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Original Research Article

Assessment of knowledge and skills of vaccine cold chain handlers in Nadia district, West Bengal: a cross-sectional study

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ABSTRACT

Background: The effectiveness of vaccination programs hinges on a reliable cold chain infrastructure, which is essential for maintaining vaccine potency. Individuals tasked with managing the vaccine cold chain play a key role in preserving this efficacy, thereby facilitating effective immunization by adhering to established storage and handling protocols. The current research aims to evaluate the proficiency and technical expertise of these handlers in managing the cold chain across selected subdivisions of the Nadia District in West Bengal.
Methods: Vaccine cold chain handlers at cold chain points in the chosen subdivisions participated in a descriptive cross-sectional facility-based study. Of the 38 handlers identified, 30 met the eligibility criteria and were included using a census method. Data was gathered using an observation checklist to evaluate the practical skills and a pretested structured questionnaire to assess knowledge. Both descriptive and suitable inferential statistical analyses were carried out.
Results: The majority of the participants were female (28; 93.3%) with a mean age of 42.6±10.3 years. The mean knowledge score was 13.66±1.18 (out of 15), with 96.7% demonstrating good knowledge. The mean skill score was 4.16±0.91 (out of 5). While temperature monitoring was correctly performed by 93.3%, only 60% correctly demonstrated the shake test. Knowledge and skill scores showed a significant positive correlation (r=0.564, p=0.001).
Conclusions: Although the majority of cold chain handlers demonstrated good knowledge, certain gaps in practical skills were identified, indicating the need for periodic refresher training and strengthened supportive supervision.

Keywords: Cold chain management, VVM, Vaccine cold chain handlers, UIP, eVIN

INTRODUCTION

Globally, an estimated 5.9 million children succumb before reaching their fifth birthday each year.[1] A substantial proportion of these deaths are due to the conditions that can be prevented or treated through uncomplicated and economically viable interventions.[2]

Immunization is one of the most effective public health interventions, markedly diminishing morbidity and mortality from vaccine-preventable diseases worldwide.[3] It is projected that routine childhood vaccination averted approximately 3.5–5 million deaths annually worldwide, thereby establishing vaccination as one of the most cost-effective public health interventions.[4] Vaccines are temperature and light sensitive biological products, and their effectiveness can be compromised when exposed to temperatures beyond the prescribed limits. Most vaccines used under the Universal Immunization Programme (UIP) must be stored within the recommended temperature range of +2°C to +8°C to maintain their effectiveness.

Exposure to temperatures outside this stipulated range has the potential to irreversibly impair vaccine potency. Certain vaccines, such as hepatitis B, pentavalent, IPV, DPT, and tetanus toxoid, are particularly sensitive to freezing, whereas reconstituted BCG and measles/MR vaccines are highly sensitive to heat and light.[5] Therefore, maintaining the prescribed temperature conditions throughout the vaccine supply chain is essential.

The vaccine cold chain refers to the system used to maintain standard temperatures during vaccine storage and transport. Maintaining an uninterrupted cold chain is essential to preserve vaccine potency from the point of manufacture to administration. Despite improvements in immunization coverage globally, the cold chain remains one of the most vulnerable components of national immunization systems.[6]

Vaccine cold chain handlers (VCCHs) play a pivotal role in maintaining vaccine potency at cold chain points (CCPs). Their knowledge, skills, and adherence to recommended practices related to vaccine storage, handling, and temperature monitoring are essential for maintaining vaccine potency and ensuring safe immunization services. Previous studies have shown that training, supervision, education level, and work experience influence the performance of cold chain handlers in vaccine management.[7]

Previous studies have highlighted that knowledge gaps among healthcare workers involved in vaccine management remain common, particularly in resource-limited and remote settings.[8] Training healthcare providers has been shown to substantially enhance cold chain monitoring and vaccine management practices, especially when regular in-service training is provided.[9] However, despite training efforts, deficiencies in knowledge and practical skills among cold chain handlers have been reported in several studies.[10]

Inadequate knowledge and improper practices can disrupt the vaccine cold chain system and compromise vaccine potency and safety. This may lead to vaccine failure, outbreaks of vaccine-preventable diseases, and increased morbidity and mortality among vulnerable populations such as children under five years of age and pregnant women.

Furthermore, inadequate cold chain management can result in vaccine wastage, leading to financial repercussions for health systems.[11] For instance, an inquiry into a measles outbreak in the Kangra district of Himachal Pradesh identified shortcomings in vaccine cold chain maintenance as one of the contributing factors.[12]

Considering the crucial role of cold chain handlers in maintaining vaccine quality, periodic assessment of their knowledge and practical skills related to cold chain management is essential. Despite the importance of effective vaccine cold chain management, relatively few studies have evaluated the knowledge and practical competencies of vaccine cold chain handlers at the field level in many regions of India.

Therefore, the present study was conducted to assess the knowledge and evaluate the practical skills of vaccine cold chain handlers regarding cold chain management in selected subdivisions of the Nadia district, West Bengal.

METHODS

Study design and setting

A descriptive cross-sectional health facility-based study was conducted from January to April 2024 at cold chain points located in the Kalyani and Ranaghat subdivisions of Nadia district, West Bengal, India. These cold chain points were situated within public health facilities, including Block Primary Health centres (BPHCs), Primary Health Centres (PHCs), sub-centres (SCs), and gram panchayats (GPs) across seven blocks.

Study population and sampling

The study population comprised VCCHs working at cold chain points in public health facilities. Kalyani and Ranaghat subdivisions were purposively selected based on feasibility and administrative permission.

All 22 cold chain points located in these subdivisions were included. Of the 38 handlers identified, 30 satisfied the eligibility criteria and were included using a census method, while eight were excluded due to ineligibility, unavailability during data collection, or maternity leave. Knowledge was assessed using a pretested structured questionnaire and practical skills using an observation checklist. Descriptive and appropriate inferential statistical analyses were performed.

Inclusion criteria

Cold chain handlers who were present during the study period and willing to participate were included in the study.

Exclusion criteria

Handlers who were unavailable even after two visits or those on maternity leave were excluded.

Data collection tools and procedures

Data were collected using a structured questionnaire to assess knowledge and an observation checklist to evaluate practical skills related to cold chain management. The tools were developed following literature review and validated by subject experts. Skill level was assessed using a structured observation checklist based on guidelines from the Handbook for Vaccine and Cold Chain Handlers, 2nd Edition, India 2016, published by the Ministry of Health and Family Welfare.

A pilot study was conducted among five handlers outside the study area to assess clarity and feasibility of the questionnaire. Based on the feedback obtained, necessary modifications were made to improve clarity and relevance. The questionnaire was prepared in English, translated into the local language, and back-translated to ensure accuracy.

Study variables

The dependent variables were the knowledge and skills of vaccine cold chain handlers regarding cold chain management.

The independent variables included socio-demographic characteristics such as age, gender, educational qualification, professional background, years of experience in vaccine cold chain management, and training received.

Measurement of variables

Knowledge regarding cold chain management was assessed using 15 questionnaire items, with each correct response scored as 1 and incorrect response as 0, giving a maximum score of 15. Knowledge scores were converted into percentages using the formula given, and categorized as poor (<65%), fair (65–79%), and good (≥80%).

$$Knowledge\ scores = (Score\ obtained \div 15) \times 100$$

Skill levels were evaluated using five observational items, including the ability to perform the shake test, read thermometer temperature, interpret vaccine vial monitor (VVM) stages, use the electronic vaccine intelligence network (e-VIN) application, and condition ice packs. Each correctly performed skill was scored 1, and incorrect or unperformed skills were scored 0. Skill levels were categorized as poor (<65%), fair (65–79%), and good (≥80%) based on percentage scores.

Data analysis

Data were entered and analyzed using IBM statistical package for the social sciences (SPSS) statistics version 25. Descriptive statistics such as frequency, percentage, mean, and standard deviation were calculated. Associations between categorical variables were assessed using the Chi-square or Fisher's exact test as appropriate. A $p<0.05$ was considered statistically significant. Pearson correlation analysis was used to examine relationships between continuous variables such as age, knowledge score, and skill score.

Ethical considerations

Ethical approval was obtained from the Institutional Ethics Committee prior to conducting the study. Written informed consent was obtained from all participants. Confidentiality and anonymity of participants were strictly maintained throughout the study.

RESULTS

A total of 30 VCCHs participated in the study out of 38 eligible participants. The majority of participants were female (93.3%), and the remaining 6.7% were male. The age of the respondents ranged from 29 to 62 years, with a mean age of 42.6±10.3 years, and the majority of participants (60%) were aged >35 years.

Regarding educational qualifications, 46.7% were graduates, while 23.3% had postgraduate degrees. In terms of professional background, female health assistants constituted the largest group (26.7%), followed by community health assistants (20%) and female health supervisors (16.7%). The mean work experience was 8.1±9.37 years, indicating wide variation among participants.

Most participants (66.7%) had ≥2 years of experience in vaccine cold chain management. The majority (83.3%) had received training in vaccine cold chain management within the past two years, and 70% expressed the need for additional training (Tables 1 and 2).

Table 1: Socio-demographic characteristics of cold chain handlers (n=30).

Variable	Category	Frequency, N (%)
Age (years)	26–35	12 (40.0)
	>35	18 (60.0)
Gender	Male	2 (6.7)
	Female	28 (93.3)
Education	Madhyamik (10th)	4 (13.3)
	Higher secondary	5 (16.7)
	Graduate	14 (46.7)
	Postgraduate	7 (23.3)
Staff category	Sr. PHN	4 (13.3)
	CHO	4 (13.3)
	HA (F)	8 (26.7)
	HS (F)	5 (16.7)
	CHA	6 (20.0)

Most respondents demonstrated good knowledge regarding cold chain management. Nearly all participants correctly identified that exposure to heat, light, and freezing can reduce vaccine potency (96.7%), and all respondents correctly reported the recommended vaccine storage temperature of 2–8°C in an ice-lined refrigerator (ILR).

Similarly, all participants correctly identified that hepatitis B, DPT, DT, and tetanus toxoid vaccines are freeze-sensitive. High proportions of respondents also correctly answered questions regarding number of ice packs in vaccine carriers (100%), use of reconstituted vaccines (100%), and storage of vaccines in domestic refrigerators (96.7%).

However, fewer participants correctly identified the cause of freezing of vaccines (76.7%) and the method to identify freeze-damaged vaccines (86.7%). Only 46.7% correctly identified that BCG and measles vaccines are supplied in amber-colored vials due to light sensitivity (Table 3).

Table 2: Training related- factors of cold chain handlers (n=30).

Variable	Category	Frequency, N (%)
Years of service in cold chain management	<2	10 (33.3)
	≥2	20 (66.7)
Training attended within the last 2 years	Yes	25 (83.3)
	No	5 (16.7)
Need more training	Yes	21 (70.0)
	No	9 (30.0)
Training required area	Cold chain management	2 (9.5)
	Equipment maintenance	4 (19.0)
	Both	15 (71.4)

Table 3: Knowledge regarding vaccine cold chain management among handlers (n=30).

Knowledge item	Correct response, N (%)
Exposure to heat/light/freezing reduces vaccine potency	29 (96.7)
2–8°C recommended temperature for most vaccines	30 (100)
HepB, DPT, DT, TT are freeze sensitive	30 (100)
Correct number of ice packs in carrier	30 (100)
Opened vials usable up to 28 days	28 (93.3)
Reconstituted vaccine usable next day	30 (100)
Domestic refrigerator unsuitable for vaccines	29 (96.7)
Medicines should not be stored with vaccines	29 (96.7)
Identification of freeze damaged vaccines	26 (86.7)
Cause of freezing vaccines	23 (76.7)
BCG/measles supplied in amber vials	14 (46.7)
Action during power failure	26 (86.7)
eVIN is internet based	27 (90.0)
VVM inner square darker than outer circle	29 (96.7)

Most participants were able to correctly read temperature using a thermometer (93.3%), interpret vaccine vial monitor (VVM) stages (100%), and condition ice packs appropriately (96.7%). However, only 60% were able to perform the shake test, and 66.7% were able to independently use the electronic Vaccine Intelligence Network (eVIN) application (Table 4).

Table 4: Practical skills of vaccine cold chain handlers (n=30).

Skill	Yes, N (%)	No, N (%)
Use eVIN* application	20 (66.7)	10 (33.3)
Read thermometer correctly	28 (93.3)	2 (6.7)
Check VVM* status	30 (100)	0 (0)
Perform shake test	18 (60.0)	12 (40.0)
Condition ice packs	29 (96.7)	1 (3.3)

*eVIN: Electronic vaccine intelligence network, *VVM: Vaccine vial monitor

The mean knowledge score among participants was 13.66±1.18 (out of 15). The majority of respondents (96.7%) had good knowledge, while only 3.3% had fair knowledge, and none had poor knowledge.

The mean skill score was 4.16±0.91 (out of 5). Regarding skill levels, 43.4% had good skills, 43.4% had average skills, and 13.3% had poor skills (Table 5).

No statistically significant association was observed between knowledge level and age, gender, educational qualification, professional background, work experience, or training received ($p>0.05$). Similarly, skill levels were not significantly associated with age, gender, educational qualification, or training status ($p>0.05$).

However, a statistically significant association was observed between work experience and skill level ($p=0.003$), indicating that participants with greater work experience demonstrated better practical skills in cold chain management.

A moderate positive correlation was observed between age and knowledge score ($r=0.401$, $p=0.028$), indicating that knowledge tended to increase with age as shown in Figure 1.

A significant positive correlation was also found between knowledge and skill scores ($r=0.564$, $p=0.001$), suggesting that participants with higher knowledge levels tended to demonstrate better practical skills.

Table 5: Descriptive statistics of knowledge and skill scores.

Variable	Mean	Median	SD	Minimum	Maximum
Knowledge score	13.66	14	1.18	10	15
Skill score	4.16	4	0.91	2	5

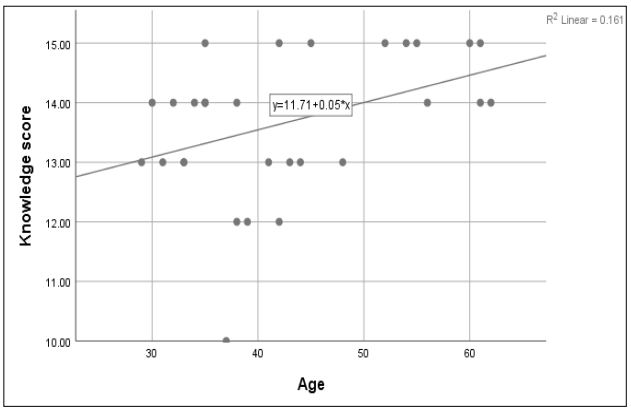

Figure 1: Simple scatter plot of knowledge score by age of vaccine cold chain handler.

DISCUSSION

The present study assessed the knowledge and practical skills of vaccine cold chain handlers working at cold chain points in the Kalyani and Ranaghat subdivisions of Nadia district, West Bengal. Effective cold chain management is crucial for maintaining vaccine potency and ensuring the success of immunization programs. The findings provide important insights into the preparedness of personnel responsible for vaccine storage and handling at peripheral health facilities.

In the present study, the majority of participants were female, reflecting the workforce composition in primary healthcare settings where nursing staff commonly manage immunization and cold chain activities. This finding contrasts with a study conducted in the Etawah district, where all participants were male, but is consistent with findings from the Tigray region of Ethiopia, where females constituted 84% of cold chain handlers.[13,14] Such variations highlight regional differences in workforce composition, which may influence training needs and program implementation.

The mean age of participants in this study was 42.6 years, with an age range of 29–62 years. Comparable findings were reported by Kunal et al, where most participants were above 40 years of age, with a mean age of 48 years.[15] In contrast, a study from Gwalior district reported a younger workforce, with a mean age of 29.3 years.[16] These differences may reflect variations in recruitment patterns, workforce retention, and local health system structures.

A large proportion of participants (83.3%) had undergone training in cold chain management within the past two years; however, many still reported a need for additional training, highlighting the importance of ongoing capacity-building efforts. In addition, the majority of participants (66.7%) had more than two years of experience in cold chain management, which is comparable to findings from studies conducted in Ethiopia (61%) and Gwalior (77.8%).[16,17] Although greater experience may enhance familiarity with standard protocols, it does not necessarily translate into appropriate practices, indicating the need for regular refresher training and strengthened supportive supervision.

This study shows, work experience exceeding two years was positively associated with better cold chain management practices, which aligns with findings from studies conducted in Bahir Dar and the Etawah district.[8,18] This suggests that both experience and ongoing training are important determinants of effective cold chain management.

Knowledge regarding vaccine storage temperature was found to be high, with all participants correctly identifying the recommended temperature range (2–8°C). Similar findings were reported in Ethiopia (95.6%) and Etawah (93.7%).[8,18] However, lower levels of knowledge have been documented in Cameroon (68.5%) and Mozambique (52%), indicating disparities that may be attributed to differences in training, educational background, and resource availability.[19,20]

Regarding practical skills, most participants demonstrated good proficiency in routine procedures such as thermometer reading and VVM interpretation. In this study, all participants correctly interpreted VVM status, which is consistent with findings from Meerut.[21] However, lower proportions have been reported in Ethiopia, including 64% in Tigray and 58.3% in Gojam Zone.[14,22] These differences may reflect variations in the quality of training and supervision.

Proficiency in the shake test was observed in 60% of participants. This is higher than findings from Durg (52.6%) and South India (22.4%), but lower than those reported in Nainital (94.2%)15 and Surat (66.7%).[23-25] These variations suggest that certain critical practical skills may not be uniformly emphasized during training programs, highlighting the need for hands-on training and periodic skill assessments.

With regard to eVIN usage, 66.7% of participants demonstrated proficiency, which is lower than the 76.5% reported in Nainital.[15] Differences in technological familiarity, training exposure, and frequency of use may explain this variation.

The overall knowledge level in this study was high, with 96.7% of participants demonstrating good knowledge, comparable to findings from Bahir Dar (92.9%) but considerably higher than those reported in Tigray (48%).[14,18] Despite this, gaps in practical skills were observed, indicating that knowledge alone does not necessarily translate into optimal practice.

A significant positive correlation between knowledge and skill scores was observed, suggesting that improved knowledge is associated with better performance. However, the persistence of skill gaps indicates the need for training approaches that integrate both theoretical and practical components.

Cold chain maintenance remains a critical component of immunization programs. Inadequate temperature control can compromise vaccine potency, leading to reduced effectiveness, increased risk of vaccine-preventable disease outbreaks, and wastage of valuable resources. Therefore, strengthening the capacity of cold chain handlers through regular refresher training, supportive supervision, and continuous monitoring is essential to ensure the effectiveness and reliability of immunization services.

Strengths and limitations of the study

One of the strengths of the study is that it included cold chain handlers from multiple cold chain points, thereby offering an in-depth look at cold chain management practices in the study area. Furthermore, both theoretical knowledge and practical competencies were evaluated using structured assessment tools and direct observation, which enhanced the reliability of the research findings. The study faced limitations due to a relatively small sample size and its confinement to selected subdivisions, which may hinder the generalizability of the results. Moreover, the potential for observer bias during the assessment of skills cannot be entirely dismissed.

CONCLUSION

The present study found that vaccine cold chain handlers working in the selected cold chain points of Nadia District generally demonstrated good knowledge regarding cold chain management. However, gaps were identified in certain practical skills related to vaccine handling and cold chain maintenance. These skill shortages may have an impact on the quality of vaccine handling and storage procedures since adequate cold chain management is necessary to preserve vaccine potency and guarantee the efficacy of immunization campaigns.

The findings highlight the need for regular refresher training, hands-on skill-based training sessions, and supportive supervision for vaccine cold chain handlers. Strengthening monitoring mechanisms and reinforcing practical training components can help improve cold chain practices at peripheral health facilities. Continuous capacity building of cold chain handlers is essential to ensure safe vaccine storage and effective implementation of the Universal Immunization Programme in India.

Further studies with larger sample sizes across different districts are recommended to better understand the knowledge and skill gaps among vaccine cold chain handlers and to guide targeted interventions for improving cold chain management practices.

Recommendations

Based on the findings of the study, regular refresher training programs should be conducted for vaccine cold chain handlers to address gaps in practical skills and reinforce knowledge related to vaccine storage and handling. Supportive supervision and periodic monitoring of cold chain practices should also be strengthened to ensure adherence to standard guidelines.

In addition, practical training sessions focusing on key procedures such as the shake test, vaccine vial monitor interpretation, and the use of the eVIN system may further enhance the competency of cold chain handlers. Strengthening these aspects of cold chain management can contribute to improved vaccine quality, reduced vaccine wastage, and more effective immunization services.

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