Reports

Towards effective and efficient COVID-19 vaccination in Nigeria

Oluwafemi T Oyadiran[1], Shamsudeen A Usman[2], Moyosoore E Osoba[2], Sarah O Olukorode[3], Don E Lucero-Prisno III[4]

[1] Medical Research Council Unit, The Gambia, London School of Hygiene and Tropical Medicine, Fajara, The Gambia, [2] St. Nicholas Hospital, Lagos, Nigeria, [3] Lagos State University College of Medicine, Lagos, Nigeria, [4] University of Ilorin Teaching Hospital, Ilorin, Nigeria

Keywords: covid-19, cold-chain, nigeria, vaccination

https://doi.org/10.29392/001c.21404

Journal of Global Health Reports

Vol. 5, 2021

Vaccines are prospective subverts in battling the COVID-19 virus ravaging the globe and the Nigerian cold-chain system needs a thorough overhaul in order to optimize vaccine distribution. This paper presents a situational analysis of the Nigerian cold chain system, the challenges and opportunities that exist. The problems plaguing the aforementioned system are diverse, ranging from lack of infrastructure, inadequate capacity and limited integration of recent technology to poor training of workers in the cold chain system and these problems are accentuated by the storage peculiarities of the Pfizer and Moderna COVID-19 vaccines. It also compares the capabilities of cold chain workers in the various geopolitical zones in Nigeria and gives a succinct insight into the situation of the cold chain system in neighbouring African countries. Additionally, measures to mitigate the devastating effects of the defective cold-chain system and facilitate effective and efficient distribution of the vaccines are also proffered and these measures include reorganization of the supply chain, training of vaccinators and technicians, accurate estimation of future needs and procurement of infrastructure to increase storage capacity and preserve the cold chain. Finally, it offers recommendations on COVID-19 vaccine procurement in consistence with our economic realities and distribution.

Although little is known about vaccination in West Africa before the colonial era, research showed the involvement of colonial doctors in introducing vaccines to Africa. With the help of their European counterparts, they built laboratories called Pasteur Institutes for vaccine production.[1]

Inasmuch as vaccination began in Nigeria during the colonial era, the World Health Organization (WHO) formally created the Expanded Program on Immunization (EPI) in Africa in 1974 with the aim of eradicating six diseases: polio, measles, diphtheria, pertussis, tuberculosis, and tetanus. In 1978, Nigeria's EPI was created by the World Health Organization (WHO) with the aim of providing vaccines against the six aforementioned diseases for children aged 0-2 years. This intervention's coverage peaked in the early 1990s reaching 81.5% of Nigeria's children population.[2]

The Nigerian government changed the EPI to the National Programme on Immunization (NPI) in 1996 to show its dedication to the programme. Eventually, the NPI was merged with the National Primary Health Care Development Agency (NPHCDA) in 2007, the agency in charge of primary health care (PHC). Nigerians are vaccinated according to the NPI schedule and are expected to have completed the schedule by the age of one. Additionally, house-house polio campaigns are held in order to maintain a polio-free status.

COLD-CHAIN SYSTEM IN NIGERIA

Vaccine cold-chain management is essential for vaccine transportation and storage in a potent state from the manufacturer to the point of use. This requires suitable cold chain infrastructure, compliance with standards, and effective management. In most countries, the vaccine cold-chain system consists of cold rooms, freezers and ice-lined refrigerators, cold boxes, vaccine carriers, ice packs and personnel. Distribution of vaccines in Nigeria would follow the political divisions of the country. Nigeria consists of six geopolitical zones further divided into a Federal Capital Territory and thirty-six states which are further divided into 774 local government areas (LGA). The cold-chain system of the country is made up of five strata; the National Strategic Cold Store (NSCS) which is the primary storage site for all vaccines in the country, six zonal stores located in each geopolitical zone in the country receive supplies from the NSCS, state stores receive supplies from zonal stores, LGA stores receive vaccines from their state store and the PHC centers get supplies from LGA store.[3]

CHALLENGES OF THE COLD-CHAIN SYSTEM

POOR INFRASTRUCTURE

With the persistent increase in population, onset of new diseases, advent of novel vaccines and breakdown of cold chain equipment (CCE), the current cold chain capacity is bound to be insufficient. Findings suggest that Nigeria currently has a cold chain capacity of $201m^2$ and needs a total capacity of $672m^2$ to meet up with demands. Hence, there is a 70% deficit of the routine maximum demand.[3] With reference to the ultra cold chain capacity of Nigeria, Dr

Faisal Shuaib, the Executive Director of the National Primary Healthcare Development Agency, disclosed during a tour of the National Strategic Cold Store (NSCS) in Abuja that the NSCS has three ultra-cold chain equipment which have a combined capacity of 2100 litres; operate at a temperature of -85°C and can store up to 400,000 doses of the Pfizer vaccine.[4]

Additionally, with the current design of the Nigerian cold chain system and possession of 6340 CCE as against the 9565 CCE needed to achieve coverage in every ward in the country, there is a CCE gap of 3225; an overt deficit that negatively impacts vaccination coverage.[3] Also, it was reported that in some facilities in Ile-Ife, equipment needed to maintain the cold chain were lacking as only 37.1% had thermometers, 31.4% had refrigerators for storing vaccines, 45.7% had cold boxes and only 20% had emergency trays. Furthermore, electricity and water supply were available in only 31.4% and 45.7% of the facilities respectively.[5] Findings from a study done in Oyo revealed that epileptic power supply and absence of generator fuel were the major challenges faced in storage facilities while others were insufficient backup refrigerators and cold boxes, poor temperature monitoring tools among others.[6]

The efficiency of the cold chain system has also been deterred by the use of dated equipment, limited integration of technology as many facilities still make use of stem thermometers while continuous temperature trackers and loggers as well as temperature-sensitive alarms are generally lacking at storage sites. Hence, out-of-range temperature may often go undetected when the monitors are not on site and this culminates in poor temperature monitoring and control and reduced potency of vaccines.[6]

SUBPAR TRAINING OF COLD CHAIN WORKERS

Human resource is integral to the proper functioning of the cold chain and the capabilities of the workers in this system will invariably have an impact on its efficiency and effectiveness. There is an important association between regular training and awareness of vaccine storage by health workers. A study carried out among vaccinators in Benin, Southern Nigeria revealed that 29.2% had received no training in cold chain management, 22.1% of respondents did not store vaccines under appropriate conditions, 64.9% had bad cold chain monitoring practices, and 64.2% had bad practice of storing heat-sensitive vaccines.[7] These findings are similar to those found in a study conducted among 457 Primary Health Care Workers in Kwara, North Central Nigeria, where about half (52.1%) of the respondents knew the optimal vaccine storage temperature, most (67.8%) of the participants were aware of the shake test but only 48.8% of them knew how to conduct it. Though 58.4% knew the VVM stages, only 45.3% could interpret it correctly.[8] A similar study conducted in Giwa, Kaduna, a state in Northwestern Nigeria to evaluate the knowledge, attitude and practice of cold chain management among primary health care workers found that majority (71.8%) of the respondents knew the right temperature range for which vaccines should be stored. However, only 3.8% had good knowledge of cold chain management. While most respondents (78.5%) showed a positive attitude towards cold chain management, about half (51.3%) had appropriate practice.[9]

Another study conducted in 35 immunization clinics in Ile-Ife, Southwest Nigeria, showed that only 54% of vaccinators were aware of the shake test, only 19% could interpret colour changes on a vaccine vial monitor and just 29% of respondents kept record of vaccine stock-on-hand.[5]

DIFFICULTY TRANSPORTING VACCINES TO ENDPOINTS

Availability of potent vaccines in sufficient quantity to the end users is crucial to the success of the cold chain. However, there are areas that are difficult to reach due to unnavigable terrain, poor access roads and distance to storage sites.[10] Individuals in hard-to-reach areas consequently have low vaccination coverage. A study revealed that over one-third of polio in 2013 were from under-immunized and hard-to-reach areas and vaccine coverage in some of these areas was as low as 23% for Oral Polio Vaccine 3 and 22% for Pentavalent vaccine 3.[11] Although transportation from national to state stores is quite reliable, there are numerous breakdowns in the supply chain from local cold stores to endpoints.

These unacceptable indices aren't peculiar to Nigeria. Drawing comparisons with Ghana, a study carried out in a rural district in Ghana revealed an average score of 60%, 32%, 27%, 53% and 16% in the areas of temperature control, stock management, distribution, vaccine management and information system respectively.[12] Similarly, exposure of vaccines to out-of-range temperature is a widespread problem in Cameroon as studies conducted in forty health facilities located in 8 districts in Cameroon revealed that only 52.5% (21 of 40 facilities), 20.6% (7 of 34 facilities) had at least one freezer and constant power supply respectively while almost 27.5% of the health facilities were conducting EPI activities without any cold chain equipment.[13] Similarly, a study conducted in 94 health centres in the Central Region in Togo revealed that approximately 30% of these facilities lacked refrigerators for storing vaccines while 19% had refrigerators were out damaged or out of commission.[14] Overall, there is limited progress in achieving universal access to immunization in sub-Saharan Africa as only 13% of countries in the region achieved 80% coverage in each district in 2015 and in 2016, only 19% of the countries supported by the Global Alliance for Vaccines and Immunization met the WHO's 80% benchmark for effective vaccine management.[15]

STORAGE PECULIARITIES OF COVID-19 VACCINES

The advent of the COVID-19 vaccines have ushered in a ray of hope in dealing with this deadly pandemic. However, low- and middle-income countries (LMIC) such as Nigeria need to figure out how to protect its teeming population and meet up with the storage requirements of the vaccines.

The Pfizer and Moderna vaccines were designed with mRNA technology that requires intensely cold storage to elongate shelf-life. The Pfizer variant requires storage at -70°C ± 10°C for up to ten days unopened and on getting to its point of use, it can either be stored in ultra-low temperature freezers for up to six months, in thermal shippers for up to 30 days whilst refilling with dry ice every five days and regular hospital refrigeration units at 2-8°C for up to five days. Once thawed or refrigerated under 2-8°C, the vaccine cannot be refrozen.[16] On the other hand, the Moderna variant can be stored at -20°C for up to six months, 2-8°c for up to 30days within the six-month shelf life after thawing and at room temperature for up to 12hours.[17]

The Oxford-AstraZeneca vaccine uses double-stranded DNA technology unlike the single-stranded mRNA technology employed by Pfizer and Moderna. Hence, it has lower chances of degrading at lower temperatures and can therefore be stored at regular refrigerator temperature. Consequently, it has a shelf-life of 6months when refrigerated at 2-8°C. Furthermore, the Oxford-AstraZeneca vaccine costs US$3-4 (N1,143-1,524) as opposed to US$37 (N14,098) for Moderna and US$20 (N7621) for Pfizer.[18]

SOLUTIONS ON STORAGE AND DISTRIBUTION

History has demonstrated that a vaccine in itself is not a panacea; it is pertinent that logistical and cold-chain systems are efficient in the storage and distribution of vaccines to ensure potency upon administration. Owing to the high cost and storage requirements of the Moderna and Pfizer vaccines respectively, the Oxford-Astrazeneca vaccine appears a feasible alternative for LMICs like Nigeria. While challenges with the Nigerian cold chain system abound, the following can be employed to ensure success in vaccinating majority of Nigerians against the novel coronavirus:

Reorganize supply chain. The Federal Government of Nigeria is in control of two levels of the chain including the NSCS. A 3-hub system was designed to reduce the burden on the NSCS after an analysis of the NPHCDA storage challenges. The 3-hub system involves Kano, Abuja (NSCS) and Lagos zonal storage sites receiving vaccines directly from suppliers and delivering them directly to States Studies show that moving from the two tier federal system to a single 3-hub federal system would reduce storage needs by 30%[3] lower cost of operations leaving zonal stores available for a sudden increase in capacity requirement. Additionally, the implementation of the 3-hub federal system will foster prompt availability of vaccines to states by eliminating the zonal level.

Increase storage capacity and integration of recent technology. Effective storage of vaccines is an integral component of the supply chain management as it ensures that vaccines do not lose their potency. Recent study showed that for current vaccine programs e.g. Polio, Bacillus Calmette-Guerin, Tetanus etc., there is a need for increase in storage capacity at all zonal levels within the federation to reach 100% reliability. Therefore, an expansion of the current storage facilities is a prerequisite prior to acquiring the coronavirus vaccines. Due to the unreliability of Nigeria's power sector, funding should be channeled towards procuring clean and efficient cooling technologies such as solar-powered refrigerators. Additionally temperature monitoring and control devices should be introduced into the cold chain system. These devices give real-time temperature, alert workers when out-of-range temperatures are detected causing them to intervene and ultimately preserve the potency of vaccines and prevent wastage.

Train vaccinators and technicians. In other to meet up with the need to rapidly vaccinate as many Nigerians as possible, vaccinators who can be mobilized swiftly will be required. As such, the number of vaccinators required may exceed the number of currently trained and experienced vaccinators, particularly because the existent immunization workforce will be required to maintain the NPI. It is unarguably a necessity that the vaccinators for COVID-19 receive comprehensive training and competency assessment to ensure that those who receive the vaccine are safe and more so, public confidence in the process is established. A complete online course on COVID-19 vaccination training has been drafted by the WHO in conjunction with the United Nations Children's Fund (UNICEF) for use by countries in the training of frontline health workers. This resource can be adapted by Nigeria's Ministry of Health, translated to major ethnic dialects, and used in the training of the nation's COVID-19 vaccination workforce.

Additionally, maintenance and repair of CCE requires extensive technical know-how. The average time taken to repair a fridge at the LGA level of the cold chain in Nigeria is two months to two years. Hence, it is important for Nigeria to adopt hands-on training approach of technicians at local technical colleges and tertiary institutions and spare parts for CCEs should also be made readily available. This will create an extensive workforce that can promptly detect and tackle problem with CCEs and this will ultimately strengthen storage and distribution capacity. This method which was adopted in Ethiopia led to the training of 516 technicians and restoration of $100m^2$ CCE capacity. CCE maintenance and repair is currently in the module of some technical colleges in Ethiopia and Tanzania.[19]

ADEQUATE NEEDS FORECASTING

Estimation of capacity and vaccine needs is pivotal to the efficiency of the cold chain given that it takes approximately two years to procure and install cold chain equipment.[19] Needs estimation can be done using previous consumption (assessed at the national level), target population (assessed at the national level) and size of immunization sessions (assessed at the primary health centres and other facilities where the vaccines are given)[20] Veritable data also needs to be taken particularly at the local level where visibility into vaccine inventory levels is generally lower as the accuracy of forecasting and needs estimation depends on the source data used.[3] The WHO EPI forecasting tool is very useful for this process as it analyses different scenarios and also provides a multiyear forecast (three to five year period) of vaccines, safe injection supplies, storage capacity and cold chain equipment.[20]

DEVELOPMENT OF MOBILE SESSIONS FOR HARD-TO-REACH AREAS

In order to ensure adequate coverage in hard-to-reach areas, immunization outreaches and adoption of non-generic transportation methods to circumvent transportation barriers should be considered. Mobile teams should be created and equipped with boats for coastland and other vehicles capable of navigating various terrains.

DISTRIBUTION OF COVID-19 VACCINES

Salient ethical considerations should guide the distribution of the COVID-19 vaccines. In light of the limitation in vaccine supply, the WHO Strategic Advisory Group of Experts on Immunization (SAGE) proposed a 3-stage prioritization roadmap for vaccine administration where (1-10 % of a country's total population is vaccinated in Stage 1, (11-20)% in Stage 2, and (21-50)% in Stage 3.[21] The public health strategy employed in the administration of vaccines should depend on the burden of disease and the local epidemiology. The current epidemiological setting in Nigeria is that of community transmission.[22] Hence, health workers and older adults within the country-defined specific age cut-off should be prioritized for vaccination in Stage 1. In stage 2, older adults not covered in stage 1 including persons with comorbidities, disadvantaged or persecuted groups, sexual minorities, people living with disabilities, refugees, internally displaced persons, health workers involved in immunization delivery, high priority teachers and school staff should be vaccinated. In stage 3, other teachers and school staff, other essential workers outside health and education sectors, pregnant women etc. should receive the vaccine.[21]

CONCLUSIONS

Despite the numerous challenges plaguing the system, opportunities are equally numerous. A sturdy roadmap, strong political will and intense collaborations will increase the feasibility of the proposed solutions. Accurate data collection and appropriation of funds should also be prioritized in order to design and implement the aforementioned solutions. With a teeming population of over 200million people, extreme poverty levels, limited primary health centres, cold chain equipment and storage capacity, procurement of the OxfordAstraZeneca variant is more in consistence with our realities if we are going to achieve a nationwide coverage. Finally, outsourcing a carefully calculated percentage of storage and distribution to accredited private facilities under the purview of the local government may reduce the burden of vaccine storage on the government and facilitate effective and efficient vaccination against covid-19 in the country culminating in eradication of COVID-19 in Nigeria.

FUNDING

None

AUTHORSHIP CONTRIBUTIONS

All authors contributed equally to the draft and final version of the manuscript

COMPETING INTERESTS

All authors have completed the Unified Competing Interest form available at http://www.icmje.org/conflicts-of-interest/ in line with the Journal of Global Health editorial policy and declare no conflicts of interest.

CORRESPONDENCE TO:

Shamsudeen Ayomide Usman
St. Nicholas Hospital, Lagos, Nigeria
deenusmansan@gmail.com

REFERENCES

1. A brief history of vaccines in colonial Africa. Accessed January 1, 2021. https://activehistory.ca/2015/04/a-brief-history-of-vaccines-in-colonial-africa

2. Ophori EA, Tula MY, Azih AV, Okojie R, Ikpo PE. Current trends of immunization in Nigeria: Prospect and challenges. *TropMedHealth*. 2014;42(2):67-75. doi:10.2149/tmh.2013-13

3. Sarley D, Mahmud M, Idris J, et al. Transforming vaccines supply chains in Nigeria. *Vaccine*. 2017;35(17):2167-2174. doi:10.1016/j.vaccine.2016.11.068

4. Nigeria readies for Pfizer COVID-19 vaccines. Accessed February 27, 2021. https://www.africanews.com/2021/01/22/nigeria-readies-for-pfizer-covid-19vaccines/

5. Ojo T, Ijadunola M, Adeyemi E, et al. Challenges in the Logistics management of vaccine cold chain system in Ile-Ife, Osun State, Nigeria. *Journal of community medicine and primary health care*. 2019;31(2):1-12.

6. Dairo DM, Osizimete OE. Factors affecting vaccine handling and storage practices among immunization service providers in Ibadan, Oyo state, Nigeria. *Afr H Sci*. 2016;16(2):576. doi:10.4314/ahs.v16i2.27

7. Ogboghodo EO, Omuemu VO, Odijie O, Odaman OJ. Cold chain management practices of health care workers in primary health care facilities in Southern Nigeria. *Pan Afr Med J*. Published online 2017:27-34. doi:10.11604/pamj.2017.27.34.11946

8. Ameen H, Salaudeen A, Bolarinwa O, Uthman M, Musa O, Aderibigbe S. Vaccine Storage and Handling Practices among routine immunization service providers in a metropolitan city of North-Central Nigeria. *African Journals Online*. 2014;26(2):18-28.

9. Nwankwo B, Joga S, Olorukooba A, Amadu L, Onoja-Alexander M, Hamza K. Knowledge, attitude, and practice of cold chain management among primary health care workers in Giwa, Northwestern Nigeria. *Arch Med Surg*. 2018;3(2):71-76. doi:10.4103/archms.archms_26_18

10. Wonodi C, Stokes-Prindle C, Aina M, et al. Landscape analysis of routine immunization in Nigeria. *International Vaccine Access Centre*. Published online 2012.

11. Bawa S, Shuaib F, Saidu M, et al. Conduct of vaccination in hard-to-reach areas to address potential polio reservoir areas, 2014-2015. *BMC Public Health*. 2018;18(S4):113-120. doi:10.1186/s12889-018-6194-y

12. Osei E, Ibrahim M, Amenuvegbe GK. Effective vaccine management: The case of a rural district in Ghana. *Advances in Preventive Medicine*. Published online October 13, 2019:1-8. doi:10.1155/2019/5287287

13. Ateudjieu J, Kenfack B, Nkontchou BW, Demanou M. Program on immunization and cold chain monitoring: The status in eight health districts in Cameroon. *BMC Research Notes*. 2013;6(1):1-7. doi:10.1186/1756-0500-6-101

14. Mvundura M, Lydon P, Gueye A, et al. An economic evaluation of the controlled temperature chain approach for vaccine logistics: Evidence from a study conducted during a meningitis A vaccine campaign in Togo. *Pan Afr Med J*. 2017;27(2):1-6. doi:10.11604/pamj.supp.2017.27.3.12087

15. Vouking M, Mengue C, Yauba S, et al. Interventions to increase the distribution of vaccines in sub-saharan Africa: A scoping review. *Pan African Medical Journal*. Published online 2019:32.

16. Covid-19 vaccine U.S. distribution fact sheet. Accessed December 31, 2020. https://pfizer.com/news/hot-topics/covid_19_vaccine_u_s_distribution_fact_sheet

17. Moderna announces longer shelf life for its covid-19 vaccine candidate at refrigerated temperatures. Accessed December 31, 2020. https://investors.modernatx.com/news-releases/news-release-details/moderna-announces-longer-shelf-life-its-covid-19-vaccine

18. McCarthy N. The cost per jab of Covid-19 Vaccine candidates. Accessed December 31, 2020. https://statista.com/chart/23658/reported-cost-per-dose-of-covid-19-vaccines/

19. Ashvin A, Brison M, LeTallec Y. Improving cold chain systems: Challenges and solutions. *Vaccines*. 2016;35:2217-2223.

20. Essential Programme on Immunization. Accessed February 27, 2020. https://www.who.int/teams/immunization-vaccines-and-biologicals/essential-programme-on-immunization/supply-chain-vaccine-management-and-logistics-support/vaccine-forecasting-and-needs-estimation

21. WHO SAGE Roadmap For Prioritizing Uses Of COVID-19 Vaccines In The Context Of Limited Supply. Accessed January 1, 2021. https://www.who.int/publications/m/item/who-sage-roadmap-for-prioritizing-uses-of-covid-19-vaccines-in-the-context-of-limited-supply

22. Garba B, Zakaria Z, Salihu MD, Bande F, Saidu B, Bala JA. Breaking the cycle of the COVID-19 transmission: A challenge for Nigeria. *J Glob Health*. 2020;10(2). doi:10.7189/jogh.10.020309