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Assessment of Knowledge, Attitude and Practice of Health Professionals on Cold Chain Management Performance in Selected Public Health Facilities of West Wallaga Zone, Oromia, Ethiopia

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A Thesis submitted to Addis Ababa University, College of Health Sciences, School of Pharmacy, Department of Social and Administrative Pharmacy for partial fulfillment of the requirements for the degree of Master of Science in Health Supply Chain Management

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DECLARATION

I, Alemu Tamiru, hereby declared that this study entitled "***Assessment of knowledge, attitude and practice of health professionals on Cold Chain Management Performance in Selected public health facilities of West Wallaga zone, Oromia, Ethiopia"*** is my original work done under the supervision of my advisor Zelalem Tilahun (PhD). This paper is submitted to the department of Social and Administrative pharmacy, school of pharmacy in partial fulfillment of the requirements for the award of Master of Science degree in Health Supply Chain Management and it has not been previously submitted to any diploma or degree in any College or University. I would like to also confirm that all the sources of materials used in this study are duly acknowledged.

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This is to certify that; the thesis prepared by Alemu Tamiru, entitled "***Assessment of knowledge, attitude and practice of health professionals on Cold Chain Management Performance in Selected public health facilities of West Wallaga zone, Oromia, Ethiopia*** " is submitted in partial fulfillment of the requirements for the degree of Master of Science in Health Supply Chain Management. It complies with the regulations of the university, and meets the accepted standards with respect to originality and quality.

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Abstract

Assessment of knowledge, attitude and practice of health professionals on Cold Chain Management Performance in Selected public health facilities of West Wallaga zone, Oromia, Ethiopia.

Introduction: Vaccination is one of the most economical public health programs used to achieve universal health coverage. Cold chain product availability saves lives in terms of under-five morbidity and mortality reduction as well as management of non-communicable diseases. Despite the efforts made to improve cold chain management in Ethiopia, significant gaps still exist. This study assessed the KAP of health professionals on cold chain management performance, an overview of VLMIS, identifying the infrastructural, logistics and administrative challenges in public health facilities.

Objective: The study aimed to assess the knowledge, attitude and practice of health professionals on cold Chain Management Performance in Selected public health facilities of West Wallaga zone, Oromia, Ethiopia.

Methodology: A facility-based cross-sectional study design with concurrent mixed methods was employed using both quantitative and qualitative data collection approaches.

Result: About 78 (57.8%) of health professionals had good knowledge of cold chain management while Majority 85 (63%) had poor cold chain management practice. Most of the respondents had strongly agreed to the idea of cold chain management with positive attitude like maintaining accurate documentation (63%), importance of staff training (75.6%), and regular temperature monitoring (67.4%) among others. challenges like shortage of cold chain equipment and their maintenance, lack of storage capacity and training were shared among all health facilities and health professionals.

Conclusion: The observed low cold chain management performance was due to the poor cold chain management practices of health professionals and lack of training for majority of health professionals. This underscore the need for training, supportive supervision and continuous monitoring and evaluation (M&E).

Recommendation: Empowering professionals engaged in Cold chain management through training, supervision and continuous monitoring and evaluation is paramount important. Additional attempt is needed to scale up, and sustain digital technologies and increase end-to-end visibility of current VLMIS to improve it.

Key Words: Vaccine, Cold chain management performance, knowledge, attitude, practice, challenge, west wallaga zone.

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Abbreviations and Acronyms

BCG	Bacillus Calmette Guerin
CCE	Cold Chain Equipment
CCM	Cold Chain Management
EPSS	Ethiopian Pharmaceutical Supply Service
FEFO	First Expire First Out
GTN	Global Training Network
HCs	Health Centers
KAP	Knowledge, Attitude and Practice
KIs	key Informants
LIAT	Logistic Indicator assessment tool
LMICs	Low- and Middle-Income Countries
M & E	Monitoring and Evaluation
MOH	Ministry of health
OLR	Ordinary Logistic Regression
OPV	Oral polioviruses vaccine
OR	Odds Ratio
PCV-13	Pneumococcal Conjugate Vaccine
PI	Principal Investigator
SDGs	Sustainable Development Goals
SOP	Standard Operating Procedure
SPSS	Statistical Package for Social Sciences
USAID	United states agency for international Development
VLMIS	Vaccine Logistics Management Information System
VMAT	Vaccine Management Assessment Tool
VRF	Vaccine Requisition Form
VSCLS	Vaccine Supply Chain Logistics System
VVM	Vaccine Vial Monitoring
WHO	World Health Organization
WoHo	Woreda Health Office
ZHD	Zonal Health Department

Operational Definition of Terms

Good knowledge on cold chain: Individuals that scored the mean knowledge score or above.

Poor knowledge on cold chain: Individuals that scored below the mean knowledge score.

Good cold chain practice: Individuals that scored the mean practice score or above.

Poor cold chain practice: Individuals that scored below the mean practice score.

Good Cold chain performance: Facilities that scored 80% or above.

Fair cold chain performance: Facilities that scored the mean score or above.

Poor cold chain performance: Facilities that scored below the mean score.

1. INTRODUCTION

1.1. Background

Accessibility and affordability of essential medicines including vaccines are a top priority of the 2030 agenda for sustainable development goals (SDGs) to achieve universal health coverage (United Nations, 2019). Vaccination is one of the most economical public health programs used to achieve this goal. So, cold chain product availability saves lives in terms of under-five morbidity and mortality reduction as well as management of non-communicable diseases.

It is essential to have a system that guarantees consistent availability of high-quality medicines in the right quantity at the right time and to the right customers in an economical way since ensuring equity and equality in access to medicines is crucial in any healthcare system; This system referred to as "supply chain" needs to be managed effectively to get desired outcomes (Chukwu and Adibe, 2022).

A cold chain is a temperature-controlled supply chain for transporting and storing products such as pharmaceuticals and vaccines at recommended temperatures. typically, between $+2^0$C and $+8\ ^0$C from the point of manufacture to the point of use, to ensure vaccine potency, safety and quality is maintained throughout the supply chain (Philippine Department of health, 2018).

The effectiveness of a cold chain system requires three main elements of reliable storage, distribution and temperature monitoring equipment, accurate inventory management along with well-trained staff (Ginenus Fekadu, Gadise Merga, Mohammed, 2018). The integrity of this cold chain system is essential for maintaining the safety, efficacy and quality of temperature-sensitive pharmaceutical products, particularly vaccines, in public health facilities. Effective cold chain management ensures that these products are, transported, stored and handled within certain temperature ranges from the point of manufacture to use (Yassin *et al.*, 2019).

Health professional's knowledge, attitude and practice recognized as critical determinants of effective cold chain management. In this context, the availability of a well trained staff, storage conformity to the WHO standards, and appropriate distribution and temperature monitoring equipment matter (Geneti *et al.*, 2024).

1.1. Statement of the problem

Cold chain management is critical for maintaining the safety, efficacy and quality of temperature sensitive pharmaceutical products and to ensure effectiveness of immunization program worldwide. Even though Cold chain remains a backbone of any successful immunization program. globally and particularly, Low- and Middle-Income countries (LMICs) continues persistent challenges in cold chain management due to inadequate infrastructure, limited human resource capacity and unreliable power supply, which compromise the life of under five children and pregnant mother specifically and public health outcomes broadly (WHO/UNICEF/FMOH, 2010).

Despite efforts made to improve cold chain management in Ethiopia, significant gaps still exist. Studies suggests that outdated and insufficient cold chain equipment, under optimum logistic management information system, frequent power interruptions and absence of skilled and trained manpower for cold chain equipment maintenance affect sustainable cold chain management. Moreover, manual recording and reporting practices and limited effective monitoring and evaluation of cold chain, contribute to inadequate data quality and delayed decision making (Gedlu *et al.*, 2021) and (Kasahun *et al.*, 2023).

The knowledge, attitude and practice of health professionals engaged in cold chain management are often suboptimal. with poor adherence to the standard, inadequate training and negligence, hinder the cold chain management performance. These infrastructural and logistic challenges, complemented with human factors, compromised vaccine storage and distribution, ultimately threatening immunization coverage and effectiveness (Erassa *et al.*, 2023).

In remote and local areas of Ethiopia, these challenges might be worsened by limited access to reliable power sources, inadequate supportive supervision, insufficient capacity- building opportunities and scarce technical support undermines effective cold chain management. Conflict affected areas in Ethiopia like this specific study area might experience aggravated cold chain challenges, due to damaged infrastructure, limited access to functional equipment and supportive supervision hindering vaccine accessibility and immunization coverage (Gebremedhin *et al.*, 2024).

Therefore, this study assessed cold chain management performance from different perspective including, how the knowledge, attitude and practice of health professionals

influence cold chain management performance, an overview of vaccine logistic management information systems data quality, alongside with identifying the infrastructural, logistics and administrative challenges in public health facilities. This insight, will provides targeted, efficient and sustainable interventions, to improve cold chain management performance and strengthen immunization outcomes, and ultimately protecting public health particularly in resource-constraint and remote areas.

Yet, there was no studies conducted in west wallaga zone, on cold chain management. Hence, this study aimed to assess cold chain management performances in the selected public health facilities. so as to come up with the targeted interventions toward improvement of such performances.

1.2. Significance of the study

The cold chain is designed to handle environmentally sensitive products under certain conditions of heat and temperature. Most of the studies found that the risks in cold chain are related to infrastructure and human factors that expose products to harsh environmental conditions, resulting in poor product quality which directly influences health outcomes (Tiya Bacha, 2016; Gedlu *et al.*, 2021; Yetnayet Yeshitela, 2023; Gebremedhin *et al.*, 2024)

The significance of this study lies in its potential to identify critical gaps in cold chain management which directly affect vaccine potency, immunization coverage and overall public health outcomes in public health facilities. Specifically: enhancing logistic management information systems: the study will shed light on effectiveness of recording and reporting trends within the cold chain logistics to improve informed decision making.

Improving vaccine efficacy and safety: by assessing the knowledge, attitude and practice (KAP) of health professionals on cold chain management, the study identifies human-related factors that influence cold chain management to improve cold chain management performance. Additionally, it will identify infrastructural and administrative challenges that compromise cold chain management performance, furthermore; findings of this study will provide evidence-based recommendations to concerned bodies and health facilities management to strengthen cold chain systems through targeted training, improved supervision, investment in infrastructure and digitalization.

Moreover, this study can be a baseline for public health facilities, stakeholders, researchers, academician and students, thus, it will provide practical significance to assess the performances of the cold chain management as well as its challenges.

1.3. Scope of the study

The scope of this study was on assessment of KAP on cold chain management performance in selected public health facilities of west wallaga zone, so geographically limited to those public health facilities under west wallaga zone administration and had been supplied from Ethiopian Pharmaceutical Supply Service (EPSS) Nekemte branch. The study also evaluated the data quality of Vaccines logistics management information systems and identified key challenges affecting cold chain management performance in those facilities.

The study considered the data from the last one year immediately before the study period (i.e. used within a period of 8th July 2023 to 7th July 2024) and including recent data in the meantime, during the data collection period (i.e. 10th Feb 2025 to 10th Apr 2025) for observations and physical count of selected products to reflect the present cold chain management context. In addition to the vaccines the study also considered other temperature-sensitive products managed within the cold chain systems in public health facilities. The study involved healthcare professionals who had lines of influence in cold chain management or were working on a cold chain site.

1.4. Research Questions

1. How data quality of Vaccines Logistics Management Information System (VLMIS) is being practiced in selected public health facilities of West Wallaga Zone?
2. What proportion of health professionals have good knowledge of cold chain management in selected public health facilities of West Wallaga Zone?
3. To what extent do health professionals demonstrate positive attitude towards cold chain management in selected public health facilities of West Wallaga Zone?
4. How many of health professionals have good cold chain management practice in selected public health facilities of West Wallaga Zone?
5. What are the challenges affecting cold chain management performance of public health facilities in selected public health facilities of West Wallaga Zone?

1.5. Objectives of the study

1.5.1. General Objective

To assess knowledge, attitude and practice of health professionals on cold Chain Management Performance in Selected public health facilities of West Wallaga zone, Oromia, Ethiopia.

1.5.2. Specific Objectives

1. To evaluate the data quality of vaccine logistics management information system (VLMIS) in selected public health facilities of West Wallaga zone.
2. To determine the proportion of health professionals with good knowledge of cold chain management in selected public health facilities of West Wallaga zone.
3. To assess the extent of positive attitude towards cold chain management among health professionals in selected public health facilities of West Wallaga zone.
6. To measure the proportion of health professionals with good cold chain management practices in selected public health facilities of West Wallaga Zone
4. To identify the challenges affecting cold chain management performance in selected public health facilities of West Wallaga zone.

2. LITERATURE REVIEW

2.1. Overview

The World health Organization (WHO) has recognized equitable access to essential medicines, vaccines, and technologies as a fundamental component of any national health system (World Health Organization, 2010). However, one-third of the World population, including half of those in Sub-Saharan countries, absences regular access to life saving essential medicines and vaccines (World Health Organization, 2010) and (Roth *et al.*, 2018).

Supply chain management is essential for cold chain medicines; since cold chain medicines are temperature-sensitive and must be kept within a specific temperature range to ensure product integrity and quality (Chukwu and Adibe, 2022). The primary purpose of the healthcare supply chain is to ensure that, the right product is delivered to the right customer, in the right quantity and right condition, to the right place, at the right time, and at right cost. So, meeting all these criteria is essential for the effective functioning of the health care system (P.Yadav, 2015) and (USAID, 1998).

The Expanded Program on Immunization (EPI) is a global initiative of the World Health Organization (WHO), whose objective is to immunize all children worldwide (World Health Organization, 1998). An efficient vaccine supply chain system is crucial for achieving this initiative. The success of the EPI heavily depends on a specialized supply chain management system for vaccines, which includes proper transportation, storage, handling, and the involvement of qualified personnel. Given that vaccines are temperature-sensitive biological substances, a robust end-to-end cold chain system is essential to maintain vaccine potency up to the point of delivery (Vanessa Rémy, York Zöllner, 2015) and (World Health Organization, 2021).

2.2. Importance of cold chain management in public health

Cold chain management is an important component of public health systems, especially for vaccines and other temperature-sensitive pharmaceutical products. Maintaining the cold chain ensures vaccines safety, effectiveness and quality from the point of manufacture to administration (Addendum, 2024). Breaks in the cold chain can lead to reduced vaccine efficacy, increased wastage of resources and disease outbreaks (GAVI, 2022).

The cold chain management is an essential procedure in modern healthcare. Complete immunity and full immunization are closely associated with health and well-being. Immunization is "a process whereby a person is made immune or resistant to an infectious disease, through administration of a vaccine". According to the WHO, the cold chain refers to the "system in which vaccines are handled and transported at ideal temperatures between two and eight degrees Celsius from the time of manufacture until they are delivered to service delivery point". This process helps to maintain the stability and potency of the vaccines (Churchman, 2020).

The cold chain process requires a high level of teamwork and depends on each person carrying out their assigned responsibilities with diligence. There is collaboration in converting distinct individual duties into significant inter- professional responsibilities, wherein the mitigation of injury and the improvement of health are paramount (Wei, Holly, Robin Webb Corbett, 2020).

2.3. Vaccine Logistics Management Information System (VLMIS)

Information is the engine that drives the logistics cycle; without information, the logistics system would not run smoothly. A robust vaccine logistics management information system (VLMIS) is essential for managing supplies, predicting demand, and strategic planning (The Global Fund, 2019). An effective health information system that supports the production, investigation, and dissemination of data is crucial for the proper functioning of a healthcare system (FMOH, 2012).

VLMIS enables real-time tracking of vaccine inventories and distribution work flows, ensuring vaccine remains potent and accessible. Additionally, effective VLMIS support demand forecasting, reduces wastage and enhancing accountability in immunization program. For example, Ethiopia's expanded program on immunization (EPI) integrated in to Ethiopia Pharmaceutical Supply Service (EPSS) to standardize logistics, nevertheless, challenges like inconsistent forms usage and low digital adoption still persist. Effective implementation of VLMIS, needs addressing infrastructural, human resource and technical barriers (Mekonen *et al.*, 2023) and (Sergiy Skybyk, 2013).

2.4. Knowledge, Attitude and Practice of health professionals

Health professionals' knowledge, attitude and practice (KAP) directly influence the effectiveness of cold chain management. Adequate knowledge, attitude and practice about

vaccine storage requirements, handling procedures and monitoring tools is important to prevent cold chain failure (Kasahun *et al.*, 2023).

Several studies conducted in Ethiopia revealed that, health professionals often have inadequate knowledge and poor practices on cold chain management. For example, a systematic review stated that only about half (49.9%) of Ethiopian health professionals showed good knowledge of cold chain management, with the factors such as longer work experience, having access to EPI guidelines and on-the -job training positively affecting their level of knowledge (Kasahun *et al.*, 2023) and (Yassin *et al.*, 2019).

A study done in southwest Ethiopia, revealed that only 54% of health professionals demonstrated adequate knowledge of cold chain management. Similar to this, studies conducted in specific regions like Oromia and Amhara regions of Ethiopia indicated that over half of vaccinators and vaccine handlers had adequate knowledge. While less than half demonstrated good practice or positive attitude toward cold chain management (Mohammed, Workneh and Kahissay, 2021), (Bogale, Amhare and Bogale, 2019) and (Yassin *et al.*, 2019). Training was consistently identified as a key determinant of knowledge and practice.

In Ghana, most of the health professionals had good knowledge and attitude, but it doesn't mean always good practice because there was weak relationship between knowledge and attitude (Asamoah *et al.*, 2021)

Appropriate practice includes, correct storage, temperature monitoring and timely reporting, however, report done in southwest Ethiopia show that only 48% of health professionals adhere to guidelines, Practice gaps linked to inadequate training and supervision (Feyisa *et al.*, 2022).

Positive attitudes toward cold chain management encourage adherence to standards, however, some of the studies conducted in Ethiopia show that less than half of the health professionals demonstrate good attitude, which negatively affect their practices, because attitude is often shaped by awareness of cold chain importance and perceived challenges in the workplace (Ginenus Fekadu, Gadise Merga, Mohammed, 2018).

2.5. Challenges of Cold chain Management performance

Common challenges identified by different studies were, inadequate training, lack of guidelines and reporting forms, inadequate supervision and infrastructural constraints, such as

unreliable power supply, insufficient equipment and transportation difficulties(World Health Organization, 2010), (P.Yadav, 2015) and (Addendum, 2024).

Inadequate temperature monitoring and under optimum record-keeping have been reported both in Ethiopia and Internationally, which limit timely decision making and response to cold chain breaches (Olutuase *et al.*, 2022), (Sudhanshu Joshi and Manu Sharma, 2022).

Additionally, shortage of Cold Chain Equipment (CCE) and absence of maintenance for available CCE and lack of trained man power on their maintenance, inadequate infrastructure, inconsistencies and shortage of VLMIS forms and uncertain reporting schedule, lack of training for health professionals engaged in cold chain management were identified as bottleneck for sustainable cold chain management. This study is supported by scope review conducted in Nigeria on Medicines and vaccines supply chains challenges (Olutuase *et al.*, 2022).

1.6. Conceptual framework of the study

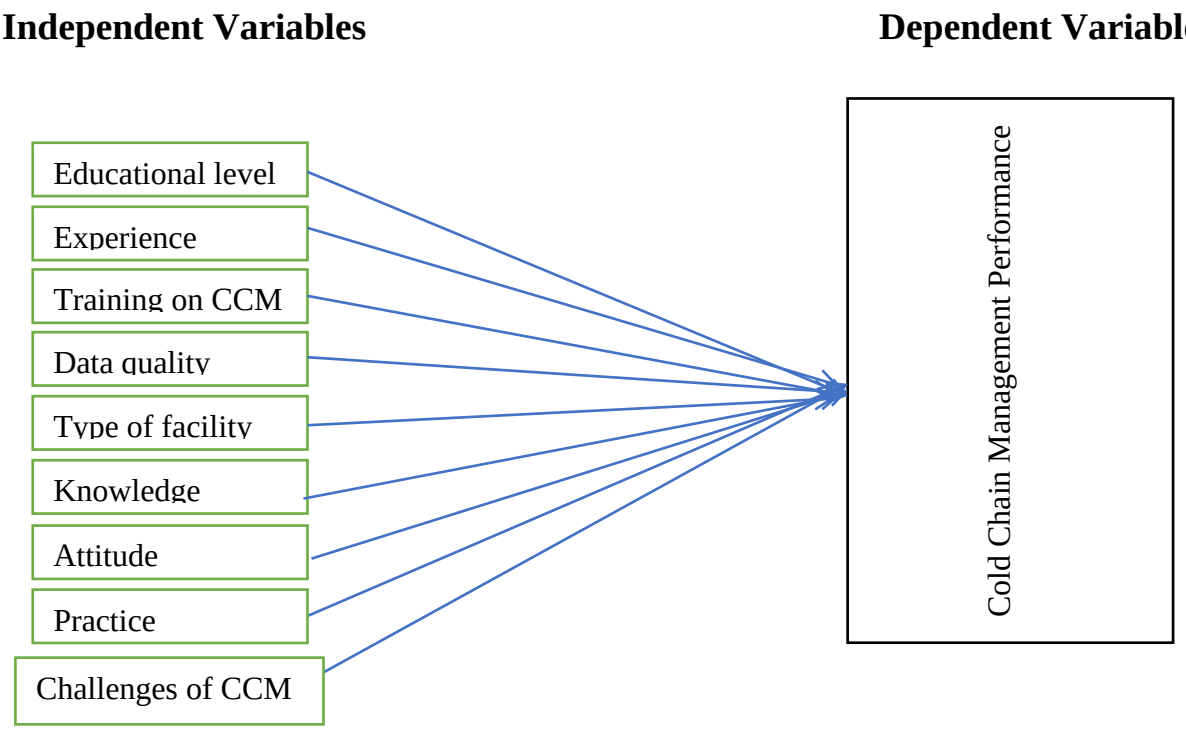

Figure 1: Conceptual framework of the study

Source: Researcher's own construct

3. METHODOLOGY

3.1. Study area and Period

This study was conducted in the selected public health facilities of West Wallaga Zone, Oromia regional state, Ethiopia and had been supplied from Ethiopian Pharmaceutical Supply Service (EPSS) Nekemte hub. West Wallaga has 19 administrative woredas and its capital town Ghimbi, located 441 Km to the west of Addis Ababa. There were five public hospitals and 70 health centers giving services in this zone. This zone was purposely selected as a study area, because it was prone to conflict and security issue remained a serious problem in the area for the last one decade. Hence, provision of quality health services became difficult in this area. This area was also remote and underserved. Hence, studying the cold chain management performance in the area has its paramount importance for intervention and service improvement. The study was conducted from Sep 2024 to June 2025.

3.2. Study design

A facility-based cross-sectional study design with concurrent mixed methods was employed using both quantitative and qualitative data collection approaches.

3.3. Population

3.3.1. Source population

The source population for the study were all public health facilities found in west Wallaga Zone, all health professionals engaged in cold chain management, all cold chain products, all documents for record keeping and report of cold chain products and all stakeholders who were involved in the cold chain management at facilities, Woreda Health Offices, zonal Health Department logistic Officers and EPSS Nekemte hub and central EPSS logistic officers.

3.3.2. Study Population

The study populations were, selected public health facilities in West Wallaga Zone been supplied from EPSS Nekemte hub, selected health professionals involved in cold chain management in those facilities, selected cold chain products and selected key informants (Pharmacy head, Logistic Officers, Store Managers, Facility Heads, EPI focal, Woreda health office and zonal health Department logistic Officers and EPSS logistic officers) who were

involved in cold chain management decision as well as one year logistic records and reports used for cold chain products.

3.4. Inclusion and Exclusion criteria

3.4.1. Inclusion Criteria

- Public health facilities supplied from EPSS Nekemte hub
- Public health facilities that had been in service at least for one year immediately before study period
- Public health facilities that had have cold chain products and provided immunization service.
- One-year cold chain products logistic records and reports
- Professionals with no less than 1 year of experience at the study facilities, WoHo, ZHD, EPSS Nekemte hub and Central

3.4.2. Exclusion criteria

- Health posts
- Facilities that had security problems during data collection time

3.5. Sample size determination

3.5.1. Sample size determination for quantitative study

Fifteen percent of the facilities were included following the recommendation of USAID's Logistics Indicators Assessment Tool; where a minimum of 15% of the total health facilities are recommended (USAID Deliver Project, 2008).

Since hospitals were expected to serve more population and have more products, all hospitals, that fulfil the inclusion criteria, were included. and the health centers were sampled using Logistics Indicators Assessment Tool (LIAT) recommendation. Accordingly, 70 health centers were found in the study area. Then one health center from each woreda fulfilling the inclusion criteria (12 health centers from 12 woredas) which was more than 15% (minimum sample size recommended by LIAT tool) were included. In general, 12 health centers and four hospitals, a total of 16 health facilities were assessed.

Sample size for study participants was calculated using Yamane's formula (Yemane, 1967). Accordingly, there were a total of 947 health professionals directly involved in cold chain management. So, $n=N/1+N(e)^2$ $n= 947/1+947(0.08)^2$ taking 8% margin of error to control

sample size error, a total of 135 health professionals were involved in the study and 5 vaccines used in routine immunization and 3 other cold chain medicines were selected. Five vaccines were taken from the list of initially launched vaccines in national immunization program of Ethiopia (WHO/UNICEF/FMOH, 2010).

3.5.2. Sample size determination for qualitative study

Eight Key Informants were interviewed. Accordingly, 5 EPI Focal/ store manager/ pharmacy head from health facilities/woredas, 1 EPI focal/logistic officer from zone and 1 vaccine logistic officer from Nekemte EPSS hub and Central EPSS were interviewed.

3.6. Source of data and Sampling technique

Data was extracted from the Logistics management information system tools (bin cards, VRF, vaccine stock keeping record). For qualitative study; Purposive sampling for most knowledgeable professionals was used. For quantitative study; simple random sampling technique was used. Then 3 pharmacy personnel and 4 Midwifes from each health center, 4 pharmacy personnel and 8 midwifes for primary hospital and 5 pharmacy personnel and 10 midwifes for General hospital were included proportionately.

3.7. Study Variables

3.7.1. Dependent Variable

- Cold Chain Management Performance

3.7.2. Independent Variables

- Educational level
- Experience
- Training
- Types of facility
- Data quality
- Knowledge
- Attitude
- Practice and
- Challenges

3.9. Data Collection Procedures

3.9.1. Data Collection tools

The quantitative data was collected by a structured data abstraction checklist through observation self-administered questionnaires. Additionally, physical counts of selected vaccines in refrigerators and other cold chain products like insulins, oxytocin and rabies vaccine were conducted. while qualitative data was gathered using interview guide for key informants.

To evaluate cold chain management performances of health facilities the Vaccine-Management Assessment Tool (VMAT) developed by the Global Training Network (GTN) Vaccine Management Team to help countries to improve the quality of their vaccine management from national stores to service-delivery level was used (World Health Organization, 2005).

Fifteen checklists were adapted from essential components of vaccine management assessment tool (VMAT) stipulated by WHO for service delivery level. checklist covered vaccine storage temperatures, cold storage capacity, cold chain equipment, Maintenance of cold chain equipment, documentation, stock management and distribution of cold chain medicines.

Checklists were used to assess cold chain management performance of health facilities with **Yes** or **No** responses. Presence of each criterion was scored '1' and '0' if otherwise, given possible minimum and maximum total scores of 0 and 15 respectively for all the items. The total score was transformed into percentage performance score. And then Performance status was divided into 'Poor', 'fair' and 'Good' performance based on the WHO minimum score of 80%.

Facilities that scored 80% or above were categorized as having good performance. Then facilities that scored less than 80% were categorized as having 'poor' and 'fair' performance based on the percentage mean performance score. Facilities that scored below the mean (57.9%) were categorized as having poor performance while those that scored the mean score or above were categorized as having fair performance in cold chain management.

The self-administered questionnaires gathered information from EPI staffs and pharmacy staffs covering demographics, knowledge, Attitudes and practices. The questions were adapted from WHO (WHO, 2013). For individual respondents a total of 38 questions were

Self-administered, 10 questions each for knowledge, attitude and practice were developed and the total score, then converted in to percentage and categorized as good and poor based on the average mean score. Those that scored below the mean score were categorized as having poor while those that scored the mean score or above were categorized as having good cold chain management for both knowledge and practice.

While attitude of the respondents toward cold chain management was evaluated by five-point Likert scale. The overall attitude of the respondents was categorized based on the mean score and the grand mean score (weighted average). Therefore, if the mean of individual item was less than the grand mean, the respondents were considered as having negative attitude (low perception) for that idea as well as if the mean of individual item was greater than or equal to the grand mean, the respondents were considered as having positive attitude (high perception) for that idea. The reliability of the questions was tested and had an acceptable value of Cronbach's Alpha (α) 0.798.

Qualitative information was collected from Pharmacy head, EPI focal, store manager, logistic officer from each woreda, Zone, Nekemte EPSS hub and Central EPSS through guiding questions. The interview guide was translated into the region's working language, Afaan Oromo. Then, the interview was undertaken with Afaan Oromo and audio recorded. The recorded data was transcribed and translated back to English by investigator. Each key informant was inter viewed approximately for 10–15 min.

3.9.2. Data Collectors

The data collection was performed by six trained final year pharmacy students. Principal investigator (PI) was involved in the overall coordination of the data collection and control the quality of data. The data collectors were trained for one day on the data collection technique and its procedure before being involved in the data collection.

3.10. Data Quality Assurance

The data collection tool was face validated with the supervisor of the study. The principal investigator gave 1-day training for data collectors regarding the objectives and significance of the study and how to collect the data with strict instructions. Incomplete and inconsistent questionnaires were cleaned before data entry. During data collection process there was a close supervision by the principal investigator to ensure consistency and completeness of the

data. Pretest was also conducted on 1 hospital and 2 health centers which were not part of the study.

3.11. Data Analysis and Interpretation

The quantitative data was manually checked for completeness and consistencies before being entered into Excel spreadsheet version 16 and then exported to and analyzed using IBM SPSS Statistics software version 26. The quantitative data was analyzed by descriptive statistics, (frequencies, percentages, means, standard deviations and ranges) and the result were subsequently presented through tables and figures. To explore the relationship between independent & dependent variables chi square test was done and p value of 0.05 was considered as statistically significant at 95% confidence level and the data further analyzed by using ordinary logistic regression.

The qualitative data was analyzed manually using thematic analysis technique. Accordingly, the investigators familiarized with the recorded data by listening repeatedly and taking notes. Next, the data were coded in the Microsoft word and organized to search for subthemes. Then, similar subthemes were brought together to form a theme and the theme were categorized in to key thematic areas. Finally, we described the theme and quoted some KIs direct speech to strengthen our finding.

3.12. Ethical Considerations

Ethical approval was obtained from Research and Ethical Review Committee of School of pharmacy (Ref. No. ERB/SoP/0424/17/2024), Addis Ababa University. The school issued off support letter (ቁጥር፡ ፋር/ሲዩቲክስ/171/17/2025) to all concerned bodies. The Support letters (Lakk. 227/WFG/17) also issued from west Wallaga zone health department to those selected health facilities. Verbal and written consent was obtained from all study participants before data collection commenced. Any individual identifiers excluded from the data collection and the data analyzed in aggregate.

4. RESULT

4.1. General Information of the health facilities

The study involved a total of 16 health facilities. The majority of the health facilities 12 (75%) were health centers, while the remaining facilities were primary hospitals and general hospital accounted for three (18.75%) and 1 (6.25%) respectively. Of the facilities surveyed 14 (87.5%) were found in urban while only 2 (12.5%) were found in rural areas (Fig- 2).

All of the surveyed health facilities had no separate vaccine store and instead used shared spaces with immunization unit except one health facility which used shared space with medicines store for vaccine.

Figure 2: Level and location of the selected public health facilities surveyed in the study area.

Overall, 15 (93.75 %) of the surveyed health facilities but one health center had dedicated EPI focal person. In all facilities there was no designated person in charge of primary responsibility for monitoring temperature of the refrigerator; instead all staff members had collective responsibility. About 14 (87.5%) health facilities had no any person assigned on maintenance of cold chain equipment in case of breakdowns in cold chain equipment because of malfunction or inadequate maintenance and power outages in all facilities, instead they call the higher levels (i.e. woreda health offices, zonal health departments) in this case; but 2 (12.5%) one general hospital and 1 primary hospital had biomedical engineer assigned on maintenance of cold chain equipment.

Fifteen (93.75%) of the facilities had no evidence of emergency repair of cold chain equipment. Only 3 (18.75%) of the facilities had labelling of near expiry vaccines while the remainder 13 (81.25%) did not. Almost all health facilities did not have SOP for temperature monitoring, Storage, repair and maintenance of cold chain equipment and only 3 (18.75%) of the facilities had SOPs for stock management and control.

Ten (62.5%) surveyed health facilities had internet connection and they were using Wi-Fi as the only source, while 6 (37.5%) had no internet connection. All surveyed health facilities had electric power supply system. Three (18.75%) used only electric power from national grid, seven (43.75%) used three power sources, electric power from national grid, generator and solar power, four (25%) used two power sources, electric power from national grid and solar power and two (12.5%) used only solar power.

All surveyed health facilities had no electric power interruption on the day of visit. All of the surveyed health facilities had standard cold boxes and vaccine carrier even though it was not in sufficient amount. All health facilities were equipped with at least one functional refrigerator, it ranges from 1 for health center and 4 for general hospital and all of those refrigerators were found within the normal temperature range on the day of visit.

The average availability of functional temperature monitoring devices (i.e. calibrated functional min/max thermometer or fridge tag) within these refrigerators were 100%. Over a course of one month, only Ten (62.5%) facilities consistently recorded refrigerator temperatures in accordance with WHO recommendations (twice daily). The number of days the temperature recorded twice in a day on the temperature recording sheet ranges from 19 to 30 days with average of 27.88 and standard deviation of ±3.6 over a course of one month in all surveyed facilities. All of the surveyed health facilities were lacked operational deep freezer.

Overall, fifteen (93.75%) of the surveyed health facilities had no supplies of spare parts and consumables for cold chain equipment maintenance and depend on higher levels for emergency maintenance. Eleven (68.75%) of the facilities had approved cold box or alternative refrigerator available to store vaccines during servicing, defrosting and cleaning, while the remainder 5 (31.25%) were not. More than half of the facilities 9 (56.25%) had no good arrangement of the items in refrigerator (FEFO order). Since most of the facilities were using solar refrigerators there was no frozen vaccines found in refrigerator and also there was no Mixing of vaccines with other items like non-vaccines medicines, water and food in refrigerator in 13 (81.25%) of the facilities.

Manual VLMIS was Utilized across the health facilities under study for vaccine stock management. All the facilities utilized Bin cards for non-vaccine cold chain products but there was no Bin card for vaccines at all. All surveyed facilities did not receive any budget for cold chain equipment maintenance and repairs. More than half 9 (56.25%) of the facilities

complained that they did not get any supportive supervision for cold chain management in the last one year before data collection of this study, while the remainder 7 (43.75%) were getting it. Woreda health offices, zonal health departments and regional health bureaus were the major government bodies providing the supportive supervision on cold chain management for those facilities.

The improvements of the supportive supervision in the supervised facilities were; Improved supply of equipment, Improved quality of service, highlighted the strengthens and weakness of the cold chain management, Improved supply of products, improved capacity building, Improved timely vaccine requisition, Improved continuous supply of vaccines and diluents, Improved Man power, Improved data quality, Improved sense of responsibility, Improved awareness of staff for cold chain products sensitivity and Decreased mortality of under 5 children.

4.2. Product Availability

From the selected key vaccines used in routine immunization, BCG, Measles and Penta were available in all surveyed facilities during the data collection period. From the selected other cold chain products Oxytocin was available in all selected health facilities and Insulin was available in 11 (68.75%) of health facilities on the day of visit. Rabies vaccine was available only at hospital level and found at 3 (18.25%) hospitals. The mean availability of the selected cold chain products in all surveyed health facilities was 42.2% (Table -1).

Table 1: Availabilities of selected cold chain products in public health facilities in the study area

Item	Availability		Percentage of availability
	Available	Not available	
BCG	15	1	93.75
PCV -13	16	0	100
Measles	16	0	100
OPV	15	1	93.75
Penta	16	0	100
Rabies Vaccine	3	13	18.25

Insulin	11	5	68.75
Oxytocin	16	0	100

4.3. Stockout rate

Within 6 months immediately before the study period, 87.5% of the selected cold chain items were out of stock at least once in selected health facilities. One of the cold chain health products (Oxytocin) was available in all facilities, whereas, seven of the cold chain products were out of stock at least once in all health facilities. The average stock out rate of cold chain products was 38.88±53.83 days. The stockout rate ranges from 0 for oxytocin and 144 days for rabies vaccine. The most frequently stockout item was rabies vaccine because it was not available in all health centers followed by insulin which was also not available in more than 50% of the health centers (Table- 2).

Table 2: Stockout rate of selected cold chain products in selected public health facilities in the study area

Items	Health facilities									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
BCG	23	21	18	21	24	12	8	30	13	14
PCV-13	36	35	23	0	32	9	17	19	22	28
Penta	0	0	6	0	12	0	0	16	11	12
Measles	0	0	5	0	0	0	0	0	8	13
OPV	28	14	13	0	15	7	11	25	19	31
Rabies vaccine	180	180	180	180	180	180	180	0	0	0
Insulin	180	180	180	180	180	22	26	27	29	22
Oxytocin	0	0	0	0	0	0	0	0	0	0

4.4. VLMIS data quality

Out of 16 Health facilities assessed, 8 (50%) of them had both Ledger book and Vaccine Requisition Form (VRF) while 10 (62.5%) of them had only ledger book.

Four dimensions were used to evaluate the quality of the data: Inventory accuracy rate, timeliness, completeness and accuracy of the report. The first dimension evaluated the accuracy of stock-keeping records (ledger book), whereas the other three dimensions focused

on VRF reports. For inventory accuracy rate, five key tracer vaccines used in child care and routine immunization and 2 other cold chain products were evaluated while all eight tracer vaccines were evaluated for the remaining data quality dimensions of VRF.

4.4.1. Inventory Accuracy Rate

Out of the total sixteen public health facilities assessed only 10 (62.5%) were used the vaccine stock management ledger book and bin card for stock management of other cold chain products considered in this study, and only 9 (56.25%) had been updating it consistently. Inventory accuracy was determined by calculating the discrepancy between physical stock count (stock on hand) and ending balance on ledger book/bin cards. Accordingly, only one health facility had 100% accuracy rate on the other hand, one health facility had 0% accuracy rate. Of these, 60% of the health facilities had less than 50% inventory accuracy rate. The average inventory accuracy of ten health facilities was 45.68% (Fig- 3).

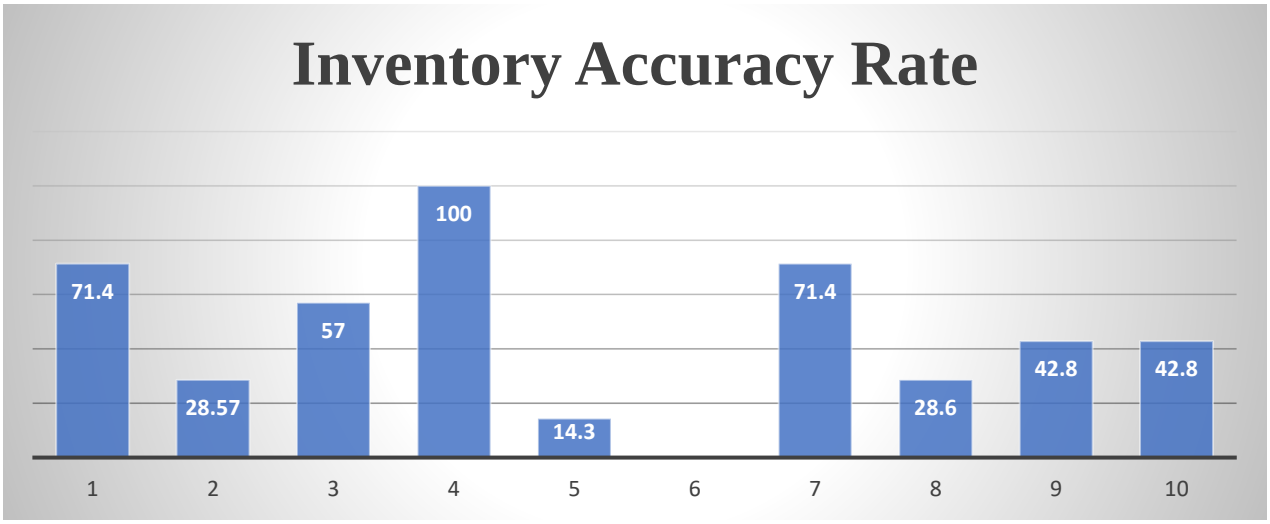

Figure 3: Inventory Accuracy rate of selected cold chain products in selected public health facilities having stock keeping record in the study area.

4.4.2. Reporting rate, Timeliness, Completeness and accuracy of the VRF

Public health facilities are required to submit monthly vaccine consumption and demand requests using the VRF. Woreda health offices, zonal health departments or Supplier (EPSS branches) then distribute vaccines based on the reports. This study analyzed one-year VRF report to evaluate their reporting rate. So, 192 VRF were expected from 16 assessed health facilities. unfortunately, 8 (50%) of the facilities were using VRF.

The average reporting rate for eight facilities using VRF was 71.8%. The most recent reporting period or VRF was emphasized to evaluate timeliness, completeness and accuracy. Hence reporting performance of the 8 facilities were 68.2%, 75%, and 57.5% for timeliness, completeness and accuracy respectively and the overall reporting performance of the eight health facilities was 68.1% Table- 3).

Table 3: VRF data quality evaluation dimensions in selected public health facilities having VRF form in the study area.

Code of Health facilities	Reporting rate	Timeliness	Completeness	Accuracy	Overall Reporting Performance
1	66.7%	50%	71.4%	80%	67%
2	66.7%	75%	71.4%	40%	63.3
3	58.3%	57%	71.4%	60%	61.7%
4	91.6%	63.6%	85.7%	80%	80.2%
5	100%	91.6%	85.7%	100%	94.3%
6	25%	100%	57.1%	20%	50.5%
7	91.6%	63.6%	71.4%	40%	66.65%
8	75%	44.4%	85.7%	40%	61.3%
Average total	71.8%	68.2%	75%	57.5%	68.1%

4.5. Cold Chain Management Performances of public health facilities

The following table shows the aggregate result score of health facilities for each of the indicators converted in to percentage and status of the health facilities depending on WHO minimum score and average score.

Table 4: Cold chain Management performance of health facilities in the study area

S.N	Indicators	Yes	No
1.	Is there WHO-prequalified refrigerator (non-domestic)?	14(87.5%)	2(12.5%)
2.	Do refrigerators are equipped with functional thermometer (fridge tag)?	16(100%)	0(0%)
3.	Is refrigerator temperature maintained at (2–8ºC)?	16(100%)	0(0%)

4.	Is there a separate temperature recording sheet for each refrigerator?	16(100%)	0(0%)
5.	Is there good arrangement in refrigerator (FEFO order) principle?	7(43.75%)	9(56.25%)
6.	Is there electric power supply system for the facility?	14(87.5%)	2(12.5%)
7.	Does the facility have backup generator?	13(81.25%)	3(18.75%)
8.	Is there timely updating of vaccine stock record book?	9(56.25%)	7(43.75%)
9.	Are there sufficient cold boxes and vaccine carriers?	10(62.5%)	6(37.5%0
10.	Is there a vaccine wastage recording system?	1(6.25%0	15(93.75%)
11.	Is there regular physical inventory of vaccine stock?	10(62.5%)	6(37.5%)
12.	Is there monitoring/review of vaccine stocks prior to ordering?	11(68.75%)	5(31.25%)
13.	Is there adequate cold chain storage capacity?	2(12.5%)	14(87.5%)
14.	Is there sufficient icepack storage capacity?	0(0%)	16(100%)
15.	Do adequate supplies of spare parts and consumables are available for CCE maintenance?	0(0%)	16(100%)

4.5.1. Cold chain Management performance status of health facilities

Out of the total sixteen public health facilities, only two (12.5%) scored 80% and meet WHO minimum standard, while fourteen (87.5%) were scored less than 80%. The minimum score was 5 (33.3%) and the maximum score of twelve (80%). The average score was 57.9% ±15.34 and ranges from 33.3% to 80%. Out of the total 16 public health facilities; two (12.5%) had good cold chain management performance, while seven (43.75%) and seven (43.75%) had poor and fair cold chain management performance respectively (Table 5).

Table 5: The status of cold chain management performance of public health facilities in the study area

CODE OF HEALTH FACILITIES	SCORE (%)
1	10 (66.6%)
2	9 (60%)
3	7 (46.6%)
4	6 (40)
5	11 (73.3%)
6	12 (80%)
7	10 (66.6%)

8	11 (73.3%)
9	12 (80%)
10	8 (53.3%)
11	5 (33.3%)
12	6 (40)
13	7 (46.6%)
14	6 (40)
15	9 (60%)
16	10 (66.6%)

4.6. Sociodemographic characteristics of the respondents

A total of 135 health professionals were participated in this study with 100% response rate. Out of this, 83 (61.5%) were Males. The age of the respondents ranges from 25 to 52 with the average age of 29.89. The respondents have different educational backgrounds, 68 (50.4%) of them were midwiferies, while 65 (48.1%) and 2 (1.5%) were pharmacy and others (i.e. health extension workers), respectively. The average numbers of years of service or total professional experience was 4.38 and ranges from 2 to 13 years (Table 6).

Table 6: sociodemographic characteristics of the respondents

Characteristics		Frequency (%)
Gender	Male	83 (61.5%)
	Female	52 (38.5%)
Professions	Pharmacy	65 (48.1%)
	Midwifery	68 (50.4%)
	Others	2 (1.5%)
Educational level	Certificate	2 (1.5%)
	Diploma	47 (34.8%)
	BSc	84 (62.2%)
	MSc/Specialty	2 (1.5%)
Health facilities of the respondents	Health Center	83 (61.5%)
	Primary Hospital	37 (27.4%)

	General Hospital	15 (11.1%)
Current Position	Pharmacy Head	15 (11.1%)
	EPI Focal	15 (11.1%)
	Store Manager	16 (11.85%)
	Dispenser	32 (23.7%)
	EPI/delivery/ANC/Ward	57 (42.2%)

Cold chain management knowledge and Practices of health professionals

About 78 (57.8%) of the health professionals had good knowledge of cold chain management while 57 (42.2%) had poor knowledge of cold chain management. 50 (37%) of the respondents had good cold chain management practice, whereas, Majority 85 (63%) had poor cold chain management practice. Of the respondents 54 (40%) had training on cold chain management in the last two years before the study period, on the other hand, 81 (60%) of them claimed that they didn't get training on cold chain management.

Most of the respondents 84 (62.2%) were BSc holder and the remainder 47 (34.8%), 2 (1.5%) and 2 (1.5%) were diploma, MSc and level or certificate respectively. Of the total participants, 83 (61.5%) were working at health centers, while 37 (27.4%) and 15 (11.1%) were working at primary hospitals and general hospital respectively.

Regarding to the Chi square statistical test, Practice ($P< 0.001$), type of health facilities ($P< 0.001$), and training on cold chain management ($P< 0.001$) had significant association with cold chain management performance, while knowledge ($P>0.05$), educational level ($P>0.05$) had no significant association with cold chain management performance (Table -7).

The success of cold chain management depends on the knowledge, attitude and practice of health professionals. In this study, Cold Chain Management practice and training on cold chain management had significantly associated with the cold chain management performance. Having good cold chain practice is having good cold chain management performance status and being trained on cold chain management is having better cold chain management performance.

Table 7: Knowledge on cold chain management, cold chain management practice, trainings on CCM, educational level and types of health facilities of health professionals.

Variables	**Frequency (%)**	**X^2**	**df**	**P-**

					Value
Knowledge status	Good	78(57.8%)	0.827	2	>0.05
	Poor	57(42.2%)			
Practice status	Good	50(37%)	42.396	2	<0.001
	Poor	85(63%)			
Training on CCM	Yes	54(40%)	23.855	2	<0.001
	No	81(60%)			
Educational level	Certificate	2(1.5%)			
	Diploma	47(34.8%)	9.206	6	>0.05
	BSc	84(62.2%)			
	MSc/Specialty	2(1.5%)			
Types of health facilities of the respondents	Health Center	83(61.5%)	32.551	4	<0.001
	Primary Hospital	37(27.4%)			
	General Hospital	15(11.1%)			

4.7. Analysis of cold chain management performance factors Using Ordinal logistic Regression

Model fitting Information

The results show that the model significantly improves the prediction of Cold Chain Management performance compared to the intercept-only model, as indicated by the model fitting chi-square statistic ($\chi^2 = 42.842$) for practice and ($\chi^2 = 23.215$) for training ($p < 0.001$) for both**.** Additionally, the Goodness-of-Fit test yielded a non-significant result ($\chi^2 = 4.123$) for practice and ($\chi^2 = 1.714$) ($p > 0.05$**)** for both. Suggesting that the model fits the data well. Together, these findings confirm that how well the model explains variations in Cold Chain Management performance across the study variable (Table- 8).

Table 8: The Model fitting information of OLR

Model Fitting Information				
Model	-2 Log Likelihood[a]	Chi-Square	df	Sig.
Intercept Only	61.919			
Final	19.076	42.842	1	.000
Goodness-of-Fit				
	Chi-Square	df	Sig.	
Pearson	4.123	1	.420	
Deviance	6.357	1	0.012	

Model Fitting Information				
Model	-2 Log Likelihood[a]	Chi-Square	df	Sig.
Intercept Only	40.638			
Final	17.423	23.215	1	.000
Goodness-of-Fit				
	Chi-Square	df	Sig.	
Pearson	1.714	1	.190	
Deviance	1.876	1	.171	

Among the independent variables, Cold Chain Management Practice and Training on cold chain management emerged as statistically significant predictors of CCM performance, with odds ratios (OR) of 12.92 and 5.56**,** respectively ($p < 0.001$ for both).

These findings indicate that for each additional unit increase in the practice score related to cold chain management, the odds of achieving a higher level of performance (for example, moving from *Poor* to *Fair*, or from *Fair* to *Good*) increase by approximately 13 times, after adjusting for other variables in the model.

Similarly, the training on cold chain management plays a crucial role. As health professionals get trained, the odds of attaining better cold chain management performance improve by a factor of approximately 5.56 (more than five-folds)**,** holding all other variables constant. Other variables, such as knowledge, educational level, profession and Type of health facility

did not reach statistical significance in this model, though they may still contribute to cold chain management performance through indirect or contextual factors (Table -9).

Table 9: Ordinal logistic regression of the Statistical output of Cold chain management performance and predictor variables

Predictor	Estimate (Coefficient)	OR	P- Value
Knowledge	0.007	1.00702455	0.984
Practice	2.559	12.92288796	0.001*
Training	1.716	5.56222349	0.001*
Educational level	1.310	3.70617371	0.497

*Significant

4.8. Attitudes of the respondents toward Cold chain Management

Majority Strongly Agree 85 (63%) & Agree 43 (31.9%) of the respondents had positive attitude toward maintaining accurate documentation and records of temperature conditions respectively. About 95 (70.3%) of the participants agreed with the idea of "vaccine should be stored and managed in a separate store by pharmacy personnel". While, 33 (24.4%) of them did not agreed with the idea. 47 (42.3%) of the respondents accepted that non-uniformity in storage temperature instructions on medicines label is a challenge for cold chain Management. Contrary, 48 (35.6%) of them did not accepted it as a challenge. While 30 (22.2%) of them remained neutral.

More than half 83 (61.5%) of the respondents strongly agreed with the idea" Store manager should consistently update stock records whenever products are added or removed" followed by 36 (26.7%), 12 (8.9%), 2 (1.5%) and 2 (1.5%) were Agreed, Neutral, disagreed and strongly disagreed respectively. Almost all, 130 (96.3%) of the respondents believed that Staff training and awareness are significant in ensuring the successful management of cold chain products. About 125 (92.6%) of the participants had positive attitude toward Maintaining the integrity of temperature- sensitive products throughout the cold chain for ensuring product efficacy.

Most 124 (91.8%) of the respondents accept the idea of "regular temperature monitoring and recording" as a crucial for effective cold chain management, while 6 (4.4%) were against it. To have the quantity needed of certain products the professionals that handle and manage that product should participate in ordering of the products, 79 (58.55%), 42 (31.1%), 11 (8.1%), 1 (0.7%) and 2 (1.5%) of the respondents strongly agreed, agreed, neutral, disagreed and strongly disagreed with this idea.

One hundred three (76.3%) of the respondents were confident enough in the effectiveness of their practice for managing and mitigating risks associated with temperature- sensitive products in the cold chain. Majority 86 (63.7%) of the respondents strongly agreed with "Maintaining the cold chain is the most important aspect of vaccine logistics" while 39 (28.9%), 3 (2.2%), 5 (3.7%) and 2 (1.5%) were agreed, neutral, disagreed and strongly disagreed respectively (Table-10).

Table 10: Attitudes of the respondents toward cold chain Management

Attitude questions	**Level of Agreement**				
	1	2	3	4	5
Maintaining accurate documentation and records of temperature conditions during the handling of cold chain products is crucial for compliance and accountability	3(2.2%)	1(0.7%)	3(2.2%)	43(31.9%)	85(63%)
Vaccine should be stored and managed in a separate store by pharmacy personnel	15(11.1%)	18(13.3%)	7(6.2%)	33(24.4%)	62(45.9%)
Non-uniformity in storage temperature instructions on medicines label is a challenge for cold chain Management	22(16.3%)	26(19.3%)	30(22.2%)	16(11.9%)	41(30.4%)
A Store manager should consistently update stock records whenever products are added or removed	2(1.5%)	2(1.5%)	12(8.9%)	36(26.7%)	83(61.5%)
Staff training and awareness are significant in ensuring the successful management of cold chain products	2(1.5%)	1(0.7%)	2(1.5%)	28(20.7%)	102(75.6%)
Maintaining the integrity of temperature- sensitive products throughout the cold chain is critical for ensuring product efficacy	2(1.5%)	3(2.2%)	5(3.7%)	43(31.9%)	82(60.7%)
Regular temperature monitoring and recording are crucial for effective cold chain management	1(0.7%)	5(3.7%)	5(3.7%)	33(24.4%)	91(67.4%)
Participating in ordering of cold chain product is needed so as to have quantity needed	2(1.5%)	1(0.7%)	11(8.1%)	42(31.1%)	79(58.5%)
You are confident enough in the effectiveness of your current practice for managing and mitigating risks associated with temperature- sensitive products in the cold chain	0(0%)	11(8.1%)	21(15.6%)	27(20%)	76(56.3%)
Maintaining the cold chain is the most important aspect of vaccine logistics?	2(1.5%)	5(3.7%)	3(2.2%)	39(28.9%)	86(63.7)

1: Strongly disagree; 2: Disagree; 3: Neutral; 4: Agree; 5: Strongly agree

The data analysis shows that majority of the respondents appeared to feel that, "*Maintaining accurate documentation and records of temperature conditions during the handling of cold chain products is crucial for compliance and accountability*". Also, they perceived that "*A Store manager should consistently update stock records whenever products are added or removed*". They highly perceived that, "*Staff training and awareness are significant in ensuring the successful management of cold chain products*". And they perceived "*Maintaining the integrity of temperature- sensitive products throughout the cold chain is critical for ensuring product efficacy*".

Most of the participants supposed to had positive attitude (high perception) for "*Regular temperature monitoring and recording are crucial for effective cold chain management*", "*Participating in ordering of cold chain product is needed so as to have quantity needed*" and "*Maintaining the cold chain is the most important aspect of vaccine logistics*".

On the other hand, majority of the respondents had low perception for the idea that "*Vaccine should be stored and managed in a separate store by pharmacy personnel*", *Non-uniformity in storage temperature instructions on medicines label is a challenge for cold chain Management*" and "*their confidence in the effectiveness of their current practices for managing and mitigating risks associated with temperature- sensitive products in the cold chain*" (Table 11).

Table 11: Analysis of attitude of the respondents based on mean and grand mean of the items

S. N	Attitude questions	Mean	S. D	Decision
1	Maintaining accurate documentation and records of temperature conditions during the handling of cold chain products is crucial for compliance and accountability	4.53	0.781	High perception
2	Vaccine should be stored and managed in a separate store by pharmacy personnel	3.81	1.422	Low perception
3	Non-uniformity in storage temperature instructions on medicines label is a challenge for cold chain Management	3.21	1.467	Low perception
4	A Store manager should consistently update stock records whenever products are added or removed	4.45	0.835	High perception
5	Staff training and awareness are significant in ensuring the successful management of cold chain products	4.68	0.687	High perception
6	Maintaining the integrity of temperature- sensitive products throughout the cold chain is critical for ensuring product efficacy	4.48	0.800	High perception
7	Regular temperature monitoring and recording are crucial for effective cold chain management	4.54	0.799	High perception
8	Participating in ordering of cold chain product is needed so as to have quantity needed	4.44	0.798	High perception
9	You are confident enough in the effectiveness of your current practice for managing and mitigating risks associated with temperature- sensitive products in the cold chain	4.24	0.996	Low perception
10	Maintaining the cold chain is the most important aspect of vaccine logistics	4.50	0.836	High perception

Grand mean score (weighted average) = 4.288±0.58246

4.9. Cold Chain Management Challenges

This study revealed the challenges in cold chain management across various levels in health care deliveries and at facilities through key informant interviews. Accordingly, Key informants were interviewed to explore the challenges they were facing regarding cold chain management and the results were thematically categorized in to the following themes.

4.9.1. Logistics and Transportation issues

Most of the of the key informants (KI) explained that there was lack of direct delivery of vaccines from EPSS to woredas caused delays and sometimes overstocking or under stocking of the vaccine at service delivery point due to the fact, "requested amount and released quantities were not match" not only this, it was challenging for woredas and health facilities to receive vaccine from zone because they did not have vehicles. Additionally, it increased the burden of workload and insufficient storage space at zonal level. There was also inadequate vaccine transportation infrastructure (e.g. no vehicles, shortage of cold boxes and vaccine carriers) were raised by almost all of the KIs. Vaccine logistic officer at central EPSS and Nekemte hub also raised shortage of temperature regulated vehicles.

One EPI focal at woreda health office stated the issue as follows:

They were facing challenges due to lack of on time delivery of vaccines since it was not direct delivery, it was difficult to transport vaccines from zone to woreda due to lack of resources. sometimes they sent VRF 2 to 3 times without receiving vaccines and often receive overstock or understock of what they requested, delay also leads to near expiry vaccines being distributed and there was also shortage of cold boxes and vaccine carriers.

Another EPI Focal from zonal health department stated as:

Only six woredas were direct delivery in the zone. EPSS delivered vaccines only to zone and it was burden to them, they were playing the role of woredas in addition to theirs. Additionally, they did not had logistics to deliver to woredas and health facilities and this made even insufficient storage space at zone.

4.9.2. Cod Chain Equipment shortage and Maintenance and shortage of storage capacity.

Widespread shortages of refrigerators, especially solar-powered and WHO pre-qualified models were seen in the study area. There was also frequent equipment down time due to lack of spare parts and poor maintenance systems. Most of the KIs complained that there was shortage of refrigerators, cold boxes, vaccine carriers and spare parts.

For example, one KI from woreda health office explained as:

There was lack of solar refrigerators, when there was electric power incontinence, the facility didn't use generator for this purpose due to lack of resources. Shortage of refrigerators; they were using same refrigerator to store vaccines and prepare icepack due to lack of deep freezer. they also had shortage of cold boxes and vaccine carriers. He added "*there was no both preventive and corrective maintenance of cold chain equipment.*

Another EPI focal from other woreda health office raised:

Problem of cold chain equipment down time and lack of maintenance and spare parts, even though they had biomedical engineer, sometimes they could not do maintenance for cold chain equipment because there was no provision of spare parts.

Lack of storage capacity is also one of the major hiccups of cold chain management in the study area. One of KI from facility said:

they were sharing storage space of health centers with Woreda health office for that of other rural health centers and in their health centers even there was no separate EPI room and they were sharing immunization unit with under-5 OPD and there was also sharing of same refrigerator with other departments like Laboratory and pharmacy.

4.9.3. Human Resource and Training gap

In the study area most of the EPI focal confirmed that, in most of the facilities and even at woreda health offices; there was no trained biomedical engineers and facilities were waiting for person coming from zone for maintenance. There was no training on maintenance of cold chain equipment for EPI staff and pharmacy personnel. There was also inadequate training on vaccine requisition forms (VRF), cold chain handling and reporting for EPI focal, pharmacy personnel and health extension workers.

Most of the KIs from health center said:

They had no recruited Biomedical engineers and there was no training on cold chain equipment maintenance for EPI focal and health extension workers.

EPSS Nekemte hub logistic officer stated as:

Before, it had been them who trained health facilities on VRF report, but now MOH take the mandate but not delivering continuous training.

4.9.4. Inadequate data Management and documentation

In the study area there was inconsistent VRF submission and poor data quality. In addition to this there was lack of VRF forms in rural areas and manual data estimation.
EPSS Nekemte hub vaccine logistic officer complained as: *Lack of VRF data quality from health facilities, in addition facilities were not adhering to the VRF reporting schedule.*

One KI from General hospital explained as: *VRF does not integrated in to IPLS like other program drugs and its report was not digitalized. he added, there was EPI focal negligence (i.e. they didn't consider reporting VRF as their routine activities.*

4.9.5. Governance and supervision weaknesses

Most of the KIs stated that: there was ambiguity of role between pharmacy, EPI staff and logistic teams. There was also weak supervision and inconsistent monitoring and evaluation (M&E).

EPSS Nekemte hub vaccine Logistic Officer stated as:

Pharmacists were responsible for receiving vaccines by model-19, but it was managed by EPI focal. He added there was weak Monitoring and Evaluation on cold chain starting from higher level to service delivery point including EPSS.

One store man from facility said: *Pharmacy store manager received vaccines by model-19 and it was managed and kept in Immunization unit by EPI staff while its responsibility was still on store manager.*

5. DISCUSSION

5.1. General Information of the health facilities

The study revealed that about 93.75% of the assessed health facilities had dedicated EPI focal, but there was no designated person in charge of primary responsibility for monitoring temperature of the refrigerator and About 14 (87.5%) had no any person assigned on maintenance of cold chain equipment as well as any written procedure for maintenance of CCE. This study was in line with studies conducted in various countries (Umit Kartoglu, James Vesper, Hanna Teräs, 2017) (Nyirimanzi *et al.*, 2023), (Kumar and Gupta, 2020).

All assessed health facilities were equipped with at least one refrigerator and temperature monitoring devices even though it was not in sufficient amount. WHO recommends, temperature of the refrigerator should be recorded twice daily every day. In Over a course of one month, only 10 (62.5%) facilities consistently recorded refrigerator temperatures in accordance with WHO recommendations (twice daily) and this was comparable with studies conducted in Dalocha district silt'e zone, Ethiopia (63.6%), East Gojam Zone, Amhara region Ethiopia (58.3%), Bale zone, southeast Ethiopia (57.1%). (Feyisa *et al.*, 2022), (Bogale, Amhare and Bogale, 2019), (Woldemichael, Bekele and Esmael, 2018). But it was Slightly greater than the study conducted in Oromia special zone, Amhara region, Ethiopia and eight health districts in Cameroon in which only 40.7% of the facilities were adhered to the standard protocol (Yakum *et al.*, 2015). This might be due to the fact that health professionals were aware of it due to frequent power interruption in this study area.

In this study 56.25% of the facilities were not applying FEFO principles while 43.75% were doing it. This was similar with that of the study conducted in northwest Ethiopia (Ergetie, Kassaw and Sendekie, 2023) Which show that only 42.9% of health facilities followed the FEFO principle, meaning 57.1% of the facilities didn't adhere to this principle. It was also comparable with another study conducted in Amhara region (Bogale, Amhare and Bogale, 2019) in which only 43.3% of the health facilities applied FEFO principle. This finding was too much different from the study conducted in kisii country Kenya (Nyandondi, 2021) indicating 92.56% of health facilities followed the FEFO principle for vaccine management. This might be due to the reason that most of the time they received same batch of vaccines and no need of putting in FEFO order except VVM color changed which is the possible reason to use color changed vaccines first.

5.2. Availability and stockout rate of cold chain products

In a pharmaceutical supply system, the goal of stock holding is to guarantee that availability of essential items almost nearly constantly (MSH, 2014). Overstocks and Stock outs in any health care facility are important indicators of weak logistics system. Stock outs may cause unavailability of life saving medicines, disrupt treatment plans and eventually loss of trust in the healthcare system. On the other hand, overstocking increases risk of products expiration or damage (Wales *et al.*, 2014).

Stock out of one or more health products could significantly affect the service provision of the public health facilities and stockout of cold chain medicines could result in increased morbidity and mortality and spread of communicable diseases. Vaccines should be available in all times at all health facilities. The mean availability of the selected cold chain products in facilities in the study area was 42.2%. This was less than the finding of the study conducted in southwest Ethiopia (Feyisa *et al.*, 2021) which is 72.1%. This difference might be due to sampling variations between the studies.

This study's finding was also lower than that of the studies done in Dares Salaam and Tanzania mainland which stated that on the day of assessment the average percent of tracer products available in district hospitals was about 80% and the mean availability of sampled cold chain products in public hospitals was about 67% (Kagashe and Massawe, 2012) and (Ministry of Health Tanzania, 2020). The difference might be due to composition of health facilities and tracer products included in the studies. (i.e. rabies vaccine which was not available in all health centers included in this study, contributed for the difference. And insulin which was also not available in most health centers.

Losing vital cold chain products such as vaccines in the public health facilities is hazard to clients particularly under- five children and pregnant women who are at high risk if they not vaccinated on time. The average stockout duration in this study was 38.88 days and it was not very different with the study conducted in south west Ethiopia (Feyisa *et al.*, 2021) which stated 29.3 days and longer than that of the study done in Tanzania mainland (13 days) (Ministry of Health Tanzania, 2020).

This study also found almost all of public health facilities visited had experienced stock out of a number of products in six months and this could be possible explanation for that, the

logistic system in the study area was underperforming. On the other hand, it might be due to difference in selection of the items in the study.

5.3. VLMIS Data quality

Availability and utilization of vaccine ledger book and standard vaccine requisition forms (VRF) are essential components of effective vaccine logistic management information system. In this study only 10 (62.5%) of health facilities had both Ledger book and Vaccine Requisition Form (VRF) while 8 (50%) of them had only ledger book. This result was less than that of the study result done in Tigray region, Ethiopia which showed 78% of the facilities had all the necessary tools, including vaccine registration book and standard VRFs (Gebretnsae *et al.*, 2022) . And it was less than the study result conducted in Arsi zone, Southeast Ethiopia which indicate 70.8% of facilities used standard vaccine reporting and requisition forms (Yetnayet Yeshitela, 2023). On the other hand, the result of this study was greater than that of the study done in Amhara region, Ethiopia found the availability of vaccine logistic management information system forms 44.1% (Mekonen *et al.*, 2023).

These studies highlight that while some regions exhibit better adherence to vaccine logistics documentation practices, others face challenges in maintaining adequate record. This indicate variations in availability and utilization of vaccine ledger book and VRFs across different regions of Ethiopia; many factors might contribute to these variations including differences in training, supervision, resource allocation and infrastructure in addition to composition of the facilities and cold chain products in the study and insecurities specific to local areas.

In the present study, data quality was measured by different dimensions; reporting rate, inventory accuracy rate, timeliness, completeness, accuracy and overall reporting performance. The inventory accuracy rate being utilized for vaccine stock record keeping and the others for VRF report. The study showed that about 60% of the facilities had less than 50% inventory accuracy rate. And the average inventory accuracy rate was 45.68% which was slightly less (58.3%) than that of the study done in Amhara region, Ethiopia (Mekonen *et al.*, 2023). This difference might be due to the geographical difference between the studies setting and operational problems in the study area and possibly due to the sampling difference in the products included in the studies.

This result was comparable with that of the study conducted in Jimma zone, southwest Ethiopia (Feyisa *et al.*, 2021) that found 42.6% and less than that (58.3%) of the study

conducted in Amhara region, Ethiopia (Mekonen *et al.*, 2023). This difference might be the result of unavailability of vaccine stock record keeping and on time delivery of the vaccine.

The current study collected 1-year data of VRF report from public health facilities and evaluated data quality from three parameters of timeliness, completeness and accuracy. Hence overall reporting performance of the 8 facilities were 68.2%, 75%, and 57.5% for timeliness, completeness and accuracy respectively. This result was in line with the study conducted in Amhara region, Ethiopia (Mekonen *et al.*, 2023) which found 65.7% and 88.4% for timeliness and completeness respectively. In contrast, it was less than the finding (73.4%) of the study in Amhara region, Ethiopia in terms of VRF report accuracy. This might be due to the difference in VRF forms.

The study done in Rwanda and Ghana showed better data quality compared to this study, after the transition from paper-based work to electronic tracking systems, improved data quality and the routine immunization data were found to be timely and complete with no significant difference between facility record and higher-level report (Vincent and Jean, 2024) (Ameyaw *et al.*, 2020). When we see the overall reporting rate and reporting performance it was 71.8% and 68.1% respectively in this study.

5.4. Knowledge of health Professionals on cold chain management

In present study, about 78 (57.8%) of health professionals had good knowledge of cold chain management. This was in line with the finding of the study conducted in Oromia special zone, Ethiopia in which 53.5% of the respondents had satisfactory knowledge on cold chain management (Mohammed, Workneh and Kahissay, 2021). it was also consistent with that of the studies conducted in Central Ethiopia, bale zone, and Gurage zone with 54.3%, 51.3% and 54.6% respectively (Rogie, Berhane and Bisrat, 2013) (Woldemichael, Bekele and Esmael, 2018) (Yassin *et al.*, 2019) and better than findings of the study done in Nigeria and India (Dairo and Osizimete, 2016) (Krishnappa *et al.*, 2014) where knowledge of health personnel on cold chain management was poor. The difference might be due to the difference in operational definitions, professional category of the study participants and possibly due to the difference in the study settings.

The current study revealed that 57.8% and 42.2% of the respondents had good and poor knowledge on cold chain management respectively, which was in contrast with the study conducted in Yemen in which 80% of the participants had good knowledge while 20 % had

poor knowledge (Sule, Alatishe and Salaudeen, 2022). Yemen been in complex situation even had commendable vaccine management compared to this study area. The difference might be secondary to the number of questions, nature of questions, study participants qualifications and sociocultural differences.

The study carried out in Nigeria (Adebimpe and Adeoye, 2021) showed that 83.9% of the study participants had good knowledge and stated that 70% of them undergone training on vaccines logistic management system and this was inconsistent with the finding of this study because only 40% of the respondents were trained. Training could increase professional's curiosity and attention to apply the principles they obtained from the training; this in-turn could improve the knowledge of health professionals on cold chain management.

5.5. Cold chain management practice of health professionals

The finding of this study indicated 37% of the respondents had good cold chain management practice which was slightly less (56.7%) than that of the study conducted in Oromia special zone, Ethiopia (Mohammed, Workneh and Kahissay, 2021) . This might be due to the difference in number of questions and participants. The result of this study was also less than that of the study conducted in Nigeria with 73% of the respondents had good practice (Dairo and Osizimete, 2016). the study stated they undergone formal training in vaccine cold chain management. In this case the lack of training for most respondents might be contributed.

Another study conducted in Nigeria showed that 77.2% of the study participants had good practice of cold chain management which is larger than the result of this study (Adebimpe and Adeoye, 2021). This might be due to the difference in nature of the questions and its quantities, more technical questions in this study.

Another study conducted in Sheger city, Oromia, Ethiopia revealed that only 52.2% of health professionals demonstrated good cold chain practice of cold chain management (Geneti *et al.*, 2024). This discrepancy might be the contribution of lack of on-site training and continuous supervision in the study area and difference in location also might be contributed, the location of this study was in remote area while sheger city found in centre of the country might have access to capacity building initiatives primarily than this study area. The finding of this study was comparable with pooled result (27.48%) of systematic review and meta-analysis study conducted in Ethiopia (Kasahun *et al.*, 2023).

5.6. Attitude of health professionals toward cold chain Management

The attitude of health care workers toward a health program determines the success or failure of the health program. Cold chain management is not different from this, as its success would also depend on the attitude of health professionals toward it. Majority of the respondents in this study had positive attitude for most of the ideas raised on cold chain management.

Most of the respondents had strongly agreed to the idea of cold chain management with positive attitude like maintaining accurate documentation (63%), importance of staff training (75.6%), and regular temperature monitoring (67.4%) among others.

This study's finding was similar with most of the studies conducted in various parts of the world. The study conducted in Wolaita zone; southern Ethiopia showed that; approximately 65.4% of health professionals demonstrated positive attitude toward vaccine cold chain management (Erassa *et al.*, 2023).

Finding from another study done in national health security office zone 4, Saraburi Thailand exhibited a high attitude score toward vaccine cold chain management with a mean score of 77. 65 out of 90 (Pumtong, 2013). This could be the possible explanation that if health professionals have good attitude, then they may have good motivation, and sense of responsibility and accountability in their daily activities in cold chain management. Such positive attitudes among personnel can facilitate adherence to protocols, encourage ongoing training, and eventually contribute to improved quality and safety of products.

The finding of the study conducted among primary health care workers in Nigeria also support the finding of this study in which 81.1% of the respondents found to had good attitude toward vaccine logistic management system (Adebimpe and Adeoye, 2021).

5.7. Cold Chain Management Challenges

The study identified cold chain management challenges through key informant interviews. In this study; cold chain management was bottlenecked by many factors. In addition to the security problems, a lot of challenges were raised by key informants: logistic and transportation issues, shortage of Cold chain equipment and lack of maintenance and lack of storage capacity, lack of training and supervision, shortage of skilled and trained man power and governance issue raised among others. The finding of this study explored similar cold chain management performance bottlenecks with the study done in Kenya (Nyandondi, 2021) and supported by a phenomenological study conducted in Ethiopia (Gebremedhin *et al.*, 2024) .

6. CONCLUSION

The major finding of the study show that practice and training were the good indicators of cold chain management performance. Furthermore, for each additional unit increase in the practice of health professionals, the odds of achieving a higher-level cold chain management performance increases by approximately 13 times. In the same manner when health professionals become trained on cold chain management, the odds of attaining better cold chain management performance improve by a factor of approximately 5.56 **(**more than five-folds).

The observed low cold chain management performance was due to the poor cold chain management practices of health professionals. Moreover, it was due to lack of training for majority of health professionals.

More than half of the respondents had good knowledge while majority of them had poor cold chain management practice. Regarding to the data quality, there was lack of Vaccine Logistics Management Information Systems (VLMIS) recording and reporting forms and their inadequate utilization. consequently, overall inventory accuracy rate and reporting performance of health facilities were low, this underscore the need for training, supportive supervision and continuous monitoring and evaluation (M&E) for those health facilities and health professionals.

Majority of the respondents demonstrated a positive attitude toward cold chain management. suggesting a general awareness and recognition of its importance and it was also a strong foundation for the successful implementation and sustainability of cold chain management performance.

Finally, challenges like shortage of cold chain equipment and their maintenance, lack of storage capacity and training were shared among all health facilities and health professionals.

7. RECOMMENDATIONS

❖ **For FMOH**

Since cold chain management performance significantly associated with practice of health professionals and training

- ✓ Empowering professionals engaged in Cold chain management through training, supervision and continuous monitoring and evaluation is necessary to enhance CCM practice of health professionals.
- ✓ And also investing on infrastructure to upgrade health facilities and fulfilling criteria for cold chain management is mandatory.
- ✓ Improving provision of CCE along with spare parts and its maintenance.

❖ **For EPSS**

So far, the Ethiopian Vaccine Supply Chain Logistics System (VSCLS) has not sustainably embraced digital logistics solutions at all service delivery levels across the country, especially in remote and conflict affected areas.

- ✓ Since all health facilities in the study area were utilizing Manual VLMIS additional attempt is needed to scale up, and sustain digital technologies and increase end-to-end visibility of current VLMIS to improve it.
- ✓ Expanding direct delivery to all woredas and health facilities as much as possible to ensure product availabilities and reduce stockout rate.

❖ **For Regional Health Bureaus/Zonal health department**

- ✓ Increasing cold chain storage capacities at service delivery point.
- ✓ Clearly defining the responsibilities of professionals doing documentation and report and then providing them in service training.
- ✓ Needs to strengthen supportive supervision and monitoring and evaluation (M&E) on cold chain management.

❖ **For public health facilities in the study area.**

- ✓ Most of the respondents demonstrated a positive attitude toward cold chain management, continued support and reinforcement of these attitudes through targeted training and resource provision are recommended to further enhance cold chain management performance.

8. LIMITATIONS

The scope of this study was limited to inbound logistic after EPSS up to the service delivery point, but cold chain management can also be affected beyond this level. It was also limited to selected public health facilities due to budget and time constraints. The findings of this study may not be generalizable to other zones and regions due to differences in health infrastructure and local challenges specific to the study area.

It should also be noted that sample units' composition was not homogeneous since it comprised of primary and secondary healthcare facilities, each of which had varying operational and manpower capacities, as a result introducing some outliers in the data analysis for some parameters. There will be a need to conduct comprehensive study at larger scale on all woredas and other regions of the country.

Finally, further study should be done on Cost-effectiveness of the mentioned recommendations and its economic evaluation should be considered.

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ANNEXES

Data Collection tool

Quantitative data collection tool

Annex One: Observation and Data Abstraction Checklist

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Section I: General Information of the health facility (Check documents, observe and ask the appropriate person)

Instruction: Please circle the answer or write on the space provided

SN	Question items	Answers
1	Code of the Health Facility	
2	Name of the Health Facility	
3	Level of the Health Facility	1. HC 2. Primary Hospital 3. General Hospital
4	Location of Health Facility (for HC) [Urban is a town having >2000 persons]	1. Urban 2. Rural
5	Distance of health facility (in KM)	1.From Woreda town 2.From Zonal town 3. From Supplier EPSS hub
6	Does the facility have dedicated vaccine store?	1.Yes 2. No
7	If not, where is the vaccine stored? (Multiple response is possible)	1.In Medicines store 2.In MCH department 3.In Immunization unit 4.Others, specify
8	Does the facility have dedicated EPI focal?	1.Yes 2. No
9	Is there any designated person in charge of primary responsibility for monitoring temperature of the refrigerator in vaccine store?	1.Yes 2. No
10	If yes for the above, what is the profession of the person assigned?	1.Pharmacy professional 2. Nurse 3. Health Officer 4. Others(specify)
11	Is there any person assigned on maintenance of cold chain equipment in case of breakdowns in refrigeration equipment because of malfunction or inadequate maintenance and power cut?	1.Yes 2.No
12	Is there electric power supply system for the facility?	1.Yes 2. No
13	If yes for the above, what is the source of electric power?	1.Electric power from

		national grid 2.Solar power 3.Generator
14	Is there electric power interruption at the day of visit?	1.Yes 2. No
15	Do standard cold boxes and vaccine carrier are available?	1.Yes 2. No
16	Does the facility have functional refrigerators?	1.Yes 2. No
17	How many functional refrigerators are there?	_____
18	How many days the temperature is recorded twice in a day on the temperature monitoring sheet? (Check at least a one-month record)	_____
19	Number of refrigerators on recommended temperature range at the time of visit?	_____
20	Does the facility have operational deep freezer?	1.Yes 2. No
21	Is there an approved cool box or alternative refrigerator available to store vaccines during servicing, defrosting and cleaning?	1.Yes 2. No
22	Does the facility have internet connectivity?	1.Yes 2. No
23	If yes for the above, where is the source of Internet?	1.Wi-Fi 2.Broad band 3.Data
24	Type of LMIS tool using for vaccine management?	1.Manual 2.Digital HCMIS (DAGU, m-brana 3.Others, specify
25	Is there any fund received for cold chain maintenance and equipment repairs?	1.Yes 2. No
26	If yes for the above, what is the regularity of its release?	1.Weekly 2.Monthly 3.Quarterly 4.Annually
27	How much is the amount per year?	_____
28	Did you get supportive supervision for cold chain Management in the last one year?	1.Yes 2. No
29	If yes for the above, who provided the most recent supportive supervision?	1.WoHo 2.ZHD 3.RHB 4.FMOH 5.(NGOs), specify____ 6.Integrated, specify___
30	What were the improvements based on the supportive supervision?	_____
31	Is there Mixing of vaccines with other items like food and water in refrigerator?	1.Yes 2. No
32	Is there frozen Vaccines found in refrigerator	1.Yes 2. No
33	Is there evidence of shake test for frozen vaccines?	1.Yes 2. No
34	Is there a written emergency retrieval and storage procedures put in place in case of equipment failures or power outage?	1.Yes 2. No
35	Is there a program for distribution of vaccine from issuing store to each receiving store?	1.Yes 2. No
36	Is there a plan for preventive maintenance of cold chain equipment?	1.Yes 2. No
37	Is there evidence of an emergency repair of cold chain equipment?	1.Yes 2. No
38	Is there labelling of close to expiry vaccines?	1.Yes 2. No

39	Is there SOPs for Temperature monitoring?	1.Yes 2. No
40	Is there SOPs for storage?	1.Yes 2. No
41	Is there SOPs for repair and maintenance?	1.Yes 2. No
42	Is there SOPs for stock management/Control?	1.Yes 2. No

Section II: Product availability Indicator Form (Key Vaccines used in routine immunization and other cold chain products)

S. N	Product	Available	Not Available
1.	BCG	**1)** Yes	**2)** No
2.	PCV-13	**1)** Yes	**2)** No
3.	Penta	**1)** Yes	**2)** No
4.	Measles	**1)** Yes	**2)** No
5.	OPV	**1)** Yes	**2)** No
6.	Rabies Vaccine	**1)** Yes	**2)** No
7.	Insulin	**1)** Yes	**2)** No
8.	Oxytocin	**1)** Yes	**2)** No

Section III: Average Stockout duration Indicator Form (records cover 6 month)

S. N	Key cold chain products	Number of days out of stock (A)	Number of days covered by the review (6months) (B)	Equivalent number of days per year [C] = A x 365/B
1.	BCG vaccine			
2.	PCV -13			
3.	Penta Vaccine			
4.	Measles Vaccine			
5.	OPV			
6.	Rabies vaccine			
7.	Insulin			
8.	Oxytocin			

Annex II: Cold Chain management performance evaluation checklist

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S. N	Indicators	Yes	No
1.	Is there WHO-prequalified refrigerator (non-domestic)?		
2.	Do refrigerators are equipped with functional thermometer (fridge tag)?		
3.	Is refrigerator temperature maintained at (2–8ºC)?		
4.	Is there a separate temperature recording sheet for each refrigerator?		
5.	Is there good arrangement in refrigerator (FEFO order) principle?		
6.	Is there electric power supply system for the facility?		
7.	Does the facility have backup generator?		
8.	Is there timely updating of vaccine stock record book?		
9.	Are there sufficient cold boxes and vaccine carriers?		
10.	Is there a vaccine wastage recording system?		
11.	Is there regular physical inventory of vaccine stock?		
12.	Is there monitoring/review of vaccine stocks prior to ordering?		
13.	Is there adequate cold chain storage capacity?		
14.	Is there sufficient icepack storage capacity?		
15.	Do adequate supplies of spare parts and consumables are available for CCE maintenance?		

Annex III: Knowledge, Attitude and Practice questions

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Information Sheet and Informed Consent

Dear respondents; This is an MSc research titled *"**Assessment of knowledge, attitude and practice of health professionals on Cold Chain Management Performance in Selected public health facilities of West Wallaga zone, Oromia, Ethiopia**"*. The purpose of this questionnaire is to gather data for the proposed study, and hence you are kindly requested to assist the successful completion of the study by providing the necessary information. Your participation is entirely voluntary and the questionnaire is completely anonymous and confidential, and data will be analyzed in aggregates. Thus, it will not affect you in any way rather it will help in improving the cold Chain performance of public health facilities. So, your genuine, frank and prompt response are vital for the success of the study. You are free to decline your participation, or if you so choose, you may withdraw from it at any moment without prior notification of the data collectors and there will not be any undue influence on you in the future.

If you have any question, please do not hesitate to ask the data collectors or research coordinators at any time. If you need any further clarification, you can contact the following persons;

1) Alemu Tamiru (Principal Investigator); +251925769431
2) Zelalem Tilahun (Supervisor); +251923109539

Are you clear with all the information stated in the informed consent section? (If no, discuss with the study coordinator/ data collectors)

If yes, are you volunteer to participate in this study?

1) If yes, please proceed to the next section
2) If No, please kindly return the questionnaire for data collectors

I want to thank you in advance for your kind cooperation and dedication of your precious time to fill this questionnaire!

Section I: Socio – Demographic Characteristics of Respondents

1.	Gender	**1)** Male **2)** Female
2.	Age (in Years)	_____
3.	Profession	**1)** Pharmacy **2)** Health Officer **3)** Nursing **4)** Midwifery **5)** Physician **6)** Others, Specify_____
4.	Educational Level	**1)** Certificate **2)** Diploma **3)** BSc **4)** MSc/Specialty
5.	Current Position	**1)** CEO/Medical Director **2)** Pharmacy Head **3)** EPI Focal **4)** Store Manager **5)** Dispenser
6.	Years of Service in Current Position	_____
7.	Total number of years of service in your profession?	_____
8.	Have you ever participated in any cold chain management related trainings in the past two years?	**1)** Yes **2)** No

Section II: Knowledge related questions

Note: Some questions may have more than one answer, so circle all your choices in case

1. What is the recommended temperature range for most vaccine stored in refrigerators?

A. +2 ^{0}C to +8 ^{0}C

B. +8 ^{0}C to +15 ^{0}C

C. -8 ^{0}C to -2 ^{0}C

D. -8 ^{0}C to -15 ^{0}C

2. What is recommended temperature range for most vaccine stored in freezers?

A. -4^{0}c to +6^{0}c

B. -140^{c} to -4^{0}c

C. -25^{0}c to -15^{0}c

D. Don't know

3. Which of these vaccines is the most heat sensitive?

A. OPV

B. DPT

C. BCG

D. TT

4. Which of these vaccines is most sensitive to freezing?

A. DPT

B. BCG

C. OPV

D. Measles

5. How many times should the temperature of the refrigerator monitored and recorded?

A. Once daily

B. Twice daily

C. Once weekly

D. Twice weekly

6. What is the first step in vaccine management?

A. Forecasting

B. Distribution

C. Storage

D. Receiving

7. Open vial policy does not applicable to one of the following vaccines

A. BCG

B. DPT

C. OPV

D. TT

8. On which of these vaccines can the shake test be carried out?

A. BCG

B. OPV

C. Measles

D. DPT

9. What do you think causes vaccines to lose their potency? circle all applicable?

A. Exposure to heat
B. Exposure to light
C. Exposure to cold
D. All of the above

10. What is the first discard point in VVM stage?

A. VVM 1
B. VVM 2
C. VVM 3
D. VVM 4

Section III: Attitude related questions

Please mark (✓) sign for your choices based on your level of agreement or your choice using the following rating scales.

[1: Strongly Disagree, 2: Disagree, 3: Neutral, 4: Agree, 5: Strongly Agree]

S. N	Attitude questions	1	2	3	4	5
1	Maintaining accurate documentation and records of temperature conditions during the handling of cold chain products is crucial for compliance and accountability					
2	Vaccine should be stored and managed in a separate store by pharmacy personnel					
3	Non-uniformity in storage temperature instructions on medicines label is a challenge for cold chain Management					
4	A Store Manager should consistently update store records whenever products are added or removed					
5	Staff training and awareness are significant in ensuring the successful management of cold chain products					
6	Maintaining the integrity of temperature- sensitive products throughout the cold chain is critical for ensuring product efficacy					
7	Regular temperature monitoring and recording are crucial for effective cold chain management					
8	Participating on ordering of cold chain product is needed so as to have quantity needed					
9	You are confident enough in the effectiveness of your current practice for managing and mitigating risks associated with temperature- sensitive products in the cold chain					
10	Maintaining the cold chain is the most important aspect of vaccine logistics					

Section IV: Practice- related questions

1. How frequently do you check the temperature of vaccine storage units during a campaign?
    A. Once a day.
    B. Once every week.
    C. Every hour
    D. Only when a temperature problem is suspected.

2. When using a thermometer to monitor vaccine storage temperatures, what measure or action do you take if the thermometer shows a temperature outside the recommended range?
    A. Do nothing until the next scheduled check and note the temperature change.
    B. Immediately adjust the refrigerator temperature and assess whether vaccines have been compromised.
    C. Discard the affected vaccines without checking them.
    D. Only adjust the temperature if the thermometer is malfunctioning.
3. How do you determine your vaccines stock position at your facility?
    A. By determining only safety stock
    B. By determining only maximum stock level
    C. By determining only minimum stock level
    D. By determining sum of stock on hand (working & safety stock) and stock on order, minus any stock-back ordered to clients.
4. What do you do in case of power failure? (circle all applicable)
    A. Store vaccine in cold box prepared for emergency case
    B. Leave vaccines in refrigerator/freezer until power maintained
    C. Report for immediate vaccine coordinators/supervisors
    D. Use kerosene
5. Where do you put DPT, DT, TT, hepatitis B vaccines and Haemophilus influenza type B (Pentavalent vaccine); in a vertical (upright refrigerator)?
    A. In the bottom, where it is coldest
    B. Nearer to the top
    C. In middle
    D. On top part where it is hot
6. If not kept in a separate freezer; where do you put BCG, polio and measles vaccines; in a vertical (upright refrigerator)? (Circle all applicable)
    A. In the bottom, where it is coldest
    B. Nearer to the top
    C. In middle
    D. On top part where it is hot
7. When do you consider the vaccines stock is at minimum stock level at your facility?
    A. When stock is at re-order level
    B. When the stock is sufficient to satisfy demand until the next order

C. When there is safety stock

D. When there is stock out

8. How did you identify when the vaccine has been frozen?

   A. By performing vaccine shake test

   B. By using vaccine vial monitor

   C. A and B

9. Please describe the process you follow for transporting cold chain products to ensure integrity is maintained?

   A. Using temperature-controlled vehicles

   B. Transporting products in regular vehicles

   C. Not having a specific process for transportation

   D. Using public transportation for transport

10. When did you update vaccine ledger book/bin card?

   A. When receive vaccine from store

   B. When dispatch to lower level

   C. At my free time

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VLMIS Data Quality

1. Inventory Accuracy Rate

Instruction: *The data will be filled in the vaccine room/cold room. Check the last transaction for the respective items from Model 19 and Model 22 to fill the updating status. Then, check the last* ***ledger balance*** *with the physical count and electronic balance)*

Inventory Discrepancy Rate/Item = $\frac{\text{Balance on ledger record-Stock on hand X 100\%}}{\text{stock on hand}}$

Inventory Accuracy Rate/Facility = $\frac{\text{Number of items with stock record count equals physical count X 100}}{\text{Total number of items counted}}$

NB: ***Check the Ledger book/BC update status one day in advance before the day of visit. Then, the physical count=Count in the stock+ Quantity in the tally sheet at the day of visit.***

SN	List of Vaccines	Is ledger book available? (Yes=1; No=0)	Is the ledger book Updated? (Yes=1; No=0)	Ledger book Balance (Manual)	Electronic Record Balance (HCMIS)	Physical Count
1.	BCG					
2.	Measles					
3.	Penta					
4.	OPV					
5.	PCV- 13					
6.	Insulin					
7.	Oxytocin					

2. Timeliness of VRF reports

Instruction; *First ask the VRF report schedule agreement from the cold chain officer. Then, take, twelve recent VRF for vaccines sent by Health center/Hospital to WHO/ZHD/EPSS. VRF sent date is the reporting date written on VRF. Write the date in Ethiopian Calendar.*					
SN	**Reporting Period**	**Is the date of report clearly indicated? (Yes=1; No=0)**	**If Yes, write the Approval/ Verified date?**	**Did the facility send the report as per the WHO/ZHD/EPSS Schedule? (Yes=1; No=0)**	**Did the facility send the report after the report schedule of WHO/ZHD/EPSS? (Yes=1; No=0)**
1.	Reporting Period 1				
2.	Reporting Period 2				
3.	Reporting Period 3				
4.	Reporting Period 4				
5.	Reporting Period 5				
6.	Reporting Period 6				
7.	Reporting Period 7				
8.	Reporting Period 8				
9.	Reporting Period 9				
10.	Reporting Period 10				
11.	Reporting Period 11				
12.	Reporting Period 12				

3. Completeness of VRF reports

Instruction; *First ask the VRF report schedule agreement from the cold chain officer. Then, take one recent VRF report sent by Health center/Hospital to WHO/ZHD/EPSS. Check whether the cells are properly filled or not (If Yes=1; N0=0)*								
SN	**List of vaccines**	**Balance at the beginning of last supply period**	**Qty received during the last supply period**	**Used or dispatched to lower level**	**Current Balance**	**Requirement for the next supply period**	**Requested amount**	**Quantity released**
1.	BCG							
2.	Measles							
3.	Penta							
4.	OPV							
5.	PCV -13							

6.	IPV							
7.	Rota							
8.	TT							

4. Accuracy of VRF reports

Instruction; *First ask the VRF report schedule agreement from the cold chain officer. Then, take* ***one recent*** *VRF report sent by Health center/Hospital to WHO/ZHD/EPSS. Check whether the calculation is right or not (refer the beginning balance, ending balance, consumption data from Bin card, STV, Model 19 and Model 22) (If Yes=1; N0=0)*								
SN	**List of vaccines**	**Balance at the beginning of last supply period**	**Qty received during the last supply period**	**Used or dispatched to lower level**	**Current Balance**	**Requirement for the next supply period**	**Requested amount**	**Quantity released**
1.	BCG							
2.	Measles							
3.	Penta							
4.	OPV							
5.	PCV 13							
6.	IPV							
7.	Rota							
8.	TT							

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Annex 3: Interview guide for in-depth interview of cold chain management key informants

Participants

Facility logistic officers

Woreda health office Logistic officers

Zonal health department logistic officers

EPSS Nekemte logistic officer

EPSS Central logistic officer

Informed consent

Dear respondents; This is an MSc research titled *"**Assessment of knowledge, attitude and practice of health professionals on Cold Chain Management Performance in Selected public health facilities of West Wallaga zone, Oromia, Ethiopia**"*. The purpose of this interview is to gather data for the proposed study, and hence you are kindly requested to assist the successful completion of the study by providing the necessary information. Your participation is entirely voluntary, During the interview (discussion) period, if you feel inconvenient, you can interrupt and clarify inconvenience, appoint to other time or even withdraw at any time. The interview will be conducted individually and will take 10-15 minutes. If you agree to participate, I can continue my questions.

Sex: _____

Age: _____

Educational status: _____

Work experiences on cold chain: _____

Total professional experiences: _____

1. How is the medicines supply chain system in your facility?
2. How is the cold chain management system in your facility?
3. What are the major challenges for Cold chain you are facing in terms of cold chain equipment, transportation, maintenance?
    - At your facility/organization
    - From other above and lower levels (Facility, WoHo, ZHD, EPSS Hub and Central EPSS)
4. What do you suggest to improve cold chain management performance?
5. Additional points you want to add?