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ASSESSMENT OF VACCINE COLD CHAIN EQUIPMENT AND THEIR MANAGEMENT IN GOVERNMENT HEALTHCARE FACILITIES IN DISTRICT THARPARKAR.

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ABSTRACT

BACKGROUND: Vaccination programs are essential for controlling infectious diseases, and their effectiveness relies heavily on maintaining vaccine potency through proper storage and handling. The vaccine cold chain system—comprising temperature-controlled environments for storage, management, and transportation—is critical for ensuring vaccine efficacy. **OBJECTIVE:** Any lapse in cold chain maintenance can lead to vaccine degradation, reducing effectiveness and posing serious public health risks. **METHODOLOGY:** This descriptive cross-sectional study was conducted in Tharparkar District, targeting government healthcare facilities providing vaccination services. Out of 189 total facilities, 21 were randomly selected using Open Epi software, with inclusion based on accessibility and consent. Participants from these facilities were selected through convenient sampling. Data were collected using a structured, written questionnaire covering knowledge, perceptions, and practices regarding cold chain and vaccine management. **RESULTS:** The findings revealed that all participants (100%) were aware of the recommended vaccine storage temperature. However, only 57% correctly performed the shake test, and 85% accurately interpreted Vaccine Vial Monitors (VVMs). Improper vaccine storage arrangements were observed in 52% of facilities. Additionally, only 43% of the facilities kept daily temperature records, and just 33% maintained accurate logs. Encouragingly, 81% of handlers adhered to the four-week open vial policy. **CONCLUSION:** The study highlights significant shortcomings in cold chain management practices across healthcare facilities in Tharparkar. Deficiencies in temperature monitoring, storage arrangements, and documentation practices threaten vaccine potency and compromise immunization efforts. Addressing these gaps through enhanced training, systematic monitoring, and resource provision is crucial to safeguard public health and ensure effective vaccine delivery.

KEYWORDS: cold chain, vaccine cold chain equipment assessment, stock management, vaccine availability, Vaccinator knowledge.

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INTRODUCTION

Given the critical importance of the cold chain to the performance of the Expanded Program on Immunization (EPI), it must not be managed carelessly. Supervisors of vaccination services must ensure staff are professionally trained and plan for both the physical and financial consequences of any storage or handling issues. Effective CC management is essential to maintaining the safety and efficacy of vaccines, while inadequate management can lead to reduced vaccine effectiveness, wastage, and increased morbidity and mortality rates[1,2.]

In Pakistan, as in other developing countries, delivering vaccines to remote and disadvantaged communities is a significant challenge. Moreover, ensuring that vaccines stay viable during transportation and storage is of utmost importance[3]. It is estimated that 14-35% of delivered vaccines are exposed to inappropriate temperatures[4.] Research has also shown that there are gaps in the implementation of vaccination services. To close these gaps, the Expanded Program on Immunization (EPI) must be strengthened in the areas of governance, human resource capacity building, facility-level services, and community perceptions. These studies also highlight health personnel' inadequate vaccination-related knowledge and obstacles to efficient supervision[5]. Notwithstanding these general conclusions, there isn't much research from Pakistan that particularly look at the caliber of care at immunization facilities, which makes it challenging to pinpoint problems or put a number on the caliber of vaccination services offered by the provincial EPI[6].

The Federal Directorate of Immunization was renamed the Expanded Program on Immunization (EPI) in 2022. The program was founded in Pakistan in 1978 with the intention of lowering child morbidity and mortality from six vaccine-preventable diseases. Vaccination coverage for fully immunized children, defined as children aged 12-23 months who have received one dose of Bacille Calmette-Guérin (BCG), three doses of Pentavalent, oral polio vaccine (OPV), pneumococcal vaccine (PCV), and one dose of measles vaccine, is only approximately 66%, indicating underutilization of available vaccination services. Vaccines are provided free of charge through the EPI[7] .

It's critical to employ working freezers and cold boxes to maintain the proper vaccine storage temperatures to protect vaccine potency and viability and to avoid waste[8,9]. Thus, maintaining adequate immunological responses in recipients, limiting vaccine formula deterioration, and lowering the need for re-immunization in populations all depend on functional cold chain equipment[10].

In many developing countries, vaccination centers are of low quality, despite the benefits of improving vaccination service delivery having been demonstrated. Inadequate resources for cold-chain management have been found in health facility studies conducted in Cameroon, Ghana, Kenya, and Uganda. This is demonstrated by the restricted usage of cold boxes and the storage of vaccines outside of the allowed temperature range[9,11].

The study aims to assess the condition of cold chain equipment and the effectiveness of cold chain management in government healthcare facilities in Tharparkar District, Pakistan. The research aims to identify deficiencies in the existing system and provide practical recommendations for improving cold chain management to enhance immunization coverage and reduce the prevalence of vaccine-preventable diseases in the region. The study aims to improve vaccine handling and storage across the nation and avoid equipment malfunctions and temperature

excursions that could reduce vaccine potency.

MATERAIL AND METHODS

The proposed study had was conducted in different government healthcare facilities in District Tharparkar, Sindh. Administratively, Tharparkar dived into seven units and forty-four union councils. District Tharparkar has 272 healthcare facilities under the control of the government. Out of 272 healthcare facilities, 189 provide routine immunization services in Tharparkar.

This research followed a descriptive cross-sectional study design. The study population consisted of vaccine handlers responsible for managing the cold chain and administering vaccinations at selected government healthcare facilities and primary hospitals. The duration of the study spanned six months, commencing after the approval of the research synopsis. District Tharparkar has 272 healthcare facilities under the control of the government. Out of 272 healthcare facilities, 189 provide routine immunization services in Tharparkar Sample size of 21 (11%) was drawn use Rao soft sample calculator by keeping 95% CI and use 5% marginal error. While non-probability convenient sampling has been applied for the selection of the study participants, who are easy to reach.

The study involved government healthcare facilities in District Tharparkar with Expanded Program on Immunization (EPI) services and vaccine storage refrigerators. Participants included vaccinators and managers, while facilities without EPI services, lack of vaccines, or security issues were excluded.

A survey was conducted using the World Health Organization's EVM Assessor to assess vaccine handler knowledge, cold chain status, vaccine management, receiving supervision, and available vaccine equipment. Six components were included: sociodemographic details, vaccine handler knowledge, cold chain status, vaccine management, receiving supporting supervision, and available tools. Data was collected through face-to-face interviews with vaccination workers and direct observation and document examination. A total of sixteen questions were used to gauge vaccine handlers' understanding of cold chain and vaccine management. Individuals with scores below the mean were classified as having bad knowledge, while those above the mean had high knowledge. Thirteen indicators were used to evaluate cold chain and vaccine management, including correct vaccine placement, diluent and ice pack packing, expired vaccines, VVM condition, and temperature records frequency. Those with scores below the mean had poor cold chain and vaccination management status.

The data was analyzed using SPSS version 28 and divided into good and poor categories based on vaccine handler knowledge, cold chain status, and vaccine management. Frequency tables were used for percentages and distributions. Logistic regression analysis was used to assess correlations between variables and predictors.

RESULTS

The study evaluated vaccine cold chain management procedures and equipment in 21 government healthcare facilities in Tharparkar district. Results were based on a comprehensive questionnaire, selecting 21 facilities through simple random sampling and non-probability (17) convenient sampling for study participants. The study aimed to improve vaccine handling and health worker practices. Table 1

Table 1. List of government healthcare facilities selected for study

S. No	Name Of EPI Centre	Type Of Health Facility	Designation staff at GHCF
1	BHU Chelar	Primary	Vaccinator
2	BHU Mubarak Rind	Primary	Vaccinator
3	GD Rajoro	Primary	Vaccinator
4	BHU Wahori Dera	Primary	Vaccinator
4	GD Sobey Jo Tar	Primary	Vaccinator
6	GD Dalan JO Tar	Primary	Vaccinator
7	GD Phangario	Primary	Vaccinator
8	GD Gogasar Landhi	Primary	Vaccinator
9	GD Rarakar	Primary	Vaccinator
10	GD Manbori	Primary	Vaccinator
11	THQ Diplo	Secondary	Vaccinator
12	RHC Islamkot	Secondary	Vaccinator
13	Civil Hospital Mithi	Secondary	Vaccinator
14	GD Seenhar vikia	Primary	Vaccinator
15	GD Nathoro	Primary	Vaccinator
16	GD Mithrio Otha	Primary	Vaccinator
17	GD Sindhian Jo Wandio	Primary	Vaccinator
18	GD Dhabo Saman	Primary	Vaccinator
19	BHU Chandia	Primary	Vaccinator
20	BHU Hirar Deeda	Primary	Vaccinator
21	GD Tagusar	Primary	Vaccinator

Table 2: Socio-Demographic Features of Respondents in Government Health Care Facilities, Tharparkar, 2024 (N = 21) and Government Healthcare Facilities

Variable	Number	Percentage
Health Facility Type	21	
Primary	19	85.71
Secondary	3	14.28
Mean Age of Respondents	32.95 (±13.29 SD) years	
Sex	21	
Male	21	100
Marital Status	21	
Married	21	100
Profession	21	
Vaccinator	21	100
Education	21	
Bachelor's degree	9	43
Intermediate	12	57
Mean of total work experience	12.71 (± 12.12 SD) years	
Work experience in cold chain management ((IQR) Inter	5.5 (±9 IQR) year	
Quartile Range) at the Median ±		
Trained in cold chain and vaccine management	21	
YES	12	57
NO	9	43
During the previous six months, I received helpful supervision on cold chain and vaccine management.	21	
YES	19	90
NO	2	10
Having a Micro plan for vaccinations	21	
YES	9	43
NO	12	57
Getting the recommended vaccination chain of supplies	21	
YES	19	90
NO	2	10
Inventory of cold chain equipment was conducted.	21	
YES	7	33
NO	21	66

Features of Government Healthcare Settings and Vaccine Handlers: The study examined healthcare facilities in government settings, with 85.71% being primary and 14.28% being secondary. The participants were married men, with 43% having a bachelor's degree and 57% having received training in critical subjects like vaccination protocols, cold chain management, and vaccine handling. (Table 2)

Immunization Workers' Understanding of Cold Chain and Vaccine Management: All 21 vaccine handlers demonstrated correct ice pack packaging and correctly deduced Vaccine Vial Monitor stages. However, only 57% understood the Early Expiry First Out approach. Only 62% could accurately calculate vaccination waste. The average knowledge score was 62.37, with 56% having good knowledge on cold chain and vaccine management. (Table 3).

Saw aware of the +2˚ to +8˚C recommended temperature range for vaccine storage.		21	100
knew that diluents should be stored between 2 and 8 degrees Celsius.		13	62
Accurately demonstrated how to fill the vaccine carrier with an ice pack		21	100
Understood how to avoid vaccines freezing while being Transported		13	62
Which Vaccine is heat sensitive (OPV, Measles, and BCG)		10	48
Which vaccine is cold sensitive (DPT-HepB-Hib, PCV, TT, IPV, and Rota)		9	43
Which Vaccine is light sensitive (BCG and MR)		7	33
Appropriately understood VVM Stages		18	85
Demonstrated and understood the shake test correctly		12	57
Know which vaccines (TT, IPV, and OPV) are eligible for the four-week open vial policy.		17	81
Understanding of the Early Expiry First Out (EEFO) principle based on the VVM state and the expiration date		8	38
Knew Early Expiry First Out (EEFO) principle based on expiry date		18	85
knew how to arrange both new and old vaccines so that older shots could be used first.		6	28
Vaccines should only be kept in GHCF for a maximum of one month.		3	14
The vaccination and diluents ought to come from the same producer, I knew.		21	100
understood how to compute the rate of vaccination waste.		13	62
Average knowledge score on vaccination administration and the cold chain		62.37 (±26.46 SD)	
Overall understanding of vaccination administration and the cold chain	Good	9	56
	Poor	6	44

Status of cold chain in Government Healthcare Facilities: The cold chain in Government Healthcare Facilities (GHCFs) was found to be problematic, with incorrect vaccine storage (52%), diluent storage (38%), and ice pack storage

(46%). Vaccines were stored with non-vaccine goods, and 35.7% of multi-dose vials in refrigerators were not properly labeled. Only 33% of facilities had current and comprehensive records, and 67% had at least one record of unusually high or low temperatures. Only 5% of facilities conducted a formal evaluation of temperature records and implemented corrective measures. Despite vaccine shortages and overstocking, all facilities used the standard procedure for vaccine requests. Only 56% of GHCFs were classified as having good cold chain and vaccine management practices, with an overall mean status of 65. (Table 4).

Table 4: The status of the cold chain and vaccination management in Tharparkar 2024 government health care facilities (N = 21).

Indicator	Number	Percentage
Vaccines organized neatly inside the fridge	11	52
Diluents in the refrigerators that are correctly packaged	8	38
Ice packs packed inside the refrigerators	21	100
GHCFs did not store out-of-date vaccinations in freezers.	21	100
GHCFs did not keep vaccines with VVM that reached discarding stage	21	100
Take two daily temperature readings.	9	43
Use foam pad in Standard Vaccine Carrier during immunization sessions	21	100
Every month, verify the physical inventory before placing the next order for vaccines.	15	71
When ordering and receiving vaccines, use the standard format for vaccine requisitions.	21	100
Every vaccination accurately listed in the stock register	16	76
GHCFs have not experienced a vaccination shortage in the previous six months.	5	23
Overstocks of any vaccine were not encountered by GHCFs in the previous six months.	3	14
Determine the monthly vaccination waste rate over the previous six months.	6	28
Average knowledge score on vaccination administration and the cold chain	65 (±32.10 SD)	
Overall understanding of vaccination administration and the cold chain Good	7	54
Poor	6	46

Availability of infrastructure and cold chain equipment: Of the total, 7 (33%) of the GHCFs had access to electricity power supply while 14 (66%) are solarized. 15 (71%) of the GHCFs had functional temperature monitoring devices. Only 76% (n = 16) GHCFs had vaccine stock register, 100% (n = 21) had vaccine requisition format, and 43% (n = 09) of the GHCFs had temperature recording chart, respectively (Table 5).

Table 5 Infrastructure and Cold Chain Equipment Availability in Tharparkar Government Health Care Facilities, 2024 (N = 21).

Variable	Number	Percent
Power supply type used in vaccine refrigerators		
Electricity	7	33
Solar	14	66
Total amount of refrigerators in the GHCF that are operational		
1	16	76
2-3	2	10
> 4	3	14
Health Facilities with a minimum of one dysfunctional refrigerator		
Yes	2	10
No	19	90
Existence of a working temperature monitoring instrument (Dial Thermometer or Real Tag-II)		
Yes	15	71
No	6	29
Availability of ice parks in the GHCF		
> 8	21	100
8	0	0
Numbers of Standard vaccine carrier in the GHCF		
None	0	0
2	18	86
> 3	3	14
Availability of Standard Vaccine Carrier foam pad		
Yes	100	100
No	0	0
Availability of necessary cold chain equipment		
Yes	100	100
No	0	0
Availability of vaccine stock register		
Yes	21	100
No	0	0
Availability of standard vaccine requisition format		
Yes	100	100
No	0	0
Availability of temperature recording chart/ Sheets		
Yes	9	43
No	12	57
Availability of necessary recording and reporting tools		
Yes	18	86
No	3	14
Cold chain equipment inventory checklist		
Yes	7	33
No	21	66
Presence of the national guidelines on immunization		
Yes	7	33
No	14	66
Presence of written instructions on the VVM reading		
Yes	7	33
No	14	66

Factors Associated with Knowledge of Vaccine Handlers, Cold Chain and Vaccine Management: A multi-variable logistic regression model revealed that receiving training on cold chain and vaccine management significantly predicts vaccine handlers' knowledge, with those who received training being nearly six times more likely to have good knowledge. (Table 4). The study found that supportive supervision and access to national guidelines significantly influenced cold chain and vaccine management practices. Vaccine handlers with supportive supervision had higher knowledge levels, while those with more experience had higher knowledge odds.

Table 6. Logistic regression analysis of selected variables based on survey participants' knowledge of cold chain and vaccination handling in government health care institutions in Tharparkar., 2024 (N = 21).

Variables	Level of knowledge		COR (95% CI)	AOR (95% CI)
	Good (%)	Poor (%)		
Age				
< 29 Year	7 (54%)	6 (46%)	1	1
> 29 Year	6 (75%)	2 (25%)	2.57 (0.34–19.49)	2.12 (0.29–15.38)
Work experience in the field of cold chain management				
< 1	0	0	Not applicable	Not applicable
> 1	13 (62%)	8 (38%)	Undefined (100%)	Undefined (100%)
Trained in managing vaccine and the management				
Yes	10 (83%)	2 (17%)	1	1
No	2 (29%)	7 (71%)	6.25 (1.26–31.02)	5.87 (1.11–31.00)
Supportive supervision in managing the cold chain and vaccines.				
Yes	18 (95%)	1 (5%)	1	1
No	0 (0%)	2 (100%)	36.00 (2.31–56.07)	28.35 (2.12–57.24)
Presence of national EPI guideline				
Yes	5 (71%)	2 (29%)	1	1
No	2 (14%)	12 (86%)	15.00 (2.21–68.32)	12.89 (2.00–63.79)

DISCUSSION

The recommended vaccine storage temperature range was known to all vaccine handlers in this study, which is consistent with data from Tigray, Northern Ethiopia (80%) and Central Ethiopia (78.4%)[12]. Still, the outcomes were better than those of research conducted in Malaysia (95.5%)[13] and Oromia (96.9%)[14]. Lower numbers were observed in Nigeria (52%)[15], Mozambique (52%)[16], Cameroon (68.5%)[17], and Ethiopia's Bale and Gurage zones (67.8% and 71.1%)[18,19]. These discrepancies could be the result of variances in training exposure, experience, occupation, and education.

In this study, only 57% of participants properly performed and understood the shake-test; this is a greater percentage than in earlier research conducted in Ethiopia (36.2% to 53.3%)[14,20], India (40%)[21], and Nigeria (51.6%)[15]. Furthermore, 85% of respondents—a higher percentage than Nigeria's (45.3%)[15] correctly deduced the Vaccine Vial Monitor (VVM) phases. The absence of follow-up and practical sessions during training and supervision may be the cause of this gap.

According to our study, vaccination potency was in danger since 52% of healthcare facilities had vaccines stored in refrigerators incorrectly. This number was greater than the 60%[18] found in the Bale

Zone Study. Moreover, none of the freezers in our research had non-vaccine goods, out-of-date shots, or shots that had

a VVM and needed to be thrown away. Combining vaccine storage with other goods may require frequent fridge openings, which could compromise vaccine potency and temperature stability. Likewise, mixing unused and expired vaccines raises the possibility of giving the incorrect shot.

In 43%, 95%, and 33% of health facilities, respectively, it was stated that vaccination micro plans, appropriate supply chains, and cold chain equipment inventories were available. In terms of shortages of vaccines, understock occurred in 23 percent of facilities, which was greater than in Cameroon (11.9%)[17] but lower than in South Africa (77%)[22] as well.

The overall cold chain and vaccine management status in this study was 56%, like Oromia (48.8%), but lower than Gojam (58.3%) and Nigeria (66.1% and 73.9%)[23,24]. It was higher than[25] Bahir Dar, Ethiopia (28.6%)[25]. These differences could be due to variations in the selection of indicators used to measure the cold chain and vaccine management.

Receiving supportive supervision was another factor associated with good cold chain management[23], consistent with other studies. Interventional studies in India also showed that cold chain management improved significantly after supportive supervision was implemented[21]. Supervision helps identify and correct mistakes on the spot, motivating vaccine handlers to improve their practices.

CONCLUSION

The study assesses cold chain equipment management in Tharparkar district, revealing gaps in maintenance practices, documentation, and vaccinators' knowledge. It highlights deficiencies in recording tools, temperature monitoring, and storage protocols. Knowledge gaps among vaccinators highlight the need for enhanced training and support mechanisms. Addressing these challenges could improve cold chain management, vaccine efficacy, and community trust in immunization programs.

ETHICS APPROVAL: The ERC gave ethical review approval. LUMHS/REC/146 DATED: 18/09/2023.

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