Original Article

Vaccine Storage In Some Selected Rural Health Facilities In Niger State, Nigeria

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Summary

This study evaluated the cold chain system used for storing and distributing vaccines in Niger State, Nigeria. Data collection involved interview of health workers, health facility audit of central and satellite cold stores and health clinics in rural communities of two Local Government Areas of the State. Of 36 health facilities surveyed, only 55.6% were connected to national electricity grid with frequent interruptions. Only 16.7% of these health facilities had functional power generator. Central cold stores exist in both LGAs. None of the health clinics and satellite cold stores had a thermometer. The facilities were insufficiently equipped with ice packs (77.8%); cold boxes (38.9%); and refrigerators (38.9%). The central cold chain systems in the two LGAs studied were insufficiently equipped with cold chain equipment required for effective immunisation services. Implementation of urgent cold chain strengthening measures therefore need be done to address the inadequate infrastructure and equipments in order to boost the delivery of potent vaccines to the communities.

Key words: Cold chain, Vaccine, Storage, Temperature maintenance, Health facilities

Introduction

Vaccination is one of the most cost-effective public health interventions for the prevention of vaccine preventable diseases (VPDs). Immunization against a disease is achieved if a potent vaccine is administered[1,2]. However potent a vaccine may be, its efficacy is compromised if cold chain is not maintained from the manufacturer to the beneficiary[3].

The cold chain plays a central role in the maintenance of vaccine potency particularly in the rural areas[4,5] Part of measures to maintain potency of vaccines over extended periods is the implementation of the World Health Organization (WHO) recommended protocol for temperature maintenance and equipment requirements at each level in the cold chain system . One of such measures recommended to maintain

potency of vaccines is the vaccine vial monitor (VVM) designed to progressively and permanently change its colour if exposed to high temperatures over an extended period of time[6]. The VVM is an indicator that guarantees that potency of vaccines has not been compromised[7].

According to the National Primary Health Care Development Agency (NPHCDA)[8], the basic health system structure that drive routine immunization programme in Nigeria runs from the Federal, State and Local Governments, wards and to settlements where the health facilities are situated. Identified barriers for delivery of immunization services include vaccine stock-out, bundling vaccines, and cold chain equipment failures. Over the years, efforts are focused on improving local government infrastructure and personnel capacity, particularly regarding vaccine procurement and the maintenance of an operational cold chain system[8,9]. The Federal Government of Nigeria with aid from donor partners including United Nations Children's fund (UNICEF) have given priority to Expanded Programme on Immunisation (EPI) support in its health programme in Nigeria by providing critical supplies, vaccines, equipment and operations/logistical support[8,9,10].

Despite decades of significant input of resources and efforts to prevent VPDs through vaccination, there is dearth of evidence-based information relating to issues of cold chain and vaccine storage in the country, particularly Niger State where systematic study on the above issues has not been adequately conducted. Available data from previous studies in the country were conducted in some South Western States[7,11,12] and some Northern States[13]. These are confined to areas that include: assessment of cold chain and potency of vaccines from the national cold store to the vaccination centres; and vaccine logistics and supply systems. In addition, report by NPHCDA[8] on a study conducted across the country in 2012 showed that 43% of cold chain equipment at the local government area (LGA) and health facility levels is non-functional, resulting in reduced storage capacity, thereby compromising vaccine potency.

Unlike in Nigeria, a review of the literature yielded previous cold chain evaluation studies in other countries in Africa[14], Asia[4,15,16,17,18,19] and Europe[20] that reported: shortcomings concerning the cold chain such as shortage of temperature maintenance equipment, power failures and improper and inadequate maintenance of the cold chain equipment; the loss of vaccine potency attributed weaknesses in the cold chain; and poor maintenance of temperature monitoring chart and low awareness of the cold chain handlers about its maintenance.

It needs be emphasised that the rationale for this study was premised on the argument of Machingaidze et al[2] that with the failure of most countries particularly in Africa including Nigeria in achieving the targets of the Millennium Development Goals (MDGs) particularly those on child survival and maternal health with the deadline now past, it is necessary for countries in Africa to take stock by critically assessing their positions, take ownership of their problems, and develop

precise strategies to overcome the identified challenges and reposition for the targets of the health-focused goal of the Sustainable Development Goals (SDGs)[21,22].

It is against the background of the need to take stock and the dearth of evidence-based information relating to issues of cold chain and vaccine storage in Niger State, North-Central Nigeria, and that none of the previous studies highlighted have addressed these issues that the findings of this study become imperative.

Method

Study area

The study was carried out between February and May 2013 in randomly selected Gbako and Katcha LGAs of Niger State (Figure 1). Each LGA is divided into 10 wards, 8 health districts with 20 immunisation fixed posts. Of the 82 health clinics in Gbako LGA, 63 that include 16 Primary Healthcare Centres (PHCs), 3 Maternal and Child Health Centres (MCH), 40 Basic Health Centres (BHCs) and 4 Comprehensive Health Centre (CHC) render routine immunisation services. Of the 71 health clinics in Katcha LGA, 63 that include 47 PHCs, 6 MCH, 4 BHCs, 1 CHC and 5 private clinics render routine immunisation services. While Gbako and Katcha has 1 and 2 central cold stores respectively, each of the LGAs in addition has 4 and 1 satellite cold stores respectively. Neither of the two LGAs has a secondary nor tertiary health facility[23]. The daily temperature during the data collection period in the communities ranged from 33°C to 42°C with a mean of 38°C (Adeneye personal communication).

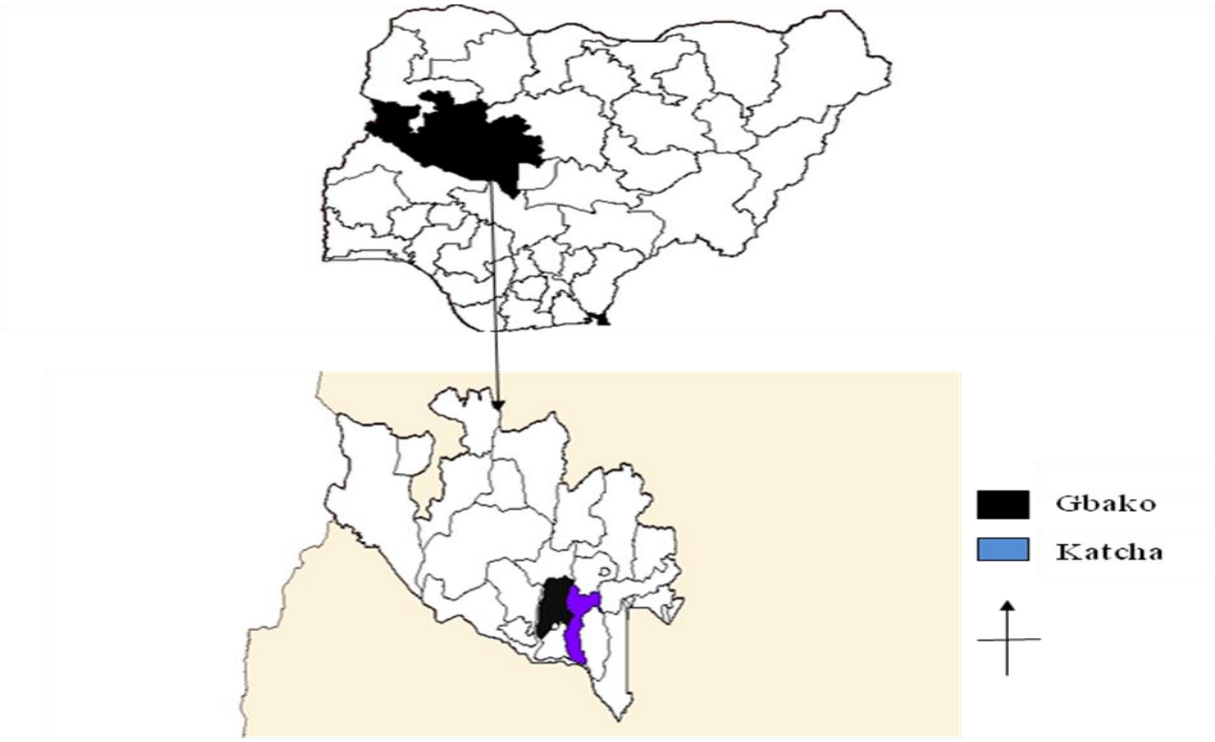

Figure 1 Map of Nigeria showing Gbako and Katcha LGAs of Niger State

Study design and sampling procedures

This is a cross-sectional study that evaluated cold chain system used for storing and distributing vaccines for immunisation services in Gbako and Katcha LGAs of Niger State. A multi-stage sampling strategy was used to select the 19 and 17 study health facilities from Gbako and Katcha LGA respectively using simple random and purposive sampling techniques[24].

Data collection procedures

The study was carried out based on universal ethical principles guiding the conduct of research. The respondents' informed consent was obtained to signify their willingness to participate in the research. Data collection involved health facility auditing of 3 central and 5 satellite cold stores and 28 health clinics in rural communities of Gbako and Katcha LGAs of Niger State using a health facility assessment checklist. The checklist probed the status of health facility, availabilty of vaccination handbook for health care workers and protocol for cold chain maintenance, and required and available cold chain items such as vaccine carriers, ice packs, and cold boxes, display of temperature chart, and the availability of infratructure such as electricity, refregrator/deep freezer, generator and its functionality.

Ethical and regulatory considerations

The study was conducted in accordance with all international ethical requirements and standards, including the Declaration of Helsinki with the principles established by the Belmont Report. The informed consent of all the officers in charge of the health facilities studied was sought and obtained in written form using an informed consent form to signify their willingness to participate in the research.

Data analysis

The data for the study were analysed using Epiinfo 6.04a software developed by the Centers for Disease Control, United States of America in collaboration with the WHO[25]. Statistical analyses of the quantitative data were conducted using analysis of variance and chi-square tests at 95% level of significance. Analysis of variance (ANOVA) was used in showing the relationship between measurements of the mean and the variance or "random error" of each sub-group in the study in order to provide information needed to determine if the difference between the two is significant. Also, chi-square which is a non-parametric test of statistical significance for bivariate tabular analysis, was used to show whether or not two different samples are different enough in some characteristics or aspects such as availability of power.

Results

Available infratructure at the cold stores and health clinics

A total of 36 health facilities comprising 3 central cold stores and 5 satellite cold stores and 28 health clinics were audited. Majority (20, 55.6%) of the 36 health facilities surveyed [100.0% central cold stores, 100.0% satellite cold stores, 42.9% health clinics] were connected to the national electricity grid with frequent power failure and 16 (44.4%) were not. Power failure is experienced in the 36 health facilities for 0 to 24 hours per day with an average of 13.3 hours per day.

The frequency of power failure in communities where the 20 facilities connected to the national electricity grid ranged from 0 to 6 times per day with an average of 3 times daily. Statistical test using ANOVA showed that the health clinics had more power failures with a mean of 15.9 hours of power failure per day compared with 4.7 hours and 4.6 hours for central stores and satellite cold stores respectively ($p < 0.05$). Only 8 (22.2%) [100.0% central cold stores, 60.0% satellite cold stores, 7.1% health clinics] and 2 (5.6%) [0.0% central cold stores, 0.0% satellite cold stores, 7.1% health clinics] had an electrical power generator and solar power system for electricity backup respectively in the LGAs. Only 6 (16.7%) [100.0% central cold stores, 40.0% satellite cold stores, 3.6% health clinics] had a functional generator used in maintaining cold storage. Of the 8 health facilities that had electrical power generator, only 3 (37.5%) are located in places where there is adequate supply of fuel at the nearby petrol filling stations. The remaining 5 (62.5%) are in villages remotely located from petrol filling stations. Here fuel is in short supply and sold at ₦160.00 ($0.97) per litre by fuel vendors shown in Figure 2 contrary to the standard pump price of ₦97.00 ($0.59) per litre. Sixteen (44.4%) of the health facilities [33.3% central cold stores, 20.0% satellite cold stores, 60.7% health clinics] reported loss of vaccines as a result of reasons that included: breakage/spillage (44.4%); loss of potency indicated by VVM (16.7%); frequent and prolonged hours of power failure (16.7%); freezing (5.6%); and expiration of vaccine (5.6%).

Required and available cold chain equipment

Only 2 (5.6%) of the 36 facilities displayed and maintained a temperature monitoring chart for the cold chain equipment with a designated health worker who keeps the record twice daily. Of these, 100.0% were the central cold stores in the LGAs. In contrast, none of the health clinics and satellite cold stores neither had a temperature-monitoring equipment, thermometer nor records on temperature maintenance as they maintained no temperature chart. Twenty-two (61.1%) of the health facilities [100.0% central cold stores, 60.0% satellite cold stores, 57.1% health clinics] had vaccination handbook for health care workers and only 2 (5.6%) [100.0% central cold stores, 0.0% satellite cold stores, 0.0% health clinics] had protocol for cold chain maintenance.

Assessment of the total different cold chain equipment required and available for cold chain operations on immunisation Plus Days (IPDs) and for routine immunisation in all health clinics rendering the service in the LGAs showed that the central cold chain systems in the two LGAs were insufficiently equipped with cold chain equipment required for effective immunisation services in Table 1. At the health facility level, available cold chain equipments for vaccine storage were: vaccine carriers (91.7%); ice packs (77.8%); cold boxes (38.9%); and refrigerators (38.9%). Only 2 (66.7%) of the 3 central cold stores and 100.0% of the satellite cold stores had freezers. However, the freezer of one (20.0%) of the 5 satellite cold stores was not working at the time of the survey.

Table 1 Required and available cold chain equipment by LGA

Cold chain equipment	Gbako		Katcha	
	Required	Available	Required	Available
Vaccine carriers	146	43 (29.5)	150	105 (70.0)
Cold boxes	60	30 (50.0)	60	45 (75.0)
0.6L ice packs for cold boxes	480	240 (50.0)	480	480 (100.0)
0.3/0.4L ice packs for vaccine carriers	1,116	146 (13.1)	1,600	1,220 (76.3)

Source: National Programme on Immunisation (NPI) Office, Gbako and Katcha LGAs, Niger State

Figure 2 Petroleum products on display for sale by fuel vendors in a village

Discussion

In this study, effective central cold stores were reported in the study LGAs unlike at the satellite cold stores and health clinics where the case was otherwise. Temperature maintenance and monitoring equipments in these facilities are lacking to enable continuous temperature records on vaccines in store. There is therefore a need to improve vaccine store management practices at these health facilities through the provision of thermometers and temperature monitoring charts for these satellite cold stores and health clinics. The State Ministry of Health in collaboration

with key partner agencies need to give urgent and adequate attention to the cold chain in the LGAs in terms of a well-planned maintenance system.

Another issue of concern emanating from the study is poor power supply at the health clinics particularly in the communities unconnected to the national electricity grid. Knowing that electrical power or an alternative source of energy is germane to cold chain maintenance, reports of frequent and prolonged hours of power failures reported at the health clinics is of concern. This is because only a very few of these health clinics had a functional power generator or other reliable alternative source of energy such as the solar power system for back-up electricity supply that can help maintain the cold chain. The proximity of a very few of the health facilities that had generators to access adequate supply of fuel at affordable costs is also of serious concern because this could significantly undermine the ability of the health workers in accessing fuel to power their generators to maintain the cold chain whenever there is prolonged hours of power failure. Given the challenge of sustaining uninterrupted power supply in maintaining cold chain at the health clinics, efforts should be intensified to explore alternative source of power such as solar energy to maintain vaccine potency that could adversely be affected by rising temperatures if not stored well. The solar energy is desirable for power generation in the health facilities due to its unlimited existence and environmental friendly nature.

Given the endemic nature of VPDs in the State particularly with report of wild polio virus in northern Nigeria where the State is located[8], it is critical that measures are taken to better secure the delivery of potent vaccines to the beneficiaries. This will help derive optimum benefit at protecting children against childhood VPDs in the communities and in the long run contribute to the achievement of the country's National Routine Immunization Strategic Plan, Polio Eradication Emergency Plan aimed at keeping Nigeria polio-free and the United Nations Millennium Development Goals (MDGs) 4 and 5 in reducing child mortality and improving maternal health by 2015 and beyond as emphasised by NPHCDA[8].

Taking into cognisance that high temperatures could compromise vaccine potency as reported by Mallik et al[19] and WHO[26] vaccine quality in the study areas needs to be effectively maintained given the observed high temperatures in the LGAs because this may adversely affect the vaccines potency. The consequence of any inaction in this regard will be the administration of non-potent vaccines to the VPD-at-risk populations particularly the children under five years. More so, there is the tendency for re-emergence of those diseases believed to be under control, which could contribute to a rise in VPD-related morbidity and mortality.

In a situation where health workers in about two-thirds of LGAs across the country in a previous study reported exposure to high temperatures as a reason for vaccine wastage consequent to non-functional and non-availability of equipments[8], cold chain systems strengthening then becomes sine qua non in the study LGAs. This is because most

health facilities in the cold chain system had inadequate cold chain equipments to function efficiently as presented in Tables 1. The issues of inadequate cold chain infrastructure and equipments are similar to those of Aggarwal et al[16] and Mallik et al[19]. These issues of lack of infrastructure and gross inadequate temperature maintenance equipments in the health facilities require urgent attention and action. Increased political and financial commitment from the governments at the Federal, State and LGA levels through adequate and routine budgeting of cold chain expenses including procurement and installation of solar panels for more regular and cost-effective power supply and set-aside budget for purchase of fuel to power the generators and at the health facilities in the long- and short-term respectively are needed for strengthening and provision of essential cold chain infrastructure and equipments for effective EPI programme implementation in the health facilities as emphasised by Machingaidze et al[2].

The low percentage of children aged 12-23 months who received all basic vaccinations in Niger State reported by National Population Commission and MEASURE DHS ICF Macro[27] and National Population Commission (NPC) [Nigeria] and ICF International[28] perhaps could be attributed to the challenges of cold chain system observed in this study. These results could probably be a reflection of what obtains in many other LGAs with similar resource-poor settings in the State. These other LGAs could probably have similar limitations in their cold chain management; serving as barriers to effective implementation of immunisation as emphasised by Machingaidze et al[2] and Medecins Sans Frontieres[29].

This study has two main limitations. First, the small sample size and limited geographical areas of study allow a limited generalization of the findings. However, the sampling process through randomisation applied in sample selection helps improves the external validity of the study. Second, this study did not include potency testing of vaccine vials to ascertain the effect of the lack of infrastructure and gross inadequate temperature maintenance equipments in the cold chain system. These limitations however did not undermine the validity of the study results.

Conclusion

None of the satellite cold stores and health clinics other than the central cold stores visited during the study had a copy of the cold chain protocol for vaccine storage, transport, packaging and handling. It is recommended that copies of cold chain protocol should be distributed to the health facilities to provide easy-to-use guidance on cold chain management for the health workers at the facilities. This will hopefully improve and harmonise their practices with the WHO-UNICEF Effective Vaccine Store Management standards at the health facilities.

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