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Vaccine Cold Chain Management Practices among Routine Immunization Service Providers in Sokoto State

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Abstract

Immunization is a cornerstone of public health policy and is demonstrably highly cost-effective when used to protect child health. Vaccines have transformed today's public health system. The potency and effectiveness of vaccines lie primarily in their handling and cold chain management systems. The success of national immunization programmes depends largely on effective logistics management of the vaccine cold chain system. The novelty of this study is to thoroughly explore the Vaccine Cold Chain management practices among Routine Immunization service providers in Sokoto State and find interrelationships between the determinants. A descriptive cross-sectional study design was employed and 230 equipped health facilities were sampled, where facility-based, mixed self-reported and actual practice evaluations were made; Analysis of the results by Chi-square test revealed the level of education, years of experience, Attendance of Vaccine Cold chain management related trainings, supportive supervision of RI Service provider determined their Vaccine cold chain management practices. According to the study, Routine Immunization Service providers need to be re-trained periodically in Vaccine cold chain management to keep them in tune with the most recent information for optimal service delivery, The health facility in charge provides the needed oversight on Routine Immunization service providers; and Supportive supervision to be prioritized and owned by the State.

Keywords: *Cold Chain System, Logistics Management, Routine Immunization, Vaccine.*

Introduction

Vaccines have transformed public health, particularly since national programmes for immunization first became properly established and coordinated in the 1960s. In countries with high vaccine programme coverage, many of the diseases that were previously responsible for the majority of childhood deaths have essentially disappeared [1]. The World Health Organization estimates that 2–3 million lives are saved each year by current immunization programmes, contributing to the marked reduction in mortality of children less than 5 years of age globally from 93deaths per 1,000 live births in 1990 to 39 deaths per 1,000 live births in 2018 [2]. Vaccines exploit the extraordinary ability of the highly evolved human immune system

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to respond to, and remember, encounters with pathogen antigens. However, for much of history, vaccines have been developed through empirical research without the involvement of immunologists. There is a great need today for an improved understanding of the immunological basis for vaccination to develop vaccines for hard-to-target pathogens, such as Mycobacterium tuberculosis and antigenically variable pathogens, such as HIV to control outbreaks that threaten global health security (such as COVID-19 or Ebola) and to work out how to revive immune responses in the ageing immune system to protect the growing population of older adults from infectious diseases [3-5].

Vaccines' potency is affected by exposure to both high temperatures and freezing temperatures [6]. The freezing can cause changes in physical appearance and lead to loss of potency of diphtheria and tetanus vaccines due to the damage of the adjuvant gel structure of toxoids. Furthermore, Oral poliomyelitis is identified as the least stable vaccine unless it is stored at low temperatures to maintain its potency. The exposure of vaccines to suboptimal temperatures is a widespread problem observed at all levels of the healthcare systems in both developing and developed countries causing vaccine damage or delivery of sub-potent vaccines [7] and [8]. Vaccines being sensitive to light, heat, and freezing, must be kept in a cold chain system within the World Health Organization's recommended temperature ranges [9,10]. All those who work with vaccines and diluents must be aware of the temperature sensitivities and recommended storage temperatures for all vaccines on the national schedule [11]. A cold chain that meets specific temperature requirements is used to maintain vaccine quality. The cold chain is a network of storage and transportation links designed to keep vaccines at an acceptable temperature range from the manufacturer until they are delivered to users [12,13].

The cold pharmaceutical chain and the healthcare supply chain are associated with the supply chain of medicines within pharmaceutical companies, hospitals, health centres, and pharmacies [14]. Unfortunately, gaps in vaccine cold chain and logistics (CCL) systems are one of the common factors limiting full and equitable access to the benefits of immunization. This is because such gaps undermine the availability and potency of vaccines at the point of administration; prevent the introduction of new life-saving vaccines, and waste precious human and financial resources [15]. For cold chain management to be efficient, three major elements are required. These include well-trained personnel, reliable transport/storage equipment and efficient management procedures [16]. An absence of any of these would lead to a deficient cold chain system. Health workers play an important role in maintaining an undisrupted cold chain as they are the last point of contact between the vaccines and the recipient. Hence, it is very pertinent that they are trained and supervised regularly to ensure the efficient practice of cold chain management; in addition to training and supportive supervision of health workers, logistic materials and tools for monitoring storage temperatures should be made available at health facilities [17].

Several factors affect cold chain systems. These include breakdown of refrigerators and freezers, delays during transportation, inappropriate refrigerators, long duration of storage at the health unit, improper use of refrigerators, power interruptions, and lack of trained personnel capable of managing the cold chain [18]. It has been established that vaccines are vital health commodities that need an appropriate supply chain system. The success of a country's vaccination programs depends solely on the vaccine cold chain system, and hence the cliché – no product, no program [19]. Previous studies in the southern parts of Nigeria and abroad, show some correlation between the levels of education,

years of experience in routine immunization practice and service delivery, vaccine management training, supportive supervisory visits and their vaccine cold chain management practices; which directly impacts service delivery. In Sokoto State, there is little data that shows this relationship; this study tries to bridge this knowledge gap.

Methods

Study Area and Period

The study was conducted in the three Senatorial zones (Sokoto North, Sokoto South and Sokoto East) of Sokoto state (figure 1). All twenty-three local government areas were selected for this study. The study was carried out from May 2022 to October 2023.

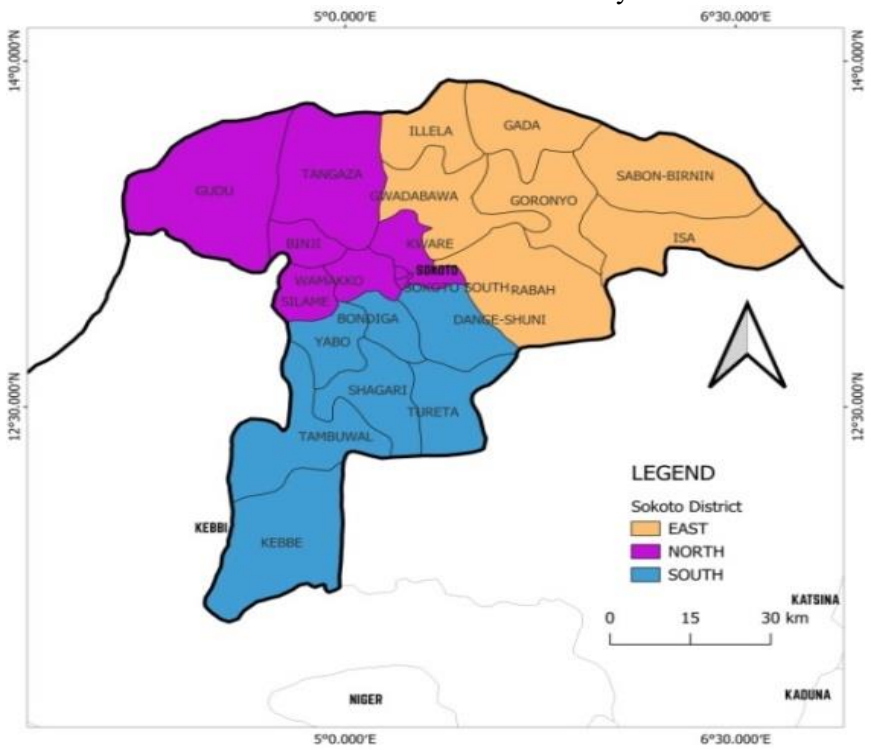

Figure 1. Map of Sokoto State Showing the Study Areas

Study Design

A descriptive cross-sectional study design was employed in this research, where facility-based, mixed self-reported and actual practice-evaluating cross-sectional studies were conducted at equipped primary health centers providing Routine Immunization services in Sokoto State.

Study Population and Sample Size

The study population for this study included Routine Immunization service providers who worked in equipped primary public health centres, clinics and dispensaries in Sokoto State. All EPI service providers who fulfilled the criteria were included.

10 equipped facilities were sampled per LGA in Sokoto State, this represented over 80% of all equipped facilities; this therefore shows a good representation of the entire population of equipped facilities.

Sokoto State has 23 LGAs, and 230 health facilities were sampled for this study.

Inclusion Criteria

All participants were above the age of 18, and they were Routine Immunization service providers in their designated health facilities that were equipped with cold chain equipment thus they could be healthcare professionals who worked in the EPI service provision system or in the vaccine and cold chain management systems.

Exclusion Criteria

Non-routine immunisation service providers or health workers in health facilities that were not equipped.

Ethical Approval and Participants' Consent

This research was approved by the Department of Health Planning Research and Statistics, Sokoto State Ministry of Health, Sokoto; an informed consent was administered to all respondents. The participants were not exposed to harm at any point in time because of their participation. They were free to withdraw their participation during the interview. Confidentiality of collected information was maintained.

Data Collection

A semi-structured questionnaire was developed by reviewing earlier studies. Mainly, two data collection methods were used to collect the data. Primary data was collected through face-to-face interviews using structured questionnaires. Secondly, the actual practices of vaccine and cold chain management at selected health facilities were evaluated by onsite observation of their management practices of cold chain, storage conditions, logistic information systems, and availability of necessary equipment and logistics.

The data collection instrument included four parts:

1. The first to consist of participants' socio-demographic characteristics.
2. The second section to consist of statements that describe the participants' training and supervision, support from regulatory bodies, and knowledge-related questions
3. The third section of the instrument to be used to assess vaccine storage and handling
4. The last section of the data collection was information used to directly observe the actual cold chain management practices of study participants in the selected health facilities

Data Analysis

Trained enumerators collected data with the free Kobo collect mobile data kit, and data was exported to Excel for cleaning. Cleaned data was entered into SPSS (IBM SPSS Statistics 20, United States) and MS Excel for the analysis of the data which gave the descriptive statistics.

Independent Variables

Includes the demographic characteristics such as age, sex, educational status, Cadre of respondents, Years of experience as Health workers and RI Service providers, Familiarity with Vaccine Cold chain systems, Attendance of Vaccine management training

Outcome Variables

These include Possession of functional fridge tag, Possession of a Temperature Monitoring Chart (TMC), Correct frequency of Recording on the Temperature Monitoring Chart, Documentation of Temperature Monitoring Charts, Analysis on the filled TMC for decision making, Documentation of vaccine received and vaccine used, Analysis on vaccine utilization for decision making, Possession and display of Standard Operating Procedures on VCCM, Possession and display of VCCM contingency plan, Conduct Routine Planned preventive maintenance CCEs; Chi-square test was then used to determine the inter-dependence of the variables the outcome variables and the independent variables.

Results

Sociodemographic Characteristics of the Study Participants

The study was conducted from May 2022 to October 2023. 230 health facilities were sampled, and consequently, 230 Routine Immunization Service providers were interviewed and observed for their vaccine cold chain management practices. Of the 230 participants targeted across the three senatorial zones, The female participants made up 20% while the male counterparts made up 80% of the total participants (Figure 2, Table 1).

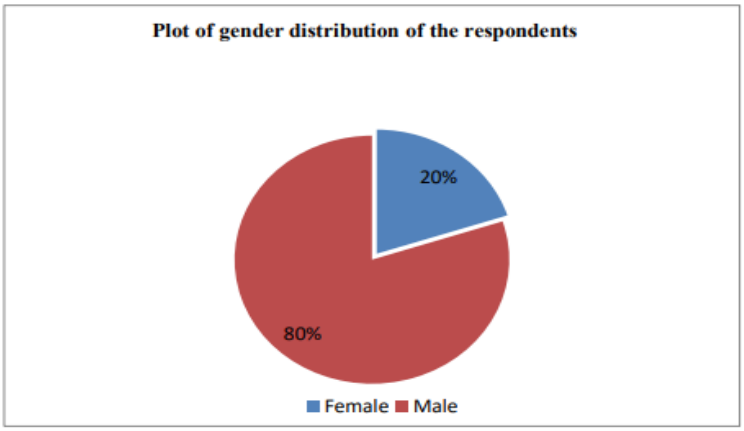

Figure 2. Plot of Gender Distribution of the Respondents

Table 1. Socio-Demographics of Participants in the Study

SOCIO-DEMOGRAPHIC DATA			
Variables		**Total data**	***Percentage***
		230	*100.0*
Sex	**Male**	184	*80.0*
	Female	46	*20.0*
Age	**<25**	7	*3.0*
	25-29	39	*17.0*
	30-34	67	*29.1*
	35-39	72	*31.3*
	40-44	35	*15.2*
	45-49	5	*2.2*
	50 & above	5	*2.2*
Highest Level of Education	**Primary**	0	*0.0*
	Secondary	3	*1.3*
	Graduate	224	*97.4*
	Post Graduate	3	*1.3*
Cadre	**Auxiliary**	3	*1.3*
	JCHEW	41	*17.8*
	CHEW	115	*50.0*
	CHO	3	*1.3*
	Tutor	0	*0.0*
	Nurse	4	*1.7*
	Midwife	2	*0.9*
	Others	62	*27.0*
Years of experience as a health worker	**< 5**	51	*22.2*
	5-10	84	*36.5*
	11-15	74	*32.2*
	16-20	14	*6.1*

	>20	7	*3.0*
Years of experience as an RI Service provider	**< 5**	81	*35.2*
	5-10	107	*46.5*
	11-15	35	*15.2*
	16-20	4	*1.7*
	>20	3	*1.3*

It is of interest to note that concerning age distribution, the majority of participants studied are between 35-39 years which was followed by the 30-34 years range, accounting for 31% and 29% of the total participants as shown in figure 3. The education level of the respondents in Figure 4 revealed that the highest number of respondents are graduates accounting for 97.4% of total participants in the Vaccine cold chain management study, while 1.3% have postgraduate and secondary school certificates respectively. It is also worth noting that, in terms of the cadre distribution, the study showed that 50% of the respondents were CHEW (Community Health Extension Workers) followed by Other cadres (Environmental Health Officers and their Assistants) these made up 27%, while 18% were JCHEW (Junior - Community Health Extension Worker); while the remaining cadres (Auxiliary, CHO, Nurse and Midwife) aggregates to 5% (figure 5); Table 2 shows the chi-square analysis which gives the interrelationship between the independent variable and the outcome variables.

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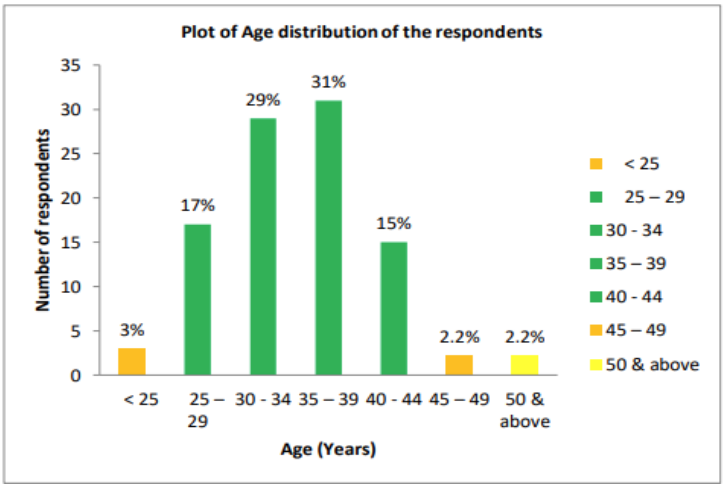

Figure 3. Plot of Age Distribution of the Respondents

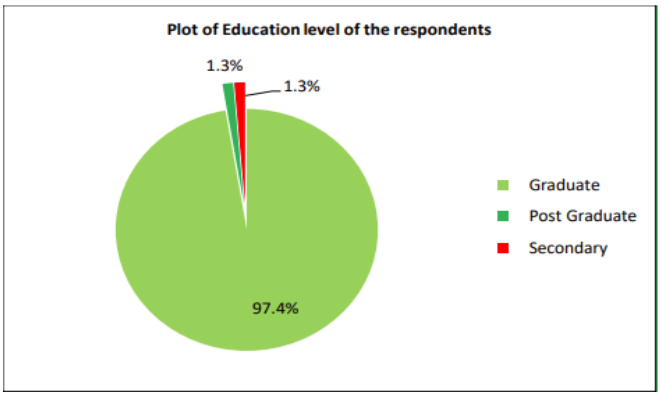

Figure 4. Plot of Education Level of the Respondents

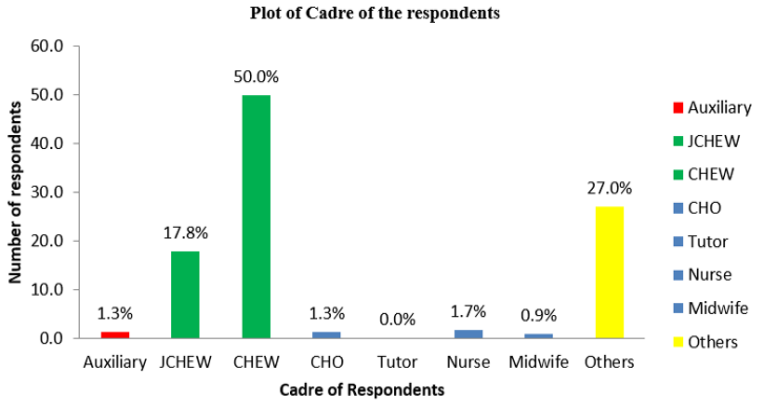

Figure 5. Plot of Respondents' Cadre

Table 2. Chi-square Analysis

Independent Variables	**X^2 value**	**P – value**	**Decision**
Level of Education			
Possession of functional fridge tag	0.249	0.883	Not significant
Possession of a Temperature Monitoring Chart (TMC)	1.142	0.565	Not significant
Correct frequency of Recording on the TM Chart	2.775	0.250	Not significant
Documentation of Temperature Monitoring Charts	1.317	0.985	Not significant
Analysis of the filled TMC for decision-making	1.148	0.361	Not significant
Documentation of vaccine received and vaccine used	9.968	0.026	Significant
Analysis of Vaccine utilization for Decision-making	2.065	0.356	Not significant
Possession and display of Standard Operating Procedures on VCCM	1.948	0.378	Not significant
Possession and display of the VCCM contingency plan	4.024	0.0134	Significant
Conduct Routine Planned preventive maintenance CCEs	1.856	0.762	Not significant
Years of Experience			
Possession of functional fridge tag	2.925	0.570	Not significant
Possession of a Temperature Monitoring Chart (TMC)	2.677	0.613	Not significant
Correct frequency of Recording on the TM Chart	2.776	0.596	Not significant
Documentation of Temperature Monitoring Charts	5.091	0.035	Significant
Analysis of the filled TMC for decision-making	1.032	0.349	Not significant
Documentation of vaccine received and vaccine used	23.133	0.007	Significant
Analysis of Vaccine utilization for Decision-making	5.023	0.028	Significant
Possession and display of Standard Operating Procedures on VCCM	6.183	0.018	Significant
Possession and display of the VCCM contingency plan	3.335	0.503	Not significant
Conduct Routine Planned preventive maintenance on CCEs	5.907	0.038	Significant
Age of RI Service providers			
Possession of functional fridge tag	12.218	0.035	Significant

Possession of a Temperature Monitoring Chart (TMC)	9.586	0.014	Significant
Correct frequency of Recording on the TMChart	4.520	0.042	Significant
Documentation of Temperature Monitoring Charts	8.350	0.035	Significant
Analysis of the filled TMC for decision-making	2.510	0.365	Not significant
Documentation of vaccine received and vaccine used	46.827	0.004	Significant
Analysis of Vaccine utilization for Decision-making	7.529	0.028	Significant
Possession and display of Standard Operating Procedures on VCCM	4.420	0.026	Significant
Possession and display of the VCCM contingency plan	9.182	0.016	Significant
Conduct Routine Planned preventive maintenance on CCEs	15.140	0.023	Significant
Sex of RI Service providers			
Possession of functional fridge tag	6.133	0.941	Not significant
Possession of a Temperature Monitoring Chart (TMC)	2.554	0.276	Not significant
Correct frequency of Recording on the TMChart	2.176	3.121	Not significant
Documentation of Temperature Monitoring Charts	3.786	0.177	Not significant
Analysis of the filled TMC for decision-making	4.107	0.590	Not significant
Documentation of vaccine received and vaccine used	6.614	0.438	Not significant
Analysis of Vaccine utilization for Decision-making	2.745	2.005	Not significant
Possession and display of Standard Operating Procedures on VCCM	3.294	1.420	Not significant
Possession and display of the VCCM contingency plan	5.124	0.976	Not significant
Conduct Routine Planned preventive maintenance on CCEs	5.907	0.701	Not significant

Discussion

An effective vaccine cold chain management system is as important as procuring the vaccines for any immunization intervention, and the vaccine cold management practices by health workers and vaccine handlers directly impact the viability of vaccines that are eventually given to the end users. This study assessed the Vaccine Cold Chain Management Practices among Routine Immunization Service Providers in Sokoto State and found that only 37% of routine Immunization service providers reported having good knowledge of the management of vaccines and the cold chain amongst other vaccine cold chain management practices. The study further revealed that the highest number of respondents are graduates accounting for 97.4% of total participants in the Vaccine cold chain management study, while 1.3% have postgraduate and secondary school certificates respectively; statistically, only *Documentation of vaccines received and vaccines used* and *the Possession and display of Vaccine cold chain management contingency plan* showed a significant relationship with the level of Education of the R.I Service providers, this finding is in agreement with [20] in a study conducted in Bahir Dar, Northwest Ethiopia, who opined that educational background played a role in vaccine cold chain management practices displayed by service providers in health facilities. It also follows the opinion of [17] in a similar study in Benin-city Edo State, Nigeria who stated that a higher level of education increases the cognitive and mental function of individuals, and bestows upon them a higher capacity to translate knowledge that has been acquired to practice. This was affirmed in this study where an increase in the level of education of the R.I

Service providers precipitated a better vaccine cold chain management practice.

The demographics of the years of experience of the R.I Service providers revealed that the group with the highest frequency for years of experience as an RI Service Provider in the Vaccine cold chain management study is between 5-10 years followed by the less than 5 years class with percentage values of 47% and 35% respectively. However, those with very high experience as RI Service providers aggregate 18% (15% for 11-15 years, 2% for 16-20 years and 1% for participants with over 20 years of experience as RI Service providers). Statistical analysis inferred that of the ten variables, five showed a significant relationship on the years of experience as RI Service providers, these include: *Documentation of Temperature Monitoring Charts, Documentation of vaccines received and vaccines used, Analysis of vaccine utilization for decision making, Possession and display of Standard Operating Procedures on VCCM* and *Conduct Routine Planned preventive maintenance on CCEs*; while the other five didn't show any dependence. It can therefore be taken that the more years of experience as an RI Service provider, the better one's cold chain management practices, this premise is however in conflict with the findings of [17] whose study found that cold chain management practice was better amongst respondents with lower years of experience.

The distribution of gender of participants in the study showed female R.I. Service providers accounted for only 20% of the study population while 80% of respondents were males. This huge disparity could be attributed to the level of literacy amongst males and females in North-western Nigeria also in congruence with the 2017 USAID study conducted in Bauchi and Sokoto States [21], and not in tandem with the study by [22]. Statistically, when all ten vaccine cold chain management variables were compared to genders of the R.I. Service providers, all were seen to have no significant relationship, and hence the difference in the practice of cold chain management observed between sexes was however not statistically significant which is in agreement with the study conducted by [17]. On the other hand, the majority of the sampled R.I. Service providers were between the 30 - 39 age group accounting for 60% of the total study population, this shows a well-distributed workforce according to age. Statistically, when all ten vaccine cold chain management variables were compared to the age of the R.I. Service providers, all were seen to have a significant relationship except for *Analysis on the filled TMC for decision making*. It therefore shows that the age of RI Service providers plays a role in their vaccine cold chain management practices.

As the burden of childhood preventable diseases in North-western Nigeria continues to be a public health problem, attention has been on the public health institutions in the management and administration of potent vaccines to the targeted age groups, it follows that proper vaccine and cold-chain management practices birth the administration of the desired potent vaccines which will serve to drastically reduce the childhood preventable disease burden in the region.

Conclusion

In conclusion, this study sought to determine the vaccine cold chain management practices amongst Routine Immunization Service providers in Sokoto State. The findings revealed that 97.4% of total participants in the Vaccine cold chain management study are graduates of schools of health technologies (CHEWs), indicating an averagely high level of education, similarly 65% of sampled health workers have greater than 5 years of experience as RI Service providers, these are indices which translated to better vaccine cold chain management practices. Similarly, 79% of the RI Service

providers have attended vaccine cold chain management / preventive maintenance training and naturally with the equipped knowledge, they are more likely to have better deposition of taking care of their cold chain equipment as well as having better vaccine Cold chain management practices. In the area of supportive supervisory visits, 54% of the RI Service providers have received at least one supervisor in the last month, with consultants from partner agencies providing over 60% of the support delivered; very distant and hard-to-reach health facilities with issues of insecurity pose an obstacle to building the capacity and on the job training the health workers would have gained. Finally, even though female RI Service providers accounted for only 20% of the study population and male participants made up the majority, there was no relationship between their vaccine cold chain management practices and their gender.

Acknowledgements

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Conflict of Interests

The authors declared no conflict of interest.

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