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ORIGINAL ARTICLE

Challenges in the Logistics Management of Vaccine Cold Chain System in Ile-Ife, Osun State, Nigeria

Ojo TO, Ijadunola MY, Adeyemi EO, Adetunji OO, Adurosakin FO, Adeyinka AM, Adeyelu CO

Department of Community Health, Obafemi Awolowo University, Ile-Ife, Nigeria.

Keywords

Vaccine cold chain; Logistics management; Nigeria

ABSTRACT

Background: The success of national immunization programmes depends largely on effective logistics management of the vaccine cold chain system. This study assessed cold chain equipment functionality, healthcare workers' knowledge and practice of the logistics management of vaccine cold chain system in Ile-Ife, Nigeria.

Methods: A descriptive study was conducted in immunization clinics of 35 health facilities in Ife East and Central Local Government Areas (LGA) in Ile-Ife. There were 100 immunization service providers in the (LGAs) and they were all recruited into the study. Information was obtained with the aid of an interviewer-administered, structured questionnaire. Cold chain equipment functionality was assessed using a checklist. Data were analyzed using SPSS version 20.0.

Results: Eleven (31.4%) of the facilities had functional refrigerators for storing vaccines, 16 (45.7%) had cold boxes while 13 (37.1%) had thermometers for vaccine temperature monitoring. Fifty-four (54.0%) of the healthcare workers were aware of the "shake test" and 19 (19.0%) could correctly interpret colour changes on a vaccine vial monitor. Consumption record was considered by 69 (69.0%) of healthcare workers when making vaccine requisitions while the required lead time was considered by 24 (24.0%) of them. Only 29 (29.0%) of healthcare workers kept records of vaccines stock-on-hand.

Conclusion: Adequate training and supportive supervision is essential to improve healthcare workers' knowledge and cold chain practices. Relevant cold chain equipment should be provided to boost storage capacity across health facilities.

Correspondence to:
Dr T. O. Ojo
Department of Community Health,
Obafemi Awolowo University, Ile-Ife, Nigeria.
Email: linktopeojo@yahoo.com
Telephone: +234-8035798224

INTRODUCTION

Immunization against vaccine-preventable diseases is one of the most cost-effective health interventions of all times. It is reputed to save about 2.5 million lives per year and it can save more if better deployed.[1] Globally, the World Health Organization (WHO) estimates that 29% of under-five mortality are vaccine preventable[1] and this spectre of child mortality still exists largely due to weaknesses in the logistics management of vaccine cold chain system and poor immunization uptake in developing countries.[2-4] In Nigeria, 2,300 under-five children die daily[5] and vaccine preventable

diseases (VPDs) account for about 22% of all childhood mortality annually.[6] These deaths can be avoided with the administration of potent vaccines to all children nationwide. For this to be achieved, logistics management of the vaccine cold chain system must receive due attention since it constitutes the essential backbone of successful national immunization programmes.

Health systems in developing countries with tropical climates continue to grapple with the challenges of maintaining the stringent temperature range of the vaccine cold chain system.[7] The "cold chain" refers to a system used for keeping and distributing vaccines in good condition starting from the manufacturer up to the point of administration.[8] All three elements of the cold chain namely: equipment transport and storage, trained personnel, and efficient management procedures must be maintained at every link in the pipeline to ensure that the administration of the vaccine is safe and effective.[9] Logistics management encompasses the efficient coordination and control of the flow of all operations that include products selection, forecasting demand, ordering and procuring, warehousing and storing, managing inventory, managing commodity-related data and transport of commodities from one level to the next until they reach the clients.[10] Fulfilling the vision of national immunization programmes therefore requires sustained investments in routine immunization through the application of the "six rights" of logistics management which entails: procuring the right vaccines, in the right quantity, in the right condition, delivered to the right place, at the right time and for the right cost.[4, 11] In Nigeria, the vaccine cold chain system comprises the manufacturer, the transit store at the airport and clearance, the national cold store, six zonal stores (one in each geopolitical zone), thirty-six State stores, 774 vaccine stores at the Local Government Areas (one in each of the 774 Local Government Area of the country), primary health centres and other health facilities.[12] Globally, it has been estimated that millions of dollars are lost yearly due to vaccine mishandling and improper storage. [13] Nigeria also experiences vaccines wastage[12] and this is attributable to some challenges being faced in managing the vaccine cold chain system. These challenges include: erratic electric power supply, fueling and transport which are necessary to ensure continuous running of cold chain equipment.[14] More importantly, ensuring well-motivated staff who have the requisite knowledge of how an effective cold chain system works is very important.[12, 15] Also, Nigeria still requires more storage capacity at the national and zonal levels if the nation is to meet the storage target of 672m^3 needed for effective storage by the year 2020. [16, 17] If these issues are not properly addressed, they may lead to unreliable delivery of supplies and vaccine stock-outs. In addition, maintaining vaccines at proper temperatures is delicate, as some vaccines such as Diphtheria, Pertussis, Tetanus, Hepatitis B and Haemophilus influenza

type-b are inactivated by exposure to freezing while other vaccines are damaged by heat exposure. Thus, poor management of the vaccine cold chain system could lead to wastages and vaccine failure with huge financial consequences particularly for developing countries that rely heavily on donor funding for their immunization programmes.

Healthcare workers involved in immunization are an important component in the vaccine cold chain system.[15] Health service providers' attitudes and management of the cold chain are critical determinants of the sustainability and effectiveness of immunization programs.[18, 19] Past studies mostly focused on availability and functionality of cold chain equipment as well as knowledge of immunization service providers.[17, 20] Moreover, only a few peer reviewed studies in Nigeria had assessed cold chain system at service delivery points.[15, 21] Hence, this study assessed availability and functionality of cold chain facilities across immunization clinics in Ile-Ife, Nigeria and healthcare workers' knowledge as well as practice of logistics management of vaccine cold chain system.

METHODOLOGY

The study was conducted in Ile-Ife, Osun State, Nigeria from January to February 2015. The town has two local government areas namely Ife Central and Ife East local government areas with a population estimates of 210,706 and 203,150 respectively in 2015 as projected from the 2006 national population census.[22] The inhabitants largely belong to the Yoruba ethnic group. The major occupations are farming and trading. Other residents are civil servants and artisans. There were 33 Primary Health Care facilities, 26 private health facilities, one secondary health facility and one tertiary health facility in the two LGAs at the time of the study. All the primary healthcare facilities, one secondary and one private health facility provided routine immunization services.

A descriptive design was employed and the study was conducted among the entire population of immunization service providers in the study location (Ile-Ife metropolis). All healthcare workers who had spent at least six months as immunization service providers were included in the study. Immunization clinics were also assessed for availability and functionality of cold chain equipment. Both public and private health facilities were surveyed. The total population of all the healthcare workers (100) who worked in immunization clinics and met the inclusion criteria were serially recruited from 33 primary health facilities, one secondary and one private health facility.

Interviewer-administered questionnaires were used to collect data from eligible healthcare workers. The following information was obtained from the health workers: socio-demographic characteristics, awareness and knowledge about the cold chain system, self-reported use of information management tools and trainings ever attended. Some questions

were adapted from the Logistics Systems Assessment Tool (LSAT).[11] The validated questionnaire had good reliability with Cronbach's alpha of 0.74 - 0.80 for the various sections. A facility checklist was used to elicit information about cold chain infrastructure and management in the facility. The facility checklist had the following sections: facility identification, availability and functionality of supplies and equipment used in vaccine cold chain system and vaccine storage management. Data were analyzed using SPSS version 20.0 software. Frequencies and percentages were used to estimate proportions.

Ethical clearance was obtained from the Research and Ethics Committee of the Institute of Public Health (IPH), Ile-Ife. Permission to carry out the survey was also obtained from the Directors of Primary Health Care in the respective LGAs and the heads of each health facility. Informed consent was obtained from the respondents and they were assured of the confidentiality of their responses.

RESULTS

Sixty-six (66.0%) of the respondents were aged 30-49 years and 96 (96.0%) were females. Fifty-five (55.0%) of the healthcare workers had worked for more than 10 years as health care providers. Forty-nine (49.0%) of the respondents were Community Health Extension Workers (CHEWs) while 13 (13.0%) of the participants were Community Health Officers (CHOs). (Table 1).

Ninety-seven (97.0%) of the respondents correctly indicated that the cold chain system is meant to ensure that vaccines are kept in the recommended temperature range. However, only 19 (19.0%) could correctly state the implications, if the colour of the inner square and outer circle of a Vaccine Vial Monitor (VVM) matches. Eighty-three (83.0%) of healthcare workers reported that no other items should be kept in a refrigerator meant for vaccines while 54 (54.0%) were aware of the shake test. Topics covered at trainings attended by the healthcare workers in the preceding two years ranged from proper storage of health products as stated by 64 (64.0%) respondents to "ways to estimate annual records" that was stated by 39 (39.0%) of respondents (Table 2).

Immunization record was used by 97 (97.0%) of the healthcare workers as information management tool for record keeping. Seventy-six (76.0%) of them usually record data about quantity of vaccines administered while only 29 (29.0%) keep records of vaccine stock on hand. Consumption record was considered by 69 (69.0%) healthcare workers when ordering vaccines while the required lead time was considered by only 24 (24.0%) healthcare workers while making orders for vaccines. (Table 3)

All the 11 health facilities that had storage facilities kept vaccines in stores that were free from insects and rodents and also separated damaged or expired products from usable ones.

Table 1: Socio-demographic Characteristics of Healthcare Workers

Characteristics	Frequency (n=100)	Percent
Age in years		
20-29	17	17.0
30-39	33	33.0
40-49	33	33.0
≥ 50	17	17.0
Sex		
Male	4	4.0
Female	96	96.0
Years of experience		
1-5	17	17.0
6-10	28	28.0
11-15	25	25.0
>15	30	30.0
Job title		
Nurse	20	20.0
CHO*	13	13.0
CHEW**	49	49.0
Health Assistant	18	18.0

*CHO - Community Health Officer **CHEW - Community Health Extension Worker

All 35 facilities surveyed had vaccine carriers and autodisable syringes, Safety boxes were available in 34 (97.0%) of the health facilities while a copy of the national guideline on immunization was sighted in only 20 (57.1%) of the facilities. Out of the 35 facilities that were surveyed, only 11 (31.4%) had refrigerators for storing vaccines, 16 (45.7%) had cold boxes, 13 (37.1%) had thermometers for vaccine temperature monitoring and only 7 (20.0%) had emergency tray. Operational water and electricity were available in only 16 (45.7%) and 11 (31.4%) facilities respectively. (Table 4).

Five (45.5%) facilities, kept the temperature in the refrigerator within the recommended range while only 3 (27.3%) facilities

Table 2: Correct Knowledge about the Cold Chain System by Healthcare Workers

Characteristics	Correct responses	
	Frequency (n=100)	Percent
Knowledge of cold chain system		
The objective of cold chain system is to keep vaccines in the recommended temperature range	97	97.0
Other items like food and drugs can be stored in refrigerator meant for vaccines	83	83.0
Tetanus toxoid is a freeze sensitive vaccine	68	68.0
Use of ice pack is appropriate for freeze sensitive vaccines	63	63.0
Temperature range for storing vaccine	57	57.0
Awareness of shake test	54	54.0
Vaccine can still be used if the colour of the square and circle matches on a vaccine vial monitor	19	19.0
Topics discussed at training attended in the last 2 years		
Proper storage of health products	64	64.0
Completion and submission of reports	62	62.0
Reviewing reports and records	52	52.0
Maintaining proper stock levels	51	51.0
Determining order quantities	46	46.0
Determining issue quantities	45	45.0
Providing feedback reports	42	42.0
Estimating annual records	39	39.0

Table 3: Self-reported Use of Information Management Tools

Characteristics	Yes	
	Frequency (n=100)	Percent
Use the following for record keeping		
Immunization records	97	97.0
Requisition and issue record	86	86.0
Stock keeping records	79	79.0
Usually document the following on data collection tools		
Quantity administered/issued in a specified period	76	76.0
Quantity received	74	74.0
Wastages and adjustment	35	35.0
Stock on hand	29	29.0
Obtain the following information from records		
Use of feedback	66	66.0
Monitoring of stock balance	50	50.0
Quantities for resupply/ order	43	43.0
Considers the following to make vaccines forecast		
Immunization data	84	84.0
Target population data	83	83.0
Service statistics	65	65.0
Distribution data	61	61.0
Stock on hand data	46	46.0
Compare previous estimated consumption with actual consumption	46	46.0
Considers the following to order for vaccines		
Consumption record	69	69.0
Wastages/losses and adjustments	55	55.0
Stock on hand	37	37.0
Maximum stock levels	29	29.0
Reserved stock	26	26.0
Required order lead times	24	24.0

kept a temperature chart. Nine (81.8%) facilities stored vaccines separate from other items and vaccines were arranged based on first to expire, first out (FEFO) in 7 (63.6%) facilities. (Table 5)

DISCUSSION

This study assessed the logistics management of the cold chain system in two Local Government Areas (LGAs) with specific focus on healthcare workers' knowledge, logistics information management as well as cold chain equipment, infrastructure and training gaps. The vaccine vial monitor (VVM) is one of the most reliable cold chain monitors.

Table 4: Availability and Functionality of Cold Chain Equipment and Infrastructure in Health Facilities

Characteristics	Available and functional	
	Yes Frequency (%)	No Frequency (%)
Equipment		
Vaccine carriers	35 (100.0)	0 (0.0)
Cold boxes	16 (45.7)	19 (54.3)
Thermometers	13 (37.1)	22 (62.9)
Refrigerator	11 (31.4)	24 (68.6)
Infrastructure		
Availability of autodisable syringes	35 (100.0)	0 (0.0)
Availability and accessibility of safety boxes	34 (97.1)	1 (2.9)
Sharps are properly disposed in sharp boxes	34 (97.1)	1 (2.9)
Copy of the National guideline on Immunization available in clinic.	20 (57.1)	15 (42.9)
Operational water	16 (45.7)	19 (54.3)
Operational electricity	11 (31.4)	24 (68.6)
Availability of emergency tray	7 (20.0)	28 (80.0)
Operational vehicle	3 (8.6)	32 (91.4)
Availability of fire safety equipment	1 (2.9)	34 (97.1)

N=35

It is a heat sensitive label that is fixed on individual vaccine vials to indicate cumulative heat exposure while transiting through the cold chain to the final point of administration to clients.[23] When properly

interpreted and utilized, the VVM assists healthcare workers to ensure that vaccines exposed to extremes of temperature are not administered to clients.

In our study, only about one-fifth of healthcare workers could correctly interpret the use of the VVM. This finding was higher than the 5% observed among healthcare workers in Lagos, [20] but much lower than the 48% and 52% reported in India [24] and Ilorin, Nigeria [21] respectively. This could be due to the fact that we surveyed healthcare workers who work in immunization clinics whereas the study in Lagos, Nigeria surveyed all cadres of healthcare workers while the Indian study was conducted among recently trained vaccinators on mobile outreach. Also, when compared with their colleagues in Ilorin, a possible reason why a smaller proportion of healthcare workers in Ile-Ife had correct knowledge on VVM was because their counterparts in Ilorin, were continually undergoing in-service training opportunities on cold chain management sponsored by donor agencies.[21] This is a knowledge gap that needs to be addressed through training and retraining of health workers on cold chain management so that they can correctly identify vaccines that have been exposed to temperatures outside the recommended range at all times.

Table 5: Storage Management across Facilities that Store Vaccines

Characteristics	Yes	
	n	%
Insect and rodent storage free area	11	100.0
Are damaged/expired products physically separated from usable products	11	100.0
Clean and well-organized store room	10	90.9
Availability of electrical support (solar, generator, and voltage stabilizer)	9	81.8
Refrigerator located away from surrounding objects	9	81.8
Separate storage of vaccines from other items	9	81.8
Arrangement of vaccines so that the expiry and manufacturing dates are visible	7	63.6
Arrangement of vaccines in FEFO	7	63.6
Security of storage area with lock and key	7	63.6
Arrangement of vaccines so that the expiry and manufacturing dates are visible	7	63.6
Are all electrical supports functioning	5	45.5
Temperature within recommended range in the refrigerator	5	45.5
Keeping temperature chart	3	27.3
Is temperature chart up to date	3	27.3

N=11

About half of the healthcare workers were aware of the shake test and a similar awareness level was reported among health workers in Surat, India, [25] but much higher than the 22.4% reported among healthcare workers in coastal south India.[26] Ideally, all storage equipment containing vaccines should not be used to store any other product to prevent contamination and frequent opening of the cold chain equipment which may affect the storage temperature. Although, about four-fifth of the interviewed healthcare workers indicated this correctly, this value was much lower than the 95% reported in a study among Malaysian healthcare workers. [27]

About one-third of the facilities had thermometers. This has significant implications for the cold chain system if potency of the vaccines at the immunization clinics is to be guaranteed. All facilities are expected to have thermometers because this is a basic tool to monitor the cold chain system for any deviation from the recommended temperature range. The universal availability of vaccine carriers may be as a result of the regular supply of vaccine carriers for the mobile immunizations campaigns for polio eradication in Nigeria. About one-third of the surveyed health facilities had vaccine storage facilities. Although this proportion is small, it is slightly more than the 20% reported in a study in Ilorin, Nigeria.[21] A major reason for this was that a reasonable number of the facilities surveyed, collected (and returned left-over) vaccines from the LGA store only on immunization clinic days. The WHO recommends that all storage facilities must have power back up, especially in countries like Nigeria where power supply from the national grid is unstable. However, at the time this study was conducted, not all the facilities had electricity back up. Only few of the surveyed facilities kept temperature charts. The poor availability of thermometers (37.1%) for vaccine temperature measurements across our study facilities may have contributed to this. This is worrisome in view of the fact that the WHO recommendation says that temperatures in vaccine refrigerators should be read and recorded twice a day.[28] The recording of temperature charts is meant to serve as a way of self-monitoring at the immunization clinics thus preventing breaks in the cold chain and vaccine failures.[28, 29] Less than half of the clinics had functional water facility. This has huge implications for hand washing and infection control while administering vaccines.

Most of the healthcare workers had trainings on completion and submission of reports and proper storage of vaccines. This was not surprising because much emphasis has been placed on proper products storage and submission of monthly reports in the Nigerian national program on immunization.[12] However more capacity building will be required in the areas where lesser proportion of immunization service providers had been trained namely; estimating annual records, providing feedbacks, determining issue and order quantities. This will improve the knowledge of health workers and enhance their capacity to prevent stock outs of vaccines.

Globally, logistics information management of vaccine cold chain has witnessed some innovations with the application of newer technologies and deployment of software applications to monitor stock levels, track supplies, forecast demand and also make new vaccine orders.[30] The Nigerian vaccines logistic information system is still paper-based and currently faced with challenges of incomplete and late reporting. Vaccine wastages (vaccine stock removed from the pipeline for reasons such as- expiration, theft or damage) and adjustments (vaccine stock issued to or received from other

facilities) were poorly documented by healthcare workers in this study. This finding is in consonance with the findings from a study in Nigeria where just about half of the surveyed health facilities had adequate vaccine records.[31] A possible reason for this was that the available forms for logistics information on vaccines lack clearly demarcated sections for recording vaccine wastages and adjustments. This has far reaching implications for the proper tracking and monitoring of the efficiency of the cold chain system. Furthermore, stock on hand was routinely recorded by few respondents. A possible reason for this was that most clinics collect vaccines from the LGA central store and return the unused vaccines on the same day, thus there may be no need to keep records of stocks on hand.

In cold chain logistics management; the ongoing process of projecting which vaccines to order, where, when, by whom, and in what quantities is termed demand forecasting.[4, 11] Majority of healthcare workers utilized immunization records and target population in making vaccine demand-forecasts whereas less than half usually compare previous estimated consumption with actual consumption. This practice where data use for forecasting is not broad-based, may facilitate vaccine stock outs or wastages. In placing new orders, about two-thirds of healthcare workers made use of data from the consumption records. This is slightly higher than the 53% reported among vaccinators in a survey on vaccine wastages in Nigeria. [31] The import of this was that cold chain workers were yet to maximize the use of the other vital records in their day-to-day vaccine requisitions.

The knowledge of healthcare workers about the cold chain system and its logistics management needs to be enhanced. Training and retraining of healthcare workers in the immunization clinics on the shake test and the correct interpretation of the VVM among others is imperative so as to update their knowledge and inform better cold chain practices. Also, availability and functionality of cold chain equipment was sub-optimal. Provision of cold chain storage equipment especially cold boxes and refrigerators (where needed) and other accessories such as voltage stabilizers, generators and thermometers will boost vaccine storage capacities across the respective immunization clinics.

This study was not without limitations, as with all cross-sectional surveys, the survey was subject to response and recall biases although this was minimized by observing clinic records in assessing logistic management information system. Another limitation was that this survey could not compare logistics management of the vaccine cold chain across private and public health facilities in the two LGAs because only one private facility provided immunization services

In conclusion, this study has shown that the logistic management system of the vaccine cold chain system in the study area is faced with some challenges such as inadequate

cold chain equipment, poor record keeping, gaps in staff training and health workers' practices that need to be improved. The following recommendations if well implemented may improve the logistics management of vaccine cold chain system across the health facilities in the Local Government Areas. It is recommended that there should be better record keeping and documentation for improved logistics information management and vaccine storage management across facilities. Continuous in-service training of healthcare workers on data demand and use in the context of logistics management information system will improve the effectiveness of the vaccine cold chain system. Further research on logistics management of vaccine cold chain system on a larger scale to cover all levels of the pipeline and different contexts (public and private health facilities) is also recommended.

Conflict of interest: None

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