DETERMINANTS OF VACCINE AVAILABILITY AMONG PUBLIC HEALTH FACILITIES UNDER HAWASSA CITY ADMINISTRATION AND HAWASSA ZURIA DISTRICT, SIDAMA REGION, SOUTH ETHIOPIA

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ADDIS ABABA, ETHIOPIA

ADDIS ABABA UNIVERSITY
COLLEGE OF BUSINESS AND ECONOMICS
SCHOOL COMMERCE
LOGISTICS AND SUPPLY CHAIN MANAGEMENT UNIT

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A THESIS SUBMITTED TO ADDIS ABABA UNIVERSITY, SCHOOL OF COMMERCE IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF ARTS IN LOGISTICS AND SUPPLY CHAIN MANAGEMENT

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Declaration

I, Negash Kebede declare that a thesis entitled with **"*Determinants of vaccine availability among public health facilities under Hawassa City Administration and Hawassa Zuria District, Sidama Region, South Ethiopia***" is my original research work and have never been submitted to any other university for any Degree. I also declare that all the resources used under this research has been acknowledged clearly.

Declared by: Negash Kebede

Date: _____

Signature_____

Statement of Certification

This is to certify research undertaken by Negash Kebede under my advice entitled with ***"Determinants of vaccine availability among public health facilities under Hawassa City Administration and Hawassa Zuria District, Sidama Region, South Ethiopia"*** submitted to the Addis Ababa University, School of Commerce in partial fulfillment of the requirements for the Degree of Master of Arts in Logistics and Supply Chain Management complies with the regulations of the Addis Ababa University and meets the accepted standards with respect to originality and quality.

Name: Matiwos Ensermu (PhD)

Signature: _____

Date: _____

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Acronyms

AAU: Addis Ababa University

BCG: Bacillus Chalmette Guerin Vaccine

CCM: Cold Chain Management

CDC: Center for Disease Control and Prevention

CI: Confidence Interval

CGPP: CORE Group Polio Project

CRT: Controlled Room Temperature

CSCMP: Council of Supply Chain Management Professional

DTP: Diphtheria, Tetanus and Pertussis

EFY: Ethiopian Fiscal Year

EML: Essential medicine list

EPI: Expanded program on Immunization

EVM: Effective Vaccine Management

EPSA: Ethiopian Pharmaceutical supply Agency

FMOH: Ethiopia Federal Ministry of Health

GAVI: Global alliance for vaccine and immunization

GVAP: Global Vaccine Action Plan

HEW: Health Extension Worker

HC: Health Center

IPLS: Integrated pharmaceuticals logistics system

ISC: Immunization Supply Chain

ISCL: Immunization Supply Chain and Logistics

JSI: John Snow, Inc

LIAT: Logistic Indicator Assessment Tool

LMIS: Logistic Management Information System

LPG: Liquefied Petroleum Gas

LSAT: Logistics System Assessment Tool

MCH: Maternal and Child Health

MSF: Medicin Sans Frontieres

NPI: National Programme of Immunization

NPPL: National pharmaceuticals procurement List

NGO: Non-governmental organizations

OR: Odds Ratio

PFSA: Pharmaceutical Fund and Supply Agency

PH: Health Post

PHCU: Primary health Care Units

RDF: Revolving Drug Fund

RED/REC: Reaching Every District/Reaching Every Community

RRF: Report and Requisition Forms

RSPI: African Regional Strategic Plan for Immunization

SDP: Service Delivery point

UNICEF: United Nations Children's Fund

USAID: U.S. Agency for International Development

VVM: Vaccine Vial Monitor

WHO: World Health organization

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Abstract

Availability of vaccine in good condition is crucial for success of any immunization program. As we go down in the supply chain to health centers and health posts, managing vaccine logistics and maintaining the cold chain may be more difficult. The purpose of this study is to assess availability and identify factors related to availability of vaccine in public health facilities under Hawassa City Administration and Hawassa Zuria District. Institution based cross sectional descriptive study was conducted in March 2022 among 16 health centers and 40 health posts. Quantitative data was collected from EPI focal persons using structured questionnaire together with six interviews. SPSS version 24 is used to analyze the quantitative data. Forty-five (80.4%) had more than eighty percent of the vaccines for immunization at time of visit. Mean availability was 78%. Frequently out of stock vaccines were OPV (57.1%), PCV (28.6%). Stock card is used in 13 health centers, but only 7 (53.8%) of them had updated one at time of visit. However, 81.3% of the health centers include stock on hand, quantities used and loss/adjustment in their LMIS report Only 31(55%) of the facilities had functional refrigerator. Seventeen (30.4%) of the respondents fail to identify the importance of shake test. Determining resupply quantity by the facility itself was strongly associated with availability of vaccines (OR 9(1.6-50.6). Availability of vaccines for routine immunization is satisfactory. Utilization of LMIS tools is disappointing. Knowledge on shake test is inadequate. Training on utilization of LMIS tools and the importance of shake test is recommended.

Key words**: **Vaccine, Availability, Public health facilities

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

According to Council of Supply Chain Management Professional (CSCMP) Logistics management is that part of supply chain management that plans, implements, and controls the efficient, effective forward and reverses flow and storage of goods, services and related information between the point of origin and the point of consumption in order to meet customers' requirements (CSCMP, 2013).

Logistics is regarded as a crucial part of the pharmaceutical industry since the activities are highly sensitive to quality and time bound. Pharmaceutical products need temperature controlled storage and distribution under strict regulatory control. In course of time, the industry has given importance to logistics by focusing on supply chain and logistic level activities such as delivering the product to the end-customer at the right time, right place, in a secure form and at a competitive operational cost. (Bigoniya, 2012).

Cold chain pharmaceuticals are one part of pharmaceutical logistics, with special requirement in storage and transportation. Among cold chain pharmaceuticals, vaccines are more sensitive to temperature fluctuations and they may lose their potency if not handled properly. Proper vaccine storage and handling are important factors in preventing and eradicating many common vaccine preventable diseases. Yet, each year, storage and handling errors result in revaccination of many patients and significant financial loss due to wasted vaccines. Failure to store and handle vaccines properly can reduce vaccine potency, resulting in inadequate immune responses in patients and poor protection against disease. Patients can lose confidence in vaccines and providers if they require revaccination because the vaccines they received may have been compromised. (CDC, 2021)

Success of supply chain is customer satisfaction. Vaccine customers are children. The satisfaction is measured on how vaccines reach the end user, eligible babies and children who cannot explain what they received. It falls under humanitarian logistics,

Effective cold chain relies on three main elements: a well-trained staff, reliable storage and temperature monitoring equipment, together with accurate vaccine inventory management. Proper vaccine inventory management is essential for appropriate vaccine ordering and stock rotation, and ensures your facility has the vaccines your patients need. Vaccines are expensive, so making sure they are unpacked, stored, prepared, administered, and transported correctly is critical (CDC, 2021). Moreover, poor transportation system, electric city interruption and other infrastructures problems are intense in developing countries.

Immunization is a global health and development success story, saving millions of lives every year. Vaccines reduce risks of getting a disease by working with your body's natural defenses to build protection. When you get a vaccine, your immune system responds. We now have vaccines to prevent more than 20 life-threatening diseases, helping people of all ages live longer, healthier lives. Immunization currently prevents 3.5-5 million deaths every year from diseases like diphtheria, tetanus, pertussis, influenza and measles. Immunization is a key component of primary health care and an indisputable human right. It's also one of the best health investments money can buy. Vaccines are also critical to the prevention and control of infectious disease outbreaks. They underpin global health security and will be a vital tool in the battle against antimicrobial resistance. Yet despite tremendous progress, vaccination coverage has plateaued in recent years and even dropped for the first time in a decade in 2020. The COVID-19 pandemic and associated disruptions over the past two year have strained health systems, with 23 million children missing out on vaccination in 2020, 3.7 million more than in 2019 and the highest number since 2009. (WHO, 2022)

In Ethiopia immunization coverage is good. According to the FMOH annual report (FMOH, 2022) nationally 2,815,320 (93%) under one infants received all types of basic antigens in before celebrating their first-year birthday. Looking into the regional data the performance ranges from 58% in Afar region to 100% in Harari, Addis Ababa and Oromia. As per the report immunization coverage is lower as we go away from the center of the country and to remote areas.

However the report also identified problems faced with regard to immunization service. Some of the challenges are global COVID 19 Pandemic, school closure in some areas, insecurity /Local unrest in some parts of the country, shortage of cold chain equipment and other supplies,

inadequate government budget allocation for immunization at service delivery points, delayed shipment of additional doses of Vaccine-uncertainties in vaccine logistics system

Availability of vaccine in good condition in service delivery points (SDPs) like health posts and health centers is crucial for success of any immunization program. As we go down in the supply chain to these SDPs maintaining the cold chain may be more difficult. The lack of reliable cold storage and inefficient cold chain management results in high waste rates and poor immunization coverage (MSF, 2014)

In light of the above few paragraphs, this study assessed availability of vaccines and tried to identify factors related to availability of vaccines in public health institutions under Hawassa City Administration and Hawassa Zuria district, Sidama Region.

1.2 Statement of the problem

Cold chain decisions, are unique because they are irreversible: if, at any one point, the vaccines cannot be kept within the safe temperature zone, the cold chain is disrupted, and vaccines turn from potential lifesavers into a threat. A better understanding of uncertainty, information and irreversibility in the planning and implantation phase is therefore key to advance the effectiveness and efficiency of humanitarian vaccine cold chains. (Comes, Sandvik and Van de Walle, 2018)

Immunization Supply Chain and Logistics (ISCL) systems, originally designed to manage fewer and less expensive vaccines, are not keeping pace with the changing landscape of immunization programmes. As a result, countries are experiencing inventory unpredictability, inadequate cold-chain capacity and insufficient funding (WHO, 2014).

Of course, financially the government of Ethiopia is spending a lot on vaccines. Between 2015 until 2018 its share has grown from 39% to 43%, while the rest is covered by donors. In 2018 the total finance (donors and government) for vaccines was more than 126 million USD. (FMOH. (2020), such a huge expenditure should ensure availability of vaccines at service delivery points.

Lack of appropriate equipment, poor stock management and lack of proper knowledge of vaccine handling are some of the factors that negatively affect availability of vaccines. Moreover, vaccine wastage due to expiry, higher temperature and freezing is another contributing factor to low stock status of vaccines (Mohammed, Workneh and Kahissay, 2021)

While there are a lot of studies on pharmaceutical logistics in Ethiopia, many are focused on the overall performance of EPSA (Ethiopian Pharmaceutical Supply Agency). And most of the studies are conducted in Addis Ababa. Studies on vaccine availability and vaccine logistics are missing

Although researches on vaccine cold chain management are available, studies on vaccines availability and vaccine logistics management are very rare. Some studies like one in East Gojam Zone of Amhara region (Bogale et al., 2019) focused on vaccine cold chain management and did see availability and logistics management side of vaccine supply chain.

One study in Addis Ababa (Tiya, 2016) revealed that on average the respondents were neutral on availability of vaccine in their health centers. The result was obtained from respondents' opinion. This study cannot show the actual status of vaccine availability. Even another study conducted in South Western Ethiopia (Feyisa et al., 2021) reported a mean availability of 72.1 % for essential cold chain products. This study also did not report vaccine availability specifically.

Moreover, LMIS side of vaccine logistics is not raised by the above few studies. Studies on Vaccine LMIS are also rare. This is practically reflected in the literature review part in the next chapter.

As seen in the preceding paragraphs research on availability of vaccines and logistics management (utilization of LMIS tools) are rare. Accordingly, this study is conducted to measure availability of vaccines and assess logistics management practice in selected public health facilities under Sidama region, South Ethiopia.

1.3 Basic research question

1. What percentage of public health facilities have usable vaccine stock at time of visit?
2. What type of Logistic Management Information System (LMIS) tools do the public health facilities utilize?
3. What is the cold chain management performance in the public health facilities visited?
4. Which factors are related to availability of vaccines in the public health facilities visited?

1.4 Objective of the study

General Objective

To identify factors related to availability of vaccine in public health facilities under Hawassa City Administration and Hawassa Zuria District.

Specific objectives

1. To measure availability of vaccines in public health facilities visited
2. To assess logistics management practice in public health facilities visited
3. To assess cold chain management practice in public health facilities visited
4. To identify factors related to availability of vaccines in public health facilities visited

1.5 Significance of the study

This research was conducted in Sidama regional state, a new regional state, only less than a year old. The results of this study will be of paramount importance to health policy makers of this young region. This study focused on health centers and health posts. In the majority of health facility assessments, the lowest level of the supply chain (i.e., the service delivery point) is of most interest to programs (USAID/DELIVER PROJECT, 2011). It can also help as an important input for future health facility based cold chain management assessments in the region. Moreover, it adds knowledge to the existing practice with regard to vaccine cold chain management and logistics management system performance in public health facilities.

1.6 Scope of the Study

The study is limited to assess public health facilities under Hawassa City Administration and Hawassa Zuria district, it did not include all public health facilities in Sidama Regional State. Limited resources and time was a constraint to access the whole region. While there are different cold chain pharmaceuticals, this study focused only on vaccines. It also excluded hospitals as these facilities do not stock all the vaccines under study. Besides the study assessed availability only at time of visit, it does not show historical availability status. Moreover, the data collected from focal persons may not reflect the real practice of the facility with regard to application of LMIS tools and cold chain management.

1.7 Limitations of the study

This study employed questions adapted from Logistic Indicator Assessment Tool (LIAT) and Logistic System Assessment Tool (LSAT) which are standard methods for conducting evaluations of health commodity supply chains in the developing world. These tools cover a wide area of the logistic system but in this particular study only selected areas are covered. Moreover, it focused only on vaccines and excludes other health commodities. The result of the study may not be generalized to the whole Sidama region as the study population was health facilities around

Hawassa city only and excludes remote areas of the region. Moreover, mean stock out rate was calculated using data as reported by respondents (focal persons), and may not show the exact figure that can be generated from a stock card or other LMIS tool.

1.8 Definition of Terms and Concepts

Vaccines: A vaccine is a biological preparation that improves immunity to a particular disease. The agent stimulates the body's immune system to recognize the agent as foreign, destroy it, and remembers it, so that the immune system can more easily recognize and destroy any of these microorganisms that it later encounters (WHO, 2015a).

Cold Chain: The term "cold chain" or "cold chain management" refers to controlled temperature transportation of pharmaceutical products, biologicals, and active ingredients. It also applies to diagnostics, research and investigational materials that require temperature control (McLean, 2009)

Inventory holding point: A location where inventory is stored, which could be a warehouse, a health facility or transport equipment

Vaccine Cold Chain: The system used for storing vaccines in good condition is called the cold chain. It is sometimes referred to as the vaccine supply chain, or the immunization supply chain. The cold chain consists of a series of links that are designed to keep vaccines within WHO recommended temperature ranges, from the point of manufacture to the point of administration (WHO, 2015b)

Vaccine availability: A measurement of the amount of time that a vaccine is available for shipment from a warehouse, or is available for use at a health facility. (WHO, 2014)

Stock-out: When a product is not available at time of visit or given period of time. (WHO, 2014)

Wastage rate: A measurement of the amount of vaccine that is not administered (due to both opened unopened vial wastage), compared to the amount of vaccine issued.

WHO tracer vaccines: Are vaccines identified by WHO as important for assessing availability of vaccines in public health institutions. They are 8 in number; BCG, TT, OPV, Penta, Measles, PCV, TAT, and Rabies vaccine

Vaccines for routine immunization in Ethiopia include BCG, OPV, Penta, Measles, PCV, HPV, Rotavirus vaccine, Vitamin A

Good product availability performance/adequate cold chain medicine stock: percentage of public healthcare facilities with stock available for more than 80% of products at the time of visit

Stockout rate at service delivery points: This indicator measures the number of service delivery points (SDPs) that experienced a stockout of a specific product that the SDP is expected to provide, at any point, in a defined period of time (i.e. the past three, six or twelve months). The indicator should be calculated separately for each product or method. (USAID, 2022).

1.9 Organization of the Research Report

The report is presented in five chapters. The first chapter covers introductory part of the study such as background, objectives and scope of the study, while chapter two presents detailed literature review. Detailed research methodology is described in chapter three Chapter four is for results, analysis and discussion. The final chapter is dedicated to summary of findings, conclusion and recommendations.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 Theoretical literature review

2.1.1 Vaccine availability

The Expanded Programme on Immunization (EPI) is a key global health programme. Its overall goal is to provide effective and quality immunization services to target populations. EPI programme managers and staff need to have sound technical and managerial capacities in order to achieve the programme's goals. The immunization system comprises five key operations: service delivery, communication, logistics, vaccine supply and quality, and surveillance. It also consists of three support components: management, financing and capacity strengthening. National immunization (WHO, 2017)

National immunization programmes (NIPs) operate within the context of national health systems, in alignment with global and regional strategies. For the decade, 2011–2020, the key global immunization strategies are conveyed through the Global Vaccine Action Plan (2011–2020) (GVAP) and the African Regional Strategic Plan for Immunization (2014–2020) (RSPI). These strategic plans call on countries to: improve immunization coverage beyond current levels.

And the key approaches for implementation of the GVAP/ RSPI include: implementation of the Reaching Every District/Reaching Every Community (RED/REC) approach and other locally tailored approaches and move from **supply-driven to demand driven** immunization services (WHO, 2017)

Vaccine availability measures the total number of unexpired vaccines available in a facility relative to the vaccines on a defined list. To effectively provide essential health services, health facilities must have available a minimum level of vaccines, including but not limited to measles, DTP, oral polio, and pneumococcal. Vaccine (PHPCI, 2022)

Good product availability performance or adequate cold chain medicine stock refers to percentage of public healthcare facilities with stock available for more than 80% of products at the time of visit. (Feyisa, et al., 2021).

2.1.2 Logistics management

Logistics management includes a number of activities. These activities are meant to address the six rights of logistics, namely the right goods in the right quantities in the right condition, delivered to the right place at the right time for the right cost. Over the years, logisticians have developed a model to illustrate the relationship between the activities in a logistics system; they call it the logistics cycle. The main activities in the cycle are serving customers, product selection, quantification and procurement, inventory management, storage and distribution.

Serving customers: Everyone who works in logistics must remember that they select, procure, store, or distribute products to meet customer needs. Storekeepers do not store drugs just for the purpose of storing; they store products to ensure that commodity security exists for every customer to obtain and use the health commodities when they need them. In addition to serving the needs of the end customer—the customer seeking health services—each person in the process is also serving the needs of more immediate customers.

Product selection: In any health logistics system, health programs must select products. In a health logistics system, a national formulary and therapeutics committee, pharmaceutical board, board of physicians, or other government-appointed group may be responsible for product selection. Most countries have developed essential medicine lists patterned on the WHO Model List. Products selected for use will impact the logistics system, so the logistics requirements must be considered during the product selection.

Quantification: After products have been selected, the required quantity and cost of each product must be determined. Quantification is the process of estimating the quantity and cost of the products required for a specific health program (or service), and, to ensure an uninterrupted supply for the program, determining when the products should be procured and distributed. See the suggested reading list at the end of the handbook for sources of additional information about quantification of health commodities.

Procurement: After a supply plan has been developed as part of the quantification process, quantities of products must be procured. Health systems or programs can procure from international, regional, or local sources of supply; or they can use a procurement agent for this logistics activity. In any case, procurement should follow a set of specific procedures that ensure an open and transparent process that supports the six rights.

Inventory management: storage and distribution. After an item has been procured and received by the health system or program, it must be transported to the service delivery level where the client will receive the products. During this process, the products must be stored until they are sent to the next lower level, or until the customer needs them. Almost all businesses store a quantity of stock for future customer needs.

In the heart of the logistic cycle is LMIS. Information is the engine that drives the logistics cycle; without information, the logistics system would not run smoothly. An LMIS collects data about commodities; this information is often used for activities, such as filling routine supply orders for health facilities (USAID/DELIVER PROJECT, 2011a)

A LMIS is the system of physical- and technology-based records and reports that supply chain workers and managers use to collect, organize, present and use logistics data gathered across all levels of the system. An effective LMIS depends on the right combination of people, processes, and technology. Skilled people must record, analyze, manage, and use supply chain data at every level. And the LMIS must leverage appropriate technology that is feasible to deploy and sustain, and is embraced by users at each level (JSI, 2020)

LMIS data is data about health commodities, i.e. quantities issued, dispensed, used, received, lost, stolen, damaged, ordered, etc. There are three data items that are absolutely essential:

Stock on hand: The quantity of usable stock available

Consumption (quantity used), refers to the quantity of stock dispensed to users or used during a particular time period

Losses and adjustments Losses refers to the quantity of stock removed from the pipeline for any reason other than consumption by clients or use at the service delivery point (due to expiration, theft, damage, etc.). Adjustments—are the quantity of stock issued to or received from other facilities at the same level of the pipeline

Although we may make good use of other data, notably indicators such as days out of stock, these three data items are absolutely required to manage a supply chain system. A LMIS is the system used to record and report them. Data are collected and recorded daily, and usually compiled and reported monthly, bi-monthly or quarterly (JSI, 2020).

The primary purpose of the LMIS is to manage the logistics of ensuring a smooth supply chain and that the data it generates are also relevant for monitoring key indicators of health system performance, namely essential medicines. Essential medicines, including vaccines and contraceptives, are those identified as meeting the priority healthcare needs of the population. They should be available in the healthcare system at all times, in adequate amounts, in the appropriate dosage forms, with assured quality, and at a price that individuals can afford. (USAID, MEASURE Evaluation, 2018)

To monitor access to essential medicines, countries select tracer medicines from the national and global essential medicine list (EML), including brand-name and generic products for each medicine. Health information officers measure availability of these medicines through indicators of stocks on hand, stockouts, and other indicators. Percentage of health facilities with essential medicines and stockout rate of tracer medicines are used to measure availability of essential medicines in health facilities. (USAID, MEASURE Evaluation, 2018)

In Ethiopia, the responsible body for vaccine import and distribution is EPSA. So as to execute its mandate in the area of pharmaceuticals supply in an efficient and effective manner, integrated pharmaceuticals logistics system (IPLS) has been developed and implemented since 2010. The IPLS integrates the management of essential pharmaceuticals including the following pharmaceuticals that were used to be managed vertically: HIV/AIDS, Malaria, TB and Leprosy, EPI, MCH and purchased essential drugs. It is the primary mechanism through which all public health facilities obtain essential and vital pharmaceuticals. Products included on the National pharmaceuticals procurement List (NPPL) are supplied and managed through the IPLS (PFSA, 2017).

Health Posts complete one part of the Health Post Monthly Report and Re-Supply Form every month and carry the report to the health centre. The health centre uses the information found on the Health Post Monthly Report and Re-Supply Form to complete the form and calculate the quantity of pharmaceuticals needed by the health post. Each month, the health centre will issue enough stock to bring the health post up to its Maximum Stock Level of two months of stock for each product. EPSA recommends the use of LMIS tools such as bin cards, stock cards, Health Post Monthly Report and Re-Supply Form, Report and Requisition Forms (RRF), Internal Facility Report and Resupply Form (PFSA, 2017).

2.1.3 Cold chain management

Operation of cold chain logistics systems can be divided into four links according to the degree of influence as follows: transportation and distribution, processing and packaging, information processing and warehousing. Transportation and distribution is the most influential factor of system failure, and extreme weather is the riskiest event. At the same time, the four risk events that have the greatest impact on the operation of the cold chain system are in descending order: transportation equipment failure, extreme weather, and unqualified pre-cooling and violation operation (Zheng, Peng, and Wei, 2021)

The term “cold chain” or “cold chain management” refers to controlled temperature transportation of pharmaceutical products, biologicals, and active ingredients. It also applies to diagnostics, research and investigational materials that require temperature control. Cold Chain and Cold Chain Management (CCM) are often used interchangeably. Cold chain also refers to refrigerated and frozen products; i.e. “cold chain products” In general, they are products which have storage temperatures cooler than Controlled Room Temperature (CRT), or are very sensitive to temperature variation, on both sides of the storage range. (McLean, 2009). The goals of cold chain management is to keep the material in the designated temperature range

The cold chain involves the transportation of temperature-sensitive products along a supply chain through thermal and refrigerated packaging methods and the logistical planning to protect the integrity of these shipments. There are several means in which cold chain products can be transported, including refrigerated trucks and railcars, refrigerated cargo ships, reefers, and air cargo. The main elements of a cold chain involve:

Cooling systems. Bringing commodities such as food to the appropriate temperature for processing, storage, and transportation.

Cold storage. Providing facilities for the storage of goods over a period of time, either waiting to be ship to a distant market, at an intermediary location for processing and distribution, and close to the market for distribution.

Cold transport. Having conveyances available to move goods while maintaining stable temperature and humidity conditions as well as protecting their integrity.

Cold processing and distribution. Providing facilities for the transformation and processing of goods as well as ensuring sanitary conditions. Consolidating and deconsolidating loads (crates, boxes, pallets) for distribution. (Rodrigue and Notteboom, 2020)

2.1.4 Vaccine cold chain management

The system used for storing vaccines in good condition is called the cold chain. It is sometimes referred to as the vaccine supply chain, or the immunization supply chain. The cold chain consists of a series of links that are designed to keep vaccines within WHO recommended temperature ranges, from the point of manufacture to the point of use. In order to maintain a reliable vaccine cold chain at the peripheral level, the following key procedures must be observed:

- store vaccines and diluents within the required temperature range at all sites
- pack and transport vaccines to and from outreach sites according to recommended procedures
- Keep vaccines and diluents within recommended cold chain conditions during immunization sessions.

Vaccines are sensitive biological products. Some vaccines are sensitive to freezing, some to heat and others to light. Vaccine potency, meaning its ability to adequately protect the vaccinated patient, can diminish when the vaccine is exposed to inappropriate temperatures. Once lost, vaccine potency cannot be regained. To maintain quality, vaccines must be protected from temperature extremes. Vaccine quality is maintained using a cold chain that meets specific temperature requirements (WHO, 2015b).

Some of the equipment used to transport vaccines at lower level health facilities include vaccine carriers, cold boxes and icepacks. However, refrigerated vehicles (vans, trucks) and international vaccine packaging containers are used at national level. (WHO, 2015b).

While transporting vaccines, temperature monitoring device (TMD) should accompany the vaccine storage equipment or carrier. Some vaccines have vaccine vial monitors (VVM) which is very important to check the cold chain status of each vial especially at lower level service delivery points. VVM is used to check if vaccines are exposed to heat. VVMs are the only temperature monitoring devices that routinely accompany vaccines throughout the entire supply chain. A VVM is a chemical indicator label attached to the vaccine container (vial, ampoule or dropper) by the vaccine manufacturer. As the container moves through the supply chain, the VVM records its

cumulative heat exposure through a gradual change in colour. If the colour of the inner square is the same colour or darker than the outer circle, the vaccine has been exposed to too much heat and should be discarded. There are currently four types of VVM, chosen to match the heat sensitivity of the vaccine. These four types are VVM2, VVM7, VVM14 and VVM30. The VVM number is the time in days that it takes for the inner square to reach the colour indicating a discard point if the vial is exposed to a constant temperature of 37 °C. The main purpose of VVMs is to ensure that heat-damaged vaccines are not administered. The VVM status is also used to decide which vaccines can safely be kept after a cold chain break occurs thus minimizing unnecessary vaccine wastage. In addition, VVM status helps the user decide which vaccine should be used first – a batch of vaccine showing significant heat exposure should be distributed and used before a batch that shows lower heat exposure, even if its expiry date is longer. VVM status should always be checked and recorded manually on the arrival voucher when it first reaches the health facility. The vaccinator must also check the VVM before the vaccine is opened to see whether the vaccine has been damaged by heat. Only use the vial if the expiry date has not passed, and if the inner square of the VVM is lighter in colour than the outside circle. VVMs do not measure exposure to freezing temperatures. If the vaccine is freeze-sensitive and freezing is suspected, then the Shake Test must be conducted (WHO, 2015b).

The "shake test" was designed to detect freeze damage in aluminum-based, adsorbed, freeze sensitive vaccines such as DTP, DT, Td, TT, typhoid, and hepatitis B. These vaccines must never be frozen as this reduces their immunogenicity. When these vaccines freeze, the alum content gets loose, tends to agglomerate, and sediments faster than vaccines that have not suffered freeze damage. If you suspect that a vaccine has been frozen (e.g., thermometer marks temperature <0o

C), conduct a "Shake test" as follows (PAHO, 2010),

Step 1. Freeze a vial until it is solid; this will be your control vial – call it "FROZEN".

Step 2. Allow FROZEN vial to thaw completely.

Step 3. Select one sample of each vaccine you suspect has been frozen – call it "SUSPECT".

Step 4. Shake FROZEN and SUSPECT vials.

Step 5. Observe FROZEN and SUSPECT vials side-by side to compare how they sediment (5-15minutes). IF SUSPECT vial sediments slower than FROZEN vial USE

IF SUSPECT vial sediments at the same rate as or faster than FROZEN vial DO NOT USE.A Shake Test must be performed for each separate batch of vaccine.

Storing vaccines properly starts with properly placing the refrigerator at comfortable space away from light and heat. It is important for a facility to have proper storage and monitoring equipment that is set up correctly, maintained appropriately, and repaired as needed. This equipment protects patients from inadvertently receiving compromised vaccine and protects facilities against costs of revaccinating patients, replacing expensive vaccines, and losing patient confidence .CDC recommends purpose-built or pharmaceutical-grade units designed to either refrigerate or freeze biologics, including vaccines, are preferred. These units can be compact, under-the-counter style or large units. (CDC, 2021).

To fully ensure the safety of vaccines, equipment should include a recommended unit with enough space to accommodate your maximum inventory without crowding. Good air circulation around the outside of the storage unit is important. Place a storage unit in a well-ventilated room, leaving space between the unit, ceiling, and any wall. Nothing should block the cover of the motor compartment. The unit should be firm and level, with the bottom of the unit above the floor. Make sure the unit door opens and closes smoothly and fits squarely against the body of the unit. If not secured properly, unit doors pose a particular risk to maintaining appropriate internal temperatures of vaccine storage units (CDC, 2021).

2.2 Empirical literature review

2.2.1 Availability and factors related to availability of vaccines

Proper vaccine storage and handling are important factors in preventing and eradicating many common vaccine preventable diseases. Yet, each year, storage and handling errors result in revaccination of many patients and significant financial loss due to wasted vaccines. Failure to store and handle vaccines properly can reduce vaccine potency, resulting in inadequate immune responses in patients and poor protection against disease. Patients can lose confidence in vaccines and providers if they require revaccination because the vaccines they received may have been compromised. (CDC, 2021)

With the introduction of new vaccines, developing countries are facing serious challenges in their vaccine supply and logistics systems. Storage capacity bottlenecks occur at national, regional, and district levels and system inefficiencies threaten vaccine access, availability, and quality (Zaffran, et al., 2013) Moreover insufficient funding is another impediment to vaccine availability. In Ethiopia lack of maintenance due to insufficient funding leads to 30% of cold-chain equipment being nonfunctional. Moreover, inventory unpredictability due to a number of inventory holding points is another constraint (WHO, 2014)

In practice different researches came up with different results with regard to availability of vaccines. Most of them reported insufficient supply.

An example may be one study (Tadesse et al., 2019) that focused on immunization service availability and service delivery in both pastoral and semi-pastoral CGPP Ethiopia implementation districts of Ethiopia. This study revealed that 92% of the Primary Health Care Units (PHCUs) reported providing an immunization service. However, only 18.1% of the PHCUs were observed and 32.4% reported providing immunization on the day data were collected. Overall, immunization service readiness was 56.6%: 85% of the Health Centers (HCs) and 46.6% of the Health Posts (HPs) were ready for immunization service over the study period. The proportion of PHCUs found to have functional refrigerators was 65%.

With the objective of assessing the effectiveness of system redesign and outsourcing to improve outdated ISC systems in Sub-Saharan Africa, one research review revealed that system redesign and outsourcing vaccine logistics to the private sector improved vaccine availability at service delivery points and reduce the cost of distributing vaccines (Vouking, et al., 2019). A study conducted in South Western Ethiopia (Feyisa, et al., 2021) reported a mean availability of 72.1 % for essential cold chain products. The same study reported that a stockout rate pf 26.2%,

Health professionals' knowledge on cold chain management is vital to effect proper utilization of available cold chain equipment, and handle vaccines according to recommended temperature ranges. Proper use of guidelines, reporting formats for vaccines is another area that health professionals are expected to be expertise. World Health Organization (WHO) presents a set of practice guidelines for different service levels, which include immunization techniques, vaccine monitoring, cold chain management and reporting systems which should be utilized by health

professionals at service delivery points (WHO, 2017a). However, some practical studies showed gaps with regard to knowledge on cold chain management.

A study in Mozambique (Mavimbe and Bjune, 2007) strongly recommended that there is a need to improve and integrate the knowledge and practices on cold chain management, especially to the peripheral level workers (primary health care facilities), by providing them with adequate training and supervision, and demonstrating how that can be effectively integrated with practice.

Additionally, a study conducted in Gambelia (Muluken and Misganaw, 2013) reported that routine EPI performance in the region is generally low due to lack of trained personnel and absence of adequate immunization logistics. Furthermore, vaccines in some facilities of central Ethiopia, were found to be at a high risk of losing their potency due to lack of knowledge and practice on cold chain management (Rogie, Berhane and Bisrat, 2013).

Although many studies report lack of knowledge and practice on cold chain management, there are studies which revealed good practice. For example, a study in Gurage zone (Yassin, et al., 2019) reported a satisfactory knowledge of health professionals with regard to cold chain management. It further reported that longer work experience, in-service training, and using expanded program on Immunization (EPI) guideline at work were factors that improved health professionals' knowledge about a cold chain management. And another study in southern Nigeria reported that 73.9% of respondents had good practice of cold chain management and the significant determinant of practice of cold chain management was cold chain management training (Ogboghodo, et al., 2017).

A study in India reported that cold chain maintenance and practices are inadequate and knowledge of vaccinators on cold chain management was also unsatisfactory (Naik, Rupani and Bansal, 2013)

Lack of appropriate equipment, poor stock management and lack of proper knowledge of vaccine handling are some of the factors that negatively affect availability of vaccines. Moreover, vaccine wastage due to expiry, higher temperature and freezing is another contributing factor to low stock status of vaccines (Mohammed, Workneh and Kahissay, 2021).

A study in Nairobi city (Kanja, et al., 2021) discovered that most facilities had experienced vaccines and accessories stock out at the time of the study and in the preceding twelve months. The most affected vaccines being tetanus (88%), measles rubella (81%) and oral polio (79%). The

same study identified rationing, unavailability at the depot, lack of transport and poor forecasting as major causes of stockouts.

2.2.2 Logistics management

LMIS is key for effective logistics management practice. Empirical evidences from Africa showed disappointing application of LMIS. According to a study in Nigeria (Ojo et al., 2019), consumption record was considered by 69 % of healthcare workers when making vaccine requisitions while the required lead time was considered by 24 % of them. And only 29 % of them kept records of vaccines stock-on-hand.

A research conducted in Wollega, Ethiopia (Tiye and Gudeta, 2018) showed that facilities' report submission rates were promising yet the quality of the reports need improvement. Poor data quality was more likely because of weak supportive supervision and the information system being managed by non-pharmacy professionals.

According to another study in south west Ethiopia, two hundred and sixty-three (43.06%) of the public health facilities visited had accurate stock records and the wastage rate due to expiration was 9.2 % for all visited health facilities (Feyisa, et al., 2021).

2.2.3 Vaccine cold chain management practice

Availability and maintenance of cold chain equipment is also important in securing vaccines quality. However, many countries face problems with regard to cold chain equipment availability and maintenance facility. For example, analysis based on data from 57 GAVI-eligible countries estimated that approximately one fifth of facilities have no cold chain equipment (such as refrigerators, freezers or cold rooms); one fifth have equipment that does not work; and more than two fifths have equipment with significant limitations, such as a high freezing risk and/or the need for expensive gas or kerosene.

When Effective Vaccine Management (EVM) assessments results were analyzed in 2015, only 8% of the assessed countries met the WHO global standard for preventive maintenance. In all assessed countries, preventive maintenance scores become progressively weaker from subnational to district to service delivery levels. Immunization supply chain systems without effective preventive maintenance programmes at all levels of the vaccine supply chain can seriously jeopardize the goals of an immunization programme and reduce its efficiency (WHO, 2017b).

Vaccine cold chain management practice is inadequate in many areas of developing countries. Practical studies done in different parts of Africa support this claim. For example, a study in Kenya (Koskei, et.al., 2017) reported that the cold chain management practices among health facilities in Kacheliba Division of Pokot County were not up to the standards set by the Kenya Extended Program on Immunization (KEPI)) Guidelines.

According to a research in Gojam, Ethiopia (Bogale et al., 2019) vaccine cold chain management was significantly associated with the overall cold chain management knowledge and profession of a health care worker in health institutions visited.

A study in Oromia Special Zone of Amhara region (Ahmed, et al., 2021), found that proper vaccine storage was observed in 17 (63%) health centers and only 13 (48.1%) health facilities had satisfactory cold chain infrastructure, while 17 (63%) had good cold chain practices. The availability of cold chain equipment in health facilities was below average and the practice of cold chain management in health facilities was average.

Another study in Jimma zone, Oromia, Ethiopia found that all public health centers had at least functional ice-lined refrigerators while 28 (68.3%) public health centers had functional deep freezers. Of the cold chain handlers, 120 (82.9%) had fair knowledge. It additionally reported that vaccine storage was appropriate per the World Health Organization's vaccine storage code in ice-lined refrigerators in 11 (24.4%) public health centers. Moreover, cold chain handlers' years of service, types of training, availability of funds for cold chain maintenance, and availability of cold chain equipment at public health centers showed the presence of significant association with vaccine cold chain management practice. (Feyisa, 2021).

According to a research conducted in Dalocha District of Silt'e Zone, Ethiopia, only 54% of the respondents have satisfactory knowledge of vaccine cold chain management while one hundred (71.4%) vaccine cold chain handlers did point correctly to the recommended range of temperature (2°C -8°C) for vaccine storage. Moreover, nearly half, (46.2%) of primary healthcare facilities have experienced poor adherence to the WHO storage practice codes. Around three-fifths of the observed primary healthcare facilities have registered undesirable vaccine management practices. (Feyisa, et al., 2022).

2.4 Conceptual framework

Figure 1 Conceptual framework compiled from independent variables identified from literature review

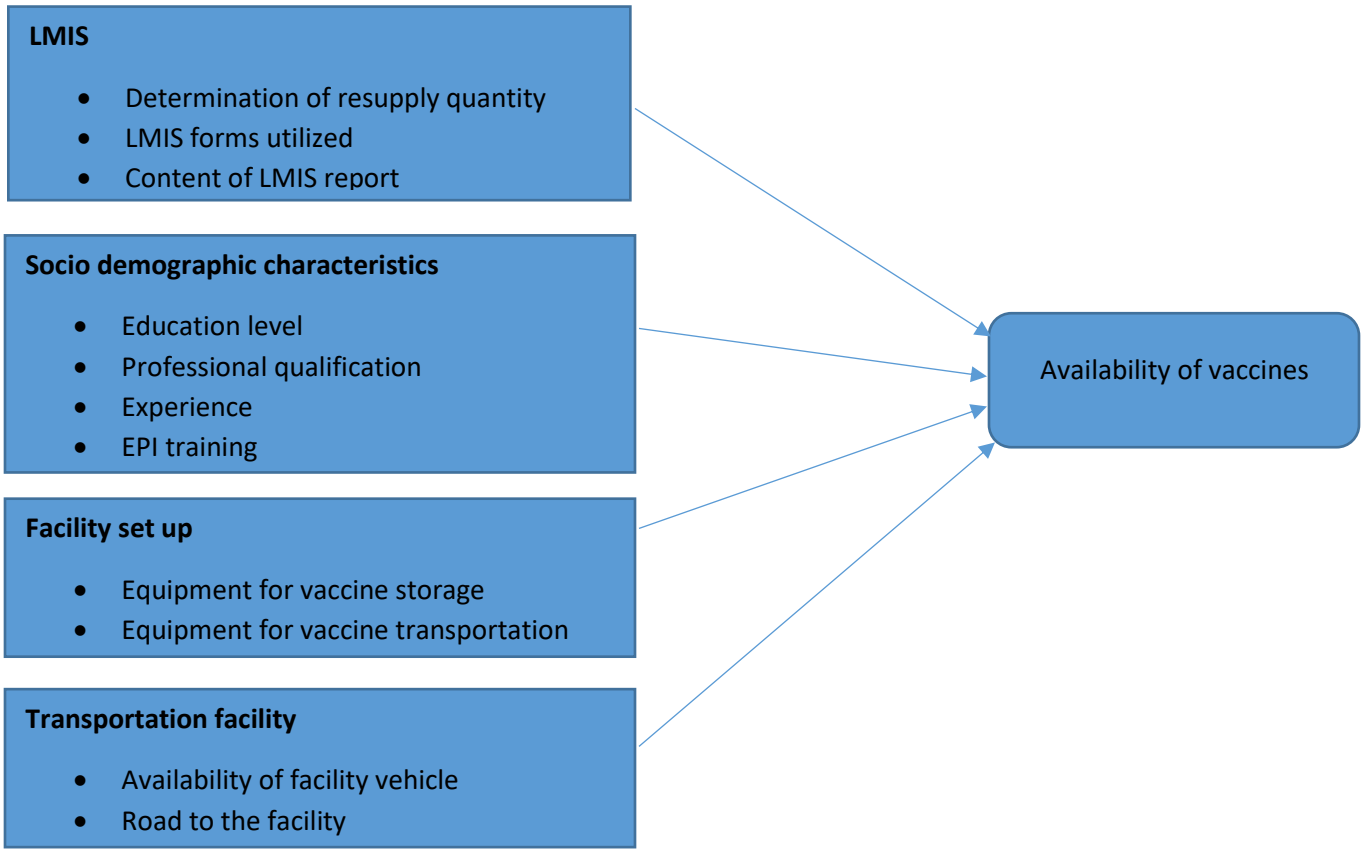

Figure 1 Conceptual framework compiled from literature review

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Description of the Study Area

The study was conducted in Sidama regional state. South Ethiopia The region is divided into 20 districts. It has a population of 4.2 million. The region has 728 public health facilities that provide health services to the general public. There are 135 health centers 4 general hospitals, 17 primary hospitals, 1 comprehensive specialized hospital and 571 health posts. The study population for this research was all public health facilities in Hawassa Zuria District and Hawassa City Administration that are offering immunization services. This includes 40 health posts and 17 health centers. These facilities get their vaccine supply from EPSA Hawassa branch. Hawassa is the capital city of the region, 273 km from Addis on the highway to Moyale, a border town between Ethiopia and Kenya. Hawassa is one destination of Ethiopian Airlines.

3.2 Research Approach

This study followed a mixed research approach which utilized both quantitative and qualitative data. The study design is descriptive and quantitative approach is used to collect data related to availability of vaccines, LMIS forms utilized that can be explained in numbers. The purpose of the qualitative approach is to support or fill gaps that the quantitative method might have missed.

3.3 Research Design

Institution based cross sectional descriptive research design was conducted in March 2022. While trying to see factors related to availability, descriptive design helps to describe the practice of the health facilities in more detail to address the specific objectives mentioned above.

3.4 Population and Sample

The study population includes all public health centers and health posts under Hawassa City Administration and Hawassa Zuria District. Excluding hospitals as they do not stock all vaccines, the total number of health facilities included in the study is 57 (17 Health Centers and 40 Health Posts). In practice data was collected from 16 health centers and 40 health posts. Qualitative data was collected from representatives of 3 health posts. 2 health centers and a focal person from EPSA Hawassa branch. The selection of these informants is purposeful to see the vaccine supply

challenges at the different levels of the vaccine supply chain. Specifically the interaction between EPSA Hawassa branch and health centers and health posts.

3.5 Data Sources and Types

The study utilized both primary and secondary data sources. Observation check lists was used to collect secondary data from every facility. Primary quantitative data was collected using structured questionnaire while interview guide was utilized to collect qualitative data from key informants.

3.6 Research instrument

Structured questionnaire adapted from literature review and LIAT was used to collect quantitative data related to the general facility characteristics, LMIS performance, and knowledge on cold chain management. Observation check lists was employed to collect information on availability and storage condition of vaccines. For qualitative data collection interview guide adapted from LSAT was used. LIAT and LSAT are standard methods for conducting evaluations of health commodity supply chains in the developing world (USAID/DELIVER PROJECT, Task order 1, 2011)

3.7 Method of data collection

For quantitative data, structured questionnaire is used to collect data from immunization focal persons in the facilities visited. Qualitative data was collected with face to face interview with key informants. The investigator of this research conducted all the interviews.

3.8 Data Collection Procedures

For quantitative data collection, two nurses were recruited and orientation was given on how to properly administer the questionnaire to respective focal persons. The questionnaire was pre-tested by administering the questions to nurses working in Millennium health center, and minor corrections was made before starting the actual data collection. After collecting observation related data, the data collectors filled the structured questionnaire through a face to face interview with the focal person of that health facility. Qualitative data was collected by the investigator from respective key informant using interview guide. Notes were taken during interview. For rural health posts without refrigerator, data was collected on the day where they were giving immunization to clients. Usually these facilities vaccinate weekly or bi weekly by collecting vaccines from respective health centers.

3.9 Study Variables

Dependent variable: Availability of vaccine in public health facilities

Independent variables: Socio-demographic characteristics of focal persons (profession, experience, level of education, EPI training), LMIS tools utilized, availability of cold chain storage equipment, knowledge on cold chain management, transportation facility, supervision

3.10 Data analysis method

Collected quantitative data was checked for completeness and entered into SPSS version 24. Frequencies, mean and proportions are computed to analyze descriptive findings. Chi square test and odds ratio (OR) were used to measure statistical association between availability and other independent variables. P-value and 95% Confidence Intervals (CI) were calculated to look for statistical significance. Quantitative data results are presented in words and tables. Qualitative data is analyzed by coding the thematic areas and presented in narrative form.

3.11 Data quality control

Data collectors were trained before starting the actual data collection. Data was collected from all the study population. Pretested structured questionnaire was used to collect quantitative data. Moreover, the quality and completeness of data was established through the direct supervision of the investigator by checking completed questionnaires on daily bases. Data is entered into a computer by the investigator and cleaned before the commencement of analysis

3.12 Ethical Considerations

Ethical clearance was obtained from Sidama Regional Health Bureau. The purpose of the study and the importance of participation in the study was explained to focal persons of the health facilities. Data was collected only after the full informed verbal consent of the respondent is obtained. Confidentiality of the data collected was guaranteed through maintaining anonymity of respondents. Respondent were free to refuse to answer any or all of the interview questions. Unauthorized persons will not have access to the data collected. The result will be circulated to Addis Ababa University and Sidama Regional Health Bureau.

CHAPTER FOUR

RESULT AND DISCUSSION

4.1 Introduction

This chapter presents results of the study and analysis. It includes response rate, data on facility attributes, sociodemographic characteristics of respondents, and availability of vaccines, logistics management performance, cold chain management practice and knowledge of respondents on cold chain management. Results of the qualitative data collected will be presented as well. Moreover, Discussion part will be presented at the end of this chapter.

4.2 Response Rate

Among 57 health facilities included in the study population, quantitative data was collected from 56 facilities which makes a response rate of 98.2% Data was collected from 16 health centers (12 from Hawassa city and 4 from Hawassa Zuria district) and 40 health posts (18 from Hawassa city and 22 from Hawassa Zuria district)

Figure 2 Geographic distribution of public health facilities

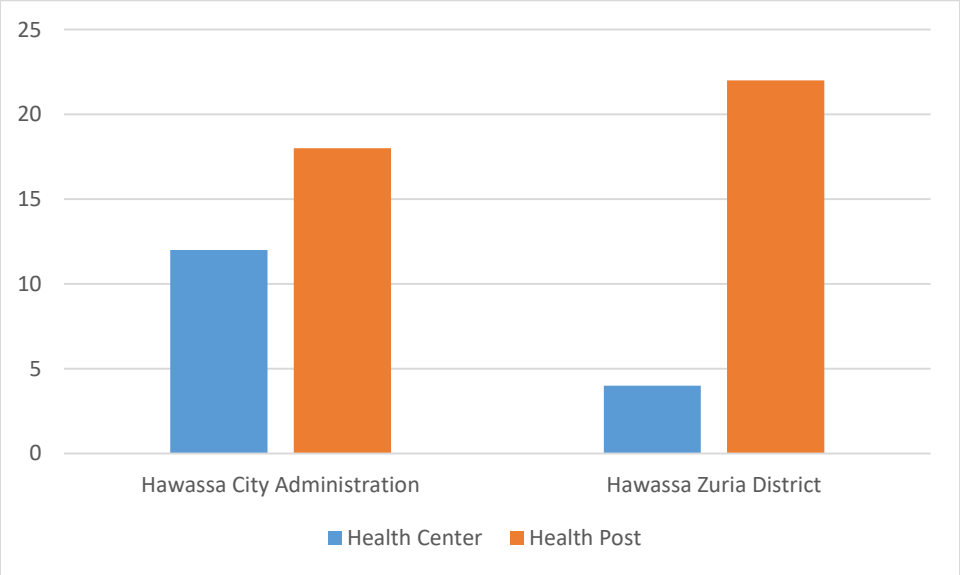

Figure 2 Geographical distribution of public health facilities

4.3 General facility attributes

All of the health centers and most of the health posts (92.5%) can be accessed by a car, have at least a gravel road to the facility. While 93.8% of the health centers had an operational electricity on day of visit, only 45% of the health posts had operational electricity or solar power. Operational water was also a problem for most (87.5%) of the health posts. Most, 81.3% of the health centers and 62.5% of the health posts reported that they have SOP or guideline on management of vaccines. The health posts are really challenged by lack of important infrastructure, which is a necessity for good availability of vaccines. (Table 1)

Table 1 *General attributes of public health facilities under Hawassa City Administration and Hawassa Zuria district, March 2022*

		Facility type				Total	
		Health Center		Health Post			
Variable		**N**	**Percent**	**N**	**Percent**	**N**	**Percent**
Road to facility	Yes	16	100.0%	37	92.5%	53	94.6%
	No	0	0.0%	3	7.5%	3	5.3%
Operational electricity	Yes	15	93.8%	18	45.0%	33	58.9%
	No	1	6.3%	22	55.0%	23	41.1%
Operational water	Yes	14	87.5%	5	12.5%	19	33.9%
	No	2	12.5%	35	87.5%	37	66.1%
Telephone available	Yes	16	100.0%	40	100.0%	56	100.0%
	No	0	0.00%	0	0.0%	0	0.0%
SOP/guideline on vaccine management	Yes	13	81.3%	25	62.5%	38	67.9%
	No	3	18.8%	15	37.5%	18	32.1%
Availability of generator	Yes	14	88%	0	0.0%	14	25.0%
	No	2	13%	40	100%	42	75.0%

Table 1. General attributes of public health facilities under Hawassa City Administration and Hawassa Zuria district, March 2022

4.4 Respondents' socio-demographic Information

Among the focal persons/representatives of EPI unit that participated in the quantitative data 47 or 93.8% were female. Many of the respondents (66.1%) have diploma level education while 16.8% are first degree holders (the highest level of education among the respondents). Professionally (current position), 60.7% were health extension workers, and 33.9% were nurses. With regard to years of service in the respective facility, 37.5% served for less than 5 years, 35.7% for 5 to 10 years and the rest had more than 10 years of experience. More than half of the respondents (57.1%)

have attended EPI training. This percentage is too small, all staff delivering EPI service should get EPI training. As described above, more than 80% have at least a diploma which makes additional trainings related to vaccine handling easier (Table 2)

Table 2. *Socio demographic characteristics of EPI focal persons in public health facilities under Hawassa City Administration and Hawassa Zuria District, March 2022*

		Facility type				Total	
		Health Center		Health Post			
Variable		**N**	**Percent**	**N**	**Percent**	**N**	**Percent**
Gender	Female	12	75.0%	35	87.5%	47	83.9%
	Male	4	25.0%	5	12.5%	9	16.1%
Level of Education	First Degree	11	68.8%	5	12.5%	16	28.6%
	Diploma	5	31.3%	32	80.0%	37	66.1%
	Certificate	0	0.0%	3	7.5%	3	5.4%
Profession of Respondent	Nurse	14	87.5%	5	12.5%	19	33.9%
	Health Officer	2	12.5%	1	2.5%	3	5.4%
	Health Extension Worker	0	0.0%	34	85.0%	34	60.7%
Years of service in the facility	Less than 5 years	7	43.8%	14	35.0%	21	37.5%
	5 - 10 years	9	56.3%	11	27.5%	20	35.7%
	Above 10 years	0	0.0%	15	37.5%	15	26.8%
EPI training attended	Yes	11	68.8%	21	52.5%	32	57.1%
	No	5	31.3%	19	47.5%	24	42.9%

Table 2 Socio demographic characteristics of EPI focal persons in public health facilities under Hawassa City Administration and Hawassa Zuria District, March 2022

4.5 Availability of vaccines

Among the 56 public health facilities visited 45 (80.4%) had at least 80% of the vaccines for routine immunization at time of visit. Mean availability of vaccines at time of visit was 78%. Mean stock out rate during the last six months from time of visit was 20.2 %. Only 2 public health facilities reported surplus of any vaccine at any given time. In contrast, most of the health centers (81%) and 58% of the health posts reported that they face stockouts for some vaccines before resupply, and the main reason was 'order not filled'. Likewise, more than 18% of the facilities had put at least one emergency order during the last 3 months before the day of visit (Table 3). Among the vaccines with stockout report are OPV (57.1%), PCV (28.6%) and Penta (7%) (Table 4).

***Table 3**. Availability of vaccines among public health facilities under Hawassa City Administration and Hawassa Zuria District, March 2022*

Variable		Facility type				Total	
		Health Center		Health Post			
		N	Percent	N	Percent	N	Percent
Availability for 80% of the vaccines for routine immunization	Yes	14	87.5%	31	77.5%	45	80.4%
	No	2	12.5%	9	22.5%	11	19.6%
Are there Vaccines that the facility stockouts before resupply?	Yes	13	81.3%	23	57.5%	36	64.3%
	No	3	18.8%	17	42.5%	20	35.7%
Reason for stockouts	Order not filled	9	69.2%	15	65.2%	24	66.7%
	Did not order	4	30.8%	8	34.8%	12	33.3%
Do you have surplus of vaccines before resupply	Yes	2	12.5%	0	0.0%	2	3.6%
	No	14	87.5%	40	100.0%	54	96.4%
No of emergency orders in the last 3 months	None	8	50.0%	32	80.0%	40	71.4%
	One	8	50.0%	7	17.5%	15	26.8%
	More than one	0	0.0%	1	2.5%	1	1.8%

Table 3 Availability of vaccines among public health facilities under Hawassa City Administration and Hawassa Zuria District, March 2022

***Table 4** Vaccines with frequent stockouts in public health facilities under Hawassa city administration and Hawassa Zuria district, March 2022*

Type of vaccine	N	Percent
OPV	32	57.1%
PCV	16	28.6%
HPV	3	5.4%
PENTA	4	7.1%
BCG	1	1.8%
ROTA	2	3.6%

Table 4 Vaccines with frequent stockouts in public health facilities under Hawassa city administration and Hawassa Zuria district, March 2022

4.6 Logistics management practice

Most of the health centers (13) have a kind of stock card (Vaccine and other EPI supplies recording and monitoring book} but only 7 or 53.8% of them have updated stock card at time of visit. Although stock card is an important LMIS tool, none of the health posts use it. All health centers

use VRF for reporting and ordering vaccines. Many of the health centers 81.3% include stock on hand, quantities used and loss/adjustment in their report. This practice is encouraging and helps higher level decision makers to get a better idea on vaccine stock management at lower levels. Another positive result is that almost all facilities (98.2%) send report to higher level within the last 3 months before the day of visit, indeed they are expected to send every month. According to the respondents, on job training (73.2%) was the major way of learning how to fill a report properly and only few attended a logistics workshop. Another constructive finding is that most of the facilities (85.7%) determine their own resupply quantity and use formula (96.4%). But to use the formula properly, continuous training and supervision may be necessary. Indeed, many facilities (85.7%) reported that they had a supervision visit within the last month before day of visit. Most of the facilities (94.6%) get their resupply within two weeks of putting an order. EPSA delivers vaccines to health centers using its own van, but 80% of the health posts collect vaccines from health centers themselves and use vaccine carrier and motor cycle to transport. This part needs improvement. (Table 5).

EPSA Hawassa branch utilizes invoices and receiving standard operating procedures (SOP) and collects Model 19 slip that confirms receipt of supply by the health center during delivery. Health centers are expected to send LMIS report to EPSA every month. As per the interview with focal persons, EPI units fill the VRF and pharmacy unit sends the report to EPSA. Although, they have VRF (vaccine Requisition Form) and a stock control register (vaccine and other EPI supplies recording and monitoring book), they are not properly filled and utilized. The latter is especially useful in redistribution of supplies. Problem related to filling VRF was also mentioned by the respondent from EPSA branch. According to this respondent VRF involves population size in the calculation, and many health centers fail to fill the VRF properly although it is a simple calculation. This created problem in delivering what the health centers exactly need. They also complained of frequent stockouts of PCV and Polio vaccines which is attributed to ‘order not filled’ by EPSA, supplier of vaccines to these facilities. However, they applauded EPSA for delivering vaccines to their door steps. Additionally, they reported shortage of cold chain storage equipment like cold boxes especially during campaign. On the other hand, availability of generators was praised by these respondents as it helped them keep their vaccines under optimum temperatures even during power interruptions. Health post focal persons who responded to the qualitative interview also mentioned that OPV, Penta valent and Rota virus vaccines are among frequently out of stock items.

According to these respondents rural health posts without refrigerator collect vaccines on weekly basis using vaccine carriers and motor cycle or public transport. They do not fill any LMIS form and collect what is allocated to them by the health centers.

Table 5*. Logistics management practice among public health facilities Under Hawassa City Administration and Hawassa Zuria District, March 2022*

		Facility type				Total	
		Health Center		Health Post			
Variable		**N**	**Percent**	**N**	**Percent**	**N**	**Percent**
Logistics forms utilized for stock control	Daily register	3	18.8%	40	100.0%	43	76.8%
	Stock control book and Daily register	13	81.3%	0	0.0%	13	23.2%
Stock card is updated	Yes	7	53.8%	0	0.0%	7	53.8%
	No	6	46.2%	0	0.0%	6	46.2%
LMIS forms utilized for reporting	VRF	16	100.0%	0	0.0%	16	28.6%
	Health post Monthly report	0	0.0%	40	100.0%	40	71.4%
LMIS report content	Only stock on hand	2	12.5%	0	0.0%	2	3.6%
	Only quantities used	0	0.0%	11	27.5%	11	19.6%
	Stock on hand and quantities used	1	6.3%	29	72.5%	30	53.6%
	Stock on hand, quantities used and loss/adjustment	13	81.3%	0	0.0%	13	23.2%
Duration since last report	Within last 3 months	16	100.0%	39	97.5%	55	98.2%
	More than 3 months ago	0	0.0%	1	2.5%	1	1.8%
Who determines the facilities; resupply quantity	The facility	15	93.8%	33	82.5%	48	85.7%
	Higher level facility	1	6.3%	7	17.5%	8	14.3%
How is resupply quantity determined?	Formula	16	100.0%	38	95.0%	54	96.4%
	No formula	0	0.0%	2	5.0%	2	3.6%
Who transports vaccines to your facility	Facility collects	0	0.0%	32	80.0%	32	57.1%
	Higher level delivers	0	0.0%	8	20.0%	8	14.3%
	Supplier/EPSA delivers	16	100.0%	0	0.0%	16	28.6%
What type of transport is used?	Facility/Supplier vehicle	16	100.0%	2	5.0%	18	32.1%
	Public transport	0	0.0%	6	15.0%	6	10.7%
	Motor cycle	0	0.0%	32	80.0%	32	57.1%
Average duration between ordering and receiving	Less than two weeks	13	81.3%	40	100.0%	53	94.6%
	Two weeks to one month	3	18.8%	0	0.0%	3	5.4%

Table 5 Logistics management practice among public health facilities Under Hawassa City Administration and Hawassa Zuria District, March 2022

4.7 Cold chain management performance

All of the health centers and 15 (38%) of the health posts had functional refrigerator at time of visit. And all the health facilities use the fridge only for vaccines and the temperature of the fridge was between 2 and 8 degrees Celsius at time of visit. Almost all facilities with refrigerators (96.8%) arrange vaccines properly and no damaged or expired items found in the fridge. Moreover, the temperature recording chart was updated for 90.3% of them. That is a good performance. Among the 16 health centers 14 have got generator. But none of the health posts are with a generator. The risk of damage to vaccines during power interruption is significant among health posts. (Table 6).

EPSA Hawassa branch has sufficient cold storage for vaccines, up to 3 cold rooms that can store at 2-8 and -15 to -25 degree Celsius. This branch collects vaccines from central store, Addis Ababa on quarterly basis. While delivering vaccines to health centers they perform VVM check to ensure that vaccines are delivered with the proper temperature range. However, participants of the qualitative interview mentioned the following points as challenges to the vaccine supply chain

1. Shortage of cold van to transport from central store to Hawassa branch. They have only one and transportation is difficult especially during campaigns. They have request for more vans and waiting optimistically.
2. Cold storage equipment maintenance problem. The region (Sidama region) is meant to facilitate this activity but so far no significant actions are taken.
3. Limited storage capacity and lack of generators at some health center leads to wastage of vaccines

Table 6 *Cold chain management practice among public health facilities under Hawassa City Administration and Hawassa Zuria District, March 2022*

		Facility type				Total	
		Health Center		Health Post			
Variable		**N**	**Percent**	**N**	**Percent**	**N**	**Percent**
Availability of functional fridge	Yes	16	100%	15	38%	31	55.4%
	No	0	0%	25	63%	25	44.6%
Fridge properly placed away from surrounding objects	Yes	15	94%	14	93.3%	29	93.5%
	No	1	6%	1	6.7%	2	6.5%
Temperature recording chart is up to date	Yes	15	94%	13	86.7%	28	90.3%
	No	1	6%	2	13.3%	3	9.7%
Vaccines are properly arranged in the fridge	Yes	16	100%	14	93.3%	30	96.8%
	No	0	0%	1	6.7%	1	3.2%
Expired/damaged vaccines removed from fridge	Yes	16	100%	14	93.3%	30	96.8%
	Yes	0	0%	1	6.7%	1	3.2%
The refrigerator is only for vaccines	Yes	16	100%	15	100.0%	31	100.0%
	No	0	0%	0	0.0%	0	0.0%
Fridge temperature is between 2-8	Yes	16	100%	15	100.0%	31	100.0%
	No	0	0%	0	0.0%	0	0.0%
Availability of generator	Yes	14	88%	0	0.0%	14	25.0%
	No	2	13%	40	100%	42	75.0%

Table 6 Cold chain management practice among public health facilities under Hawassa City Administration and Hawassa Zuria District, March 2022

Overall knowledge of respondents on cold chain management was encouraging. However, seventeen or 30.8% of them failed to properly tell what shake test is used for. (Table 7).

Table 7. *Cold chain management knowledge among Epi focal persons in public health facilities under Hawassa City Administration and Hawassa Zuria District, March 2022*

Variable		**N**	**Percent**
Do you know that vaccines are heat sensitive?	Yes	56	100.0%
	No	0	0.0%
Is freezing harmful to vaccines?	Yes	56	100.0%
	No	0	0.0%
Know correct temperature for vaccine storage	Yes	56	100.0%
	No	0	0.0%
Know what VVM is	Yes	55	98.2%
	No	1	1.8%
Know what shake test is	Yes	39	69.6%
	No	17	30.4%

Table 7 Cold chain management knowledge among Epi focal persons in public health facilities under Hawassa City Administration and Hawassa Zuria District, March 2022

4.8 Factors related to availability

Bivariate analysis was conducted to see any relation between availability of vaccines and independent variables such as profession, experience, level of education, EPI training and knowledge of focal persons on cold chain management, availability of SOP, utilization of stock cards, who determines resupply quantity, transportation facility, availability of regular supervision. Many of these variables showed insignificant relationship with availability of vaccines in the public health facilities studied. Being a nurse by profession compared to HEW showed positive relationship with availability, but was insignificant (OR, 1.03(0.31-3.46). Additionally, LMIS report content, LMIS forms used and type of transport used also showed insignificant relations with availability. However, determination of resupply quantity by the facility itself showed strong positive relationship with availability of vaccines. (OR 9(1.6-50.6)). This finding supports the importance of pull system of vaccine supply chain approach. Moreover, knowledge on the importance of shake test showed significant (OR 0.19(0.04-.96) negative relationship with availability of vaccines. This implies that those who are not aware of the use of shake test may count damaged vaccines as usable. For those health posts who collect vaccines themselves, availability was significantly better than those health posts whose supply is delivered by higher level facility (health centers). (Table 8)

***Table 8**. Relationship of selected variables with vaccine availability in public health facilities under Hawassa City Administration and Hawassa Zuria District, March 2022*

		Vaccine Availability		
Variable		**Yes N (%)**	**No N (%)**	**OR (95% CI)/χ2, df, p)**
Availability of SOP	**Yes**	24(63.2)	14(36.8)	0.48(0.14-1.78)
	No	14(77.8)	4(22.2)	
Level of Education	**First Degree**	9(56.3)	7(43.8)	0.54(0.16-1.83)
	Diploma	26(70.3)	11(29.7)	
Profession of Respondent	**Nurse**	13(68.4)	6(31.6)	1.03(0.31-3.46)
	HEW	23(67.6)	11(32.4)	
Years of service in the facility	**< 5 years**	14(66.7)	7(33.3)	χ2 = 0,29,df=2, p=0.86
	5 - 10 yrs.	13(65)	7(35)	
	> 10 years	11(73.3)	4(27.7)	
EPI training attended	**Yes**	19(59.4)	13(40.6)	0.39(0.11-1.29)
	No	19(79.2)	5(20.8)	
Know what shake test is used for	**Yes**	23(59)	16(41)	**0.19(0.04-.96)**
	No	15(88.2)	2(11.8)	
Who determines the facilities; resupply quantity	**The facility**	36(75)	12(25)	**9(1.6-50.6)**
	Higher level	2(25)	6(75)	
Logistics forms utilized for stock control	**Daily register**	29(70.7)	12(29.3)	1.61(0.47-5.52)
	Stock control book and Daily register	9(60.0)	6(40.0)	
Who transports vaccines to your facility (health posts only)	**Facility collects**	25(78.1)	7(21.9)	**10.71(1.76-65.24)**
	Higher level delivers	2(25.0)	6(75.0)	

Table 8 Relationship of selected variables with vaccine availability in public health facilities under Hawassa City Administration and Hawassa Zuria District, March 2022

4.9 Discussion

The key approaches for implementation of the GVAP/ RSPI include: implementation of the Reaching Every District/Reaching Every Community (RED/REC) approach and other locally tailored approaches and move from supply-driven to demand driven immunization services (WHO, 2017). To reach every district and every community infrastructure is essential. But this study revealed that availability of electricity (58.9%) is inadequate. Electricity/solar power is vital to keep vaccines in good condition in refrigerators.

The study found that only 57.1% of the focal persons have attended EPI training. This may affect vaccine availability negatively. According to Mohammed, Workneh and Kahisay (2021) lack of proper knowledge of vaccine handling are one of the factors that negatively affect availability of vaccines.

Availability of vaccines for routine immunization in public health facilities under Hawassa city administration and Hawassa Zuria district is satisfactory. It is slightly more than 80% and is in line with good product availability at health facilities. Good product availability refers to percentage of health facilities with stock available for more than 80% of products at time of visit (Feyisa et al., 2021). And the mean availability (78%) is higher than mean availability reported by one research conducted in South Western Ethiopia (Feyisa, et al., 2021). It is also better than a finding in the pastoral and semi pastoral CGPP implementation districts of Ethiopia where only 32.4% of PHCUs reported providing immunization services on date of visit. Stockout rate for OPV (polio vaccine) is found to be 57.1 % and the main reason reported for vaccine stockout was 'order not filled'. This implies shortage of supply from the main supplier, EPSA Hawassa branch. This finding is coherent with one study in Nairobi which reported that unavailability at the depot was one reason for stockouts of certain vaccines like Polio (Kanja, et al., 2021. Outsourcing vaccine logistics to private sector may be important to improve availability of vaccine in health post as proved by one study in Kenya (Vouking, et al., 2019).

Most facilities determine their own resupply quantity and it is significantly related to availability of vaccine. Moreover, the study revealed good reporting practice by public health facilities visited. But quality or content of the report is more important. None of the health posts found to include all the three important logistics management information (stock on hand, quantity used and losses/adjustments) in their report. This practice challenges the quality of their report. Similarly, one study in Wollega (Tiye and Gudeta, 2018) stressed the importance of improving the quality of report in the study area. Additionally, according to one study from Nigeria (Ojo et al., 2019) only 29 % of health facilities visited kept records of vaccines stock-on-hand

Updating stock cards is also another problem seen in this study. This is also a problem in other countries like Nigeria. According to a study in Nigeria (Ojo et al., 2019), only 29% of health facilities visited had records of vaccine stock on hand. Incapability of health centers to fill LMIS

reports properly has also impacted the services of EPSA Hawassa branch with regard to vaccine supply as told by the representative of the branch during the interview.

As seen in the result section overall cold chain management practice is encouraging. All health centers and 38% of the health posts have functional refrigerator for vaccines and they are using only for vaccines as is expected. This practice is consistent with a study in Nigeria (Ogboghodo, et al., 2017) which reported that 73.9% of respondents had good practice of cold chain management. Similarly, a study in Jimma zone, Ethiopia reported that all public health centers had at least functional ice-lined refrigerators while 28 (68.3%) public health centers had functional deep freezers (Feyisa, 2021). On the other hand, availability of functional refrigerator among health posts is inadequate. Even, functional refrigerator was 65% in pastoral and semi pastoral areas of CGPP Ethiopia implementation districts of Ethiopia (Tadesse et al., 2019).

Among the five cold chain management knowledge questions four were answered correctly by all respondents. This is satisfactory and is in line with a study in Gurage zone (Yassin, et al, 2019). But knowledge on the importance of shake test was not clear for some of the respondents (30.4%). The "shake test" was designed to detect freeze damage in aluminum-based, adsorbed, freeze sensitive vaccines such as DTP, typhoid, and hepatitis B. These vaccines must never be frozen as this reduces their immunogenicity (PAHO, 2010).

Being a nurse by profession showed a positive relationship with availability compared to HEW. This finding supports the recommendation of one study in Mozambique (Mavimbe and Bjune, 2007) which asserted the importance of improving knowledge and practice on cold chain management especially to primary health care workers. It also supports the conclusion made by a study in Gojam which stated that cold chain management practice was associated with knowledge and profession of vaccine handlers (Bogale et al., 2019).

And more importantly determining resupply quantity by the facility itself showed significant relation with availability of vaccines. This finding strengthens the importance of pull system of vaccine supply chain strategy (demand driven immunization services). This is in line with the key approaches for implementation of the GVAP/ RSPI which are: implementation of the Reaching Every District/Reaching Every Community (RED/REC) approach and other locally tailored approaches and move from supply-driven to demand driven immunization services (WHO, 2017)

According to the findings of the interview, shortage of cold chain storage equipment especially during campaigns is a major complaint of both EPSA and the health facilities. Such a problem was also emphasized by one report on vaccine supply and logistics system (Zoffran, et al., 2013). It revealed that storage capacity bottlenecks occur at national, regional and district levels in developing countries and affects availability and quality of vaccines.

Additionally, some health posts use public vehicles to transport vaccines. This finding compares with the one study in Gojam (Bogale et al., 2019) which reported that cold chain management weaknesses are often observed during transportation and storage of the vaccines. The result of the interview revealed that public health facilities in the study area have problem of cold storage materials, shortage of trained manpower especially to properly fill LMIS reports. Besides the interview revealed lack of cold chain equipment maintenance as well. This finding is in line with WHO report (WHO 2014) which concluded that in Ethiopia, 30% of cold chain equipment are nonfunctional due to lack of finance for maintenance.

CHAPTER FIVE

SUMMARYOF FINDINGS, CONCLUSION AND RECOMMENDATION

3.1 Summary of major findings

Facility attributes and socio-demographic characteristics of focal persons

Many of the rural health posts are without electricity (55%), and operational water (87.5%) at time of visit. Only 25% of the facilities acquired generator. The health centers EPI units are run by nurses (87.5%) while most of the health posts are run by HEW (85%). And 83.9% of these focal persons are female.

Availability of vaccine for routine immunization

Availability of vaccines for routine immunization is found to be more than 80.4%, Mean availability of vaccines at time of visit was 78%. While mean stock out rate during the last six months from time of visit was 20.2 %. Moreover, more than 18% of the facilities had put at least one emergency order during the last 3 months before the day of visit

Logistics management practice

Although stock cards are available in many of the health centers, they are not utilized properly. Most of the health centers (13) have a kind of stock card (Vaccine and other EPI supplies recording and monitoring book} but only 7 or 53.8% of them have updated stock card at time of visit. Almost all of the health post do not include important information such as stock on hand, quantity used and loss/adjustment in their LMIS reports. Additionally, most of the facilities (85.7%) determine their own resupply quantity and use formula (96.4%). Most of the facilities (94.6%) get their resupply within two weeks of putting an order. EPSA delivers vaccines to health centers using its own van, but health posts collect vaccine themselves from health centers

Cold chain management practice

EPI training is not satisfactory, only slightly more than 50% of focal persons had EPI training. All of the health centers and 15 (38%) of the health posts had functional refrigerator at time of visit. Almost all facilities with refrigerators (96.8%) arrange vaccines properly and no damaged or expired items found in the fridge. Where available refrigerators are properly used for vaccines

only, and the temperature is maintained between 2-8 ℃. Most of the health posts lack refrigerator. Cold chain equipment maintenance is another problem identified by this study. And knowledge on shake test is unsatisfactory.

Factors related to availability of vaccines

Determination of resupply quantity by the facility itself showed strong positive relationship with availability of vaccines. This finding supports the importance of pull system of vaccine supply chain approach. Moreover, knowledge on the importance of shake test showed significant (OR 0.19(0.04-.96) negative relationship with availability of vaccines indicating that those who are not aware of the use of shake test may count damaged vaccines as usable.

3.2 Conclusion

1. Availability of vaccines for routine immunization in public health facilities under Hawassa City Administration and Hawassa Zuria district is satisfactory.
2. Logistics management practice especially, utilization of LMIS tools in the health facilities visited is unsatisfactory. Transportation of vaccines to rural health posts is insufficient.
3. General cold chain management practice is good. Knowledge on cold chain management is promising but inability to understand the importance of shake test may result in the use of poor quality vaccines for immunization.
4. Lack of refrigerator and cold chain equipment maintenance is another problem identified by this study
5. Determining resupply quantity by the facilities themselves is important to bear good availability of vaccines.

3.3 Recommendations

1. Immunization stake holders (FMOH, NGOs) should provide training to EPI focal persons (Nurses and HEW) on how to properly utilize LMIS forms and fill reports.
2. The regional state should endeavor to improve on availability of electricity and transportation facility to raise vaccine availability to rural health posts

3. Immunization stake holders (FMOH, NGOs) should provide training to nurses and HEWs on cold chain management emphasizing the importance of shake test.
4. The regional health bureau should work hard to avail refrigerators to rural health posts.
5. The regional state and EPSA should work harmoniously to alleviate the current problem related to cold chain equipment maintenance.
6. Demand driven immunization services should be strengthened.
7. Further research in the area of more vaccine logistics system indicators in public health facilities under the whole Sidama regional state is recommended as this particular research addressed only few points of vaccine logistics in limited number of facilities. Moreover, research on demand driven immunization service and knowledge on shake test is essential.

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Appendix I Structured questionnaire

Addis Ababa University

School of Commerce

Questionnaire on Determinants of vaccine availability among health institutions under Hawassa City Administration and Hawassa Zuria district, Sidama Region, South Ethiopia

001. Facility code number _____

002. Interviewer Name _____

003. Date of interview_____

004. Checked by supervisor: Name: _____signature _____

Date _____

005. Checked by investigator: Signature _____ Date-_____

Hello. My name is _____. I am here on behalf of Addis Ababa University School of Commerce to assist the investigator Negash Kebede in obtaining information from your facility to assess availability of vaccines. Your participation in the interview is completely voluntary. You may skip any question that you prefer not to answer, but I would appreciate your cooperation. You may also ask me to clarify questions if you do not understand them or can stop the interview at any time. Finally, all the information that you provide for this study is kept completely confidential. Your responses to our questions are identified only by number, never by name. Your participation in the study is really appreciated.

Do I have your agreement to participate? 1. Yes

2. No = STOP!

(Signature of the interviewer certifying that informed consent has been given verbally by respondent)

Thank you! Let's begin. Time at the beginning of the interview _____

Section I Facility Characteristics

No	Question	Response	Code	Skip to
101	Road to the facility?	Yes No	1 2	
102	Operational electricity / solar panel on day of visit?	Yes No	1 2	
103	Operational water in the building on the day of visit?	Yes No	1 2	
104	Operational telephone or radio on day of visit?	Yes No	1 2	
105	Is there SOP/guideline for managing vaccines?	Yes No	1 2	

Section II Socio demographic characteristics of respondents

201	Gender	Female Male	1 2	
202	Level of education	Masters Bachelor degree Diploma Certificate Other	1 2 3 4 5	
203	Profession of person responsible for managing vaccines at this facility?	Nurse Health Officer HEW Other (Specify) ____	1 2 3 4	
204	Number of years you have worked at this facility?	Less than 5 5-10 Above 10	1 2 3	
205	Did you take EPI training?	Yes No	1 2	

Section III Logistics management performance indicators

301	Do you use and fill out the following logistics forms to manage vaccines?			
	A. stock cards	Yes No	1 2	
	B. daily register	Yes No	1 2	
302	What LMIS forms do you use for reporting/ordering?		None	306
	A. VRF	Yes No	1 2	
	B. Health Post Monthly Report and Re-Supply Form	Yes No	1 2	

	C. Other (specify)			
303	Do LMIS reports include the following?			
	A. stock on hand	Yes No	1 2	
	B. Quantities used	Yes No	1 2	
	C. Losses and adjustments	Yes No	1 2	
304	How often are these LMIS reports sent to the higher level?	Monthly Quarterly Bi annually Annually Other	1 2 3 4 5	
305	When was the last time you sent an order/report for vaccines at this facility?	Never Within last 3 months More than 3 months ago	1 2 3	
306	How many facilities are supposed to send LMIS reports to this facility?	Number……. Not applicable		 307
	How many facilities submitted complete LMIS reports for the month of _____ (two months prior to survey month)?			
307	How did you learn to complete the forms/records used at this facility?	During logistic workshop On the job training Self-learning Other (specify)	1 2 3 4	
308	How many emergency orders for vaccines have you placed in the last 3 months?	None 1 More than 1	1 2 3	
309	Who determines this facility's resupply quantities for vaccines?	The facility itself Higher level facility Other (specify)	1 2 3	
310	How are the facility's resupply quantities determined?	Formula (Specify) Don't know Other means	1 2 3	
311	Who is responsible for transporting products to your facility?	This facility collects Higher level delivers EPSA delivers Other (specify)	1 2 3 4	
312	What type of transportation is most often used?	Facility vehicle Public transport Private Vehicle Motor Cycle Other (specify)	1 2 3 4 5	

313	On average, approximately how long does it take between ordering and receiving products?	Less than 2 weeks 2 weeks to 1 month Between 1 and 2 months More than 2 months	1 2 3 4	
314	When did you receive your last supervision visit that included drug management (e.g., stock cards checked, reports checked, expired stock removed, supplies checked)?	Never received. Within the last month Within the last 3 months Within the last 6 months More than 6 months ago Other (specify)	1 2 3 4 5 6	
315	Are there certain vaccines that you always stock out of before resupply?	Yes NO	1 2	 318
316	List the vaccines you stock out of most frequently (up to 3 vaccines).	1. 2. 3.		
317	Reason for stock out	Expiry Order not filled did not put order other	1 2 3 4	
318	Do you always have a surplus of certain vaccines before resupply?	Yes NO	1 2	 401
319	List the vaccines you have a surplus of most frequently (up to 3 products).	1. 2, 3.		

Section IV Cold chain management practice

401	Do you have a functioning refrigerator(s) to store vaccines?	Yes NO	1 2	
402	Are refrigerators located away from any surrounding objects (approximately ½ meter)?	Yes NO NA	1 2 99	
403	Is the temperature chart up-to-date? (To be up-to-date, there must be an entry for the day before the visit).	Yes NO NA	1 2 99	
404	Availability of generator?	Yes NO NA	1 2 99	
405	Vaccines are stored and organized in a manner accessible for first-to-expire, first-out (FEFO) counting and general management	Yes NO NA	1 2 99	
406	The facility makes it a practice to separate damaged and/or expired vaccines from usable vaccines and removes them from inventory	Yes NO NA	1 2 99	

Section V Knowledge of respondents on cold chain management

501	Do you think that vaccines are heat sensitive?	Yes NO	1 2	
502	Is freezing harmful to vaccines?	Yes NO	1 2	
503	What is the correct temperature for vaccine storage	 ----------	1 2	
504	What is VVM?	Yes NO	1 2	
505	Do you know the correctly interpreted shake test?	Yes NO	1 2	

NA: Not Applicable

Thank you for your time and information.

Appendix II Interview Guide for HC/ HP / District / Sub city focal persons

I am happy that you devote your precious time to discuss with me. I am from AAU School of commerce; I am conducting a study on Assessment of availability of vaccines in health care facilities. The aim of the study is to improve the performance of vaccine logistics.

Now please feel free to give your opinion. You can avoid part of any question or quit response at any moment if you are not comfortable.

Name of health institution ----------

2. Name of Health worker (optional) ----------

3. Profession/position

Logistic system assessment, areas that are relevant to these health facilities will be addressed

Logistics Management Information System (LMIS)

- Describe the flow of information from the health facility to higher level.
- Frequency of reporting, who's responsible, and where data is aggregated.
- How often are reports sent to each higher level of the system?

Obtaining Supplies/Procurement

- Who is responsible for requesting vaccines in your facility (e.g., pharmacy unit, EPI unit)?

Inventory Control Procedures

- Specify what type of inventory control system is used (e.g., push, pull, etc.)
- Are there written provisions for the redistribution of over-stocked supplies?
- How did the stock outs affect program services and performance (specify which products and levels)?

Warehousing and Storage

- Are there written guidelines for storage and handling of vaccines (e.g., manuals, posters, etc.)?
- Is the existing storage capacity adequate to handle the current quantities of products at the following levels?

Transport and Distribution

- How are products delivered to your facility (include frequency and means of transportation)?

Organizational Support for Logistics System

- Is there a supervision system that covers logistics activities, how often?
- Are there written procedures and guidelines (e.g., manuals, job aids, standards) to help staff carry out their logistics responsibilities?

Others

- Do you have generator? What do you do in case of power failure?
- Challenges in procurement, ordering, transporting, receiving and storing vaccines?

Appendix III Interview guide for EPSA Hawassa branch focal person

1. What is the process in vaccine distribution from national level to lower health facilities?
2. Who is responsible for procurement of vaccines?
3. How do you transport vaccines?
4. How do you store vaccines?
5. Who distributes vaccines to health centers and health posts?
6. What LMIS forms do you use while transporting, storing and distributing vaccines?
7. Challenges with vaccine, storage, transportation and distribution.

Appendix IV Observation checklist

STOCK STATUS							
Name of vaccine	**UOM**	**Managed at facility (Y/N)**	**Stock available today? (Y/N)**	**Stock card available (Y/N)**	**Stock card updated (Y/N)**	**Stock out during last 6 months (Y/N)**	**Stockout today? (Y/N)**
BCG							
TT							
OPV							
Rotavirus							
Penta/DPT							
Measeles							
PCV							
VIT. A							
HPV							

Cold chain checklist

SN	Questions	Response (Y/N)
1	Is the refrigerator only for vaccines	
2	Is refrigerator temperature maintained between 2-80C?	
3	Is there functional thermometer for refrigerator?	
4	Is vaccines properly arranged in refrigerator?	
5	Are there expired vaccines present in refrigerator?	
6	Is there frozen vaccines present in refrigerator?	

Appendix V Interviewers training guide*

I. Background and purpose of the study

II. Administrative matters

- Where to Address Questions, Office Hours
- How to Prepare for Your Interview
- Materials You Will Need on This Study
- What Is Expected of You
- Asking for Help

III. General points of interviewing

- Introducing Yourself
- How to Answer Respondents' Questions and Complaints
- How to Maintain Confidentiality

IV. Basic techniques for interviewing

- How to Read Questions
- How to Get Adequate Answers
- How to Record Answers

** Adapted from: AIDSCAP/GPA/WHO Voluntary Counseling and Testing Efficacy Study, the Center for AIDS Prevention Studies (CAPS), University of California, San Francisco, CA, USA*