Research Article

iMedPub Journals
www.imedpub.com

Hospital & Medical Management
ISSN 2471-9781

2025
Vol.11 No.2:397

Effect of Cold Chain Management Practices on Health Centers Operational Performance: A Facility Based Cross-Sectional Study

Million Girma[1*], Yesuneh Tefera Mekasha[2], Mihret Fikreyesus Yami[3], Addisu Afrassa Tegegne[2], Abenezer Asfaw[1], Girma Beyene[4] and Rashed Edris Usure[5]

[1]Department of Pharmacy, College of Medicine and Health Sciences, Wolaita Sodo University, Walaita Sodo, Ethiopia

[2]Department of Pharmaceutical Sciences, Pharmaceutical Quality Assurance and Regulatory Affairs, University of Gondar, Gondar, Ethiopia

[3]Department of Nursing, Dilla University, Dilla, Ethiopia

[4]Department of Pharmacy, Dilla University, Dilla, Ethiopia

[5]Department of Pharmaceutical Chemistry, Hawassa University, Hawassa, Ethiopia

[*]**Corresponding author:** Million Girma, Department of Pharmacy, College of Medicine and Health Sciences, Wolaita Sodo University, Walaita Sodo, Ethiopia; E-mail: milliongirma1985@gmail.com

Received date: September 04, 2024, Manuscript No. IPJHMM-24-19593; **Editor assigned date:** September 06, 2024, PreQC No. IPJHMM-24-19593 (PQ); **Reviewed date:** September 20, 2024, QC No. IPJHMM-24-19593; **Revised date:** April 10, 2025, Manuscript No. IPJHMM-24-19593 (R); **Published date**: April 17, 2025, DOI: 10.36648/2471-9781.11.2.397

Citation: Girma M, Mekasha YT, Yami MF, Tegegne AA, Asfaw A, et al. (2025) Effect of Cold Chain Management Practices on Health Centers Operational Performance: A Facility Based Cross-Sectional Study. J Hosp Med Manage Vol:11 No:2

Abstract

Background: Access to essential cold chain pharmaceutical products is crucial for improving healthcare. Pharmaceutical organizations recommend a global standard for handling, storing, and distributing these items. However, resource-limited countries like Ethiopia face challenges in implementing cold chain management practices for temperature-sensitive products.

Objective: The study aimed to assess the cold chain management practice, and operational performance in the government health centers in the Administration of Addis Ababa, Ethiopia.

Methods: A cross-sectional facility-based study was conducted on health centers in Addis Ababa from September 5–30, 2023 G.C. logistic indicator assessment tools were used in 20 health centers. Key informants such as the warehouse manager, pharmacy head, and expanded program immunization focal person were purposefully sampled. Three focal persons were selected from each health center. Generally, sixty (n=60) study participants were included. Previously published literature and guidelines were used to review cold chain management practice and operational performance. Statistical analyses including the *Chi-square* test, and multivariate regression were conducted, with significance set at $p<0.05$.

Results: The study revealed that the majority of 34 individuals (56.7%) possessed work experience exceeding 3 years. As for practice-related aspects, the study showed that storage and facility (4.19 ± 0.271), distribution system (4.01 ± 0.247), technical capacity (4.43 ± 0.116), and information system (4.25 ± 0.138) were deemed sufficient for maintaining cold chain products in health centers. Furthermore, the *Chi-square* test demonstrated a strong correlation (P=0.0001) between the educational background, work experience, and years of service of employees and their cold chain management practices. The evaluation of cold chain management performance in public health facilities revealed an 85% rate of inaccurate inventory records, 55% undesirable storage practices, 85%inadequate stock records, and a notable level of product wastage (80%) in these health centers. Notably, the experience of respondents in cold chain management, product storage systems and facilities, distribution systems, and technical capacity of health facilities were identified as significant associated factors ($p<0.05$ at 95% CI) with the operational performance of cold chain management.

Conclusion: Overall, the findings underscored the importance of addressing operational performance inefficiencies in the handling of cold chain products at health facilities. By implementing better training, standard operating procedures, logistics and inventory management techniques, and infrastructure, health facilities can ensure the quality and efficacy of their cold chain products, ultimately improving patient outcomes and public health.

Keywords: Cold chain product; Practice; Operational performance; Cross sectional; Health-centre; Addis Ababa; Ethiopia

Introduction

Access to essential health services is crucial for improving the health of citizens. Effective cold chain management is critical to the success of critical health programmers such as the extended vaccination programmer, reproductive, maternity, neonatal, child, and adolescent health services, diabetic care, and human immune virus/acquired immune deficiency syndrome care services. Organizations working within the pharmaceutical supply chain must adhere to a range of international regulatory standards when managing, storing, and distributing

environmentally sensitive products. Their primary focus is on implementing cold chain management practices for temperature-sensitive pharmaceuticals in order to safeguard the quality and effectiveness of the products.

In low-resource settings, particularly in Africa, the effectiveness of cold chain management for temperature-sensitive products faced challenges during execution. For example, research carried out in Nigeria demonstrated that insufficient understanding of cold chain management among healthcare workers could result in mishandling of vaccines, potentially leading to a decrease in vaccine efficacy or failure to detect compromised potency. Similarly, a study in Ethiopia indicated that vaccine handlers had inadequate knowledge regarding cold chain maintenance and vaccine management. The study suggested that, on-site training should be provided to vaccine handlers to increase their knowledge, so as to improve their practices on cold chain and vaccine management. Therefore, detailed cold chain management practice should be cultured for temperature sensitive pharmaceuticals. Temperature-sensitive medications are volatile goods that must be stored and distributed in a regulated environment. Ergometrine, oxytocin, and insulin, as well as vaccinations, cold chain supplies, and diagnostic reagents, are among them. When exposed to temperatures outside of the permitted range, the potency of these items may be reduced or even lost. They need to be maintained between 2°C and 8°C temperature throughout the supply chain. Errors in cold chain management can cause patient harm, including unknown disease vulnerability that necessitates costly revaccination. Errors in vaccination administration can potentially result in unintentional and unrecognized vulnerability, leaving individuals vulnerable to serious disease.

Despite the evidence that cold chain management practices affect the potency and effectiveness of both vaccines and non-vaccine commodities, most of the research in Africa focuses on vaccines. A study from Uganda revealed that few facilities were correctly filling stock cards (29%) and conducting physical inventories (27.5%) for non-vaccine products. Also, almost half (48.1%) of the participants lacked knowledge on refrigerator use. Therefore, by far training, and education should require for healthcare professions for advancing their knowledge towards cold chain management in a given health institution. Most study highlighted the problem in the cold chain management of vaccine, no study revealed about non-vaccines products like oxytocin which is very sensitive to temperature. Study conducted by Asamoah A in 2020 in Ghana with respect to cold chain management practices, (66.7%) also observed that the district was involved in incorrect cold chain practices such as storage of non-vaccines in vaccine refrigerators, inadequate monitoring of vaccine temperature (50%), inadequate temperature ranges for vaccine storage (41.7%), few facilities arranging vaccines correctly (16.7%), inadequate emergency power supply (8.3%) and non-availability of contingency plan (100%). As per literature indicated that, no evidential study on effect of cold chain management practice on operational performance in the health centers.

Effective management of the cold chain is essential for preserving the potency of temperature-sensitive pharmaceuticals such as vaccines. Inadequate cold chain management could have a substantial negative impact on the efficacy of these vaccines, even with advancements in vaccination coverage. As per the WHO report while the rise in coverage from 39% in 2016 to 43% in 2019 is a positive development, it underscores the necessity for enhanced cold chain systems to guarantee the continued effectiveness of vaccines and their delivery to the targeted population. It is crucial to ensure the correct temperature is maintained during storage and transportation in order to preserve the potency of vaccines. Overcoming the obstacles in in resource limited settings cold chain system may require enhancements in storage facilities, personnel training, and infrastructure.

In tropical countries such as Ethiopia where power supply is unreliable and facilities for its maintenance are not well developed maintaining the cold chain is very challenging. In these areas, it is not uncommon to observe, at any given time, most of refrigerators and freezers being out of order. Overall, this study endeavors to contribute to the literature by identifying the supply chain antecedents and performance consequences of cold chain management practices in the centre's operational performance. Although the existing literature recognizes various strategies and frameworks for identifying, analyzing and mitigating risks in cold chain supply system, there is a relative lack of research on effect of cold chain management practice on the health centers operational performance. There is a study gap literature regarding the effect of cold chain management for temperature sensitive products. Study focuses only single biological products specially on vaccines. Poor nations where immunization coverage and quality are both subpar, the level of good vaccine cold chain maintenance system and temperature monitoring is still a big concern. The percentage of people in Ethiopia who have received all required vaccinations has steadily increased. The national health and demographic health surveys show that 43% of people in 2019 had received all recommended immunizations, up from 39% in 2016.

Weaknesses in the cold chain are frequently seen during vaccine storage and distribution. Delays in transportation, the caliber of refrigerators, how they are stored, how long they are kept at the health facility, how they are used improperly, equipment breakdowns, power outages, and a lack of qualified staff who can manage the cold chain are some of the factors that weaken the cold chain. Study conducted in Gojam zone of Amhara region of public facilities, revealed that among 60 health institutions, 25 (41.7%) had inappropriate practice. The national cold chain equipment inventory conducted in 2013 revealed that 38% of the refrigerators and freezers at the level of health facilities and 36% of those at the administrative level (Woreda to region) were not in working order. In recent years, global regulatory agencies have increased oversight to ensure the integrity of pharmaceutical products in the distribution chain. The latest guidelines provide a thorough overview of cold chain management throughout the supply chain, encompassing manufacturers, warehouses, distributors, transporters, and retailers. Recent trends in regulatory inspection findings indicate

a growing emphasis on the variables impacting these sensitive products and guaranteeing their quality and reliability. Given the numerous uncontrolled factors in the distribution process, establishing a suitable monitoring scheme is crucial. Study conducted in Ethiopia showed that, about 15 (42.9%) of primary health care units had no national cold chain monitoring guideline. No study yet addressed the status of cold chain management practice on health centers operational performance beyond vaccine. This situation sparked my interest in the study area of available health centers. By considering the above issues into account, the current study aims to assess the effect of cold chain management practice in the health centers operational performance under Addis Ababa city administration heath bureau.

Research questions

The study aimed to investigate the effect of cold chain management practices on the operational performance of health centers by developing four research questions derived from existing literature and supply chain guidelines. These questions are: How do cold chain management practices affect the technical capabilities of health centers? What is the effect of the information system of health centers on cold chain management? How do the storage systems and facilities of health centers affect cold chain management? and What is the effect of the distribution system on cold chain management within the health centers under the Addis Ababa city administration health bureau?

Materials and Methods

Study setting and period

The study was carried out at healthcare facilities in Addis Ababa between September 5th and September 30th, 2023 G.C. As per the population projection of 2021, the city is home to approximately 3,774,000 individuals, with 1,782,000 being male and 1,992,000 being female residents. Based on the report from the Addis Ababa health office, the city consists of an additional sub-city, making it a total of eleven sub-cities. Within these sub-cities, there are a hundred and twenty-four woredas, along with various healthcare facilities. These facilities include seven government hospitals at the regional level (n=7), seven federal hospitals (n=7), twenty-nine private hospitals (n=29), one thousand three hundred and nineteen drug vendors and drug stores (n=1319), four hundred and thirty-three specialty clinics (n=433), three primary hospitals (n=3), sixty-eight specialty centers (n=68), and one thousand pharmacies (n=1000). All of these establishments collectively cater to a population of 3,774,000 residents [1].

Study design

A facility-based cross-sectional study was conducted at health centers within the Addis Ababa Administrative Health Bureau. Data collection took place between September 5 and September 30, making it a cross-sectional design used to gather information on pertinent variables. This study utilized an explanatory research approach to explore the connection between dependent and independent variables. The data collected was presented quantitatively, with self-administered questionnaires distributed to the Warehouse manager, Pharmacy head, and EPI focal person.

Source and study population

All of the government health centers found in under Addis Ababa administrative health bureau was used as source of population. Government Health centers found under Addis Ababa administrative health bureau that have recoded documents regarding cold chain management, guidelines, list of cold chain products registered, and licensed health care professionals. All pharmacy head, general director and store manager in the sampled health facilities was the study population. The target population considered under the study was 101 registered health centers under Addis Ababa Administrative health bureau. However, by considering economic constraints, the target population reduced to 20 health centers as per the Logistic System Assessment Tool (LSAT)[2].

Sampling techniques, and sample size determination

In the Addis Ababa Administrative health bureau, a total of 101 health centers facilities were found that were functional. It was challenging to address these healthcare facilities. Therefore, for general representation of the study site, a simple random sampling technique was utilized using the logistics indicators assessment. The sample size of public pharmaceutical supply chains in Ethiopia was calculated using the logistics indicators assessment tool. According to this guideline, the sample size of health facilities was determined based on the logistics indicators assessment tool that recommends 20% (101 × 20/100) of health facilities when constraints are available that we had in the current study such as budget and time constraints. Therefore, a total of 20 health centers were included in the study.

For quantitative self-administered questionnaires, ware house manager, pharmacy head, and Expanded Program of Immunization (EPI) focal person, in the selected facilities were purposefully selected as key informants because they are supposed to be more information-rich than other health professionals.

Source of data and data collection method

Previously published literature and guidelines were used for the quantitative study to review all records of the cold chain management practice, and operational performance status of health centers and related health facilities file and to abstract secondary data on the status, types of cold chain products, level of practice and operational performance. Primary data were collected using self-administered questionnaires and questionnaires as the key instruments designed and administered to the respondents. The secondary data were collected through reviewing documents that consist of journals, SOPs, reports, bidding documents, bid evaluation documents, tender award documents, purchase orders, contract

agreements, and any other documents that were used only for information to enrich the research. To facilitate the study and gather relevant information, a customized standard questionnaire was prepared in accordance with supply chain integration and performance and distributed for all the 60 (Ware house manager, Pharmacy head, and EPI focal person) employees under study and collected by the researcher. The questionnaires developed from relevant published literatures, and cold chain management practice internationally recognized guidelines. To ensure the effectiveness of the study and adherence to international standards, the questionnaire was developed based on previously published literature and internationally recognized guidelines for cold chain management practices. The questionnaires were attached as a supplementary file to provide comprehensive context and reference for the study participants [3,4].

Study variables

Independent variables: In this study, cold chain management practice including storage practice, distribution practice, technical capacity and information system were included as the independent variables.

Dependent variables: The level of operational performance (adequate/poor) was also included under dependent variables.

Method of data analysis and scientific interpretation

The collected data was checked initially to detect any errors and ensure consistency and completeness. After the data is checked and coded, entered, and analyzed with the use of IBM Statistical Package for the Social Sciences (SPSS) version 20, the quantitative data result is presented using descriptive statistics (frequency and percentage) and a table. The level of practice was presented in the form of mean ± Sd. A *Chi-square* was employed to determine the association between the scociodemographic profile of study participants and the practice of cold chain management ($P<0.05$). Regression analysis is a statistical method to investigate relationships between more than one independent variable and only one dependent variable. The study employed standard bivariate and multiple regressions with improved power.

The five-point Likert scale was employed for assessing cold chain management practices in the studied health facilities, such as items related to storage systems and facilities, distribution systems, technical capacity, and information systems. The facility was assessed through a total of sixty (n=60) questionnaires prepared as per a Likert scale that ranged from strongly disagree (n=1) to strongly agree (n=5). Respondents were asked to rate the cold chain management practices in the health centers on a five-point Likert-type scale ranging from 1 being strongly disagree to 5 being strongly agree. The mean value of the Likert scale aggregated to satisfactory (strongly agree and agree) (mean value ranged from 3.5–4.5 and above), unsatisfactory (strongly disagree and disagree) (mean value ranged from 0-2.50), and didn't know (neutral) (mean value ranged from 2.5–3.5) regarding the factors included for effective implementation practice regarding cold chain management.

The overall cold chain management performance for key temperature-sensitive pharmaceuticals at public health centers in Addis Ababa Ethiopia were evaluated based on previously published studies. Accordingly, high cold chain product wastage: When the product wastage of healthcare facilities is found to be above tolerable wastage ranges, above 25% of products were wasted. acceptable, desirable, or good storage and handling performance: Percentage of public healthcare facilities that met more than 70% storage condition criteria or parameters of cold chain storage condition that need to be met, good product availability performance, or adequate cold chain medicine stock: Percentage of public healthcare facilities with stock available for more than 80% of products at the time of visit, and the median stock-out duration should ideally be zero [5].

Validity and reliability of the study

Validity test: Prolonged engagement with the data, persistent observation, negative case analysis, and referential adequacy are all procedures that can be used to increase the credibility of a quantitative study. Then, the data was coded, checked for accuracy, consistency, omissions, and irregularities, and then prepared for analysis from all selected supply chains using validated data collection forms. Prior to data collection, a data collector is trained for one day on the data collection instruments and processes. The validity of the tool was also checked by conducting a pretest study on 10 members of the population.

Reliability test: The most common technique used in the literature to assess the scale's reliability and stability is the use of Cronbach's alpha statistics, which identify to what extent items, added together as one set. Low Cronbach's alpha values mean the items do not capture the same construct, but high values of Cronbach's alpha indicate the items well measure and reflect the construct. Ideally, Cronbach's alpha should be over 0.7 to produce a reliable scale. In the study, the reliability coefficients were found to be 0.734 for storage system and facility-related items, 0.725 for distribution system-related items, 0.772 for technical capacity-related items, 0.792 for information system-related items, and 0.825 for cold chain management practice performance-related questionnaires. These coefficients indicate that the data collected from these instruments can be considered reliable [6]. However, the overall reliability of the data collection instruments in this research was found to be 0.770, which is considered to be of average reliability (Table 1).

Table 1: The Cronbach's Alpha value of the variable under the study.

S/No	Name of variable	No. of items	Cronbach's Alpha value
1	Storage system and facility	10	0.734
2	Distribution system	9	0.725
3	Technical capacity	9	0.772
4	Information system	9	0.792
5	Operational performance	4	0.825
Overall the reliability of the data			0.77

Results

Socio demographic study profiles

According to the data outlined in Table 2, 60% of the survey participants were male, making up 36 individuals. In contrast, 40% of the respondents were female, totaling 24 individuals. These numbers emphasize the higher representation of men in the supervision of cold chain products in health centers. Moreover, the majority of respondents, accounting for 53.3%, were under the age of 26. From the total 60 respondents involved in the study, 30 (50%), 21 (35%) and 9 (15%) had educational qualifications of bachelor's degree, diploma and MSc, respectively. This implies that the organization is in a good position in the case of cold chain product handling and dispensing this will improve the health outcome indirectly in the health centers in Addis Ababa The majority of 34 (56.7%) had work experience ranging greater than 3 years. 26 (43.3%) of the respondents had less than 3 years of experience. This implies that the organization is in a good position in the case of cold chain product handling in the health centers in Addis Ababa [7].

Table 2: Demographic Characteristics of respondents of the study.

Variables		Frequency	percentage
Gender	Male	36	60.00%
	Females	24	40.00%
Age of respondent	<26 yrs.	32	53.30%
	>26 yrs.	28	46.70%
Educational qualification	Diploma	21	35.00%
	BA/BSc	30	50.00%
	MSc	9	15.00%
Experience on cold chain management	<3 yrs.	26	43.30%
	>3 yrs.	34	56.70%
Professional of in-charge/ coordinator/ immunization focal person of the facility cold chain	Pharmacist	26	43.30%
	Health officer	14	23.30%
	Nurse	12	20.00%
	Midwife	5	8.30%
	Others	3	5.00%
How many years have you been employed in this health facility?	<5 Years	35	58.30%
	>5 Years	25	41.70%

Description of the effect of cold chain management practices of government health centers in Addis Ababa city administration

The participants in the study were requested to evaluate the cold chain management practices in the health centers using a five-point Likert scale, with 1 representing strongly disagree and 5 representing strongly agree. The average Likert scale value was categorized into satisfactory (ranging from 3.5-4.5 and above, including strongly agree and agree), unsatisfactory (ranging from 0-2.50, including strongly disagree and disagree), and neutral (ranging from 2.5-3.5) in terms of factors that contribute to effective implementation practices in cold chain product management. Accordingly, the mean scores have been computed for all components of the independent variables and the dependent variable by equally weighting the mean scores of all the items under each dimension.

Items related to storage system and facility

In this study, the mean of the analyzed variables ranged from 3.52 to 4.93 (Table 3). The results show that respondents (4.93 ± 0.252) agree on the availability of SOPs for proper vaccination storage. Respondents' mean scores for storage system and facilities ranged from 3.5 to 4.5 or higher. This shows that the storage and facility practice in the cold chain product management in the health facilities were adequate according to the specifications.

Table 3: Mean score of storage system, and facility in the study.

S. no	Items related to score of storage system	N	Mean	SD
1	Special storage area available for cold chain in the health facility	60	4.32	0.748
2	There is enough vaccine storage space	60	3.72	0.454
3	The vaccines are stacked properly inside the refrigerator	60	3.52	0.504
4	Storage equipment's are fully functional	60	3.83	0.376
5	There is different storage equipment for different kinds of vaccines	60	4	1.179
6	Storage equipment's are regularly checked for compliance	60	4.9	0.303
7	SOPs are available to ensure proper vaccine storage	60	4.93	0.252
8	Existing SOPs are followed to ensure proper storage	60	3.67	0.896
9	There is any type of temperature monitoring devices in use	60	4.42	0.72
10	Temperature record readings remains between 2-8°C	60	4.58	0.497

Items related to distribution system

The mean score of the distribution system in the study ranged from 2.77 ± 0.981 to 4.62 ± 0.490 (Table 4). The respondents in the study were neutral on special vehicles for transportation of cold chain items (2.90 ± 0.933) and enough containers to meet demand for distribution (2.77 ± 0.981). This implies that the respondents didn't know the distribution system of cold chain products. This means there is a chance of cold chain items being

damaged during transportation because specialized vehicles and containers should be used to transport cold chain products and be fitted with monitoring devices. The remaining mean score of the parameters of the distribution system for the cold chain products was between 3.5 and 4.5 and above. From this study, it was possible to determine that the distribution practice in the study area was mostly satisfactory to ensure the cold chain management in the study.

Table 4: Mean score of items related to distribution system in the study area.

Variables	N	Mean	SD
There are special vehicles for transportation of cold chain items	60	2.9	0.933
There are enough containers to meet demand for distribution	60	2.77	0.981
Appropriate mode of transportation is used	60	4.38	0.613
There is temperature-monitoring system during transportation	60	4.62	0.49
Temperature readings remain between 2-8°C during transportation	60	4.32	0.469
Vaccine collection schedule time table is available	60	3.65	0.709
Delivery is done within recommended timelines	60	4.32	0.469
SOPs are available to ensure proper transport conditions	60	4.55	0.502
SOPs are followed to ensure proper transport conditions	60	4.55	0.502

Items related to technical capacity

As Table 5 illustrates, the mean score of study participants regarding technical capacity ranged from 3.62 ± 0.666 to 4.93 ± 0.252. Accordingly, the respondents agree on reliable electric power supply, enough employees to handle the demand, and enough employees to handle the maintenance of equipment in the study. They strongly agree on the remaining parameters, as can be seen in Table 5. Based on the aggregated mean score, there is satisfactory technical capacity in the health centers.

Table 5: Mean score of Items related to technical capacity in the study area.

Variables	N	Mean	SD
Staffs who handle cold chain items are specifically trained	60	4.73	0.516
Enough training provided for the staff on cold chain products distribution system	60	4.45	0.565
There are enough employees to handle maintenance of equipment's	60	4.48	0.504

Enough employees to handle the demand	60	4.32	0.469
Equipment's are regularly checked and serviced to avoid breakdown and ensure compliance	60	4.52	0.504
There is enough equipment to handle demand	60	4.32	0.469
There is reliable electric power supply	60	3.62	0.666
There is a power backup to ensure constant power supply for equipment	60	4.93	0.252
Quality checks are done to ensure compliance with cold chain supply regulations	60	4.52	0.504

Items related to information system

As can be seen in Table 6, the mean score of items related to informa ion systems ranged from 3.65 ± 0.709 to 4.72 ± 0.454. As respondents responded, they agree on most informa ion systems as their mean score is between 3.5 and 4.5, while they strongly agree that SOPs are available to ensure proper information systems and that SOPs are followed to ensure proper information systems due to their mean score being above 4.50. The parameters' averaged sum demonstrates that the health centres have an adequate information system in place.

Table 6: Items related to information system in the study area.

Variables	N	Mean	SD
The facility has proper cold chain products forecasting	60	3.65	0.709
Consumption reports are regularly prepared and reported to the appropriate organization	60	3.97	0.317
Cold chain products stock balance and physical count of sample cold chain products are equal	60	4.28	0.454
Cold chain products requisition forms are used for ordering	60	4.17	0.378
SOPs are available to ensure proper information system	60	4.72	0.454
SOPs are followed to ensure proper information system	60	4.52	0.504
There is adequate inventory control system in the health facility	60	4.38	0.49
Cold chain products wastage reports are regularly prepared	60	4.38	0.481

and reported to the appropriate organization			

Aggregated mean of practice related items

The average score for each practice parameter used in the health centers was calculated, and the average was then categorized as satisfactory, unsatisfactory, and neutral. The analyzed variables' means fell between the ranges of 4.01 and 4.43 (Table 7). This suggests that respondents concur that elements pertinent to practice are crucial to cold chain management. The Addis Ababa health centers satisfied the requirements for cold chain management.

Table 7: The overall aggregated mean of practice related items.

Parameters	Mean	SD
Items related to storage system and facility	4.19	0.271
Items related to Distribution system	4.01	0.247
Items related to technical capacity	4.43	0.116
Items related to information system	4.25	0.138

Factors related to cold chain management practice

The educational background, work experience, and years of service of the employee were strongly linked (p=0.0001) to the cold chain management practices (Table 8).

Table 8: Factors associated with cold chain management practice.

Variables	Practice (X^2; p<0.05)			
	Storage and facility	Distribution system	Technical capacity	Information system
Educational background	(60^a; 0.0001)	(60^a; 0.0001)	(51.354^a; 0.0001)	(34.860^a; 0.0001)
Experience	(180^a; 0.0001)	123.982^a; 0.0001)	61.431^a; 0.0001)	132.104^a; 0.0001)
Service year	(60^a; 0.0001)	(60^a; 0.0001)	(60^a; 0.0001)	(26^a; 0.0001)

Operational performance of the health centers in the study area

The study evaluated the effectiveness of health centers by analyzing performance measurement criteria. According to the study participants, the median duration of stock-outs was (32/13) days for the health facilities, whereas the average duration of stock-outs was 49.23 days for the public health facility in the present study. Additionally, the study found that, the stock-out rate for temperature-sensitive products was 80% (4/20). Out of the 20 facilities surveyed, 4 (20%) had sufficient stock for temperature-sensitive products, while the remaining 16 (80%) had inadequate stock. This highlights the lack of a proper cold chain for these products in the health centers, which can be attributed to the insufficient allocation of public health funds, falling below 80% [8].

The inventory-record-accuracy-rate indicated that the majority of the facility's stocks-records were either poor or inaccurate (85%). Approximately 17 (85%) accurate LMIS-reports were conducted in the health-centers. A considerable portion of PHFs were found to be undesirable storage practices (55%). The overall performance of the supply chain management for temperature-sensitive cold chain products consisted of a significant number of PHFs adhering to desirable storage practices (45%) and accurate LMIS-reports (85%), while some had inadequate stock records (85%) (Table 9). The wastage rate of cold chain products was categorized as either good/low product wastage if the rate was below 25% or poor/high wastage rate if it exceeded 25% (26). It was observed in Table 9 that the wastage rate of 16 health centers exceeded 25% (80%), indicating a high level of product wastage in those health centers [9].

Table 9: Overall cold chain management performance at health centers in Addis Ababa Ethiopia, October 2023 (N=20).

Indicator	Empirical results	Performance category
% of PHFs with temperature medicines Available	4 (20%)	Good stock
	16 (80%)	Poor stock
Inventory record accuracy rate	3 (15%)	Good/accurate stock records
	17 (85%)	poor/inaccurate stock records
% of PHFs that had accurate LMIS reports	17 (85%)	Good/accurate LMIS reports
	3 ((15%)	Poor/inaccurate LIMIS report
Product wastage management	4 (20%)	Good/low product wastage
	16 (80%)	Poor/high product wastage
% of PHF with acceptable storage condition	9 (45%)	Good/desirable storage condition
	11 (55%)	Poor/undesirable storage condition
Note: PHF: Public Health facility; LMIS: Logistic Managements Information System		

Factors related to cold chain management performance level at health facilities

The mean scored by respondents' operational performance level were between 3.18-3.47. Accordingly, the result indicates that, the respondents agree on supply of cold chain product at the right quantity (3.47 ± 1.04). This indicates that, the operational performance level in the health centers were inadequate as per specification (Table 10).

Table 10: Factors related to cold chain management performance level at health facilities.

Variable	N	Mean	SD
Delivers cold chain goods and services at right place	60	3.28	1.05
Delivers cold chain goods and services effectiveness on right time	60	3.39	1.07
Cold chain supply management flexibility	60	3.18	1.11
Supply of cold chain product at right quantity	60	3.47	1.04
Aggregate of factors related to cold chain operation performance level	60	3.38	1.08

Multivariable logistic regression analysis of factors affecting overall cold chain management operation performance

On bivariate logistic regression analysis, the variables that had showed significant statistical association ($p<0.05$ at 95% CI) with the cold chain management operation performance were selected for multivariate analysis. Consequently, the result of multivariate logistic regression analysis showed the experience of respondents on cold chain management, product storage system and facility, distribution system and technical capacity of health facilities were found as significant associated factors ($p<0.05$ at 95% CI) with operation performances of cold chain management (Table 11).

The experience level of health professionals on cold chain management showed that strong statistical association with cold chain management operation performance at their health

facilities. Health workers who had more than three years work experience were about 6 times (AOR=6.66, 95% CI: (1.29-34.36); p-value=0.024) more likely operate the management of cold chain product and services in good manner as they compared with those who had less than or equal to three year's work experience on cold chain management (Table 11). The other strong predictor of cold chain product and services management operation performance was presence of adequate storage facility and systems. The odds of performing cold chain management in good manner were six times higher in health facilities that had adequate storage facility and systems (AOR=6.13, 95% CI: (1.09-34.63); p-value=0.040) than the health facilities that had shortage of storage facility and systems.

Table 11: Bivariate logistic regression analysis and factors affecting overall cold chain management performance level at public health facilities in Addis Ababa Ethiopia, October 2023 (N=60).

Variables	Categories	Overall health facilities operation performance level				Crude OR (95% CI) and p-value		Adjusted OR (95% CI) and p-value	
		Poor/Inadequate performance		Adequate performance		P	Crude odd ratio (95%, CI)	P	AOR (95%, CI)
Educational background	Diploma	13	21.70%	8	13.30%	1	1		
	BA/BSc	9	15.00%	21	35.00%	0.026	3.79 (1.17-12.30)	0.629	1.55 (0.26-9.22)
	MSc	2	3.30%	7	11.70%	0.059	5.69 (0.94-34.46)	0.952	1.08 (0.08-15.03)
Experience on cold chain management	<3 years	17	28.30%	9	15.00%	1	1		
	>3 yrs	7	11.70%	27	45.00%	0.001	7.29 (2.29-23.22)	0.024	6.66 (1.29-34.36)
Total service year in current health facility	<5 Years	18	30.00%	17	28.30%	1	1		
	>5 Years	6	10.00%	19	31.70%	0.036	3.35 (1.08-10.40)	0.406	2.23 (0.34-14.68)
Storage system and facility	Poor Storage	20	33.30%	11	18.30%	1	1		
	Good storage	4	6.70%	25	41.70%	0	11.36 (3.139-41.14)	0.04	6.13 (1.09-34.63)
Distribution system	Poor distribution	16	26.70%	8	13.30%	1	1		
	Good distribution	8	13.30%	28	46.70%	0.001	7.00 (2.202-22.25)	0.038	6.13 (1.11-33.86)
Technical capacity	Poor capacity	17	28.30%	7	11.70%	1	1		

	Good capacity	7	11.70%	29	48.30%	0	10.06 (3.01-33.63)	0.046	5.21 (1.03-26.31)
Information System (IS)	Poor IS	17	28.30%	16	26.70%	1	1		
	Good IS	7	11.70%	20	33.30%	0.048	3.04 (1.01-9.11)	0.698	1.42 (0.25-8.10)

Similarly, the probability that the health facilities which have good distribution system for cold chain product had to operate the cold chain management in adequate manner were more than 6 times higher (AOR: 6.13, 95% CI (1.11-33.86); p-value=0.038) then the health facilities which had poor distribution system for cold chain pharmaceutical products and supplies. On other hand, the factors related to technical capacity of health facilities have also revealed a significant association with cold chain management operation performance level of health facilities. The odds of performing cold chain management sufficiently were more than five times for health facilities that had good/adequate technical capacity than inadequate ones (AOR=5.21, 95% CI (1.03-26.31); p-value=0.046).

Discussion

The study's results were thoroughly explored in this section by making comparisons to other study results from around the world. Theoretical and empirical discoveries that strengthen the results were included in the discussion, as well findings that reasonably contradicted the study. Each study variable was covered in detail.

The study was attempted to assess the cold chain management practice, and operational performance in selected health centers under Addis Ababa administrative health bureau. Observing the demographic trend or characteristics of the sample population during data collection was useful for conclusion scientific findings. From the total of 60 study participants, 36 (60%) of the respondents were male, while 24 (40%) were female. This indicates the dominance of men in managing cold chain products in health centers. Similar study reported by Mohammed et al. in 2018 indicated that the gender distribution was dominated by male employees in the health centers. However, the study was different from study conducted by Firomsa in which among 47 respondents 20.9% and 79.1% were male and female respectively. The difference of the finding may be the number of sample sizes, and type of facility type assessed. Additionally, the age range of the majority of respondents was <26 years, which accounts for 32 (53.3%). From the total 60 respondents involved in the study, 30 (50.0%), 9 (15.0%) and 21 (35.0%) had educational qualifications of bachelor's degree, MSc and diploma, respectively. The majority of 34 (56.7%) had work experience greater than 3 years. 26 (43.3%) of the respondents had less than 3 years of experience. This implies that the organization is in a good position in the case of cold chain product handling in the health centres in Addis Ababa. Aside from this, nurse 12 (20.0%) and midwife 5 (8.3%), was mostly involved in the in-charge/coordinator/ immunization focal person of the facility cold chain.

Cold chain management plays a crucial role in ensuring the effectiveness of cold chain storage, handling, and stock management; rigorous temperature control in the cold chain; and adequate logistics management information systems. However, concerns over having adequate control in the cold chain are increasing in recent decades in the aftermath of an increasing volume and complexity of cold medicines and the complexity of the worldwide supply. The rapid growth of biopharmaceutical business, complex global sourcing, and distribution chain has brought global interest in the supply chain management of cold pharmaceuticals. Therefore, it is better to assess the level of practice in the management of cold chain products in a given public facility. In this study the mean of studied variables ranged from 3.52 to 4.93 respectively. Accordingly, the result indicates that, the respondents agree on SOPs are available to ensure proper cold chain storage (4.93 ± 0.252). The mean scored by respondents regarding storage system and facilities were between 3.5-4.5, and above. This indicates that, the storage and facility practice in the cold chain product management in the health centres were satisfactory as per specification. Similar study reported from Addis Ababa that support the present study which stated that, the storage practice in cold chain management of vaccine providing immunization service is on good status. However, different from Tanzania were posted in which the storage practice was unsatisfactory for cold chain products particularly. This revealed Ethiopia followed good storage practice for assuring the cold chain products management in the public facilities.

The cold chain distribution process is the process by which cold chain products move from the point of manufacturing to the end user. Products typically move across multiple locations including manufacturing, distribution, and storage before reaching the end user. Lack of reliable transport at district level contributes to shortage of cold chain products at health facility level. This suggests that, good distribution system should be in place for effective and safe delivering of such products at point of interest. In this study, the mean score of the distribution system in the study ranged from 2.77 ± 0.981 to 4.62 ± 0.490. The respondents in the study were neutral on special vehicles for transportation of cold chain items (2.90 ± 0.933) and enough containers to meet demand for distribution (2.77 ± 0.981). This implies that the respondents didn't know the distribution system of cold chain products. This means there is a chance of cold chain items being damaged during transportation because specialized vehicles and containers should be used to transport cold chain products and be fitted with monitoring devices.

Similar study conducted in coast region, Tanzania, and Ethiopia showed that the main cause of delay in delivery of vaccines to the health centers was shortage or lack of transport to distribute the vaccine. Training is a very important constraint which needs to be considered to improve the cold chain distribution plan. People involved in transportation and supply of cold chain products need to be trained and have knowledge of cold chain and how to handle breakage of cold chain.

Training supply chain personnel is usually focused narrowly on specific activities, such as storekeeping, maintaining cold-chain records, and providing security for commodities, rather than the higher order planning, analysis, and performance management skills needed by supply chain managers. In the study, the mean score of study participants regarding technical capacity ranged from 3.62 ± 0.666 to 4.93 ± 0.252. Accordingly, the respondents agree on reliable electric power supply, enough employees to handle the demand, and enough employees to handle the maintenance of equipment in the study. They strongly agree on the remaining parameters. Based on the aggregated mean score, there is satisfactory technical capacity in the health centers. The study different from Mozambique which stated that, inadequate knowledge and practices exist regarding cold chain management in primary health care facilities. According to study done on pharmaceutical distributors in Nairobi Country 41% of respondents have absolutely no special training in cold chain.

Appropriate information regarding cold chain products paramount important for effective implementation of cold chain management practice in the health facilities. In the study, the mean score of items related to information systems ranged from 3.65 ± 0.709 to 4.72 ± 0.454. As respondents responded, they agree on most information systems as their mean score is between 3.5 and 4.5, while they strongly agree that SOPs are available to ensure proper information systems and that SOPs are followed to ensure proper information systems due to their mean score being above 4.50. The parameters' averaged sum demonstrates that the health centres have an adequate information system in place. The study was different from report of Firomsa, in which respondents remained neutral on maintaining stock balance through regular recording and use of requisition forms for vaccine ordering. The study conducted on Effective Vaccine Management (EVM) analysis done by WHO in 75 countries revealed that with a few exceptions, information systems are weak at each level in each region. The average score for each practice parameter used in the health centers was calculated, and the average was then categorized as satisfactory, unsatisfactory, and neutral. The analyzed variables' means fell between the ranges of 4.01 and 4.43. This suggests that respondents concur that elements pertinent to practice are crucial to cold chain management. This implies that, the Addis Ababa health centers satisfied the requirements for cold chain management.

Assessing factors most likely associated with cold chain management practice was important for taking intervention. Employee who has educational background highly associated with storage and facility, and distribution system both accounted (60a; 0.0001) followed with technical capacity. This implies that respondents who educated likely better engaged in the management practice of cold chain products. Experience and service year of employees positively associated in the practice of cold chain management practice. The study was different from Tiya B, reported that, information system has no significant positive effect on availability of cold chain unlike this study.

An empirical finding should be necessary for supply chain management practices in the assurance of cold chain product in the ware house for reliable predictors for operational performance. The study attempted to give some insights into consideration that help to improve the cold chain management performances at public health facilities in the study area and other regions with similar characteristics to the studied facilities. The average duration that the key temperature-sensitive pharmaceuticals are out of stock indicates the capacity of a system to maintain constant supply of products over time. In the present study, the median stock-out duration was (32/13) days for the health facilities, while the average stock-out duration was 49.23 days for the public health facility in the current study. These results show the logistics system in Health centers in Addis Ababa supplied by the Ethiopian supply chain service was not performing well. As per specification, the median stock-out duration should ideally be zero. The present finding different from study conducted in Tanzania which revealed the average stock-out duration of the cold chain product in public health facilities to be 15 days. Also the present study was higher than from study conducted in Jimma zone which revealed that, the median stock-out duration was 23.04 days for the health facilities while the average stock-out duration was 29.30 days for each public health facility in the current study. The present study also figures out that, 4 (20%) have good stock for temperature-sensitive products, while poor stock in 16 (80%) facilities was observed during the survey. This noted a poor product cold chain available in the stock in the health centers due to the percentage of public health funds being less/equal to/ than 80%.

Accurate inventory record keeping is essential for proper inventory management at all levels of public facilities. In the study, the inventory record accuracy rate showed that the facility mostly has poor or inaccurate stock records (85%). This study found that all health facilities, regardless of the facility type, had incorrect stock record keeping. Similar study finding reported from Jordan, and Ethiopia that evidenced that presence of inaccurate stock record in the public health facility. The transforming cold chain performance and management in lower-income countries stressed that lack of technology to improve cold chain capacity, information, decision making, and infrastructure were some of the challenges for the cold chain management. Apart from that, less education, experience, and knowledge were established to be some of the challenges for cold chain management improvements. The studies indicated that the issues of stock record management are critical.

During storage and distribution, suitable procedures and equipment should be in place to monitor the environmental conditions of medicinal products storage areas. Proper storage is vital to maintain the purity, potency, safety, and effectiveness of cold chain medicines. However, cold chain storage condition performances in the study facilities were found to be unacceptable, with a significant number of Public Health

Facilities (PHFs) practicing undesirable storage conditions (55%). Similar report reported from Ethiopia that show inaccurate storage performance in the health facilities. The Cold chain medicine wastage indicates the inefficiency of logistics system management performance. The wastage rate of cold chain products was aggregated into good/low product wastage if the wastage rate is less than 25%, and poor/high wastage rate if the rate is more than 25%. In the study, the wastage rate of 16 health centers was more than 25% (80%). This showed that high products wastage was observed in the health centers this may be the temperature sensitivity attributed to frequent as erratic electric power supply, fueling and transport, which are necessary to ensure continuous running of cold chain equipment.

The multivariate logistic regression analysis revealed that, experience of respondents on cold chain management, product storage system and facility, distribution system and technical capacity of health facilities were found as significant associated factors ($p<0.05$ at 95% CI) with operation performances of cold chain management. The experience level of health professionals on cold chain management showed that strong statistical association with cold chain management operation performance at their health facilities. Health workers who had more than three years work experience were about 6 times (AOR=6.66, 95% CI: (1.29-34.36); p-value=0.024) more likely operate the management of cold chain product and services in good manner as they compared with those who had less than or equal to three year's work experience on cold chain management. This warranty work experience should be critical parameters in improvement of operational performance in effective cold chain management

Conclusions

The study shed light on the effect of cold chain management practices on health center operational performance. The study revealed that health centers in Addis Ababa administrative city demonstrated satisfactory cold chain product management practices in terms of storage and facility (4.19 ± 0.271), distribution system (4.01 ± 0.247), technical capacity (4.43 ± 0.116), and information-related items (4.25 ± 0.138). Additionally, the study found that, the educational background, work experience, and years of service of the employee were strongly linked (p=0.0001) to the cold chain management practices.

Additionally, the research revealed that the operational efficiency of the healthcare facilities was inadequate, with an 80% stock-out rate for temperature-sensitive items (4 out of 20). Among the 20 facilities examined, 4 (20%) had adequate stock for temperature-sensitive products, while the remaining 16 (80%) had insufficient stock. Overall, the operational performance of the health centers was insufficient in managing cold chain products. The multivariate logistic regression indicated that, experience of respondents on cold chain management, product storage system and facility, distribution system and technical capacity of health facilities were found as significant associated factors ($p<0.05$ at 95% CI) with operation performances of cold chain management. The insufficient operational performance in health centers is caused by various internal and external factors such as storage and facility issues, distribution system challenges, technical capacity limitations, and information system deficiencies. These issues pose dynamic problems for the management of cold chain products in a health center. Therefore, it is essential for health center administrators, supply chain coordinators, cold chain handlers, and stakeholders like the Federal Ministry of Health, Health Bureau, Pharmaceutical Fund and Supply Agency, and researchers to collaborate in order to establish an efficient working environment for cold chain products, ensuring the effective execution of operational performance activities.

Limitations and opportunities for future investigation

The study utilized a cross-sectional approach to gather a substantial amount of data in a short period. However, this method's limitations include the potential for different results compared to longitudinal studies. Furthermore, the use of questionnaires instead of interviews may have hindered the depth of responses. Expanding the study to various levels of cold chain management and including non-governmental health facilities could have yielded more insightful outcomes.

This study provides an opportunity for researchers and staff working in the cold chain sector to identify specific areas within the supply chain where inefficiencies may be occurring. By conducting a thorough analysis of the current processes and procedures, organizations can pinpoint areas for improvement and implement necessary measures to enhance operational efficiency. Furthermore, by continuously monitoring and evaluating the effectiveness of these measures, organizations can ensure that they are consistently improving their supply chain management practices to meet the demands of a rapidly changing industry. Ultimately, this research offers a valuable opportunity for organizations to stay competitive and meet the growing demands of the cold chain health sector.

Data Availability Statement

The original contribution presented in the study was included in the article.

Author Contributions

MG: Conceptualization, data curation, formal analysis, investigation, methodology, validation, and writing, review, and editing. YTM: Data curation, formal analysis, methodology, validation, writing (original draft), and writing (review and editing). MFY, AAT, AA, GB and REU: Conceptualization, validation, supervision, and writing—review and editing.

Funding

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

Acknowledgments

The authors express their gratitude to the health centers within Addis Ababa administrative for their open and clear communication with the data collectors, as well as for their valuable scientific input in supplying pertinent information.

Ethics Approval and Consent to Participate

Ethical approval for this study was obtained from the National Aviation College Ethical Review Board (ERB). Before data collection began, the NAC College communicated with the Addis Ababa city administration health bureau through a formal letter to secure official authorization to conduct the research. Prior to distributing the research tool, explicit consent was obtained from all participants before including them as respondents in the study. All information collected from the participants was handled with the utmost ethical consideration, ensuring that their initial concerns were addressed and confidentiality was maintained. The respondents confirmed that any data collected during the study would be kept strictly confidential. To safeguard the anonymity of the respondents, no individual was identified in any reports or publications based on their responses. Additionally, informed consent to participate was obtained from all participants before the study commenced.

Consent for Publication

Not applicable.

Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

References

1. Shrivastava SR, Shrivastava PS, Ramasamy J (2015) Strengthening cold chain mechanism to enhance the effectiveness of immunization program. Int J Adv Med Health Res 2:63–64
2. Ki-Moon B (2015) Access to Essential Medicines, Vaccines and Health Technologies. World Health Organization, Copenhagen, Denmark.
3. WHO (2002) Biological: Ensuring the quality of vaccines at country level, guideline for health staff. Geneva: World Health Organization.
4. WHO Immunization Practices Advisory Committee (2014) Immunization supply chain and logistics: a neglected but essential system for national immunization programmes: a call-to-action for national programmes and the global community. Geneva: World Health Organization.
5. Bishara RH (2006) Cold chain management–an essential component of the global pharmaceutical supply chain. Am Pharm Rev 9:105–109
6. Ogboghodo EO, Omuemu VO, Odijie O, Odaman OJ (2017) Cold chain management practices of health care workers in primary health care facilities in Southern Nigeria. Pan Afr Med J 27
7. Gebretnsae H, Hadgu T, Ayele B, Gebre-Egziabher E, Woldu M, et al. (2022) Knowledge of vaccine handlers and status of cold chain and vaccine management in primary health care facilities of Tigray region, Northern Ethiopia: institutional based cross-sectional study. PLoS One 17:e0269183
8. Kartoglu U, Nelaj E, Preza I, Bino S (2020) Vaccine Vial Monitor Based Vaccine Management: An Albania Experience. J Pharma Care Health Syst 7:2376
9. Hibbs BF, Miller E, Shi J, Smith K, Lewis P, et al. (2018) Safety of vaccines that have been kept outside of recommended temperatures: reports to the vaccine adverse event reporting system (VAERS), 2008–2012. Vaccine 36:553-558