COLD CHAIN MANAGEMENT PRACTICES AND ITS CHALLENGES: THE CASE OF NATIONAL BLOOD BANK SERVICE, ADDIS ABABA, ETHIOPIA

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I, Dagmawi Abate, declare that this thesis work entitled "**Cold Chain Management Practices and Challenges: The Case of National Blood Bank Service in Addis Ababa"** is my original work in partial fulfillment of the requirement for the award of Degree of Masters' of Art in Logistics and Supply Chain Management. I also declare that it has never been presented in this or any other university and that all resources and materials used in the thesis have been duly acknowledged.

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This thesis entitled as **Cold Chain Management Practices and Challenges: The Case of National Blood Bank Service in Addis Ababa** has been submitted for examination with my approval as a university advisor. In my opinion, this thesis is suitable for submission in partial fulfillment of the requirements for the award of Degree of Masters' of Art in Logistics and Supply Chain Management.

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Acronyms

BIMS - Blood information Management System

BSCM – Blood Supply Chain Management

CDC- Centers for Disease Control and Prevention

CHAI - Clinton Health Access Initiative

CMDs- Continuous Monitoring Devices

DTR - Daily Temperature Reading

DW – Developing World

FDA – Food and Drug Administration

FEFO – First Expiry First Out

HBV – Hepatitis B Virus

HCV – Hepatitis C Virus

HIV – Human Immunodeficiency Virus

NBBS - National Blood Bank Service

NBTS- The National Blood Transfusion Services

PQS – Performance Quality Safety

QMS – Quality Management System

RFID – Radio Frequency Identification

SOPs - Standard Operating Procedures

TTI - Temperature Time Indicators

VPDS - Vaccine Preventable Diseases

VRF - Vaccine Requisition Form

VVMs - Vaccine Vial Monitors

WHO – World Health Organization

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ABSTRACT

The purpose of this study was to assess the cold chain management practice and identify the major challenges related to cold chain management at National Blood Bank Service, Addis Ababa, Ethiopia. Cross-sectional study was used to assess the cold chain management and its related challenges at the facility. Based on the finding of the study, on availability of cold chain equipment, almost two third (71.7%) of the study participants responded that there is an adequate cold chain equipment at National Blood Bank Service. Technical capacity was also assessed and the study result revealed that more than half of the participants (52.8%) responded that personnel are technically capable of practicing cold chain management at the facility. The finding also revealed that cold chain management practice was poor as reported by majority 66.9% of the respondents. As compared to the other challenges the study result showed that challenges related to power supply was the first major challenge followed by maintenance problems and transportation related challenges respectively. Overall from the finding of the study it can be concluded that there is an adequate availability of cold chain equipment and a greater number of technically capable personnel responsible for cold chain management practice. But there is a poor cold chain management practices at National Blood Bank Service. In addition all the major challenges were observed that are related to cold chain management practice which affects the overall operation of National Blood Bank Service.

Key words; Blood, Blood Cold chain, Cold chain management practice, cold chain equipment, cold chain storage, cold chain Temperature monitoring

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Blood transfusion is an integral part of the modern healthcare system. Used correctly, Blood can save life and improve health. Blood should be stored at a temperature range of 1-6 degrees Celsius. Blood can become contaminated and unsafe to use, if it is not stored at the required temperature and suitable storage condition. (World Health Organization, 2002)

Cold chain management is the process of maintaining a consistent temperature range for perishable products, such as blood, vaccines, and pharmaceuticals. The cold chain is very critical in ensuring the quality and safety of blood products, as temperature excursion leads to an increased risk of adverse effects and a compromised efficacy of blood products. Cold chain management plays an important role in guaranteeing the effectiveness of cold chain storage, handling, and stock management; rigorous temperature control within the cold chain; and adequate supply management information systems. Well-trained employees, dependable storage and temperature monitoring equipment, and precise cold chain inventory management are the 3 essential aspects of a productive cold chain. (Feyisa et al., 2021)

The cold chain is weak almost everywhere, but weaker in the developing regions of the world. The situation of the cold chain in the developing world (DW) is very diverse and complex; it is underdeveloped in some regions and very developed in others. In some parts of the DW the cold chain does not even exists, and it is not adequately maintained in many regions. It is very difficult to collect and find accurate data on the cold chain, especially in the DW. (Yahiya, 2010)

There is still a significant challenge in developing countries, and weaknesses are often observed during the transportation and storage of cold chain medicines. Some factors contributing to weaknesses of the cold chain are delays during transportation, quality of refrigerators, a method of storage, and too long storage at the health unit, improper use of refrigerators, power interruption, equipment breakage, and lack of trained personnel on cold chain management.

The purpose of this research is to assess the current state of National Blood Banks Service cold chain management practices and identify the major challenges related to cold chain management and also provide insight and recommendations that enable the facility to improve the overall cold chain management practice.

Therefore, this research aims to provide an overview on the overall practice of cold chain management and its related challenges at National Blood Bank Service.

1.2 Statement of the problem

Despite its importance, cold chain management has different challenges that can affect the quality of blood products; these include challenges with temperature control, transportation, and storage. In Ethiopia, researches conducted by Gebremeskel et al. (2019), Tadesse et al. (2019), and Tsegaye and Molla (2018) have identified several factors that contribute to poor cold chain management practices in blood banks, including inadequate temperature monitoring systems, lack of training and awareness among staff, and insufficient resources. These challenges can lead to unforeseen or increased costs, shortages of blood supply, and compromised patient safety. Due to this, there is an urgent need to understand and deal with these demanding situations in an effort to make sure the safety and effective way of delivering blood products to patients in Ethiopia and past." Furthermore, a comprehensive assessment of the cold chain control measures and its related challenges has not been conducted at the National Blood Bank Service. Hence, the primary aim of this study is to scrutinize the cold chain management practice and its challenges encountered by NBBS in Addis Ababa, an aspect that has not been explored in prior studies.

1.3 Basic Research Questions

The research questions are listed below;

- ✓ How cold chain management is being practiced at National Blood Bank Service?
- ✓ How is the technical capacity of personnel responsible for the cold chain practice at National Blood Bank Service?
- ✓ How is the availability of cold chain equipment at National Blood Bank Service?
- ✓ What are the major challenges affecting the cold chain management practice of National Blood Bank Services in Addis Ababa?

1.4 Objectives of the study

1.4.1 General objective

The overall objective of this study is to evaluate the cold chain management practice and its challenges at National Blood Bank Service in Addis Ababa.

1.4.2 Specific Objective

- ✓ To evaluate the cold chain management practice of National Blood Bank Service in Addis Ababa
- ✓ To assess the technical capacity of personnel responsible for the cold chain practice at National Blood Bank Service?
- ✓ To assess the availability of cold chain equipment at National Blood Bank Service in Addis Ababa
- ✓ To identify the major challenges affecting the practice of cold chain management at National Blood Bank Service in Addis Ababa

1.5 Significance of the study

The research will provide comprehensive evidence on the National Blood Bank Service cold chain management practices and challenges. This information will be valuable to all stakeholders in the sector to help develop and implement standard guidelines and also provide both technical and financial support to blood bank service centers. It also enables the healthcare sector to obtain reliable and important information on the current practice of the National Blood Bank Service in relation to cold chain management, which includes gaps and challenges. The results of the study will also help the organization in taking the required steps to strengthen the cold chain management practice. Last but not least, it will fill a gap in the literature that has not been addressed in previous studies involving the National Blood Bank service.

1.6 Scope of the study

The scope of this study encompasses the cold chain management practices and its challenges in relation to cold chain practice at National Blood Bank Service.

1.7 Limitation of the study

This research was conducted solely at headquarter of the National Blood Bank Service in Addis Ababa. Consequently, the results cannot be universally applied to other blood bank facilities operating throughout Ethiopia.

1.8 Definition of terms

1.8.1 Conceptual definition

Blood Cold Chain: is an established supply system utilized for the purpose of storing, transporting, and dispensing blood in a regulated atmosphere with temperatures ranging from +1 to +6 degrees Celsius. (WHO, 2018)

Technical capacity: is expressed by an ability of personnel that is trained for handling overall processes of cold chain management to make sure blood product quality and safety. (WHO, 2018)

Cold chain management practice challenges: includes both internal and external challenges that affect the cold chain management process.

1.8.2 Operational definition

Organization or Service: National Blood Bank Service

Stakeholders: the entities that have close relations for supporting NBBS through technical and or financial ways.

Investigator: a person who is responsible to carry out this research proposal.

Cold chain practice: a standard practice of cold chain that include temperature monitoring, proper storage and implementation of SOP throughout the cold chain process. (CDC, 2019).

1.9 Organization of the study

The study consists of five different chapters. The first chapter one involves an introduction that comprises study background with special focus on cold chain management practice in particular, problem statement, research question, objective, significance and scope of the study, limitation, and definition of terms. The next chapter consists of detailed reviews of literature and conceptual frame work. Whereas chapter three covers research methodology, area of study, the research design and approach, study population & sampling, data collection procedures, analysis of data, reliability, validity and ethics. Chapter four consists of result, discussion and data interpretation. The last chapter includes summary of study findings, conclusion of the study and its recommendation.

CHAPTER TWO

RELATED LITERATURE REVIEW

Introduction

This section emphasizes on different reviews of literatures on the key and crucial points that the study focuses. The chapter tries to discuss variety of theoretical literatures with a main target on objectives of the study and theoretical inceptions of the research. It also consists of empirical literature, conceptual frame work and literature gap of the study.

2.1 Theoretical literature review

2.2.1 Cold chain management practice

The term cold chain refers to a system in which the temperature of products being stored or transported should be maintained in a managed variety. The most common storage temperature for pharmaceutical items is 2 °C to 8 °C degrees. However particular temperatures can range relying at the actual product. Hulea et al., 2018

A supply chain of perishable products including blood is called a “cold chain”. Cold chain protects a wide type of meals, pharmaceutical, and chemical products from degradation, flawed exposure to temperature, humidity, light or particular contaminants to maintain them frozen, chilled and clean. Any disruption in time-distance or temperature inside the chain ought to abate the value of the activities and their added value in the cold chai practice. Blood management need to be responsive to every system adjustments, quickly and flexibly. Managing blood cold chain is expected to be adjusted on demand fluctuation and blood provide pattern. One most of the main essential things to be finished are strategizing blood procurement that might cater to the demand. (Mansur et al., 2018)

Blood cold chain control is an important factor of the blood supply chain that guarantees the safety and efficacy of blood products. It includes number tasks, along with temperature monitoring, transportation, and storage of blood products. Effective blood cold chain control requires responsive and flexible blood management that may modify to call for fluctuations and blood deliver styles. Temperature tracking is a crucial aspect of blood cold chain control. Temperature monitoring device is important for ensuring that blood merchandise are maintained in the proper temperature range all through storage, transportation, and distribution. The use of temperature tracking device can help to locate and correct any temperature deviations that might compromise the nice and safety of blood products. A research by way of Yakovleva et al. (2021) evaluated the performance of temperature monitoring gadgets in Russian blood banks and discovered that digital statistics loggers were the maximum correct and reliable temperature tracking gadgets for blood cold chain control.

Handling and transportation of blood products also are important aspects of blood cold chain management. Blood products should be dealt with and transported with care to prevent publicity to fallacious temperature, humidity, mild, or contaminants that might compromise their fine and protection. The use of appropriate shipping containers and packaging substances can assist to preserve the desired temperature variety all through transportation. One Indian research carried out by Saini et al. (2019) evaluated the overall performance of transport boxes used for blood transportation in India and decided that using insulated delivery bins with gel packs became effective in keeping the favored temperature range at some point of transportation.

The temperature and different environmental conditions ought to be monitored frequently to make certain that they're inside the acceptable variety. Another research by way of Ahmadi et al. (2021) attempted to evaluate the overall comprehensive performance of different procedures of blood storage systems in Iran and discovered that the use of separate temperature controls for the fridge and freezer booths became effective in maintaining the favored temperature range for storage of blood products.

In addition to temperature monitoring, handling, transportation, and storage, using era also can beautify blood cold chain manipulate. For instance, the usage of radio-frequency identity (RFID) era can help to enhance traceability and transparency within the blood chain system. RFID era can provide real-time tracking of blood products, making sure that they may be well treated and transported. When we see the research via Kulkarni et al. (2020) evaluated the general performance of RFID technology in blood banks in India and confirmed that it advanced the traceability and transparency of blood products within the chain.

One of the primary goals of blood supply chain is to control the demand and reduce waste of blood products. Usually it consists of four main activities these are blood collection, inventory, and blood distribution and supply of blood products (Hamadneh et al., 2021)

2.2.2 Cold chain Temperature monitoring

Temperature monitoring is the process of tracking the temperature of blood and blood products throughout the cold chain. It is very important to monitor and control that blood products are stored and transported at the desired temperature, which is very essential for their safety and effectiveness. One of the common methods to monitor temperature is the use of temperature indicators. Temperature indicators are small, disposable devices that are placed in blood and blood products. The indicators change color when they are exposed to temperatures outside of the recommended range. This allows staff to easily identify if blood and blood products have been exposed to unsafe temperatures. (WHO, 2018).

Another common method of temperature monitoring is to use continuous monitoring devices (CMDs). CMDs are electronic devices that record the temperature of blood and blood products in real time. This allows staff to track the temperature of blood and blood products throughout their journey, which can help to identify any potential problems early on.

The World Health Organization (WHO) recommends that temperature monitoring be carried out at all stages of the blood cold chain, from collection to transfusion. This includes regular checks of the temperature of blood storage and transportation equipment, as well as the use of temperature indicators to track the temperature of blood throughout its journey. WHO also recommends that temperature monitoring data be recorded and reviewed regularly to identify any potential problems.

As per the recommendation blood should be collected in a clean, cool environment and stored at a temperature of 10-24 degrees Celsius within two hours of collection. And during transportation blood should be transported in a refrigerated or frozen vehicle that maintains a constant temperature.

Temperature indicators should be placed in the blood bags to track the temperature throughout transportation. It is also clear that blood better be placed in a refrigerator at an appropriate temperature. Temperature indicators should be placed in the blood storage units to track the temperature throughout storage. Even at the point of use blood should be checked for temperature before transfusion. If the blood has been uncovered to a temperature outdoor of the encouraged range, it should no longer be transfused. (WHO, 2010).

Blood collection facilities, blood processing facilities, and transfusion services should use a continuous monitoring device (CMD) to track the temperature of blood storage and transportation equipment. The rationale for this recommendation is that CMDs can provide a more accurate and reliable record of temperature than manual checks. CMDs can also be used to identify any potential problems with the cold chain early, before they have a chance to cause harm to the blood supply. (CDC, 2015)

In addition to temperature monitoring, other environmental factors consisting of humidity, mild exposure, and air pleasant also can impact the satisfactory and safety of blood and blood products. Therefore, it's far crucial to make sure that those elements are also monitored and managed throughout the blood cold chain.

Humidity can affect the quality of blood products by making them to deteriorate or lose their efficacy. High humidity also can sell the boom of microorganisms, which could result in contamination and infection. Therefore, it's miles vital to save and transport blood products in an surroundings with controlled humidity stages. (WHO, 2018)

Light publicity can also affect the great and protection of blood and blood merchandise. Exposure to light can purpose degradation of positive components in blood products, main to reduced effectiveness or even toxicity. Therefore, it's far crucial to shop and shipping blood merchandise in an environment with limited light publicity. (WHO, 2018)

Air also can affect the great and safety of blood and blood products via introducing contaminants or microorganisms. Therefore, it's very vital to make certain that the air first-rate in blood storage and transportation facilities is controlled and monitored to prevent contamination. (FDA, 2016)

To ensure the protection and efficacy of blood and blood products, it's also critical to put in force a comprehensive pleasant management system (QMS). A QMS is a set of regulations, strategies, and methods which might be designed to make certain that blood and blood products meet the desired best standards. A QMS for blood control must include everyday quality manage assessments, workforce training, and documentation of all blood and blood product dealing with procedures. (WHO, 2012)

In addition to QMS, it's also essential to have a robust cold chain management plan in location. A cold chain management plans have to encompass unique procedures for temperature tracking, handling, transportation, and storage of blood and blood merchandise. The plans have to also encompass contingency measures for addressing any ability issues or disruptions within the cold chain. (CDC, 2016)

Temperature tracking is just one element of blood cold chain management that is essential for ensuring the safety and efficacy of blood and blood products. Other environmental factors along with humidity, light publicity, and air first-rate also can affect the excellent and safety of blood and blood products. Therefore, it's far essential to implement a comprehensive pleasant management system and a strong cold chain

management plan to make sure that blood and blood products meet the specified satisfactory requirements for the duration of the cold chain. Blood cold chain temperature tracking is an important aspect of blood management that guarantees the protection and effectiveness of blood and blood products. Temperature tracking is the procedure of tracking the temperature of blood and blood merchandise for the duration of the cold chain to make certain that they're stored and transported on the favored temperature. The World Health Organization (WHO) recommends that temperature monitoring be executed at all degrees of the blood cold chain, from series to transfusion. (WHO, 2017)

Temperature monitoring can be done the usage of numerous techniques, inclusive of temperature indicators and non-stop monitoring devices (CMDs). Temperature indicators are small, disposable gadgets which can be positioned in blood and blood merchandise to music their temperature. These indicators trade shade while they're exposed to temperatures out of doors the endorsed variety, allowing team of workers to without problems perceive if blood and blood merchandise were uncovered to hazardous temperatures. Temperature signs are useful for monitoring temperature during transportation, as they permit group of workers to fast identify any capacity troubles. (FDA, 2012)

CMDs are digital gadgets that file the temperature of blood and blood products in real-time. These devices provide a more accurate and reliable file of temperature than manual exams and may be used to identify any potential troubles with the cold chain early. CMDs are mainly beneficial for monitoring temperature all through storage, as they can offer a continuous report of temperature through the years. (WHO, 2017)

The use of temperature tracking gadget is crucial for ensuring that blood merchandise are stored and transported at the favored temperature. Blood series centers, blood processing centers, and transfusion offerings ought to use temperature tracking device to song the temperature of blood storage and transportation system. This includes everyday exams of the temperature of blood storage and transportation device, in addition to using temperature indicators and CMDs to track the temperature of blood and blood products at some point of their adventure. (FDA, 2016)

Temperature monitoring records ought to be recorded and reviewed regularly to become aware of any capacity issues. This consists of tracking temperature records during storage, transportation, and transfusion. Temperature data should be analyzed to discover any potential developments or styles that might suggest a hassle with the cold chain. (WHO, 2017)

The use of era, along with far flung monitoring systems and statistics loggers, also can improve temperature monitoring inside the blood cold chain. Remote monitoring structures can offer actual-time temperature tracking and indicators, permitting group of workers to quickly become aware of and address any ability troubles. Data loggers can offer a non-stop report of temperature over time, making it easier to pick out any potential issues with the cold chain. (CDC, 2016)

In end, temperature monitoring is an important factor of blood cold chain management that ensures the protection and effectiveness of blood and blood merchandise. The use of temperature tracking system, inclusive of temperature signs and CMDs, is important for tracking the temperature of blood and blood merchandise at some stage in the cold chain. Regular tracking and recording of temperature records are necessary to perceive any capacity troubles with the cold chain. The use of generation, which includes faraway tracking structures and records loggers, also can improve temperature monitoring within the blood cold chain. (WHO, 2017)

2.2.3 Cold chain storage

Cold chain storage is the process of storing blood and blood products at a constant temperature. This is essential to ensure that blood and blood products remain safe and effective for transfusion. The WHO recommends that blood be stored at a temperature of 2-6 degrees Celsius. This temperature range is known as the "cold chain" and it is essential for maintaining the safety of blood. Blood can become contaminated with bacteria or viruses, if it is not stored at the intended temperature which will lead to serious health problems for the blood recipient.

The WHO recommends that blood be stored in a clean, dry environment so as to prevent the growth of any microorganisms and to minimize the risk of contamination by pests. (WHO, 2018)

The CDC has similar recommendations to the WHO. The CDC recommends that blood be stored at a temperature of 1-6 degrees Celsius. The CDC also recommends that blood be stored in a clean, dry environment. Another important tasks recommended by both are to label all blood products with the date and time of collection, the donor's blood type and Rh factor, and the expiration date. The other is to inspect all blood products for any signs of contamination, such as leaks or cracks. Both WHO and CDC warn the use blood products that have been exposed to extreme temperatures or that has expired. (CDC, 2019)

2.2.4 Cold chain equipment

Cold chain equipment are the variety of equipment utilized to store and transport blood and blood products at a constant temperature. This is essential to ensure that blood products remain safe and effective for transfusion. (WHO, 2010).

There must be a sufficient availability of cold chain equipment in order to maintain effective cold chain management. Types of blood cold chain equipment include refrigerators, freezers, cold chain transport equipment and so on. Refrigerators are used to store blood and blood products that require a temperature of 2-6 degrees Celsius. And freezers are used to store blood and blood products that require a temperature of -18 degrees Celsius or colder. Transporting equipment is used when blood products are transported in insulated containers that maintain a constant temperature. The containers are labeled with the blood product type, the donor's blood type and Rh factor, and the expiration date. In addition to availability cold chain equipment must be regularly inspected and maintained to ensure that it is working properly. This is important to prevent blood and blood products from being exposed to unsafe temperatures. (CDC, 2012).

2.2.5 Technical capacity of personnel

The World Health Organization (WHO) and the Centers for Disease Control and Prevention (CDC) both emphasize the importance of technical capacity of personnel performing the cold chain practice. Technical capacity of personnel is one of the three major required elements for cold chain management to be efficient." This means that having well-trained and knowledgeable staff is essential for ensuring that blood products are stored and transported safely and effectively. (WHO, 2010)

The CDC also stresses the importance of technical capacity, stating that "The staff that handle and transport blood products must be trained in proper procedures." This training should cover topics such as importance of maintaining a constant temperature, proper use of cold chain equipment and identification and reporting of any problems during the cold chain process. By providing adequate training to their staff, blood transfusion services can help to ensure that blood products are safe and effective for patients.

In addition to training, personnel should also have experience working with blood products and cold chain equipment. This experience can be gained through on-the-job training or through internships or fellowships. Personnel should have a working knowledge of the principles of cold chain management. This knowledge can be gained through formal education, self-study, or on-the-job training. Personnel should have the skills necessary to properly handle and transport blood products. These skills can be gained through training, experience, and practice. (CDC, 2012).

2.3 Empirical review

2.3.1 Cold chain temperature monitoring

Temperature tracking system is essential for making sure that blood products are maintained inside the suitable temperature range during storage, transportation, and distribution. Shrestha et al. (2021) study evaluated the performance of temperature monitoring gadgets, which includes virtual statistics loggers, infrared thermometers, and temperature indicator labels, in blood banks in Nepal. The study found that virtual

information loggers have been the maximum correct and reliable temperature tracking devices for blood cold chain management.

A research done in Southwest Ethiopia exhibits one of the first reasons for holding inventory within the supply chain system is to make certain the availableness of crucial stock almost all the time. In the finding the average availability of heat sensitive pharmaceuticals in health facilities was 72.1%.The average length of period where key temperature-sensitive pharmaceuticals are out of stock indicates the capability of a system to take care of constant supply of products over time. The median stock-out duration was 23.04 days for the health facilities whereas the common stock-out duration was 29.30 days for every public medical institution in the study. The availability of key temperature-sensitive pharmaceuticals in public health facilities was not adequate. A majority of public health facilities were inefficient as temperature-sensitive pharmaceutical wastage was high. Despite most of the facilities' recording normal temperature ranges, however, a brief span of temperature recordings does not guarantee for quality of cold chain as proven by similar studies. (Feyisa et al., 2021)

Pharmaceutical companies maintain to lose hundreds of thousands because of spoilage from temperature fluctuations and potential dangers for sufferers and next regulatory actions. Pharmaceutical producers produce the bulk of biologics, which might be exceedingly sensitive to storage conditions. Temperature tracking of some pharmaceutical should be performed by means of following cold chain approaches, whether or not they may be in storage or in transit. (Shashi, 2022)

Maintaining the cold chain in unpredictable medical areas, including in remote populations or in excessive temperatures, stays as a worldwide task. Medicines fridges powered via energy from a dependable supply as a way to work for at the least eight hours per day, solar energy or gas are used and each have their benefits and drawbacks. (Krishnappa et al., 2014)

2.3.2 Cold chain storage

WHO classifies refrigerators as; electrical, solar energy and bottled gas (or kerosene) fridges. Solar fridges are highly-priced to purchase and deploy than electric powered refrigerators, but they need no running fees, aside from cleansing and preventative renovation.

WHO continually warns that domestic compression fridges and freezers need to never be used to store temperature sensitive products until they have been examined towards the applicable PQS verification protocol and located to be first-class for the placing throughout which they may be intended for use. (WHO, 2018)

A medical refrigerator differs from a domestic fridge in that it have to exert a tighter manipulate over the temperature variety. To reap this, the air inside a medicines fridge is circulated through a fan, which keeps a uniform temperature. The fan additionally rapidly returns the temperature to its premiere stage after the refrigerator door has been opened. In addition, the fridges have a virtual temperature controller, which presents the temperature on the outside of the fridge in order that the inner temperature may be intently monitored. An alarm system is constructed into the medical refrigerator in order that within the occasion of an electricity shortage, or where the temperature rises or falls out of doors of the regular variety, a visible alarm will be displayed.

The temperature managing mechanisms in domestic fridges aren't accurate to preserve the ideal temperature for medicines, such as vaccines, for the duration of emergency conditions, consisting of strength cuts lasting over one or two hours.

In addition to the usage of a medical refrigerator, the cold chain can be maintained through the use of cold boxes and vaccine carriers to transport pharmaceuticals. Validated cold chain boxes can also act as a transient storage measure in the case of mechanical failure of a medical fridge. A verified cold box is a scientific-grade cold storage device from a diagnosed clinical supply organization, which has been examined as suitable for transporting pharmaceuticals that require specific temperature range. One

research also defined the cold chain as an insulated, solid walled box with a tightly fitting lid, which continues the required temperature with ice or gel packs. (Hatchett, 2017)

The simple difference among the supply chain of non-perishable objects and the cold chain is the possibility of reduction in quality and value of the product, which start from the manufacturer's place till it is consumed. A typical cold chain infrastructure commonly includes pre-cooling facilities, storages, refrigerated carrying devices, packaging, warehouse, traceability, retailer, and consumers, underneath the aegis of facts control systems. (Joshi et al., 2009)

Proper storage is significant in keeping the purity, efficiency, protection, and effectiveness of cold chain pharmaceuticals. Cold chain storage performances at facilities were not encouraging as only slightly greater than half had ideal storage conditions. (Feyisa et al., 2021)

2.2.3 Cold chain equipment

The establishment of an adequate cold chain calls for good enough infrastructure, technology use, maintenance and adequate cold chain equipment. The cold chain is weak nearly anywhere, but weaker within the developing regions of the world. South Africa has the maximum developed infrastructure and development of cold chain in Africa, with enhanced cold storage warehouses, pre-cooling facility, and refrigerated port facilities. There has been reasonable increase in cold chain infrastructure in Morocco, Egypt and Kenya, and recently in Libya, however in all African nations there's still main room for growth and lots exceptional efforts to enhance capability education to form better technicians and to enhance applications.

Even in many regions or sites where adequate cold chain equipment is not available, overall knowledge of proper cold chain practices, maintenance (including availability of spare parts), and applications are weak in most of the developing, and it is generally worst in facilities owned or operated by government than in facilities owned or operated privately.(Yahia, 2010)

Refrigerators and freezers are the number one storage system used in the chain. A research by Mouton et al. (2021) evaluated the performance of fridge-freezer mixtures used for blood storage in South Africa. The have found that refrigerator-freezer combinations with separate temperature controls for the fridge and freezer compartments have been the most effective in retaining the favored temperature variety for blood storage.

Transport packing containers are used for transporting blood products from the collection website to the end consumer. The finding from Khanna et al. (2020) evaluated the performance of shipping packing containers utilized in blood banks in India. It observed that transport boxes with built-in temperature monitoring devices had been the only in keeping the desired temperature range for the duration of transportation.

The performance of cold chains has been hampered by large quantities of outdated equipment, which fails to provide the protective benefit of more recent designs. These previous-generation units often have poor temperature control, shorter holdover times and lack freeze protection, putting new vaccines at risk and limiting the efficiency of cold chains. (Ashok et al., 2017)

2.3.4 Technical capacity of personnel

Over the past few years it has been seen that is proper management practice, which involves good staff and their good training, as well as simple inventory management practices and collaboration across the hospital, are key to proper blood inventory management in health facilities (Yates et al., 2017)

Rapid evolution within the cold chain management approaches, operations with technological change and changing client necessities have caused the prevailing ability gaps in this region. Cold storage managers, loading supervisors and refrigerated truck drivers are the paintings profiles in these segments that want to be evolved in terms of both quality and quantity. Some areas in which existing skills are missing consist of: familiarity with contemporary equipment (reach stackers, pallet trucks and so on.), with IT systems (temperature time indicators (TTI), information-loggers, handheld), enterprise

unique stocking and handling practices for perishables, practices around safety and safety of inventory and so forth.(Joshi et al., 2009)

A Study done by Alizadeh et al. (2020) assessed the expertise and competencies of blood financial institution group of workers in Iran. The research finding located that even as the team of workers had an excellent understanding of the significance of blood cold chain management, they lacked sensible skills in temperature tracking and manage, and in responding to temperature excursions.

When we see one study with the aid of Mouton et al. (2020), it evaluated the technical potential of healthcare specialists concerned in blood transfusion practices in South Africa. The study located that at the same time as the healthcare professionals had an excellent understanding of blood transfusion practices, they lacked realistic talents in blood cold chain management, particularly in temperature monitoring and manipulate.

One study done on information and capabilities of blood bank body of workers in Iran observed that the workforce had precise theoretical knowledge however lacked sensible talents in blood cold chain control. The authors emphasized the want for more sensible schooling to enhance the technical ability of employees. Hedayati-Moghaddam et al. (2019).

The study evaluating the technical capability of healthcare professionals involved in blood transfusion practices in Ethiopia showed that healthcare specialists had a very good know-how of blood transfusion practices however lacked sensible abilities in blood cold chain control. The authors advocated providing more realistic training to enhance the technical capability of employees. Tsegaye et al. (2020)

Another survey by Osei-Bonsu et al. (2020) assessed the technical capability of blood bank staff in Ghana. The researcher discovered that whilst the group of workers had exact theoretical know-how, they lacked realistic abilities in temperature tracking and control. The authors endorsed supplying more arms-on training to improve the technical potential of personnel. Although a training was given to healthcare professionals, evidence suggested due to gaps in knowledge, attitudes, skills, and non-adherence to cold chain management practices negatively affected the cold chain management system.(Asamoah et al., 2021)

2.3.5 Challenges of cold chain management

In addition to problems directly related to the cold chain infrastructure and applications, there are several other problems related to the cold chain, which result in worsening the problem. For example, the inadequate packing and packaging systems in the developing world result in a rather inefficient cold chain even in regions of the developing world where adequate cold chain infrastructure has been developed. Inadequate packages (such as inadequate materials used, inadequate sizes and designs) make it difficult for an adequate application of the cold chain even in regions of the developing world where the cold chain infrastructure development is adequate.(Yahia, 2010)

One of the maximum enormous demanding situations in cold chain management is the shortage of good enough infrastructure in many low- and center-profits countries. This can consist of insufficient transportation systems, unreliable power supply, and inadequate storage facilities. The study by the way of Alizadeh et al. (2020) evaluated chain management practices in blood banks in Iran and found that inadequate infrastructure was a sizeable task. The conclusion highlighted the need for investment in infrastructure to improve the effectiveness of cold chain management practices.

Another great undertaking is the confined technical potential of blood bank team of workers and healthcare experts involved in cold chain management. This can include a loss of education and education in cold chain control practices and insufficient equipment preservation and calibration. An African study by Mouton et al. (2020) evaluated the technical capacity of healthcare experts worried in blood transfusion practices in South Africa and observed that restrained technical potential became an enormous project. The look at emphasized the need for practical schooling and ongoing training to enhance the technical capacity of employees.

Thermal transport, where blood products are held above acceptable temperatures, can compromise the safety and efficacy of blood products. Temperatures can fluctuate during transportation, storage or delivery, due to equipment malfunctions, power outages, or human error. A study by Khanna et al (2020) investigated cold chaining used in blood banks in India and found high temperatures to be a major challenge. The study recommended the implementation of risk management strategies to reduce the risk of heat transfer.

Complying with regulatory requirements and standards can be a challenge in many industries, especially in low- and middle-income countries. This may include lack of resources and resources for compliance, lack of awareness and understanding of regulations and procedures. The study by Osei-Bonsu et al. (2020) tried to express the technical skills of blood bank staff in Ghana and found compliance with legal requirements to be a major challenge. The review recommended continued education and training to improve compliance with regulations and guidelines.

Implementing and maintaining an effective cold chain management system can be expensive, and the cost of equipment, training, and supplies, especially for low- and middle-income countries fewer, can be a major obstacle to implementing and maintaining effective cold chain management system. A study by Tsegaye et al. (2020) investigated the technical skills of healthcare professionals involved in blood donation in Ethiopia and found cost to be a major challenge.

Ensuring traceability and duty in the course of the cold chain is vital in making sure the protection and efficacy of blood merchandise. However, inadequate information management systems and practices can pose a task in many settings.

A study by Shrestha et al. (2021) evaluated the technical potential of blood financial institution personnel in Nepal and observed that traceability and responsibility have been vast challenges. The look at advocated the implementation of effective information control systems and practices to ensure traceability and accountability for the duration of the cold chain.

Cultural and social elements can also pose a challenge in cold chain control practices. For example, in some settings, there may be a cultural preference for blood transfusion right now after donation, which can pose challenges for storage and transportation. A observe via van der Meer et al. (2019) evaluated the technical potential of healthcare specialists concerned in blood transfusion practices within the Netherlands and found that cultural and social factors have been a huge undertaking. The research recommended elevating focus and understanding of cultural and social elements to improve cold chain management practices.

Effective collaboration and coordination amongst stakeholders worried within the cold chain, including blood banks, healthcare centers, and transportation carriers, are

important in ensuring the protection and efficacy of blood products. However, inadequate conversation and coordination can pose a project in many settings, specifically in low- and center-earnings international locations. Another study in Africa by Osei-Bonsu et al. (2020) recognized verbal exchange and coordination as an enormous project in Ghana and recommended the development of effective conversation and coordination strategies.

The reliability and accuracy of temperature monitoring device can pose a task in cold chain control practices. Inadequate device preservation and calibration can result in faulty temperature readings, which could compromise the safety and efficacy of blood products. A study through Mouton et al. (2020) identified equipment protection and calibration as a vast task in South Africa and encouraged the implementation of normal gadget upkeep and calibration methods.

High personnel turnover and inadequate retention can pose a mission in cold chain control practices, especially in low- and center-income countries. A study by way of Tsegaye et al. (2020) recognized body of workers turnover and retention as a widespread undertaking in Ethiopia and recommended the improvement of effective personnel retention techniques, along with supplying competitive salaries and advantages.

Effective supply chain control practices are essential in making sure the availability and timely shipping of blood merchandise. However, inadequate deliver chain control practices can pose a task in lots of settings, mainly in low- and center-income countries. A study through Alizadeh et al. (2020) identified deliver chain control as a considerable undertaking in Iran and recommended the implementation of effective deliver chain control practices, such as stock control and demand forecasting.

Public belief also can pose an undertaking in cold chain management practices. Negative perceptions and lack of believe in blood transfusion offerings can bring about low demand for blood products that may compromise the availability and timely transport of blood merchandise. A study with the aid of van der Meer et al. (2019) recognized public perception and accept as true with as a giant mission within the Netherlands and endorsed the improvement of powerful communication strategies to enhance public belief and believe.

Risk and resilience of supply chains is increasingly gaining importance due to the high uncertainty and vulnerability related to perishable goods is it because of change in climate or to inadequacies in operations and/or in abilities. Supply chains working at low temperature to deliver perishable goods, not like the ones working at ambient temperatures, are greater susceptible or susceptible to nature disasters or environmental alternate or structures. Pre- and publish-incident impact resilience requires cautious attention in the course of the designing and configuring cold supply chains. Existing danger and resilience models require further improvement, and then checking out and validating in the context of supply chains. In international locations in which infrastructure including energy grids, roads and storage centers isn't appropriately constructed, the obstacles to the implementation of cold chains are insurmountable, as a minimum in the short term. The problems are exacerbated if the staff is inadequately equipped or trained to handle current cold chain demand. Thus, any frequent cold chain implementation framework or version will must be exceedingly customizable to cater for unique contexts and eventualities.

The success of health service delivery depends on the availability of medicines and vaccines at health facilities and the protection of their potency. The quality of cold chain commodities can only be assured by a functional cold chain system. All over the world, the importance of the cold chain is apparent to governments and key stakeholders within the health sector. However a number of factors affect cold chain systems. These include breakdown of refrigerators and freezers, delays during transportation, inappropriate refrigerators, long duration of storage at the health unit, improper use of refrigerators, power interruptions, and lack of trained personnel capable of managing the cold chain. In addition, non-uniformity in storage temperature instructions on the label, patient education and lack of awareness about cold chain management are responsible for the breakdown in the cold chain management.(Yahia, 2010)

Cold chains do not always function perfectly, and inadequate temperature maintenance can damage potency of the product. In addition, the cold chain infrastructure and facilities are limited or dated in some regions due to lack of power or fuel, etc.

furthermore, the cold chain equipment is usually expensive and the effort of cold chain monitoring is very costly.

Besides cold chain cooling systems, temperature monitoring is also essential for keeping a cold chain work efficiently. Temperature indicating materials, which change colors at temperature excursions, are important for temperature maintain because it is the way of telling whether the cooling system has worked during cold chains.(Business & Research, 2021)

With the support of local governments and development partners, CHAI's work has identified three key issues limiting cold chain performance insufficient cold chain capacity, lack of latest technology or 'optimal' equipment and inadequate temperature monitoring and maintaining system.

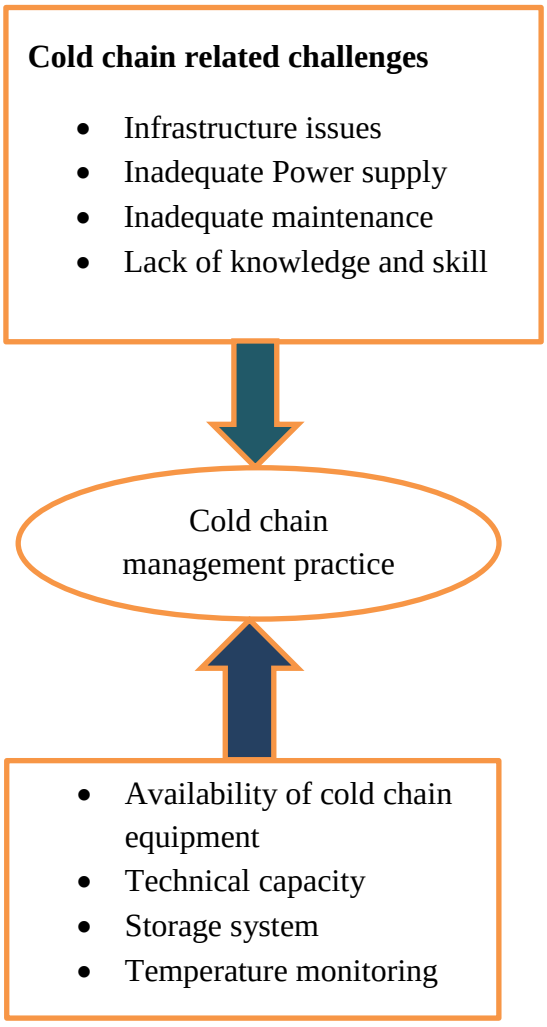
The performance of cold chains has been hampered by large quantities of outdated equipment, which fails to provide the protective benefit of more recent designs. This previous-generation equipment's often have poor temperature control, shorter holdover times and lack freeze protection, putting blood products at risk and limiting the efficiency of cold chains. (Ashok et al., 2017)

In conclusion this section tried to review different studies related to blood cold chain management practice and challenges. It assessed the practice of different countries and health setups including blood bank, clinics and hospitals in which the overall process of blood cold chain is being practiced. The review also showed the major challenges identified as a barrier to the cold chain management. These include challenges related to infrastructure, cost, technical capability, availability of cold chain equipment and also the challenges regarding blood cold chain temperature monitoring and storage.

2.4 Conceptual Frame work

As stated via CDC there are three fundamental factors which are crucial to make certain a powerful cold chain; a properly skilled group of employees, dependable storage and temperature monitoring and control systems and accurate inventory management and records. Failure in a cold chain may be high-priced. Health care providers can ensure customers obtain best quality services that have no longer been compromised via following a few easy steps and implementing CDC encouraged storage and practices. (CDC, 2019).

Figure 1 Conceptual frame work adopted from (WHO, 2018 and CDC 2019) and modified



CHAPTER THREE

RESEARCH METHODOLOGY

This chapter targets on the overall procedures of a research used in gathering relevant data in order to achieve the study objective. Research methodology consists of study area description, research approach and design, population and sampling, data analysis, and data interpretation.

3.1 Description of study area

The National Blood Transfusion Services (NBBS) was first established in 1969 G.C by the help of Ethiopian Red Cross society. Starting from 2004 it's been transferred to Federal Ministry of Health Ethiopia, and entrusted with the responsibility of coping with the Blood donors, collection, checking out and transfusion of blood and blood products in Ethiopia. Its principal center is placed in Addis Ababa and it has also the responsibility to oversee aid and display the activities of regional blood financial institution inside Ethiopia. National Blood Bank Services Office's mission is to make certain the provision of secure and adequate supply of blood and blood products to all Transfusing Health facilities in Ethiopia.

The departments of the NBBS include the following;

1. Blood donor carrier management: Responsible for mobilizing and recruiting blood donors; organizing blood collection events and amassing blood from blood donors.

2. Laboratory Department : Responsible for screening the gathered blood for transfusion transmissible infections (HIV,HBV,HCV and syphilis);perform blood typing; prepare blood additives(focused crimson cells, fresh frozen plasma, platelets and cryoprecipitate) and distribute secure blood for health establishments. The laboratory department has infectious screening and issue practice case teams.

3. Quality control and safety: The primary challenge of this unit is to oversee the activities carried out through the distinctive departments of the blood bank.

4. Human useful resource and General services: Has the duty to recruit and lease the necessary team of workers for the blood financial institution in keeping with the permitted shape through the civil carrier

5. Marketing and communication department: This unit is set up to coordinate the practice of promotional and educational substances to sell voluntary blood donation in the territory.

6. Data control: Responsible for recording of donor data and all of the records that result all through the gathering, processing and distribution of blood and blood products.

7. Pharmaceutical logistics procurement unit: This unit handles the procurement of supplies, reagents and check kits required by facility. Also controls the correct usage of reagents and kits in the process of working.

3.2 Research Approach

A mixed research approach was used in the study. Quantitative approach was used for capturing those variables in a descriptive manner quantitatively while qualitative approach was used to capture and narrate different types of cold chain management practice challenges.

3.3 Research Design

Descriptive cross sectional study (A facility based) design was used for the research conducted at National Blood Bank Service Addis Ababa, Ethiopia.

3.4 Population and Sampling

3.4.1 Target Population

The target population of the study was all health professionals responsible for cold chain management practice at National Blood Bank Service.

3.4.2 Sampling

There are 127 health professionals responsible for the cold management practice at NBBS. The sampling technique was census that included all 127 health professionals.

3.5 Sources of data

The research used a primary data source that included National Blood Bank Service health professional staffs. The study data was collected from April 15, 2023 to April 29, 2023.

3.6 Data Collection Procedures

A five point likert scale questionnaire was used for data collection. The research instrument was designed clearly which is free from any ambiguity to address the specified objectives of the study. Prior to starting data collection all the selected participants were communicated for their consent.

3.7 Data analysis methods

The research data that was gathered from NBBS was analyzed based on the study objective. To make sure completeness and consistency of the responses, editing and coding was performed by the researcher. Finally, by the using SPSS version 26 the data that was collected through research instrument was analyzed quantitatively. The researcher analyzed socio demographic characteristic of participants by using frequency, and also conducted descriptive statistics for availability of cold chain equipment, technical capacity, and cold chain management practice and its related challenges. From the total score by the respondents for availability of cold chain equipment a score greater than 66.6% was considered as adequate availability. This is supported by a study conducted by Teka et al. (2016) and Mohammed et al. (2017). Technical capacity cut point score was 54.5%.Where a total score above 54.5% considered as capable. The cut point used is adopted from a study done by Abebe et al. (2017) and Afolabi et al. (2017). Regarding cold chain management practice score above 75% was taken as a good cold chain practice which is taken from a study conducted by Tumwine et al. (2023) and Kebede et al. (2019). In addition to the above regression analysis was performed to investigate the relationship between variables.

3.8. Validity and reliability

The data collection tools were piloted on some of the study participants to make sure the validity of the instrument by checking the validity, clarity, ambiguity, and readability of the questionnaire. A data collector was trained on the data collection instruments and

processes and the investigator supervised all the data collection process. To secure data quality, the date collection were carried out by trained health personnel.

Completed questionnaires were examined for any gaps in completeness and consistency during the process.

3.9 Research Ethics

Approval to conduct this study was obtained from Addis Ababa University, School of Commerce Ethical review committee. Discussions were held about the purpose of the study to secure permission from the facility management before starting data collection. In addition, verbal consent was obtained from the respondents. Before study participants was requested for consent they were informed in detail about the purpose and procedures of the study, the content of the questionnaire, its benefit, confidentiality of the information collected from them, the voluntary nature of participation and their right not to respond to questions if they do not want to answer as well as to stop answering and withdraw from the interview at any time.

CHAPTER FOUR

RESULTS, DISCUSSION AND INTERPRETATION

Introduction

This section presents the findings of the study and provides a detailed analysis of the data collected from the research. It starts with analysis of the data according to the research questions listed in the study.

Response rate

All the 127 health professionals responsible of cold chain management practice have agreed to participate in the study and all of them were involved. Therefore, the response rate in the study was 100%.

4.1 Socio demographic characteristics of study participants

Table 1 Socio demographic characteristics

Characteristics (n=127)		
Gender	Frequency	Percent
Male	72	56.7
Female	55	43.3
Age		
21-30 years	46	36.2
31-40 years	38	29.9
41-50 years	30	23.6
51-60 years	13	10.2
Educational qualification		
Diploma	18	14.2
Degree	85	66.9
Masters and above	24	18.9
Year of experience		
1-5	38	29.9
6-10	36	28.3

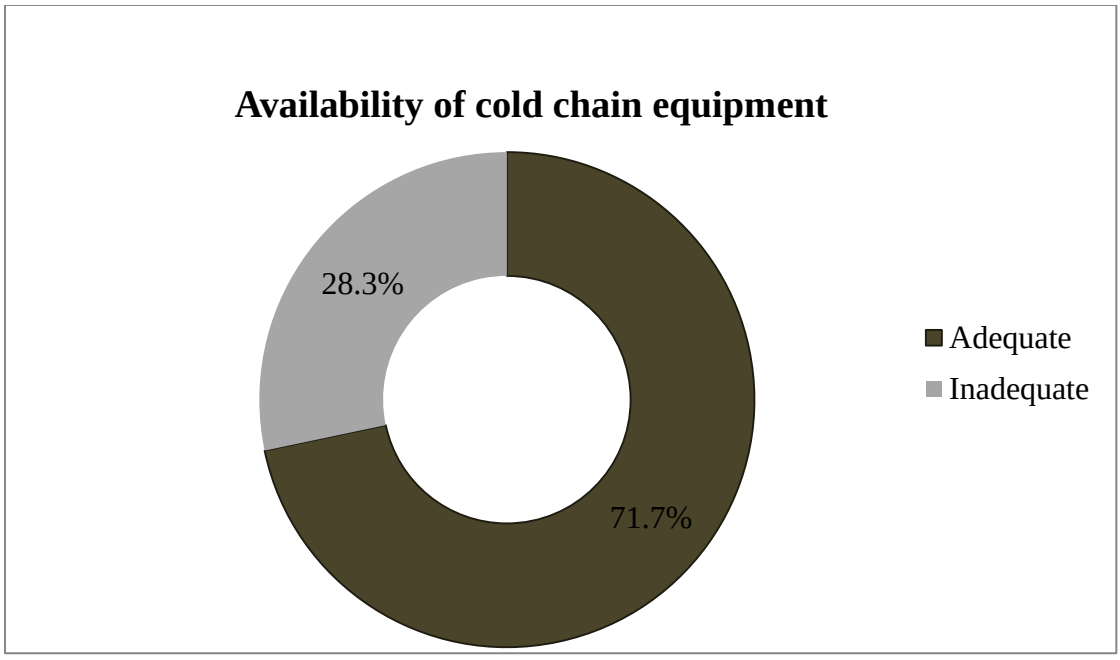
11-15	27	21.3
16-20	26	20.5
Profession		
Nurse	51	40.2
Laboratory	34	26.8
Pharmacy	22	17.3
Health officer	20	15.7

Data Source: Survey Result, 2023

As showed on the table for socio demographic characteristics more than half of the participants were male participants. The mean age of the study participants were 35.67(Std. Deviation ± 8.727). Out of 127 respondents in this study almost two third (66.9%) of the participants were Bachelor degree holders. The average year of work experience at National Blood Bank Service was 9.17 years (Std. Deviation ± 5.7). Coming to their profession the majority of the total respondents were nurse professional and the least were pharmacy professionals.

4.2 Availability of cold chain equipment

Figure 2 Availability of cold chain equipment



Data Source: Survey Result, 2023

As seen in the diagram above almost two third (71.7%) of the participants responded that there is an adequate availability cold chain equipment at National Blood Bank Service. The remaining participants of the study (23.3%) responded with in adequate availability of cold chain equipment at the facility.

Discussion on availability of cold chain equipment

One of the basic elements of cold chain practice includes availability of adequate cold chain equipment to achieve effective cold chain management. The World Health Organization (WHO) has established guidelines on the quality, safety, and efficacy of blood products, which includes recommendations on cold chain management. In the guidelines on the storage and transportation of blood products, it is stated that "the availability of suitable equipment is essential to maintain the cold chain" (WHO, 2017, p. 20).

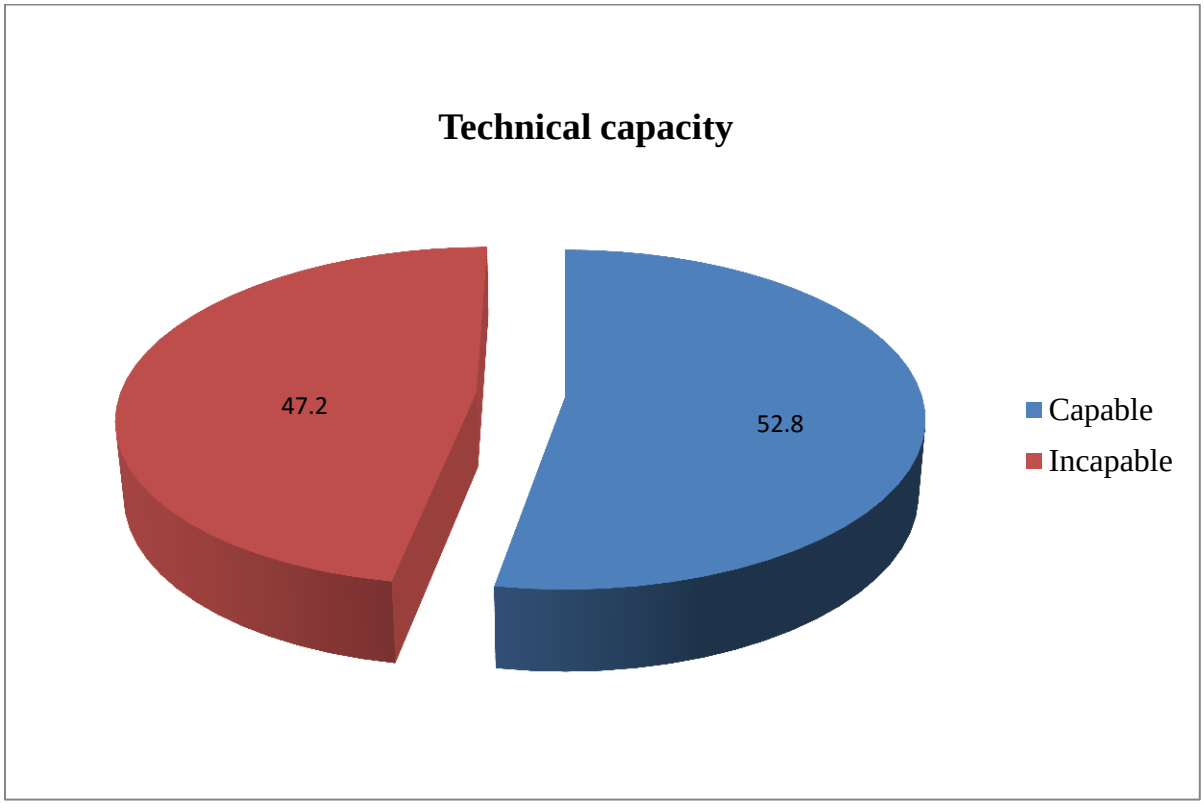
The result from this study that almost 72% of participants reported adequate availability of cold chain equipment at National Blood Bank Service is not relaxing and highlights the need for improvement in cold chain management practices .This is because any blood bank facility should be well equipped to efficiently practice the overall cold chain practice. This result finding is better as compared to a study conducted in Ghana where only 10% of blood banks surveyed had adequate cold chain equipment. The study also revealed that lack of equipment was a major challenge in maintaining the cold chain. (Ansong et al., 2017).

Another study conducted in Nepal found that the majority of blood banks surveyed did not have adequate temperature monitoring devices, and that this was a major barrier to maintaining the cold chain. (Gyawali et al., 2017). Similarly a study conducted in Malaysia found that the majority of blood banks surveyed had adequate refrigeration facilities and temperature monitoring devices, although there were still some challenges in maintaining the cold chain. (Yusof et al., 2013). The same is true in India where one study revealed that the availability of temperature monitoring devices was inadequate in most blood banks. Bhanwra S et al., (2019).

A study from Kenya also showed that a lack of proper cold chain equipment were one of the major challenges in maintaining an effective cold chain. Maina M et al., (2013). Overall, the findings from this study, along with other studies, suggest that there is a demand for improvement in adequate cold chain equipment availability at blood banks.

4.3 Technical capacity

Figure 3 Technical capacity of personnel



Data Source: Survey Result, 2023

Regarding technical capacity of the personnel, greater than half of the study participants (52.8%) responded that personnel working at National Blood Bank Service are technically capable.

Discussion on technical capacity

Apart from availability of adequate cold chain equipment there must be a trained personnel capable of handling any tasks regarding the cold chain management practice.

According to the WHO's "Guidelines on the Clinical Use of Blood" (2010), blood transfusion services should have a quality management system in place to ensure that staff are appropriately trained and competent in their roles. In this study it is revealed that 52.8% of respondents believe that personnel working at National Blood Bank Service are technically capable.

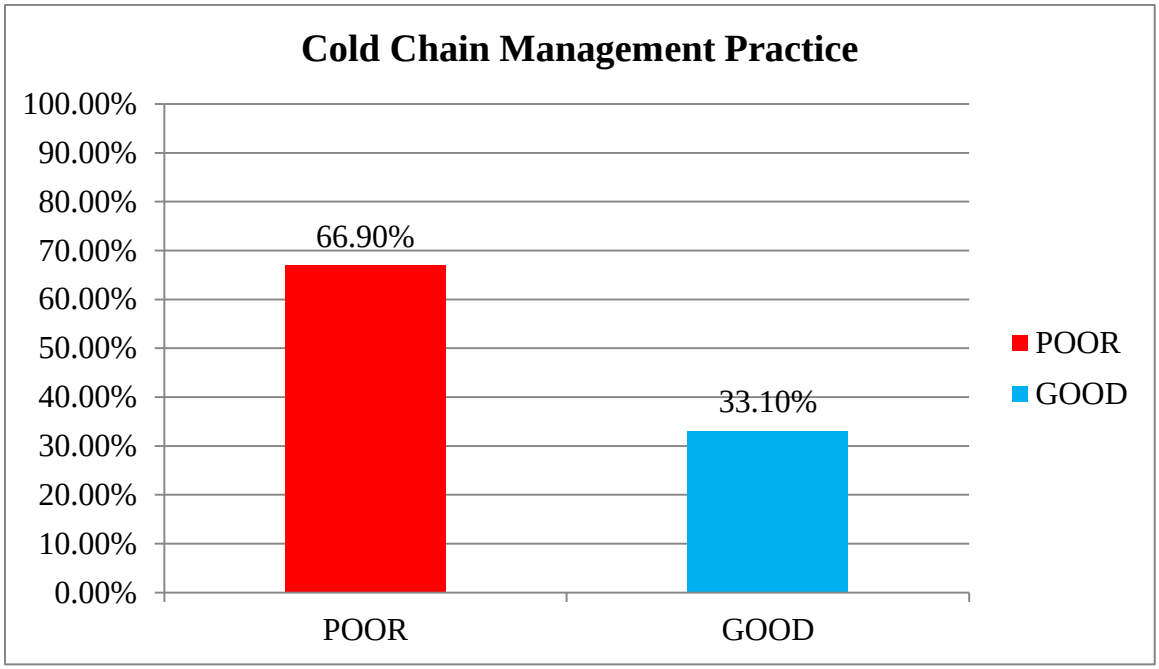
A study conducted in Ghana found that many blood bank personnel lacked knowledge on important technical aspects, such as cold chain management and quality control. The recommendation from the study result suggests that staff training programs should be implemented to improve technical competence and ensure the safety of transfused blood products. Asamoah-Akuoko et al., (2018).

Another study in India revealed that only 34% of blood bank personnel had received proper training in blood banking. The study identified a lack of technical competence among staff as a major challenge faced by blood banks in India. Chatterjee et al., (2017)

In summary, this study shows that greater numbers of staffs responsible for cold chain equipment are technically capable. But there is a lot of rooms for improvement as near half of the staffs are technically incapable of handling the required standard procedures and operations at National Blood Bank Services. This needs to be addressed through regular training programs. Inadequate training and knowledge on technical aspects such as cold chain management, quality control and blood transfusion practices have been identified as major factors contributing to technical incapability among staff by the above related studies.

4.4 Cold chain manage practice

Figure 4 cold chain management practice



Data Source: Survey Result, 2023

The overall cold chain management practice was reported to be poor practice by majority (66.9%) of the respondents as seen above on the chart.

Discussion on cold chain management practice

The practice of cold chain involves of different tasks which include temperature monitoring, proper storage and efficient management procedures. It is one of an important indicator for successful performance of the National Blood Bank Service. Monitoring and recording the temperature of blood products throughout the supply chain is very essential. Monitoring a temperature will help identify any problems with the cold chain equipment and procedures. The WHO recommends blood banks to have a functional cold chain system that includes reliable refrigerators, temperature monitoring devices, trained personnel, and appropriate procedures for handling and storing blood and blood products. WHO (2010).

When we see finding of this research, the overall cold chain management practice was reported to be poor practice by majority of the respondents in blood banks is consistent with WHO's emphasis on the need for improvement in cold chain management practices to ensure the safety and efficacy of blood and blood products.

A study done in Nigeria found that blood transfusion services had poor cold chain management practices, with inadequate monitoring of temperatures and lack of backup systems in case of power failures. (Ikefuna et al., 2017). Another survey of blood banks in Pakistan reported there were gaps in standard operating procedures related to cold chain management practice. (Ali et al., 2017)

Similar study in Ghana reveals that although blood banks had cold chain equipment, there were challenges in maintaining and monitoring the equipment, and that there was a need for improved training to ensure effective cold chain management. (Owusu-Ofori et al., 2016)

Another study conducted in India found that 58% of blood banks in India had at least one deficiency in their cold chain management practices. The major obstacles were related to the maintaining constant temperature during transportation and storage, and the availability of backup power. ISBTI. (2016)

4.5 Challenges of cold chain management

The study finding revealed to different challenges related to the cold chin management practice which are described as follows.

4.5.1 Challenges related to Transportation

Table 2 Challenges related to transportation

Challenges related to transportation	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Mean	Std. Deviation
Maintaining the required temperature during transportation	3.9%	14.2%	17.3%	47.2%	17.3%	3.60	1.056
Ensuring proper disposal of blood products during transportation	7.9%	14.2%	13.4%	61.4%	3.1%	3.38	1.031
Acquiring vehicles suitable for maintaining cold chain during transportation	11.0%	11.0%	18.9%	49.6%	9.4%	3.35	1.145

Data Source: Survey Result, 2023

The table reveals that a greater number of respondents (60 or 47.2%) agree that the blood bank faces challenges in maintaining the required temperature during transportation. This is followed by 22 respondents (17.3%) who strongly agree with this statement. Only 5 of the total respondents (3.9%) strongly disagree with this statement.

The table also illustrates that the blood bank faces challenges in ensuring proper disposal of blood products during transportation with a majority of respondents (78 or 61.4%) agreeing with this statement. Only few of the respondents 4 (3.1%) strongly disagree with this statement.

The table also explains that from the total number of respondents (63 or 49.6%) agree that the blood bank faces challenges in acquiring vehicles suitable for maintaining the cold chain during transportation which is followed by 12 respondents (9.4%) who strongly agree with this statement. Only 14 respondents (11.0%) strongly disagree with this statement.

Discussion on challenges related to transportation

One of the primary major challenges in the cold chain management practice is the issue in transportation of temperature sensitive products. Especially in developing countries where major infrastructure including electricity, roads and storage facilities is not well organized, it makes it mandatory to acquire suitable vehicles typically designed to transport blood products. As revealed in this study, there are challenges related where most of the respondents agree. These are challenges in maintaining the required temperature during transportation, ensuring proper disposal of blood products during transportation and acquiring vehicles suitable for maintaining cold chain during transportation.

This study finding is the same with other related studies. A study in India also found that there were major challenges related to transportation due to temperature fluctuations, mishandling and improper packaging during transportation of blood products. (IITB, 2017). The study from United States found that the main challenges in transporting blood products were maintaining the cold chain throughout the transportation process especially in hot climates. The study also revealed a challenge which was contamination of blood products during transportation especially when blood products are being transported over long distances. AABB. (2018).

4.5.2 Challenges related to knowledge and skill of personnel

Table 3 Challenges related to knowledge and skill of personnel

Challenge	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Mean	Std. Deviation
Limited availability of personnel with cold chain management training	15 (11.8%)	19 (15.0%)	18 (14.2%)	27 (21.3 %)	48 (37.8%)	3.58	1.422
There are not enough personnel trained to practice cold chain management effectively	19 (15.0%)	15 (11.8%)	18 (14.2%)	32 (25.2 %)	43 (33.9%)	3.51	1.411
The blood bank faces challenges due to lack of technical know-how to practice cold chain management.	43 (33.9%)	15 (11.8%)	8 (6.3%)	52 (40.9 %)	9 (7.1%)	2.76	1.457
The blood bank has no system in place to ensure that all staff is trained in cold chain management practices.	20 (15.7%)	18 (14.2%)	23 (18.1%)	44 (34.6 %)	22 (17.3%)	3.24	1.330

Data Source: Survey Result, 2023

As observed on the table above on the question regarding challenges related to staff training most (37.8%) of the respondents strongly agree on the statement that states there is limited availability of personnel with cold chain management training. Out of the total respondents only 11.8% of the participants strongly disagree with this statement. The table also tries explaining that highest number of respondents (33.9%) strongly agree that there are not enough personnel trained to practice cold chain management effectively.

On the contrary (15.0%) respondents strongly disagree and (11.8%) study participants disagree with this statement. At last the table tries to show that most (34.6%)of the respondents agree on the statement that states the blood bank has no system in place to ensure that all staff is trained in cold chain management practices. And only few of the respondents (15.7%) strongly disagree with the above statement.

Discussion on knowledge and skill of personnel

One of the requirements to achieve effective cold chain practice is adequate availability of well trained personnel. But according to this study most of the study respondents revealed that there is a challenge in inadequate availability of trained personnel, lack of technical know-how to practice cold chain management and also unavailability of system in place to ensure that all staff is trained in cold chain management practices.

In a 2014 report, the WHO found that only 50% of blood banks in developing countries have staffs that are adequately trained in cold chain management. This lack of adequate training can lead to errors in the handling, transportation and storage of blood, which can compromise the overall safety and quality of the blood supply. (WHO 2014).

From the finding in the present study, it seems that there are significant challenges related to staff training in cold chain management practices. The greater numbers of respondents strongly agree that there is a limited availability of personnel with cold chain management training at NBBS and that there are not enough personnel trained to practice cold chain management effectively. The finding from study at NBBS is not different as compared with previous literature conducted in India that has identified a shortage of trained personnel as a significant challenge to maintaining effective cold chain management practice (Kumar et al., 2014).

Additionally, the finding that most respondents agree that the blood bank has no system in place to ensure that all staff is trained in cold chain management practices is also consistent with previous literature. The study identified barriers to effective cold chain management in previous studies due to the lack of institutional support and inadequate training programs have been identified as (Haidara et al., 2017).

4.5.3 Challenges related to budget, infrastructure and technology use

Table 4 Challenges related to Budget infrastructure and technology use

Challenge	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Mean	Std. Deviation
The blood bank doesn't have a system in place to monitor cold chain management costs.	20 (15.7%)	18 (14.2%)	23 (18.1%)	44 (34.6%)	22 (17.3%)	3.39	1.476
The blood bank doesn't prioritize cold chain management expenditures in its budget allocation.	20 (15.7%)	14 (11.0%)	23 (18.1%)	51 (40.2%)	19 (15.0%)	3.28	1.295
The blood bank has no process of identifying and eliminating unnecessary cold chain management expenses.	15 (11.8%)	18 (14.2%)	23 (18.1%)	47 (37.0%)	24 (18.9%)	3.37	1.271
The blood bank uses an outdated technology or below standard cold chain equipment	20 (15.7%)	23 (18.1%)	14 (11.0%)	58 (45.7%)	12 (9.4%)	3.15	1.279
The blood bank has inadequate resources to invest in the necessary equipment, infrastructure, and technology to maintain the appropriate temperature range for	5 (3.9%)	18 (14.2%)	13 (10.2%)	65 (51.2%)	26 (20.5%)	3.70	1.071

blood products							
The blood bank is facing a challenge due to lack of suitable infrastructure to maintain the appropriate temperature range for blood products.	10 (7.9%)	23 (18.1%)	21 (16.5%)	63 (49.6%)	10 (7.9%)	3.31	1.103

Data Source: Survey Result, 2023

As seen on the table above, majority of respondents (34.6%) agree that the blood bank does not have a system in place to monitor cold chain management costs, while 17.3% strongly agree. It is also shown that a most of the respondents (40.2%) agree that the blood bank does not prioritize cold chain management expenditures in its budget allocation, while 15% strongly agree with this statement. For the statement that states the blood bank has no process of identifying and eliminating unnecessary cold chain management expenses, 47 respondents (37%) agree and only 15 respondents (11.8%) strongly disagree with the statement.

As stated on the table, near half of the study participants (45.7%) agree that the blood bank uses an outdated technology or below standard cold chain equipment. On the contrary only few 15.7%) of the respondents strongly disagree with this statement. In this study (51.2%) the respondents agree with the statement that the NBBS has insufficient resources to invest in the necessary equipment, infrastructure, and technology to maintain the appropriate temperature range for blood products. Only few 5 respondents (3.9%) strongly disagree with the statement. Near half of the respondents (49.6%) agree that the NBBS is facing a challenge due to lack of suitable infrastructure to maintain the appropriate temperature range for blood products. On the other way (18.1%) respondents disagree with this statement while only few (7.9%) strongly disagree.

Discussion on challenges related to infrastructure

Facilities must allocate adequate budget and improve infrastructures to effectively manage the overall cold chain management practice. In this study the challenges related to budget, infrastructure and technology use were raised significantly. Other studies also reveal similar findings. Based on the study review by Khatib, M., & Jamali, R. (2018) the lack of resources, inadequate infrastructure, and poor training were among the major barriers facing healthcare facilities in implementing an effective cold chain management practices.

American Society of Hematology (ASH) in 2019 also reported and highlighted the major challenges facing blood banks that hinder the proper implementation of an effective cold chain management practices. The report noted that limited budget allocation and inadequate infrastructure were among the major challenges facing blood banks in ensuring proper temperature control and storage of blood products.

Another study conducted in India discussed the challenges facing blood banks in implementing effective cold chain management practices. The study reveals that limited funding was a major barrier to implementing proper temperature monitoring and equipment maintenance practices. The study emphasized the need for proper budget allocation to ensure adequate resources for cold chain management. Choudhury, N., et al 2017.

Overall, these and other studies and resources emphasize the importance of adequate budget allocation, infrastructure design and maintenance, and technology use in implementing effective cold chain management practices in healthcare facilities, including blood banks. The findings of this study presented regarding challenges related to budget, infrastructure, and technology use highlights the need for improved practices and resources to ensure the safety and efficacy of blood products.

4.5.4 Challenges related to power supply

Table 5 Challenges related to power supply

Challenge	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Mean	Std. Deviation
The blood bank has no contingency plan in place for power outages	9 (7.1%)	25 (19.7%)	12 (9.4%)	68 (53.5%)	13 (10.2%)	3.40	1.129
The blood bank doesn't conduct regular checks on its backup power supply	27 (21.3%)	5 (3.9%)	65 (51.2%)	30 (23.6%)	27 (21.3%)	3.77	1.040
The blood bank has no plan to ensure uninterrupted power supply for critical areas such as blood storage areas	23 (18.1%)	27 (21.3%)	47 (37.0%)	30 (23.6%)	23 (18.1%)	3.66	1.033

Data Source: Survey Result, 2023

As observed on the table above, the majority of respondents (53.5%) agree that the blood bank has no contingency plan in place for power outages, while 10.2% strongly agree. The table also shows that a most of respondents (51.2%) agree that the blood bank does not conduct regular checks on its backup power supply, while (21.3%) strongly agree. Finally, the table shows that a majority of respondents (23.6%) agree with the statement that the National Blood Bank Service has no plan to assure uninterrupted power supply for critical areas such as blood storage areas, while 18.1% strongly agree.

Discussion on challenges related to power supply

The other challenge especially in developing countries is a sustainable power supply for different operations. As illustrated in the finding of this study, all challenges related to power supply were observed. These were lack of contingency plan in case of power outages, no regular check up on backup power supply and lack of planning to maintain uninterrupted power supply. This is similar with a survey study conducted by Gupta and Singh that revealed 60% of cold chain facilities surveyed did not have a contingency plan in place for power outages. The study also found that 50% of facilities did not conduct regular checks on their backup power supply. The study also found that 60% of companies had not been able to maintain uninterrupted power supply for critical areas such as vaccine storage. These studies suggest that the challenges related to power supply are a common problem in cold chain management. The lack of a contingency plan for power outages, the lack of regular checks on backup power supply, and the lack of planning to maintain uninterrupted power supply can all lead to the loss of temperature-sensitive medical products like blood.

4.5.5 Challenges related to maintenance

Table 6 Challenges related to maintenance

Challenges	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Mean	Std. Deviation
The blood bank has a no regular maintenance schedule for its cold chain equipment.	9 (7.1%)	14 (11.0%)	8 (6.3%)	87 (68.5%)	9 (7.1%)	3.57	1.020
The blood bank has no system in place to quickly repair or replace cold chain equipment that is not functioning properly.	8 (6.3%)	24 (18.9%)	4 (3.1%)	69 (54.3%)	22 (17.3%)	3.57	1.165

Data Source: Survey Result, 2023

As shown on the table the majority of respondents (87%) agree that the blood bank has no regular maintenance schedule for its cold chain equipment, while 9% strongly agree. As observed on the table most of respondents (54.3%) agree that the blood bank has a system in place to quickly repair or replace cold chain equipment that is not functioning properly, while 22% strongly agree.

Discussion on challenges related to Maintenance

To maintain a sustainable cold chain management practices every facility should be able to have a regular maintenance schedule and quick repairs of cold chain equipment in place. But as seen on the result in this study the National Blood Bank Service is facing all the challenges related to maintenance. The findings from this study are consistent with the findings of other studies on blood cold chain management. A study review conducted in 10 countries in Africa, Asia, and Latin America revealed that a lack of regular maintenance is a major challenge to blood cold chain management in developing countries. The study finding revealed that a lack of regular maintenance of cold chain equipment can lead to cold chain break down, which can disrupt the supply of blood to hospitals and lead to shortages of blood products. Another study in from Spain showed that a lack of a system in place to quickly repair or replace cold chain equipment is also a major challenge to blood cold chain management. The study found that delays in repairing or replacing equipment can lead to blood being stored at incorrect temperatures and becoming unusable.

Overall all challenges related to cold chain management practice were present at NBBS. According to the score from the respondents the challenges are ranked as follows. The first major challenge was power supply related followed by the second that is maintenance related. The third ranked challenge was transportation related followed by the fourth that is the challenge related to budget, infrastructure and technology use. Last but not least, the challenge observed was related to knowledge and skill of personnel working at National Blood Bank Service.

Table 7 Association between Variables

Variables	Categories	Cold-chain management practice		COR (95% CI)	AOR (95% CI)
		Poor	Good		
Field of profession	Nurse	36	15	7.917 (0.970-64.594)	**14.274 (2.732-74.290)**
	Laboratory professional	18	16	**16.889 (2.026-140.759)***	**15.778 (13.793-180.500)***
	Pharmacy professional	12	10	**15.833 (1.792-139.922)***	**15.4087 (9.513-24.958)***
	Health officer	19	1	1	1
Availability score	Adequate	77	14	**0.052 (0.020-0.137)***	**0.004 (0.001-0.066)***
	Inadequate	8	28	1	1
Technical capacity score	Capable	62	5	**0.050 (0.018-0.143)***	**0.043 (0.006-0.331)***
	Incapable	23	37	1	1

Data Source: Survey Result, 2023

The table shows that there is a statistically significant association between several variables and cold-chain management practice. For example, nurses, laboratory professionals, and pharmacy professionals are more likely to practice poor cold-chain management as compared to health officers. Additionally, individuals with less experience and/or lower educational qualifications are more likely associated to poor cold-chain management practices. Finally, inadequate cold-chain equipment availability and technical incapability of personnel are more likely associated with poor cold-chain management practices.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Summary of major findings

The socio demographic from the finding shows the respondents were educated health professionals with 9 years of experience in average working at NBBS.

Based on the finding, the majority (71.7%) of the study participants responded that there is adequate availability cold chain equipment at the facility. The study also assessed the technical capacity of personnel where more than half of the study participants (52.8%) responded that personnel working at the NBBS are technically capable. In addition the study also assessed the overall cold chain management practice which was reported poor by the majority 66.9% of the respondents. Although all the cold chain related challenges were present, the study result showed that challenges related to power supply was the first major challenge followed by maintenance problems and transportation related challenges respectively.

5.2 Conclusion

The blood cold chain is a critical component of the blood supply system. It is the system of maintaining the temperature of blood and blood products at a specific level throughout the supply chain, from donation to transfusion. This includes collection, processing, storage, and transportation. The blood cold chain is essential to ensure the safety and availability of blood for patients who need it. But it is a difficult task to achieve the goal of cold chain practice without well-trained and capable personnel who properly manage cold chain equipment guided by specified procedures. Apart from this, there are a lot of challenges both internal and external to achieve an effective cold chain practice throughout the whole process.

From this study at National Blood Bank Service, a number of major challenges were identified. The overall cold chain management practice at NBBS was poor according to the majority (66.9%) of the respondents 66.9% in the study. In the study all challenges related to cold chain management were assessed. While all the challenges were present and affected the NBBS performance, the major challenge observed was the challenge related to power supply followed by Maintenance and transportation challenges, infrastructure, budget and technology use last but not least challenges related to knowledge and skill of staff or personnel respectively.

5.3 Recommendations

There are a number of things that the National Blood Bank Service must do to address the challenges that have impacted the overall cold chain management practice. These include acquiring adequate cold chain equipment in order to keep blood products at a safe temperature. These equipment can be purchased through grants or loans from international organizations. The other recommendation will be investing in reliable power supplies.

The facility should invest in reliable power supplies in order to prevent problems with keeping blood products at a safe temperature during power outages. This can be done by installing a reliable and efficient backup generators or solar panels. The other thing to consider will be providing an up-to-date training for staff. Blood banks should provide training for staff in cold chain management in order to ensure that blood products are kept safe. This training should cover topics such as cold chain management, proper storage, handling, and transportation of blood products.

The blood bank should also implement quality control measures in order to identify and correct problems with cold chain management. This can be done by conducting regular audits and inspections. Apart from this the National Blood Bank Service should develop and implement standardized procedures for the storage, handling, and transportation of blood products. This will help to ensure that all staff is following the same procedures and that blood products are always kept at a safe temperature. In addition the facility

should use technology to improve the cold chain management process. For example, they can use temperature monitoring devices to track the temperature of blood products throughout their journey. They can also use mobile apps to help staff to manage the cold chain process.

Last but not least National Blood Bank Service must collaborate and work with partners, such as government agencies, international organizations, and other healthcare providers, to share best practices and resources.

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Annexes

Appendix 1: Consent Form

ADDIS ABABA UNIVERSITY SCHOOL OF COMMERCE DEPARTMENT OF LOGISTICS AND SUPPLY CHAIN MANAGEMENT

My name is Dagmawi Abate. I am conducting a research on the Cold Chain Management Practices and Challenges in the case of National Blood Bank Service to partially fulfill for Master's Degree in Logistics and Supply Chain Management in Addis Ababa University, School of Commerce. The data that will be gathered for this research project will be kept private. By participating in this research you will contribute towards solving the major problems of cold management of blood products in the facility. If you have any query you can contact the researcher at any time.

Dagmawi Abate, Addis Ababa University

Tel: +251912374930

Email: dagmawiabate@yahoo.com

Name _____ Signature Date _____

Appendix 2: Research Instrument

Part I: General Information and Demographic background of respondents

Please mark ✓ for your appropriate choice.

1. Gender: Male ☐ Female ☐

2. Age……

3. Educational qualification

- ☐ Diploma
- ☐ Degree
- ☐ Masters
- ☐ PhD

Others (specify) ----------

4. How long have you worked in the organization? ----------

5. Professional in charge of facility cold chain management

- ☐ Nurse
- ☐ Laboratory professional
- ☐ Pharmacist/Druggist
- ☐ Laboratory

Others (specify) ----------

Part II: Cold Chain Management Practice and Challenges Assessment

This section of the questionnaire is designed to obtain information about your level of agreement with the assessment of cold chain management practice and challenges.

- ❖ Please indicate ✓ to what extent you agree on the following statements under each category using **Five-point Likert scale** as given below.

A. Availability of cold chain equipment						
No.	**1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree**	**1**	**2**	**3**	**4**	**5**
A1	The blood bank has adequate cold chain storage equipment.	◯	◯	◯	◯	◯
A2	The blood bank has adequate transportation equipment to maintain the cold chain.	◯	◯	◯	◯	◯
A3	The cold chain storage equipment is regularly maintained to ensure proper temperature control.	◯	◯	◯	◯	◯
A4	The transportation equipment is regularly maintained to ensure proper temperature control.	◯	◯	◯	◯	◯
A5	The blood bank has a backup power supply for the cold chain equipment.	◯	◯	◯	◯	◯
A6	The cold chain storage equipment has sufficient space to store blood products.	◯	◯	◯	◯	◯
A7	The transportation equipment has adequate space to transport blood products.	◯	◯	◯	◯	◯
A8	The cold chain storage equipment has a backup temperature monitoring system.	◯	◯	◯	◯	◯
A9	The transportation equipment has a backup temperature monitoring system.	◯	◯	◯	◯	◯
A10	The cold chain storage equipment is easily accessible for maintenance.	◯	◯	◯	◯	◯
A11	The blood bank has a WHO standard refrigerator for	◯	◯	◯	◯	◯

	cold chain.					
A12	The blood bank has an alternative storage in case of refrigerator breakdown	◯	◯	◯	◯	◯
B. Technical Capacity of Personnel						
No.	**1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree**	**1**	**2**	**3**	**4**	**5**
B1	The blood bank staff strictly follows the SOPs of the facility.	◯	◯	◯	◯	◯
B2	The blood bank staff is able to handle maintenance of cold chain equipment during failure	◯	◯	◯	◯	◯
B3	The blood bank staff is familiar with the different types of blood cold chain equipment	◯	◯	◯	◯	◯
B4	The blood bank staff is well trained to monitor temperature during storage and transportation.	◯	◯	◯	◯	◯
B5	The blood bank staff is fully capable to respond to temperature excursions.	◯	◯	◯	◯	◯
B6	The blood bank regularly conducts cold chain management training for staff.	◯	◯	◯	◯	◯
B7	The blood bank staff follows all safety procedures when working with blood cold chain equipment.	◯	◯	◯	◯	◯
B8	The blood bank staff is capable to identify and respond to potential risks to the blood cold chain system.	◯	◯	◯	◯	◯
B9	The blood bank staff practices FEFO (First Expire First Out) principle.	◯	◯	◯	◯	◯
B10	The blood bank staff is aware of the latest blood cold chain technologies and practices	◯	◯	◯	◯	◯
B11	The blood bank staff is able to maintain the highest standards of safety and quality in the blood cold chain system.	◯	◯	◯	◯	◯
C. Cold Chain Management Practices						

No.	1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree	1	2	3	4	5
C1	The blood bank has a system to take a corrective action when the temperature of blood falls outside of the acceptable range.	◯	◯	◯	◯	◯
C2	The blood bank uses the appropriate device to monitor the temperature of blood.	◯	◯	◯	◯	◯
C3	The blood bank has a system in place to monitor temperature during storage and transportation.	◯	◯	◯	◯	◯
C4	The blood bank has a system in place to respond to temperature excursions.	◯	◯	◯	◯	◯
C5	The facility has sufficient capacity for storage of blood.	◯	◯	◯	◯	◯
C6	The blood bank has a system in place to inspect cold chain storage equipment regularly.	◯	◯	◯	◯	◯
C7	The blood bank has a system in place to ensure that blood products are not exposed to direct sunlight or heat.	◯	◯	◯	◯	◯
C8	The blood bank has a clean storage area of blood that is free from any contamination.	◯	◯	◯	◯	◯
C9	The blood bank has a well-established SOP for cold chain management practice.	◯	◯	◯	◯	◯
C10	The blood bank has a system in place to document cold chain management practices.	◯	◯	◯	◯	◯
C11	The blood bank practices FEFO(first expiry first out) management.	◯	◯	◯	◯	◯
C12	The blood bank perform a regular audit to evaluate the effectiveness of a cold chain system	◯	◯	◯	◯	◯
Challenges related to transportation						
D1	The blood bank faces challenges in maintaining the required temperature during transportation	◯	◯	◯	◯	◯
D2	The blood bank faces challenges in ensuring proper	◯	◯	◯	◯	◯

	disposal of blood products during transportation					
D3	The blood bank faces challenges in acquiring vehicles suitable for maintain cold chain during transportation.	◯	◯	◯	◯	◯
Challenges related to knowledge and skills of personnel						
E1	There is a limited availability of personnel with cold chain management training	◯	◯	◯	◯	◯
E2	There is not enough personnel trained to practice cold chain management effectively	◯	◯	◯	◯	◯
E3	The blood bank faces challenges due to lack of technical know-how to practice cold chain management.	◯	◯	◯	◯	◯
E4	The blood bank has a system in place to ensure that all staff is trained in cold chain management practices.	◯	◯	◯	◯	◯
Challenges related to budget and infrastacture and technology use						
F1	The blood bank has a system in place to monitor cold chain management costs.	◯	◯	◯	◯	◯
F2	The blood bank prioritizes cold chain management expenditures in its budget allocation.	◯	◯	◯	◯	◯
F3	The blood bank has a process for identifying and eliminating unnecessary cold chain management expenses.	◯	◯	◯	◯	◯
F4	The blood bank uses a latest technology or optimal cold chain equipment	◯	◯	◯	◯	◯
F5	The blood bank has adequate resources to invest in the necessary equipment, infrastructure, and technology to maintain the appropriate temperature range for blood products	◯	◯	◯	◯	◯
F6	The blood bank has standard refrigeration equipment to maintain the appropriate temperature range for blood products.	◯	◯	◯	◯	◯

Challenges related to power supply						
G1	The blood bank has a contingency plan in place for power outages.	◯	◯	◯	◯	◯
G2	The blood bank conducts regular checks on its backup power supply.	◯	◯	◯	◯	◯
G3	The blood bank has a plan to ensure uninterrupted power supply for critical areas such as blood storage areas.	◯	◯	◯	◯	◯
Challenges related to maintainance						
H1	The blood bank has a regular maintenance schedule for its cold chain equipment.	◯	◯	◯	◯	◯
H2	The blood bank has a system in place to quickly repair or replace cold chain equipment that is not functioning properly.	◯	◯	◯	◯	◯