non-uniformity in storage temperature guidelines on labels	5 (11.1%)	37 (82.2%)	3 (6.7%)	0 (0%)	0 (0%)
Lack of current technology or 'optimal' equipment	0 (0%)	0 (0%)	0 (0%)	26 (57.8%)	19 (42.2%)
Inadequate financing	0 (0%)	0 (0%)	0 (0%)	38 (84.4%)	7 (15.6%)
Absence of trained personnel	7 (15.6%)	34 (75.6%)	4 (8.9%)	0 (0%)	0 (0%)
Transportation delays	0 (0%)	0 (0%)	0 (0%)	42 (93.3%)	3 (6.7%)
Equipment failure	3 (6.7%)	5 (11.1%)	2 (4.4%)	34 (75.6%)	1 (2.2%)
Lack of information/consumption data	0 (0%)	43 (95.6%)	2 (4.4%)	0 (0%)	0 (0%)
Poor supervision and monitoring of cold chain service delivery	0 (0%)	2 (4.4%)	3 (6.7%)	39 (86.7%)	1 (2.2%)
Absence of other sources power	0 (0%)	0 (0%)	0 (0%)	41 (91.1%)	4 (8.9%)
Lack of appropriate cold chain equipment	0 (0%)	0 (0%)	3 (6.7%)	37 (83.2%)	5 (11.1%)
Shortage of trained service providers	0 (0%)	8 (17.8%)	2 (4.4%)	32 (71.1%)	3 (6.7%)
Lack of dependable transportation	0 (0%)	0 (0%)	0 (0%)	45 (100%)	0 (0%)

Source: adapted from Danso, 2021

On poor supervision and monitoring of cold chain service delivery, a greater number of the respondents 40 (88.9%) agreed, 3 (6.7%) had no opinion and 2 (4.4%) disagreed. Similarly, 35 (77.8%) respondents agreed to shortage of trained service providers and equipment failure as challenges, 8 (17.8%) disagreed and 2 (4.4%) respondents maintained that they did not have any opinion. On lack of a comprehensive list of cold chain materials, a greater number 36 (80%) disagreed to it being a challenge, 5

(11.1%) respondents were neutral and 4 (8.9%) agreed.

The findings imply that many challenges exist that affect the cold chain delivery of COVID-19 vaccines as professed by the respondents. This can be interpreted to mean that systemically, COVID-19 vaccine management is a challenge which affects COVID-19 service delivery and uptake of vaccines.

Discussion

Perception of Cold Chain Practices in COVID-19 Service Delivery

A greater number of the respondents have a good knowledge of the usefulness of cold chain practices in managing cold chain delivery. Generally, the ratings for all the listed cold chain practices were high with 100% ratings for training of staff in cold chain; storage of products at required temperatures; presence of backup equipment for emergencies; and inventory management. This finding supports the statement that COVID-19 vaccines require a special supply cold chain and logistics system from the beginning to the end of the process [20]. These systems ensure effective vaccine storage, distribution, handling, and management as well as leverage logistics management information systems to promote effective system performance. The ultimate goal of efficient system performance is to ensure continuous availability of quality vaccines from the producer to the service-delivery points [20]. Therefore, for a successful vaccination program, a functional and resilient vaccine supply chain is vital so that opportunities are not missed because vaccines are not available [2, 20].

Perceptions on Impacts of an Efficient Cold Chain Delivery Practice on Covid-19 Service Delivery

Findings from respondents' knowledge on statements as impacts of an efficient cold chain delivery practice on COVID-19 service delivery show that the respondents perceive efficient cold chain delivery practices to have a significant impact on COVID-19 service delivery. This goes to imply that supply chain systems if strengthened will in turn lead to the availability of high-quality vaccines. Hence, will help to ensure that adequate vaccines are available at all times which might increase the trust of the masses and may also lead to increased uptake of the vaccines.

Perceptions of Challenges that are Related to the Cold Chain Provision of COVID-19 Vaccines

The findings here from the respondents' perceptions on statements on challenges that are related to the cold chain provision of COVID-19 vaccines show that many challenges exist that affect the process. A greater number of the respondents perceived inadequate storage facilities or cold chain capacity; transportation delays; absence of other sources of power and lack of dependable transportation as the greatest challenges. These findings point to the storage and logistics of vaccines to the end-users as major challenges. These two issues are major pointers to the availability of vaccines and eventual uptake by the general public. This is in consonant with the findings from a scoping study [2], which found that concerns exist that the requirements for recipient countries to maintain deep-freeze production, storage and transportation networks, especially for the Pfizer vaccines, will reduce the ability of suppliers from taking the vaccine to low and middle-income countries. It goes further to state that, 'successful distribution of vaccines to remote areas is a function of the mechanisms in place to prevent obvious exposure to many stresses such as temperature, light, and agitation that may result in loss of vaccine efficacy. Delivering temperature-sensitive biological products to the public is faced with obstacles like warm climate and poor intercity-connectivity. For example, in Peru, 30 ultra-

cold freezers existed, but none outside of Lima city. These specialized freezers take 4 - 6 weeks to be produced and the cost of production will be between $10,000 and $25,000. One of the proposed solutions, therefore, is to fill the containers with dry ice every 5 days to keep temperatures stable although this is not a practical solution as dry ice may be scarce in rural areas. Transporting dry ice, which sublimates and changes to carbon dioxide gas, is costly and dangerous' (Fahmi et al., 2022, "Equitable Access and Public Health Policy", Section) [2].

Conclusion

The Nigerian government has rolled out containment and mitigation measures in response to COVID-19 infection. However, the adequacy of these measures needs to be examined further. This study reveals that for the country to sustain its vaccination efforts as an effective way to eliminate the burden of COVID-19 infection depends on an efficient supply chain system. Nigeria needs to strengthen its supply chain system using evidence-based interventions aimed at:

1. Revamping and upgrading of the cold stores infrastructures at the States and Local Government Areas.
2. Ensuring regular power supply/providing back-up power supply to maintain the quality of the vaccines during storage thereby increasing trust of the general public on its efficacy.
3. Strengthening inventory management system at the States and Local Government Areas and training/retraining of key officers on COVID-19 vaccines supply chain including temperature logging, real-time monitoring and reporting of temperature to maintain warehouse and vaccine quality.

Conflict of Interest Declaration

There is none to declare.

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