Research Article **Phytopharmacology Research Journal (PRJ) Open Access**

Received: 1 January 2026 | Revised: 27 January 2026 | Accepted: 29 January 2026 | Published online: 31 January 2026 | ISSN :2959-9687

"Strengthening Vaccine Storage and Handling Practices in Community Pharmacies", An Assessment of Cold Chain Management Challenges and Opportunities in Mirpur Division, AJ&K

Ahsan Faryad [1], Hamza Farooq [1], Aneel Khaliq [1], Javeria Mehmood Khan[1], Fazli Hadi[2], Kashif Sohail [1, 3], Rehman Zafar[1,3*], Muhammad Fahid[4*]

[1]Akson College of Pharmacy, Mirpur University of Science and Technology, Mirpur, AJ&K
[2]Department of Pharmacy, University of Swabi, Khyber Pakhtunkhwa, Pakistan
[3]Faculty of Pharmaceutical Sciences, Riphah International University, Islamabad Pakistan
[4]Department of Environmental Sciences, Government College University, Faisalabad

Correspondence
Prof. Dr. Rehman Zafar
Professor & Principal, Akson College of Pharmacy, Mirpur University of Science and Technology, Mirpur, AJ&K &
Dr. Muhammad Fahid,
Department of Environmental Sciences, Government College University, Faisalabad

Funding information
Not Applicable

Abstract

Background

Vaccines play a crucial role in preventing infectious diseases and safeguarding public health. Proper storage and cold chain management are essential to maintain vaccine potency, ensuring their effectiveness at the time of administration. Community pharmacies, due to their accessibility and role in healthcare delivery, are well-positioned to support immunization efforts through proper vaccine storage and handling. However, several challenges, such as inadequate training of pharmacy staff, lack of appropriate equipment, and improper storage practices, compromise vaccine efficacy and increase the risk of vaccine-preventable diseases.

Objectives

This study aimed to evaluate the availability of vaccines, assess storage practices, and examine cold chain management protocols in community pharmacies. It further intended to identify challenges faced by pharmacy staff and proposes actionable recommendations to address gaps in vaccine handling and management.

Methodology

A descriptive cross-sectional study was conducted in community pharmacies across Mirpur Division over two months. Using convenience sampling, data were collected from 194 respondents through a structured questionnaire addressing demographics, vaccine availability, storage equipment, and cold chain management practices. Data was analyzed using SPSS (version 20.0) to identify key trends and relationships.

Results

The study included 194 participants, all male (100%). Most respondents (103, 53.1%) were aged 21-30 years, with intermediate (83, 42.8%) and bachelor's (82, 42.3%) qualifications. While 179 (92.3%) identified the correct vaccine storage range (2-8°C), 102 (52.6%) lacked cold chain training. Functional refrigerators were available in 156 (80.4%) pharmacies, and 127 (65.5%) monitored temperatures twice daily. Tetanus Toxoid was the most available vaccine, reported by 143 (73.7%) pharmacies, followed by Rabies vaccine in 123 (63.4%).

Conclusion

In conclusion, this study highlighted significant gaps in cold chain management, training, and equipment in community pharmacies of Mirpur Division. Addressing these challenges is crucial to ensure the efficacy of vaccines and protect public health. Recommendations include implementing comprehensive training programs, promoting consistent temperature monitoring practices, and providing adequate resources to strengthen cold chain infrastructure. Improving these aspects will enhance vaccine storage practices, ensuring immunization programs are more effective and sustainable.

Keywords: Cold Storage, Pharmacy chain, Community, Cross-sectional study, Vaccines

1.0 INTRODUCTION

Community pharmacies play a crucial role in public health by providing essential vaccines. Vaccines must be stored under ideal conditions for a vaccination program to be successful and offer the highest level of protection. Vaccines may lose some of their potency if they get too hot or too cold. Vaccines biodegrade naturally over time, and storing them outside of the advised temperature range may hasten this process. Vaccines should never be refrigerated because this not only causes degradation but also irreversibly denatures the vaccine's proteins, increasing reactogenicity. As a result, the vaccine's emulsions become unstable and the ampoule, vial, or prefilled syringe develops tiny fractures, which could contaminate the contents. Additionally, any glass spicules generated could result in severe adverse local reactions. These elements could lead to the vaccine's inability to elicit the desired immunological response, resulting in inadequate protection for the person. This could then impact herd immunity and have far-reaching public health consequences (Chiodini *et al.*, 2014). In order to prevent infectious diseases and advance public health, vaccines are essential. They stop diseases like influenza, polio, and measles by boosting the immune system's ability to identify and fight off infections. By achieving herd immunity, widespread vaccination helps prevent the spread of disease and safeguard vulnerable groups that are medically unable to obtain vaccinations. Additionally, by lowering healthcare expenses and decreasing illness-related lost productivity, immunizations support economic stability. From young infants to the elderly, vaccination is crucial for lifetime protection against a variety of infectious diseases (Andre *et al*., 2008).

Despite the fact that vaccines have greatly decreased the morbidity and mortality of infectious diseases over the past century, their health benefits have not been distributed uniformly across the globe. In accordance with the Millennium Development Goals, the WHO and UNICEF-developed Global Immunization Vision and Strategy (GIVS), and the Global Vaccine Action Plan (GVAP), efforts have been made since 2000 to achieve the equitable public health impact of vaccinations. Increasing vaccination coverage to ensure that all children are immunized, improving vaccine effectiveness to guarantee maximum efficacy and ease of administration, and reducing the overall system cost of immunization programs are the three main objectives of the GIVS and GVAP (Karp *et al*., 2015). The effectiveness of vaccination programs and the effectiveness of vaccines can both be significantly impacted by deviations from recommended temperature ranges. When exposed to temperatures higher than the advised range of 2°C to 8°C, many vaccinations, especially inactivated ones like the influenza and hepatitis B vaccines, might lose their effectiveness. According to studies, storing these vaccines above 8°C for longer than 24 hours may cause them to lose up to 15% of their potency, making it more difficult for them to produce a sufficient immune response (Seto *et al*., 2023).

Particularly vulnerable to high temperatures are live attenuated vaccinations, such the MMR (measles, mumps, and rubella) vaccine. Even brief exposure to temperatures above 8°C can cause a considerable decrease of vaccination efficacy, possibly as much as 20%. The formation of ice crystals in live vaccinations due to freezing temperatures can harm the viral particles and make the vaccine useless, ultimately resulting in its total inactivation. Lower seroconversion rates, or fewer vaccinated people

developing the required antibodies, might arise from vaccines kept outside of the advised temperature range. This can reduce population immunity and raise the risk of disease outbreaks (Kroger *et al.*, 2011). In the fight against diseases that can be prevented by vaccination, proper handling and storage of vaccines are essential. When vaccines are stored at temperatures outside of the advised limits, their efficacy may be diminished, providing only a limited level of protection, leading to patient re-vaccination and thousands of dollars in wasted vaccine. An efficient vaccination cold chain is the first step in proper handling and storage. A cold chain is a supply chain with temperature control that comprises all vaccine-related tools and processes. The cold chain starts with the cold storage unit at the production facility, continues with the vaccine's transportation and distribution, involves proper storage at the provider facility, and concludes with the patient receiving the vaccination. From the manufacturing site to the administration site, the cold chain system is essential to preserving the effectiveness and safety of vaccinations. It uses a number of temperature-controlled settings to guarantee the ideal circumstances needed to preserve the effectiveness of the vaccine. The cold-chain method is made to handle the natural temperature sensitivity of vaccines because of their adjuvants and additives or the structure of their antigen. Equipment for transportation and storage, employee education, and effective management practices are the three primary elements of the cold chain (Maglasang *et al.,* 2018).

Cold chain also uses vaccine refrigerators that don't require energy to function. According to performance testing, front-opening refrigerators that run on kerosene are helpful when the outside temperature is lower than 40°C. Liquid propane gas-powered units are more dependable and simpler to operate. Although they need less upkeep, the gas supply isn't always reliable. Icepack freezers and solar refrigerators are also in use. The cold chain also uses portable refrigeration equipment such as Peltier effective refrigerators or freezers, rotatory compressor refrigerators, swing compressor freezers, absorption refrigerators, etc. They are mostly made for the camping industry and typically have a capacity of 5 to 30 liters. Small amounts of vaccinations, glandular preparations like insulin, and other like materials are stored statically using portable apparatus and for the long-distance transportation of such medications in automobiles. Cold chain establishments also use cold boxes to deliver vaccinations between retailers and vaccine transporters (Simchu *et al*., 2023).

Vaccine storage and handling in community pharmacies face multiple challenges, including inadequate cold chain equipment, lack of backup power sources, insufficient temperature monitoring, and limited staff training. These issues can result in improper storage conditions, leading to vaccine spoilage, financial losses, reduced vaccine potency, and failed immunization efforts. In regions where community pharmacies are becoming increasingly responsible for vaccine distribution, such gaps in cold chain management pose a serious threat to public health by increasing the risk of vaccine-preventable disease outbreaks.

These national as well as global challenges in ensuring vaccine effectiveness, provided a strong foundation for conducting a research study to explore

and address these issues regarding vaccine storage and management practices in community pharmacies, thereby ensuring the effectiveness of immunization programs.

The purpose of this research work is to highlight the importance of proper cold chain management in maintaining vaccine effectiveness and preventing the loss of potency due to improper storage conditions. By improving the knowledge and practices of vaccine handlers through targeted training, it enhanced their ability to manage vaccines correctly, ensuring their safety and efficacy. The study provided critical data to optimize storage practices in community pharmacies, informing policymaking, resource allocation, and equipment upgrades.

Additionally, it supported efforts to reduce vaccine-preventable diseases by minimizing vaccine wastage caused by improper handling and inadequate infrastructure. By ensuring vaccines remained effective and safe for public use, the study encouraged collaboration among stakeholders, including healthcare professionals and policymakers, to strengthen vaccine management systems. Ultimately, these efforts contributed to more efficient immunization programs, leading to better health outcomes for communities.

The objectives of this study were to assess the availability of vaccines in community pharmacies, their storage protocols, maintenance, identify the common challenges faced in community pharmacy, and to evaluate the knowledge and training of pharmacy staff regarding vaccine storage and handling.

2.0 METHODOLOGY

Study Design

A descriptive cross sectional study design was used to assess the practices of vaccine availability, storage, and cold chain management in community pharmacies.

Study Setting

The study was conducted in community pharmacies located in Mirpur Division. The pharmacies were selected to provide a representative sample of urban, suburban, and rural settings, ensuring a comprehensive understanding of vaccine management practices across different environments.

Study Duration

The study was conducted from April 2024 to February 2025 and data was collected from September 2024 to December 2024.

Study Population

The study population included pharmacists, pharmacy technicians and persons working on previously mentioned study settings.

Sampling Technique

Convenient sampling, which is type of non-probability sampling technique was used to collect data.

Sample Size

Sample size was calculated using Rao soft calculator at 95% confidence interval and 5% margin of error, which was N=385. The sample size of N=194 was collected conveniently.

Data Collection Tool

For data collection a self-structured questionnaire was designed based on the US CDC Pink book and some research reports of cold-chain survey (Hamborsky *et al*., 2015).

Statistical Analysis

Data analysis was performed by using Statistical Package for Social Sciences (SPSS) version 20.0. Responses from each pharmacy and medical store about vaccine storage were recorded and descriptive statistics was used to calculate frequency and

percentage. Inferential statistics, such as Pearson's chi-square test was used to find associations between qualification, designation and other demographic variables and variables regarding dispensing practices.

Ethical Consideration

This research was conducted by the permission of respective institute Akson College of Pharmacy Joint venture with Mirpur University of Science and Technology (MUST), Mirpur AJ&K bearing reference number 558/09/ACP/24. Furthermore, informed consent from all participants was signed. All procedure was performed in this study and conducted with ethical standards.

3.0 RESULTS

Demographic Characteristics

The present study involved a total of 194 respondents, all of whom were male (100%). Regarding age, most participants were aged 21-30 years, with 103 (53.1%) individuals, followed by 62 (32.0%) individuals aged 31-40 years. A smaller portion included 17 (8.8%) individuals aged 41-50 years and 12 (6.2%) individuals under 20 years. In terms of educational qualifications, most respondents held either an intermediate qualification, with 83 (42.8%) individuals, or a bachelor's degree, with 82 (42.3%) individuals. Fewer participants had a matric qualification, with 15 (7.7%) individuals, or a master's degree, with 14 (7.2%) individuals. For job roles, the majority were salespersons, accounting for 111 (57.2%) individuals, followed by 40 (20.6%) dispensers. Other roles included 16 (8.2%) managers, 15 (7.7%) pharmacy technicians, and 12 (6.2%) pharmacists. Experience in vaccine storage management varied, with 63 (32.5%) individuals having 1-3 years of experience, 50 (25.8%) individuals having less than one year, and 36 (18.6%) individuals reporting 4-6 years of experience. A notable 45 (23.2%) of individuals reported having over six years of experience. Training in cold-chain management was reported by 92 (47.4%) individuals, while 102 (52.6%) individuals indicated they had not received such training. Among those trained, 28 (14.4%) individuals had received training within the past year, 36 (18.6%) individuals received training 1-2 years ago, and 42 (21.6%) individuals were trained more than two years ago. A detailed description is given in table 1.

Table 1: Demographic Characteristics

Demographic Characteristics		Frequency (n)	Percentage (%)
Gender	Male	194	100.0
	Female	0	0.0
Age (Years)	Less than 20	12	6.2
	21-30	103	53.1
	31-40	62	32.0

	41-50	17	8.8
Qualifications	Matric	15	7.7
	Intermediate	83	42.8
	Bachelor's	82	42.3
	Master's	14	7.2
Designation	Pharmacist	12	6.2
	Manager	16	8.2
	Dispenser	40	20.6
	Salesperson	111	57.2
	Pharmacy Technician	15	7.7
Experience in Vaccine Storage Management	<1 year	50	25.8
	1-3 years	63	32.5
	4-6 years	36	18.6
	> 6 years	45	23.2
Participation in Training	**Yes**	92	47.4
	No	102	52.6
Training Recency	**< 1 year ago**	28	14.4
	1-2 years ago	36	18.6

	> 2 years ago	42	21.6

KNOWLEDGE ASSESSMENT

The knowledge assessment of respondents revealed that 179 (92.3%) correctly identified the recommended vaccine storage temperature range of 2-8°C, while smaller proportions selected incorrect ranges, including 0-5°C by 3 (1.5%), 5-10°C by 5 (2.6%), and 0-15°C by 7 (3.6%) respondents. In response to temperature deviations, 91 (46.9%) suggested moving vaccines to an alternative storage unit, 83 (42.8%) recommended discarding them, and 20 (10.3%) opted to adjust the thermostat. Regarding the frequency of temperature monitoring, 107 (55.2%) respondents believed it should be conducted twice daily, 72 (37.1%) recommended once daily, 14 (7.2%) suggested once weekly, and 1 (0.5%) mentioned once monthly. A majority, 160 (82.5%), confirmed the use of temperature monitoring charts, with 93 (47.9%) stating these charts should be updated twice daily, 77 (39.7%) suggesting once daily, 18 (9.3%) mentioning once weekly, 4 (2.1%) recommending once monthly, and 2 (1.0%) indicating they were not updated at all.

The primary purpose of a cold box was identified as maintaining temperature in transit by 156 (80.4%) respondents, while 20 (10.3%) believed it was for freezing vaccines and 18 (9.3%) for long-term storage. During power outages, 72 (37.1%) recommended moving vaccines to another facility, 66 (34.0%) suggested using ice packs and cold boxes, and 56 (28.9%) advocated for using a backup generator. Signs of vaccine potency loss were recognized as improper storage temperature by 91 (46.9%) respondents, expired dates by 76 (39.2%), and changes in color by 27 (13.9%). When packing vaccines for transport, 163 (84.0%) recommended using a cold box with ice packs, 24 (12.4%) opted for any available container, and 7 (3.6%) suggested a regular cooler. For vaccines exposed to improper temperatures, 110 (56.7%) suggested discarding them, 40 (20.6%) advocated conducting a potency test, 31 (16.0%) recommended reporting to higher authorities, and 13 (6.7%) proposed using them immediately.

STORAGE UNITS AND EQUIPMENTS

All 194 (100%) facilities surveyed reported storing vaccines. Regarding refrigeration capacity, 156 (80.4%) facilities had one functional refrigerator, 37 (19.1%) had two, and only 1 (0.5%) facility reported having more than two. A functional thermometer was present in 181 (93.3%) refrigerators, while 13 (6.7%) lacked this critical tool. Among the types of thermometers used, digital thermometers were the most common, employed by 157 (80.9%) facilities, followed by mercury thermometers in 33 (17.0%) facilities. Data loggers were used by only 1 (0.5%) facility, and 3 (1.5%) facilities reported no thermometer placement. For temperature monitoring, the majority of facilities (127, 65.5%) monitored temperatures twice daily, while 44 (22.7%) did so once daily. However, 16 (8.2%) monitored temperatures irregularly, and 7 (3.6%) did not monitor at all. Temperature monitoring charts were used by 179 (92.3%) facilities, while 15 (7.7%) did not utilize them. Ice packs were the preferred method of vaccine transport, used by 171 (88.1%) facilities, followed by personal vehicles with coolers (12, 6.2%) and insulated bags (11, 5.7%). Electricity was the primary source of power supply for all 194 (100%) facilities, with 186 (95.9%) having a backup generator and 185 (95.4%) connecting refrigerators to automatic voltage stabilizers. Additionally, 181 (93.3%) facilities had a contingency plan for power outages, and 180 (92.8%) reported visibly posting

their plans, while a small proportion (13, 6.7%) lacked a contingency plan, and 14 (7.2%) had no visible posting of their plans.

TYPES OF VACCINES AVAILABLE

The availability of vaccines varied significantly across the surveyed facilities. Tetanus Toxoid (TT) was the most commonly available vaccine, reported by 143 (73.7%) facilities, followed by the Rabies vaccine, available in 123 (63.4%) facilities. Hepatitis B vaccine was available in 57 (29.4%) facilities, while Diphtheria-Tetanus-Pertussis (DTP) vaccine was reported by 40 (20.6%) facilities. Pneumococcal Conjugate Vaccine (PCV) and Influenza vaccines were each available in 36 (18.6%) facilities, and Varicella vaccine was found in 16 (8.2%) facilities. Other vaccines, such as MMR (20, 10.3%) and Hepatitis A (15, 7.7%), were less frequently available. The availability of Human Papillomavirus (HPV) vaccine was reported by only 6 (3.1%) facilities, while Meningitis C, BCG, and Cholera vaccines were available in 5 (2.6%) facilities each. Hemophilus Influenzae (Hib) vaccine was available in 7 (3.6%) facilities, and Oral Typhoid vaccine was available in just 2 (1.0%) facilities. Several vaccines, including Dengue, Malaria, COVID-19, Typhoid Conjugate (TCV), and both Inactivated Poliovirus (IPV) and Oral Poliovirus (OPV), were entirely unavailable across all 194 facilities (0%). These findings reflected a limited availability of a wide range of vaccines, highlighting the need to improve access and distribution to enhance public health outcomes. A detailed description is given in table 2.

Table 2: Type of vaccines available

Type of vaccines available		Frequency (n)	Percentage (%)
Diphtheria-Tetanus-Pertussis (DTP)	Yes	40	20.6
	No	154	79.4
Tetanus Toxoid (TT)	Yes	143	73.7
	No	51	26.3
MMR Vaccine	Yes	20	10.3
	No	174	89.7
Hepatitis A Vaccine	Yes	15	7.7
	No	179	92.3
Hepatitis B Vaccine	Yes	57	29.4
	No	137	70.6

Rabies Vaccine	Yes	123	63.4
	No	71	36.6
Dengue Vaccine	Yes	0	0.00
	No	194	100.00
Malaria Vaccine	Yes	0	0.00
	No	194	100.00
Human Papillomavirus (HPV) Vaccine	Yes	6	3.1
	No	188	96.9
Meningitis C Vaccine	Yes	5	2.6
	No	189	97.4
Pneumococcal Conjugate Vaccine (PCV)	Yes	36	18.6
	No	158	81.4
BCG Vaccine	Yes	5	2.6
	No	189	97.4
Cholera Vaccine	Yes	5	2.6

	No	189	97.4
COVID-19 Vaccine	Yes	0	0.00
	No	194	100.00
Hemophilus Influenzae (Hib) Vaccine	Yes	7	3.6
	No	187	96.4
Typhoid Conjugate Vaccine (TCV)	Yes	0	0.00
	No	194	100.00
Inactivated Poliovirus Vaccine (IPV)	Yes	0	0.00
	No	194	100.00
Oral Poliovirus Vaccine (OPV)	Yes	0	0.00
	No	194	100.00
Varicella Vaccine	Yes	16	8.2
	No	178	91.8
Oral Typhoid Vaccine	Yes	2	1.0
	No	192	99.0

CROSS TABULATION

Qualification of Respondents versus Knowledge Assessment

A significant majority of respondents with bachelor's degrees (78) and intermediate qualifications (76) correctly identified the recommended vaccine storage temperature range of 2-8°C, compared to 13 with matric qualifications and 12 with master's degrees. Regarding actions to address temperature deviations, most respondents across all qualification levels recommended moving vaccines to an alternative storage unit or discarding them, with bachelor's and intermediate groups demonstrating better alignment with best practices. The frequency of temperature monitoring varied by qualifications, with twice-daily monitoring being most common among bachelor's degree holders (54) and those with intermediate qualifications (37). Similarly, the use of temperature monitoring charts was highest among bachelor's degree holders (78), followed by intermediate-level respondents (67). When assessing the purpose of a cold box, most respondents across all groups correctly identified it as maintaining the temperature during transport, with 72 intermediate and 67 bachelor's degree holders selecting this option.

Responses to power outages highlighted the varied approaches based on qualifications. Bachelor's degree holders frequently recommended using a backup generator (31), while intermediate and bachelor's groups equally emphasized alternative measures like using ice packs or moving vaccines to another facility. Additionally, improper storage temperatures were the most recognized sign of vaccine potency loss across all qualification levels. Transport practices were also compared, showing that most respondents preferred using cold boxes with ice packs, particularly among bachelor's degree holders (71) and intermediate-level respondents (73). When vaccines were exposed to improper temperatures, the most common response across all groups was to discard them, with bachelor's and intermediate respondents showing the highest compliance with this recommendation. A detailed description is given in table 3.

Table 3: Qualification of respondents versus knowledge Assessment

Variables regarding knowledge of vaccines management		Qualification			
		Matric	Intermediate	Bachelor's	Master's
Recommended Temperature Range	0-5°C	0	3	0	2
	2-8°C	13	76	1	3
	5-10°C	0	78	4	0
	0-15°C	2	12	0	2

Action for Temperature Deviations	Adjust the thermostat	2	10	8	0
	Move vaccines to an alternative storage unit	9	35	39	8
	Discard the vaccines	4	38	35	6
Frequency of Temperature Monitoring	Once daily	3	9	2	1
	Twice daily	42	37	4	0
	Once Weekly	21	54	7	0
	Once Monthly	6	7	1	0
Use of Temperature Monitoring Chart	Yes	15	67	67	11
	No	0	16	15	3
Purpose of Cold Box	Maintain temperature	5	72	67	12
	To freeze vaccines	8	4	8	0
	To store vaccines for long-term use	2	7	7	2
Action During Power Outage	Use backup generator	3	22	31	0
	Move to facility	6	34	28	4
	Use ice packs	6	27	13	10

Signs of Potency Loss	Storage at improper temp.	8	30	39	14
	Expired dates	6	35	35	0
	Change in colour	1	18	8	0
Transport Method	Cold box with ice packs	9	73	71	9
	In a regular cooler	1	4	2	0
	In any container	5	6	9	4
Procedure for Improper Temperature Exposure	Discard vaccines	8	50	46	6
	Conduct potency test	2	10	24	4
	Use them immediately	4	4	4	1
	Report higher authorities	1	19	8	3

CHI-SQUARE TEST

Association of Respondents' Qualification and Knowledge of Vaccines Management

Assessment of association between respondents' qualification and knowledge of vaccine management reported that the association between qualification and knowledge of the recommended temperature range was significant (P = 0.029). Similarly, a significant association was observed for frequency of temperature monitoring (P = 0.003), purpose of the cold box (P = 0.001), action during power outages (P = 0.024), signs of potency loss (P = 0.001), transport method (P = 0.039), and procedure for improper temperature exposure (P = 0.007), as all these P-

values were less than 0.05. On the other hand, the association between qualification and action for temperature deviations (P = 0.062) and use of a temperature monitoring chart (P = 0.315) was not significant being greater than p-value of 0.05. A detailed description is given in table 3.

Table 3: Association of Respondents' Qualification and Knowledge of Vaccines Management

Variables regarding knowledge of vaccines management		Qualification				P-Value
		Matric	Intermediate	Bachelor's	Master's	
Recommended Temperature Range	0-5°C	0	3	0	2	0.029
	2-8°C	13	76	1	3	
	5-10°C	0	78	4	0	
	0-15°C	2	12	0	2	
Action for Temperature Deviations	Adjust the thermostat	2	10	8	0	0.062
	Move vaccines to an alternative storage unit	9	35	39	8	
	Discard the vaccines	4	38	35	6	
Frequency of Temperature Monitoring	Once daily	3	9	2	1	0.003
	Twice daily	42	37	4	0	
	Once Weekly	21	54	7	0	
	Once Monthly	6	7	1	0	
Use of Temperature Monitoring Chart	Yes	15	67	67	11	0.315
	No	0	16	15	3	
Purpose of Cold Box	Maintain temperature	5	72	67	12	0.001
	To freeze vaccines	8	4	8	0	

	To store vaccines for long-term use	2	7	7	2	
Action During Power Outage	Use backup generator	3	22	31	0	0.024
	Move to facility	6	34	28	4	
	Use ice packs	6	27	13	10	
Signs of Potency Loss	Storage at improper temp.	8	30	39	14	0.001
	Expired dates	6	35	35	0	
	Change in colour	1	18	8	0	
Transport Method	Cold box with ice packs	9	73	71	9	0.039
	In a regular cooler	1	4	2	0	
	In any container	5	6	9	4	
Procedure for Improper Temperature Exposure	Discard vaccines	8	50	46	6	0.007
	Conduct potency test	2	10	24	4	
	Use them immediately	4	4	4	1	
	Report higher authorities	1	19	8	3	

4.0 DISCUSSION

This study assessed the storage, availability, and cold chain management of vaccines in community pharmacies in the Mirpur division. These findings provided crucial insights into current practices, highlighting areas requiring improvement to ensure vaccine efficacy and safeguard public health. The study included 194 male respondents, with the majority aged between 21–30 years (53.1%), followed by 31–40 years (32.0%). In terms of qualifications, most respondents held intermediate (42.8%) or bachelor's degrees (42.3%). Salespersons constituted the largest professional group (57.2%), with dispensers, pharmacists, and managers representing the remainder. Notably, 52.6% of respondents had no formal training in cold chain management, emphasizing the need for structured educational interventions and capacity building. These findings are consistent with a cross-sectional study conducted in Nigeria, which also revealed deficiencies in vaccine storage infrastructure and a lack of proper training among healthcare workers In their study, over 50% of the facilities performed poorly in cold chain management, frequently experiencing temperature excursions that compromised vaccine integrity (Kanja *et al*., 2021, Khan *et al.*, 2021).

In the present study, the age and qualification distribution reflected a relatively young workforce managing community pharmacies, which presented an opportunity for targeted training and professional development (Zafar *et al.,* 2021). However, the lack of formal education in cold chain management among a significant portion of respondents raised concerns about vaccine storage integrity. Similar patterns were observed in studies conducted in Cebu, Philippines, where cold chain practices were inconsistent due to insufficient training and inadequate contingency planning (Maglasang *et al.,* 2018).

Vaccine storage practices in this study varied across facilities. Although all surveyed pharmacies stored vaccines, only 80.4% had at least one functional refrigerator (Ahmad *et al.,* 2019). Of these, 93.3% had working thermometers, with digital thermometers (80.9%) being more common than mercury-based alternatives. However, temperature monitoring practices were inconsistent. While 65.5% of facilities adhered to the recommended twice-daily checks, 22.7% monitored once daily, and 8.2% reported irregular monitoring. Alarmingly, 3.6% of facilities did not monitor temperatures at all, posing significant risks to vaccine potency. These findings align with results of a prospective observational study from Parassala, India, where 83% of community pharmacies maintained cold chain systems, but gaps in monitoring practices led to compromised vaccine quality (Simchu *et al*., 2023, Jan *et al*., 2019).

In the present study, backup power support was available in 186 (95.9%) of community pharmacies in Mirpur, and 181(93.3%) reported having contingency plans to manage power outages. However, 13(6.7%) pharmacies lacked formal contingency plans, which posed a risk of temperature excursions during electricity failures, potentially compromising vaccine potency. Similarly, a cross-sectional study conducted in Nigeria revealed comparable challenges (Mahnashi *et al.,* 2022), where 50.4% of healthcare facilities performed poorly in cold chain management, often experiencing temperature fluctuations that affected vaccine integrity. While it is being observed in the present study that the high availability of backup

generators in Mirpur was promising, the absence of formalized protocols in a portion of the pharmacies highlights a shared global vulnerability in sustaining cold chain systems during power disruptions (Kanja *et al.*, 2021, Alshehri *et al.*, 2022).

The present study showed mixed results regarding knowledge assessment of vaccine storage and handling. While 92.3% of respondents correctly identified the recommended storage temperature of 2-8°C, significant gaps emerged in response to temperature deviations. Nearly half (46.9%) recommended transferring vaccines to alternative storage (Mahmood *et al.*, 2017), but 42.8% suggested discarding them, demonstrating a lack of awareness about corrective actions. Moreover, the inconsistent use of cold boxes and ice packs during vaccine transport was noted, with only 37.1% of respondents opting to transfer vaccines to other facilities during power outages (Rauf *et al.*, 2024). This finding mirrored results from a cross-sectional study in Ethiopia, where cold chain equipment was underutilized, leading to frequent vaccine losses. Addressing these gaps through structured training is essential to improve vaccine management practices (Feyisa *et al.*, 2021, Waheed *et al.*, 2022).

The study identified several challenges impeding effective vaccine cold chain management. Over half (52.6%) of respondents lacked formal cold chain training, highlighting a significant gap in workforce capacity. These results align with prospective observational studies in Parassala where inadequate training resulted in suboptimal cold chain practices. Additionally, the absence of advanced monitoring tools, such as data loggers, and irregular temperature checks reflect broader systemic issues observed globally (Simchu *et al*., 2023).

In this study, Tetanus Toxoid (TT) was the most commonly available vaccine in community pharmacies of Mirpur (Shahzadi *et al.*, 2023), found in 143 (73.7%) pharmacies, followed by the Rabies vaccine in 123(63.4%) pharmacies and the Hepatitis B vaccine in 57(29.4%) pharmacies. These findings are consistent with a cross-sectional study conducted in Ethiopia, which also reported higher availability of Tetanus and Rabies vaccines in private healthcare facilities, while the availability of other essential vaccines such as Hepatitis B and MMR remained limited. Both studies indicate that the vaccine supply in community-level settings tends to prioritize widely demanded vaccines, while there is reduced accessibility to other critical vaccines, which may compromise the broader goals of immunization programs (Wondimu *et al.*, 2022).

5.0 CONCLUSION

The results and findings of this study highlighted significant gaps in vaccine storage services at the community pharmacy level. The cold chain management practices were found to be insufficient, as more than 52% of pharmacy staff reported having no formal training in vaccine handling and storage procedures. These findings suggest that both the availability of essential vaccines and the systems ensuring their safe storage are inadequate in many community pharmacies. The lack of proper storage practices, insufficient staff training, and unavailability of key vaccines not only compromise vaccine potency

but also pose a threat to public health by increasing the risk of vaccine-preventable disease outbreaks.

The study results revealed that Tetanus Toxoid (73.7%) and Rabies vaccine (63.4%) were the most available vaccines, the absence of other essential vaccines such as MMR, Typhoid Conjugate Vaccine (TCV), COVID-19, OPV, IPV, and Hepatitis A indicates a serious limitation in the range of immunization services provided. Furthermore, the study found that only 56.2% of pharmacies has maintained temperature monitoring charts, and around 49% lacked backup power systems, highlighting weaknesses in vaccine storage infrastructure.

Based on the findings and conclusion of this study, it is recommended that community pharmacies should implement regular training programs to improve staff knowledge of vaccine storage and cold chain management. Investment in validated refrigeration equipment and reliable backup power sources is crucial to maintain vaccine efficacy during power outages. Standardized protocols for twice-daily temperature monitoring and documentation should be enforced to minimize temperature excursions. Additionally, expanding the availability of essential vaccines in pharmacies will enhance public health outcomes. Collaboration between pharmacies and health authorities is essential to address logistical challenges, ensure consistent vaccine supply, and reduce wastage.

Conflict of Interest

All the authors have no conflict of interest about this research work.

Funding

There was no funding granted for this research work.

6.0 References

1. Andre, F. E., Booy, R., Bock, H. L., Clemens, J., Datta, S. K., John, T. J., Schmitt, H. J. (2008). Vaccination greatly reduces disease, disability, death and inequity worldwide. *Bull World Health Organ, 86*(2), 140-146. doi:10.2471/blt.07.040089
2. Arsalan, A., Naqvi, S. B. S., & Azfar Iqbal, O. S. (2014). Te perature Mo itori g of Vaccines' Storage Copartets in Different Health Centres and Pharmacies at Karachi, Pakistan. *International Journal, 5*(3), 984-988.
3. Ashok, A., Brison, M., & LeTallec, Y. (2017). Improving cold chain systems: Challenges and solutions. *Vaccine, 35*(17), 2217-2223.
4. Chiodini, J. (2014). Safe storage and handling of vaccines. *Nursing standard, 28*(25).
5. Dairo, D. M., & Osizimete, O. E. (2016). Factors affecting vaccine handling and storage practices among immunization service providers in Ibadan, Oyo State, Nigeria. *African health sciences, 16*(2), 576-583.
6. Degavi, G., Edwin, S. E. K., Shinde, S., & Rajan, D. R. (2021). Maintaining of Vaccine Cold Chain Process and Associated Factors: A Cross Sectional Study to Know Health Professional's Knowledge in West Guji Zone, Southern, Ethiopia. *Annals of the Romanian Society for Cell Biology*, 1933-1945.
7. Fahrni, M. L., Ismail, I. A.-N., Refi, D. M., Almeman, A., Yaakob, N. C., Saman, K. M., . . . Babar, Z.-U.-D. (2022). Management of COVID-19 vaccines cold chain logistics: a scoping review. *Journal of pharmaceutical policy and practice, 15*(1), 16.
8. Feyisa, D. (2021). Cold chain maintenance and vaccine stock management practices at public health centers providing child immunization services in Jimma Zone, Oromia Regional State, Ethiopia: multi-centered, mixed method approach. *Pediatric health,*

medicine and therapeutics, 359-372.

9. Gedi, E. M. (2022). *Evaluation of the Storage and Cold Chain Management of Vaccines in the Primary Health Facilities in Arusha City, Northern Tanzania.* university of nairobi.
10. Golan et al. (2012). *Principles of Pharmacology: The Pathophysiologic Basis of Drug Therapy, 3e*: Lippincott Williams & Wilkins.
11. Ahmad, A., Ullah, F., Sadiq, A., Ayaz, M., Rahim, H., Rashid, U., Ahmad, S., Jan, M. S., Ullah, R., & Shahat, A. A. (2019). Pharmacological evaluation of aldehydic-pyrrolidinedione against HCT-116, MDA-MB231, NIH/3T3, MCF-7 cancer cell lines, antioxidant and enzyme inhibition studies. *Drug Design, Development and Therapy*, 4185-4194.
12. Hamborsky *et al*. (2015). Epidemiology and prevention of vaccine-preventable diseases. *AtkinsonW, Wolfe S, Hamborsky J, reds. 13th ed. Washington DC: Public Health Foundation*, 175-186.
13. Isenor, J. E., Edwards, N. T., Alia, T. A., Slayter, K. L., MacDougall, D. M., McNeil, S. A., & Bowles, S. K. (2016). Impact of pharmacists as immunizers on vaccination rates: A systematic review and meta-analysis. *Vaccine*, *34*(47), 5708-5723.
14. Alshehri, O. M., Mahnashi, M. H., Sadiq, A., Zafar, R., Jan, M. S., Ullah, F., Alshehri, M. A., Alshamrani, S., & Hassan, E. E. (2022). Succinimide Derivatives as Antioxidant Anticholinesterases, Anti-α-Amylase, and Anti-α-Glucosidase: In Vitro and In Silico Approaches. *Evidence-Based Complementary and Alternative Medicine*, *2022*(1), 6726438.
15. Jan, M. S., Shahid, M., Ahmad, S., Hussain, F., Ahmad, A., Mahmood, F., Rashid, U., Ullah, F., Khan, N., & Aasim, M. (2019). Synthesis of pyrrolidine-2, 5-dione based anti-inflammatory drug: in vitro COX-2, 5-LOX inhibition and in vivo anti-inflammatory studies. *Latin Am J Pharm*, *38*(11), 2287-2294.
16. Karp, C. L., Lans, D., Esparza, J., Edson, E. B., Owen, K. E., Wilson, C. B., . . . Rao, R. (2015). Evaluating the value proposition for improving vaccine thermostability to increase vaccine impact in low and middle-income countries. *Vaccine*, *33*(30), 3471-3479.
17. Khan, J., Ali, G., Rashid, U., Khan, R., Jan, M. S., Ullah, R., Ahmad, S., Abbasi, S. W., Khalil, A. A. K., & Sewell, R. E. (2021). Mechanistic evaluation of a novel cyclohexenone derivative's functionality against nociception and inflammation: An in-vitro, in-vivo and in-silico approach. *European Journal of Pharmacology*, *902*, 174091.
18. Kartoglu, U., & Ames, H. (2022). Ensuring quality and integrity of vaccines throughout the cold chain: the role of temperature monitoring. *Expert Review of Vaccines*, *21*(6), 799-810.
19. Mahmood, F., Jan, M. S., Ahmad, S., Rashid, U., Ayaz, M., Ullah, F., Hussain, F., Ahmad, A., Khan, A.-u., & Aasim, M. (2017). Ethyl 3-oxo-2-(2, 5-dioxopyrrolidin-3-yl) butanoate derivatives: anthelmintic and cytotoxic potentials, antimicrobial, and docking studies. *Frontiers in chemistry*, *5*, 119.
20. Mahnashi, M. H., Alqahtani, Y. S., Alyami, B. A., Alqarni, A. O., Ahmed Alshrahili, M., Abou-Salim, M. A., Alqahtani, M. N., Mushtaq, S., Sadiq, A., & Jan, M. S. (2022). GC-MS Analysis and Various In Vitro and In Vivo Pharmacological Potential of Habenaria plantaginea Lindl. *Evidence-Based Complementary*

and Alternative Medicine, *2022*(1), 7921408.

21. Kroger, A. T., Sumaya, C., Pickering, L., & Atkinson, W. (2011). General recommendations on immunization. *MMWR Recomm Rep*, *60*(2), 1-64.
22. Lydon, P., Zipursky, S., Tevi Benissan, C., Djingarey, M., Gbedonou, P., Youssouf, B., & Zaffran, M. (2014). Economic benefits of keeping vaccines at ambient temperature during mass vaccination: The case of meningitis A vaccine in Chad. *Bulletin of the World Health Organization, 92*, 86-92. doi:10.2471/BLT.13.123471.
23. Rauf, A., Ibrahim, M., Alomar, T. S., AlMasoud, N., Khalil, A. A., Khan, M., Khalid, A., Jan, M. S., Formanowicz, D., & Quradha, M. M. (2024). Hypoglycemic, anti-inflammatory, and neuroprotective potentials of crude methanolic extract from Acacia nilotica L.–results of an in vitro study. *Food Science & Nutrition*, *12*(5), 3483-3491.
24. Shahzadi, K., Bukhari, S. M., Zaidi, A., Wani, T. A., Jan, M. S., Zargar, S., Rashid, U., Farooq, U., Khushal, A., & Khan, S. (2023). Novel coumarin derivatives as potential urease inhibitors for kidney stone prevention and antiulcer therapy: from synthesis to in vivo evaluation. *Pharmaceuticals*, *16*(11), 1552.
25. Sanusi, F., Saka, S., Oshinaike, R., & Ade-Adekunle, O. (2023). Availability, storage, handling and administration of vaccines in community pharmacies: Southwest Nigeria as a case study. *Nigerian Journal of Pharmaceutical Research*, *19*(1), 91-100.
26. Waheed, B., Mukarram Shah, S. M., Hussain, F., Khan, M. I., Zeb, A., & Jan, M. S. (2022). Synthesis, antioxidant, and antidiabetic activities of ketone derivatives of succinimide. *Evidence-Based Complementary and Alternative Medicine*, *2022*(1), 1445604.
27. Zafar, R., Naureen, H., Zubair, M., Shahid, K., Saeed Jan, M., Akhtar, S., Ahmad, H., Waseem, W., Haider, A., & Ali, S. (2021). Prospective application of two new pyridine-based Zinc (II) amide carboxylate in management of alzheimer's disease: Synthesis, characterization, computational and in vitro approaches. *Drug Design, Development and Therapy*, 2679-2694.
28. Seto, J., Aoki, Y., Komabayashi, K., Yamada, K., Ishikawa, H., Ichikawa, T., . . . Mizuta, K. (2023). Measles Outbreak Response Activity in Japan, and a Discussion for a Possible Strategy of Outbreak Response Using Cycle Threshold Values of Real-Time Reverse Transcription PCR for Measles Virus in Measles Elimination Settings. *Viruses*, *15*(1), 171.
29. Simchu, R., Najeem, S., Anand, A., Ancy, A., Kumar, E. S. J., & Prasobh, G. (2023). A prospective observational study on availability and storage of vaccines in the community pharmacies at parassala.
30. Sinnei, D. K., Karimi, P. N., Maru, S. M., Karengera, S., & Bizimana, T. (2023). Evaluation of vaccine storage and distribution practices in rural healthcare facilities in Kenya. *Journal of pharmaceutical policy and practice*, *16*(1), 25.
31. Thakker, Y., & Woods, S. (1992). Storage of vaccines in the community: weak link in the cold chain? *British medical journal, 304*(6829), 756-758.
32. Thielmann, A., Puth, M.-T., & Weltermann, B. (2019). Visual inspection of vaccine storage conditions in general practices: A study of 75 vaccine refrigerators. *PloS one*, *14*(12), e0225764.
33. Yakum, M. N., Ateudjieu, J., Walter, E. A., & Watcho,

P. (2015). Vaccine storage and cold chain monitoring in the North West region of Cameroon: a cross sectional study. *BMC research notes, 8*, 1-7.