Addis Ababa University

አዲስ፡አበባ፡ዩኒቨርሲቲ

EFFECT OF COLD CHAIN MANAGEMENT PRACTICES ON AVAILABILITY OF VACCINES: THE CASE OF HEALTH CENTERS UNDER ADDIS ABABA CITY ADMINISTRATION HEATH BUREAU

BY

TIYA BACHA

May, 2016

Addis Ababa

Addis Ababa University

School of Commerce

Department of Logistics and Supply Chain Management

Graduate Studies

EFFECT OF COLD CHAIN MANAGEMENT PRACTICES ON AVAILABILITY OF VACCINES: THE CASE OF HEALTH CENTERS UNDER ADDIS ABABA CITY ADMINISTRATION HEATH BUREAU

By

TIYA BACHA

Advisor

MATIWOS ENSERMU (PhD)

A thesis submitted to the School of Commerce Addis Ababa University in partial fulfillment of the requirements for the degree of Master of Arts in Logistics and Supply Chain Management

May, 2016

Addis Ababa

Addis Ababa University

School of Commerce

Graduate Studies

Approved by Board of Examiners

____________________	____________________	____________________
Advisor	Signature	Date
____________________	____________________	____________________
Internal examiner	Signature	Date
____________________	____________________	____________________
External Examiner	Signature	Date
____________________	____________________	____________________
Chairman of Graduate Committee	Signature	Date

Declaration

I, Tiya Bacha Bulcha, announce this research paper entitled "Effect of cold chain management practices on availability of vaccines: The case of health centers under Addis Ababa city administration health bureau" is my own and I dare to say original research work that has not been produced by others in any other universities for any other requirements in any form. To this end, I acknowledged all sources of information that I used to produce the study appropriately and I would say perfectly.

Tiya Bacha	______________	____________
Student Researcher	Signature	Date

Letter of Certification

This is to certify that Tiya Bacha has carried out her thesis work on the topic entitled “Effect of cold chain management practices on availability of vaccines: The case of health centers under Addis Ababa city administration health bureau” under my guidance and supervision. Accordingly, I here assure that her work is appropriate and standard enough to be submitted for the award of Master of Arts in Logistics and Supply Chain Management.

Matiwos Ensermu (PhD)	________________	___________
Research Advisor	Signature	Date

Acknowledgments

First and foremost I would like to thank God for everything. Next, I would like to acknowledge all the subjects who participated in this study. I am also very grateful to my advisor Matiwos Ensermu (PhD) for his guidance while writing this thesis. His willingness to give his time so generously has been very much appreciated. I acknowledge the important role played by Ato Birhanu Abera to help in the data collection process. I would like to offer my special thanks to Dr Ermias Shenkutie whose encouragement, guidance and support from the initial to the final level was with me. Finally, I must express my very profound gratitude to my family providing me with unfailing support and continuous encouragement throughout my years of study. This accomplishment would not have been possible without them.

Effect of cold chain management practices on availability of vaccines: the case of health centers under Addis Ababa city administration heath bureau

Table of Contents

List of Tables

List of Figures

List of acronyms

FMOH- Federal ministry of health

MDVP -Multi-Dose Vial Policy

MOH- Ministry of Health

PFSA- Pharmaceuticals Fund & Supply Agency

UNICEF- United Nations Children’s Fund

VVM - Vaccine Vial Monitors

Abstract

This research was designed to assess the effect of cold chain management practices on availability of vaccines: the case of health centers under Addis Ababa city administration health bureau. The study used a quantitative methodology with explanatory study design to generate answers to the research questions. Primary data were collected through questionnaire from cold chain responsible personnel in selected health centers. To determine the sample size for selecting health centers the researcher employed a sample determination formula developed by Cochran in 1963. In order to select the respondents, the study used probability sampling method specifically simple random sampling. Accordingly, an aggregate of 71 respondents were selected and participated in this study and out of these, data were obtained from 62 respondents. Data collected through questionnaire were analyzed using descriptive statistics such as frequency and mean. As an aside, correlation was used so as to assess the relationship between cold chain management practices and availability of vaccines. Multiple regression equation was used to test the hypothesis of research. The findings of the study revealed that all the components of cold chain management practices and also availability of vaccines were rated average except information system. The regression analysis revealed that storage and distribution practices have significant positive effect on the availability of vaccines. On the other hand technical capacity and information system were found to have no significant effect on the availability of vaccines. In order to improve the availability of vaccines in the health centers the researcher recommend to FMOH and other concerning bodies to focus on all distribution and storage practices. Among the recommendations, using electronic databases such as Health Commodities Management Information System (HCMIS), accelerating the transition of vaccine supply chain responsibility from the Federal Ministry of Health to the Pharmaceuticals Fund and Supply Agency, purchasing more cold chain equipments are some to mention. On top of that, the researcher recommend others to conduct similar research by expanding their scope to include private and other governmental health facilities and also to find out actual vaccine wastage.

Key words: cold chain, vaccine, availability

1 Chapter One: Introduction

1.1 Background of the Study

A cold chain is a monitored temperature controlled supply chain (Kohli, 2008). The goal of the cold chain is to keep a sample or material within a certain temperature range during all stages of delivery, processing and storage. Cold chains are widely used to ensure the viability of products in the pharmaceutical and agricultural sectors, and are critical components of vaccination programs (David Wolking, 2013).

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 remember it, so that the immune system can more easily recognize and destroy any of these microorganisms that it later encounters (WHO, 2015b). Vaccines need specialized storage because of the very sensitive nature of these biological products. As a result, the type of equipment used for storing vaccines needs to be specialized according to different temperature zones, and the service level of storage. Most vaccines need to be stored in a temperature controlled environment (either in a freezer or a refrigerator) all the time; improper storage temperatures reduce vaccine potency and result in recipients not being protected against diseases (Lala & VVM, 2003). Appropriate cold storage equipment is an essential prerequisite in order to ensure the quality of vaccines administered to the population. Many vaccines lose their effectiveness if they're exposed to extreme heat or freezing conditions. Excessive heat, cold, or light exposure can damage vaccines, resulting in reduced potency. Once potency is lost, it cannot be restored (CDC, 2014). Eventually, if the cold chain is not properly maintained, potency will be lost, and the vaccines become useless.

The vaccine cold chain is a temperature controlled environment used to maintain and distribute vaccines in optimal condition. A proper cold chain is a temperature controlled supply chain that includes all equipment and procedures used in the transport and storage and handling of vaccines from the time of manufacture to administration of the vaccine (CDC, 2014). According to World health organization (WHO) cold chain is a system of storing and transporting vaccine at the recommended temperature range from the point of manufacture to point of use (Immunization &

Biologicals, 2004). The cold chain relies on three main elements well-trained personnel, reliable transportation and storage equipment and efficient management procedures. The cold chain begins with the cold storage unit at the manufacturing plant, extends through transport of vaccine to the distributor, then delivery and storage at the provider facility, and ends with administration of vaccine to the patient. Appropriate storage conditions must be maintained at every link in the cold chain (CDC, 2014).

Vaccine supply chain management has received increasing attention in recent years as both a priority and a challenge for many countries (Lydon, Raubenheimer, Arnot-Krüger, & Zaffran, 2015).Vaccination is one of the methods that have been proven effective in preventing the transmission of infectious diseases and hence reduction of infant and child mortality rate in the world. It is one of the most cost-effective health investments, estimated to avert between 2 and 3 million deaths globally each year, with proven strategies that make it accessible to even the most hard-to-reach and vulnerable populations(Matthias, Robertson, Garrison, Newland, & Nelson, 2007). To be effective, however, a number of elements in a vaccination program need to be implemented properly, including cold chain management, vaccine management, logistics management, and waste management. Failure to properly implement these can reduce the level of protection that is expected from a vaccination program (WHO, 2008). Therefore, the availability of a proper cold chain and vaccine and logistics management system from the vaccine manufacturer to the end user, and follow-up after the vaccination program is finished must ensured. Without vaccines as well as safe and effective distribution systems and delivery practices, disease would become more rampant and the public health and the community would be overburdened with treatment costs and deaths particularly in children.

The national Immunization program in Ethiopia was launched in 1980. At the national level, the maternal and child health directorate of the Ministry of Health (MOH) coordinates the program (MOH, 2012). Existing Country Context for Vaccine Distribution shows Cold Chain system for vaccines and other cold storage requires health commodities consists of five levels, following the Federal ministry of health (FMOH) administrative structures the current vaccine cold chain system incorporate Pharmaceuticals Fund & Supply Agency (PFSA) , Regional health bureaus, Zonal health divisions , woreda health offices and health facilities. Transition Strategy for

Vaccines was started in 2013 to transfer responsibility for vaccine supply chain to PFSA and the transition process is taking place in selected three hubs.

In tropical countries such as Ethiopia where power supply is unreliable and facilities for its maintenance are not well developed maintaining the cold chain is very challenging. In these areas, it is not uncommon to observe, at any given time, most of refrigerators and freezers being out of order (FMOH, 2015; WHO, 2008). Lack of accountability for vaccines stock monitoring, absence of sensitive vaccine wastage monitoring indicator, lack of clear vaccine distribution plans, lack of budget specifically allocated for vaccine transportation at all levels and inaccurate use of temperature monitoring devices are some of challenges in the vaccine management system in the country (FMOH, 2013).

This study seeks to examine the effect of cold chain management system on availability of vaccines in governmental health centers Addis Ababa.

1.2 Statement of the Problem

With few exceptions, vaccine supply and logistics systems around the world are unable to keep pace with growing immunization programs (WHO, 2014a). According to WHO less than 25% of countries are operating at even a minimum standard within the criteria of maintenance, stock management and distribution. Furthermore, only 29% of countries are meeting minimum standards for temperature control. In 2011 2.8 million Vaccine doses ware lost in five countries due to cold chain failures (WHO, 2014c). WHO and the United Nations Children's Fund (UNICEF) have estimated overall wastage rates in developing countries of around 50% (Lloyd, 1999).

Total cost of vaccine per fully immunized child in a developing country is $38.75/31.64 (WHO, 2014c). Ethiopia has a population of 3 million children which means 116 million USD (2 billion birr) is spend on vaccines each year (FMOH, 2013). A huge amount of money is allocated both by partners and the government of Ethiopia for the procurement of vaccines each year. In Ethiopia, even though, there are no significant problems in the availability of vaccines at national level weak vaccine stock and inventory management has been noted at regional and service delivery levels (FMOH, 2015). The vaccine distribution system in Ethiopia comprises several distribution steps with average of five levels of inventory holding points that are considered unnecessary (FMOH, 2013; WHO, 2014c). This kind of system is likely to result in vaccine wastage and expired vaccine, and that led to overstocks at some distribution points. Each transfer in a complex supply chain processes could increases the risk of bottlenecks or breakdowns (Kaufmann, Miller, & Cheyne, 2011). A study done in immunization centers of Ethiopia revealed that 32.8% of the health institutions used to collect vaccines at intervals longer than a month. Vaccine storage in the refrigerator was observed to be improper in 73.4% of the functioning 64 centers and Lack of technicians for refrigerator maintenance was reported by 61.2% of the institutions (Berhane & Demissie, 2000). According to the national cold chain equipment inventories carried out in 2013, About 38% of the refrigerators/freezers at health facility level and 36% of refrigerators/freezers at administrative level (woreda to region) were not functional (FMOH, 2015). In addition, inventory control and vaccine wastage are not traceable due to lack of a reporting system (JSI, 2015a). The same study from the immunization centers of Ethiopia shows that a complete record of the vaccines stock was observed only in 59.4% of the health institutions (Berhane & Demissie, 2000).

Although, studies are indicating that such poor management of vaccines could result in overstocking of vaccines at central level while sub national cold rooms are not storing adequate vaccines, there is no study that shows the availability of vaccines in the health facilities in Ethiopia (Kaufmann et al., 2011; WHO, 2014c). Thus this research will assess the management of vaccine in order to analyze its effect on the availability of vaccines in service delivery level.

1.3 Research Questions

Based on the previous statement of research problem, the following main research questions were formulated.

1. How the current vaccine cold chain management practices in Governmental health centers of Addis Ababa does looks like?
2. How much available are vaccines in governmental health centers of Addis Ababa?
3. How vaccine cold chain management practices influence the availability of vaccines in governmental health centers of Addis Ababa?

1.4 Objectives

1.4.1 General Objective:-

The general objective of the research is to assess the Effect of vaccines cold chain management practices on the availability of vaccines in health centers under Addis Ababa city administration health bureau.

1.4.2 Specific Objectives:-

- To assess the effect of technical capacity of health centers under Addis Ababa city administration health bureau on availability of vaccines.
- To assess the effect of information system of health centers under Addis Ababa city administration health bureau on availability of vaccines.
- To assess the effect of Storage system and facilities of health centers under Addis Ababa city administration health bureau on availability of vaccines.
- To assess the effect of distribution system of governmental health centers on availability of vaccines.

1.5 Significance of the Study

This study will identify the effect of vaccines cold chain management on the availability of vaccines in health centers under Addis Ababa city administration health bureau. The findings and recommendations of the study will be useful for policy makers and regulatory authorities by way of designing guidelines and enforcement of cold chain standards for compliance. The study will contribute helpful information to the available literature on vaccine Distribution system and its storage practices. The study will contribute valuable information for local health policy makers, EPI, healthcare providers, donors and all stakeholders involved in cold chain medicines to effectively plan, manage and supervise the distribution system and storage practices of vaccines in Ethiopia. Finally, the research brings to the fore questions to expose gaps that would require further investigation.

1.6 Delimitation of the Study

This study was delimited on governmental health centers in Addis Ababa because of their significant/ key role on the immunization programs. The study did not include regional and central levels of cold chain management due to time and budgetary constraints. This study only addresses cold chain management practices in terms of storage, distribution and information systems and technical capacity of the health centers. The other delimitation was made on the subject of the study. The study addressed only personnel responsible for vaccine cold chain management (vaccination focal person) in the health centers. Finally, this study was delimited itself to all the mentioned parts of the methodology which some of them were considered as the limitation of the study.

1.7 Limitation of the Study

The study was cross-sectional research design for the fact that such a design would enable the researcher to obtain large amount of data within limited time. This study was limited in a sense that the result may not be similar as to what might have been obtained if longitudinal methodologies were applied. Another limitation of this study was related to the employed data gathering tool. Questionnaire has no possibility of probing the respondents like that interview. Though pilot study was made, it was likely that respondents may not clearly understand the meaning of the questions and the researcher cannot exactly trace the real feeling of the respondents. The other limitation of the study is that it only participate cold chain focal persons in the public health centers. More meaningful results would have been produced if the scope of the study was extended to central, regional and sub city levels of clod chain management. Last but not the list the research has been cared only in governmental health facilities due to resource limitation.

1.8 Organization of the Study

This study is organized into five chapters. The first chapter dealt with background, problem statement and objectives of the study. The second chapter presented the review of related literature and chapter three described the methodology of the study. The fourth chapter devoted to the presentation, analysis and discussion of data and the last chapter consisted of the summary, conclusion and recommendations of the study.

2 Chapter Two: Review of Related Literature

This chapter reviews relevant literature on the key areas that the study covers. This chapter presents the theoretical underpinnings of the study. With a focus on the objectives and theoretical thresholds of this study, the chapter reviews related and contemporary literature on the concept of the cold chain and availability of vaccine. An attempt has also made to give a highlight on Global perspective of vaccine distribution and management and finally the vaccine cold chain management in Ethiopia. The chapter examines various research studies and reports done locally (Ethiopia), regionally (Africa) and globally. Historical perspectives and the conceptual framework of the study are addressed in this chapter.

2.1 The cold chain in vaccine supply chain management

A cold chain is a temperature-controlled supply chain. An unbroken cold chain is an uninterrupted series of storage and distribution activities which maintain a given temperature range. It is the integrated system of equipments (e.g., cold rooms, shipping containers, refrigerators, and vehicles), procedures, records, and activities used to handle, store, transport, distribute and monitor temperature sensitive products. It is used to help extend and ensure the shelf life of products such as fresh agricultural produce, seafood, frozen food, photographic film, chemicals and pharmaceutical drugs (Kohli, 2008). The cold chain encompasses all the storage and transport facilities necessary to ship a product requiring controlled low-temperature storage from the manufacturer to the end user. The goal of the cold chain is to keep a material within a certain temperature range during all stages of delivery, processing and storage (Taylor, 2001). Cold chains are common in the food and pharmaceutical industries and also in some chemical shipments. Many biological substances deteriorate when exposed to heat, sunlight, or fluorescent light. When transporting and storing such biological substances, it is imperative to control environmental conditions, ensuring that exposure to potentially damaging environmental factors is minimized. One common temperature range for a cold chain in pharmaceutical industries is 2 to 8 °C. But the specific temperature (and time at temperature) tolerances depend on the actual product. This is also the recommended temperature range by WHO for the cold chain system of transporting and storing vaccines (Health & Council, 2008).

The system used to keep and distribute vaccines in good condition is called the cold chain. The cold chain has three main components: transport and storage equipment, trained personnel, and efficient management procedures. All three elements must combine to ensure safe vaccine transport and storage. The cold chain begins with the cold storage unit at the vaccine manufacturing plant, extends through the transfer of vaccine to the distributor and then to the provider's office, and ends with the administration of the vaccine to the patient. Proper storage temperatures must be maintained at every link in the chain. Excess heat or cold will reduce their potency, increasing the risk that recipients will not be protected against vaccine preventable diseases. To ensure the optimal potency of vaccines, careful attention is needed in handling practices at all levels of the cold chain (Afsar & Kartoğlu, 2006; Association, 2007).

Choosing the right cold chain equipment is strategically important; as such choices can facilitate changes in delivery routes and frequencies, which in turn could have an effect on vaccination schedules and strategies. Make the decision on what type of cold-chain equipment to use on detailed knowledge of the local situation. The first question to ask is whether or not reliable electricity is available. If it is available, whether from a grid or a generator, various types of electric refrigerator can be used, provided they are of known reliability. In areas with an electricity supply of 8 or more hours during a 24-hour period (whether the source is grid and/or generator), the ice-lined compression refrigerator is highly suitable because it has a holdover time of 24 hours at +43 °C ambient temperature; it can therefore prevent vaccines from damage during power interruptions or regular outages (WHO, 2008). According to WHO, in any temperature-controlled rooms, cold rooms, freezer rooms, refrigerators and freezers used to store vaccine air temperature and Humidity monitoring systems and devices should be installed. Electronic sensors should be accurate to ± 0.5 °C and ± 5% relative humidity or better. Sensors should be located in areas where the greatest variability in temperature is expected to occur within the qualified storage volume and they should be positioned so as to be minimally affected by transient events such as door opening (WHO, 2011).

2.2 Association between vaccine cold chain management and availability of vaccine

WHO recommends the range of temperatures for storing and transporting vaccine should be on the basis of data supplied by manufacturers. Each vaccine has its own specific storage requirements so it is extremely important to know how long, and at what temperature, each vaccine can be stored. All vaccines can be stored at positive temperatures (between +2 °C and +8 °C). However, only some vaccines can be stored at negative temperatures (between -15 °C and -25 °C) (WHO, 2008).

Vaccines are delicate biological substances that can become less effective or destroyed if they are not stored and transported properly. Literatures suggest that vaccines could be destroyed or become less effective if they are allowed to get too hot, frozen, or exposed to direct sunlight or fluorescent light (CommonwealthofAustralia, 2013; Kartoglu & Milstien, 2014).

2.2.1 Freezing

Freezing is the most common reason for vaccine damage. Freezing of vaccine refers to situation whereby vaccines stored at or below 0°C of temperature for type of vaccines which need to be stored in refrigerator temperature range of +2 °C and +8 °C. Vaccine damage at temperature of 0°C is common although it may not appear frozen (CommonwealthofAustralia, 2013). Because the original problem with the cold chain was keeping the vaccines cold enough, most of the training efforts for the effective management of cold chain were directed at keeping the vaccine cold enough. But researches are reveling that vaccines are more sensitive to freezing than they are to heat (Kartoglu & Milstien, 2014). For example, according to the product information sheets inactivated polio vaccine, diphtheria-tetanus-pertussis vaccine (DTP), diphtheria and tetanus toxoids vaccine, hepatitis B vaccine (HepB), and tetanus toxoid vaccine (TT) are seriously damaged at temperatures less than 0°C. A study in Indonesia that monitored the temperature of HepB vaccine shipped from the manufacturer to the provider found that 75% of vaccine shipments were being frozen (C. M. Nelson et al., 2004). Studies involving site visits show that 15% of refrigeration units had temperatures of 34°F (1°C) or lower (Bell, Hogue, Manning, & Kendal, 2001; Gazmararian et al., 2002).

2.2.2 Allowed to get too hot

When vaccines are exposed to repeated episodes of heat the loss of vaccine potency is cumulative and cannot be reversed (CommonwealthofAustralia, 2013). The transport and storage of vaccines at temperatures higher than 8°C have been reported in the United States and Australia. In the United States, a temperature study was conducted of refrigerators used to store vaccines in medical clinics. Thermometers were used to measure the minimum and maximum temperatures for a 24-hour period. The results indicated that 59% reached temperatures higher than the acceptable range, and 93% were both higher and lower than the acceptable range (Miller & Harris, 1994; Woodyard, Woodyard, & Alto, 1995) A study in Bolivia that monitored the temperature of DTP-HepB-Haemophilus influenza type B vaccine throughout its transportation from the national warehouse to 11 communities in 3 provinces reported that 7 of the 11 routes from provincial to district warehouses had a temperature higher than 8°C (C. Nelson et al., 2007).

2.2.3 Exposed to direct sunlight or fluorescent light

Vaccines and cold chin equipments should be placed in such a way in the room that they are not exposed to sunlight any time during the day. Exposure to sunlight will lead to increase in core temperature of the cold chain equipment, which would break the cold chain by causing an increase in the temperature of the vaccines (Naik, Rupani, & Bansal, 2013).

There have been a number of reports demonstrating an association between vaccine quality and appropriate vaccine transport and storage. In Nigeria, the potency of oral polio vaccine (OPV) as well as vaccines for measles and yellow fever was found to decrease below international standards when they were transported from the national warehouse to health facilities (Acu, Adedeji, Esan, & Odusanya, 1996). Diphtheria toxoid containing vaccines may change their appearance and lose potency when frozen due to freezing destroying the gel structure of the adjuvant and could be destroyed in three to five hours if exposed to 60°C (Kartoğlu, 2012). An estimated 17% to 37% of providers expose vaccines to improper storage temperatures (Bell et al., 2001) WHO estimates that in some countries, 50% of all vaccine doses are wasted either before or after a vial is opened (WHO, 2005). Most closed-vial vaccine wastage can be attributed to supply chain issues including accidental freezing, expiry, vaccine vial monitor indication, breakage, theft, and loss(Guichard et al., 2010; WHO, 2005) .

Loss of vaccine potency due to improper storage conditions is a costly mistake. Patients receiving vaccine with decreased potency caused by improper storage conditions may not be fully protected against the vaccine preventable disease. Unless these supply chain issues are solved, vaccine wastage will continue to consume much needed vaccine and unnecessarily inflate the cost of vaccination programs.

2.3 Challenges in cold chain management

Now a days there are number of vaccines available and inventions of new vaccines have generated serious challenges in their vaccine supply and logistic systems. Storage capacity bottlenecks and system inefficiencies threatens the access, availability and quality of vaccines. People who have been involved in vaccine supply chains over the years generally agree that the following the major challenges facing lower and middle income countries (Kaufmann et al., 2011).

2.3.1 Information system

Many countries do not have reliable data about past vaccine usage or accurate projections of target population and their locations. National vaccine forecasting is done using population estimates, birth rates, infant mortality rates, vaccine waste rates, and prior year estimates of usage(Kaufmann et al., 2011). Because census data are typically only brought up to date every ten years, even in the best organized developing countries, the combination of inaccurate estimates means that incorrect vaccine forecasts are replicated year after year. Unnecessary in-country logistical burdens and expense are the result when too much or too little vaccine is ordered as a result of the inaccuracies. Inaccurate or outdated census counts, population migrations, and unforeseen changes in birth rates all contribute to the problem. Local health managers may try to counteract these by head counts but they introduce their own biases, including inflation of numbers to ensure adequate amounts of vaccines and deflation to make coverage rates look high (FMOH, 2013).

There is considerable lack of coordination between those people and organizations that finance and procure vaccines for shipment to developing countries and those supply-chain managers and storekeepers responsible for receiving and distributing the shipments. Financing and procurement stakeholders have limited knowledge of the constraints faced by vaccine officials in developing countries. Supply-chain planners and managers are rarely consulted or involved in the plans that ultimately produce incoming vaccine shipments (Kaufmann et al., 2011).

2.3.2 Technical capacity

Training supply chain personnel is usually focused narrowly on specific activities, such as storekeeping, maintaining cold-chain records, and providing security for commodities, rather than the higher order planning, analysis, and performance management skills needed by supply chain managers. studies done in different countries show that inadequate knowledge and practices exist regarding cold chain management in primary health care facilities (de Timóteo Mavimbe & Bjune, 2007). Those who manage the supply chain must be given higher status and a seat at the planning table, so managers can advise on logistical road blocks and how to overcome them. People involved in transportation and supply of vaccines need to be trained and have knowledge of cold chain and how to handle breakage of cold chain. Without pre-requisite knowledge of how to handle vaccines being transported can seriously affect the vaccine potency which in turn can result in wastage of vaccines and thus, increase in their price.

Cold chain equipment requires installation and maintenance, which necessitates the availability of properly trained technicians, replacement parts, a system to monitor equipment performance, and the capability to rapidly respond to breakdowns and failures. Although existing supply chains should already have maintenance plans in place, recent cold chain assessments reveal consistent deficiencies in this area (PATH., 2008). Developing, procuring, supplying, and maintaining shipment and storage materials, including appropriate vehicles, refrigerators, and cold boxes, is an ongoing challenge.

2.3.3 Storage and Transportation

When multiple vaccines become available and are added to existing vaccine regimens, storage and delivery capacity in many countries can quickly be overwhelmed. Donor support of in country transportation needs is often limited. The ability in country to analyze and plan efficient transportation routes, develop and operate transportation schedules and networks, or procure and maintain the right vehicles to meet transport needs is often lacking. Some countries lack skills, funding, and equipment to handle incoming shipments, maintain what limited equipment they do have, or overcome institutional barriers to effectively use and share needed vehicles and equipment among programs (Kaufmann et al., 2011).

2.4 Global perspective on vaccine distribution and management

The global vaccination market is a large one, with a double digit growth rate. Global vaccine sales by major manufacturers have grown from US$3.6 billion in 1999 to US$9.9 billion in 2004, representing a compound annual growth rate of about 29% (Belsey, de Lima, Pavlou, & Savopoulos, 2006). The total global sales are projected to grow to US$30–42 billion by 2015. Even though vaccines are widely recognized for their efficiency and cost- effectivness vaccine uptakes in populations have typically been low (Blue, 2008). Such undesirably low vaccine coverage can be attributed to two main factors:

Supply-Side Issues: Operational issues on the supply side, such as uncertainty in the supply often lead manufacturers to under-produce, resulting in supply shortages. For example shortage of influenza vaccine in the market is because of this reason (Deo & Corbett, 2009).

Negative Network Effect: When the fraction of vaccinated individuals grows, the chance of contacting an infection will decrease. Therefore, the willingness to pay for the vaccine reduces (Katz & Shapiro, 1985).

Over the past 15 years, the field of supply chain and logistics management has steadily evolved. With Advances in information technology, products including perishable and temperature sensitive products, now routinely travel to even the most remote villages on predictable and reliable schedules (Yadav, Stapleton, & Van Wassenhove, 2013).

Today, global vaccine supply chain is growing very fast. Internet connection is sometimes all that is required to track shipments, check inventories, estimate the date and time of delivery, and request changes or new products (Zaffran et al., 2013). In 2011 national governments, donors, and international agencies developed a global vision for vaccine supply and logistics systems to enable the supply systems meet the changing needs of a changing world by ascertaining the right vaccines to be in the right place, at the right time, in the right quantities, in the right condition, at the right cost (PATH., 2008).

Internationally, the UNICEF Supply Division procures vaccines for some 55 percent of the world's donated vaccine supplies. In 2009 UNICEF procured 2.99 billion doses of vaccine for eighty-two countries and $18 million worth of refrigerators, insulated shipping containers and other ancillary materials (Kaufmann et al., 2011). According to the Healthcare Distribution Management Association, of the close to 200 billion dollars in pharmaceutical distribution, about 10% are drugs that are temperature sensitive. This makes the cold chain responsible for transporting a near 20 billion dollar investment.

WHO Global Data Analysis of Effective Vaccine Management (done in 75 countries from 2010 to 2013) revels that more than 10% of national stores assessed do not have cold or freezer rooms, that more than 10% do not store any vaccine at sub-zero temperatures, and that refrigerated vehicles are used in only a quarter of countries. More than half of the stock record templates in use do not contain all of the recommended fields, that more than a third of facilities have inaccurate stock records and have been unable to meet demand on at least one occasion in the year preceding assessment. The quality related indicators of this analysis reveal poor temperature monitoring practice and equipment. Less than a fifth of countries have conducted a temperature monitoring study in the past 5 years, less than a fifth of cold rooms have been temperature mapped. Less than a half of all cold rooms and refrigerators have the recommended temperature monitoring equipment, and monitoring of exposure to freezing temperatures during transport in passive containers with ice-packs is almost non-existent. About 50% of the countries assessed do not have an up to date cold chain equipment inventory. In addition, the data reveal that about 25% and 50% of national and sub-national stores respectively still use paper based stock management systems. More than a third of vaccine storage facilities do not monitor vaccine wastage. Less than 50% of national stores do not have a set of standard operating procedures, and that more than a third of health workers and store managers do not receive regular supportive supervision. On the bright side, the quality related questions of this analysis do reveal a high level (>80%) of health worker and store manager knowledge and understanding of vaccine temperature sensitivities and recommended vaccine storage temperatures (WHO, 2014b).

In 2013, more than 40% of low and middle-income countries suffered a national- level stockout of at least one vaccine that lasted at least one month (WHO, 2014a). The Study done in Pakistan shows that chronic mismanagement of vaccines had created an adverse scenario at the Federal EPI. In addition to the wastage of 1.3 million doses of pentavalent, severe negligence of storage practices and operational management, and non-adherence to SOPs was evident from the overall performance of the warehouse. Additionally, there was a high-dependence on support from international partners (USAID|Deliverproject, 2015). Evaluation of Vaccine Cold Chain in Urban Health Centers of Western India shows that only 3 (15%) of the health centers had either a working inverter or a generator. Though, an alternate working refrigerator was available in 13 (65%) health centers. In this study It was good to see that 15 (75%) vaccinators knew the definition of cold chain exactly in its stated form, It was reassuring to see that almost all (95%) vaccinators knew the correct arrangement of vaccines according to temperature sensitivity (Naik et al., 2013).

Over the first eight years of this century, the global vaccine market almost tripled, reaching over US$ 17 billion in global revenue by mid-2008, according to recent estimates. This increase represents a 16% annual growth rate, making the vaccine market one of the fastest-growing sectors of industry generally more than twice as fast as that of the therapeutic drugs market (Maurice & Davey, 2009).

One study shows that more than half of the countries involved in the study had received vaccine in unsatisfactory condition. Only 41% of the countries have ensured that customs staff at the arrival airport has been trained to look after vaccine, and only 50% have ensured that a contingency plan is in place in the event of flight delays and other eventualities. 26% expected customs clearance to take longer than 24 hours and 18% did not have a cold room at the airport.

Taken in account the above studies done in different countries the overall vaccine supply chain is rather poor.

2.5 Global regulation of cold chain medicines

The World Health Organization declares that as much as 25% of all vaccine products reach their destination in a degraded state (Makuru, 2012). In view of this the WHO has put in place guidelines and Good Distribution Practices (GDP) requirements for the storage and distribution of cold chain medicines. According to the WHO, although the target end users includes regulators, logisticians, and pharmaceutical professionals industry, government and the international agencies, it also accepts the fact that local legislation and regulations will continue to take precedence (WHO, 2015a). Medicines requiring controlled-temperature storage conditions must be distributed in a manner that ensures that their quality will not be adversely affected (C. M. Nelson et al., 2004). This applies to low risk product as well as high risk product such as vaccines and blood products which normally require storage between 2 °C to 8 °C. All distributors of drug products are required to record storage and transportation temperatures as well as being licensed by the appropriate authorities. Temperature monitoring devices should be used to demonstrate compliance with the records that are kept. The responsibility for the cold chain ultimately resides with the manufacturer but accountability is shared across the supply chain. This requires increased oversight, management, and control of environmental conditions across the entire supply chain. There should be mandatory increased importance of temperature control and monitoring with heightened priority of patient safety and focus on product quality (Matthias et al., 2007). Regulations include temperature controlled products which have specific storage temperature requirements. Cold chain products and starting materials used in the manufacture of temperature sensitive products should be stored and transported under conditions which ensure that their quality is maintained. Good warehousing and distribution practices require that storage areas for medicines should be maintained within acceptable temperature limits and that, where special storage conditions are specified by the manufacturer; these should be provided, checked and monitored (WHO, 2011). Measuring and monitoring equipment should be calibrated and checked at defined intervals. Temperature sensitive products should be transported in such a way that they are not subjected to unacceptable degree of heat and cold, and specialized means of transportation should be used where necessary to ensure that the quality of the products are maintained throughout all distribution networks (WHO, 2009).

2.6 The vaccine supply chain and logistics in Ethiopia

The Federal Ministry of Health has been working to ensure an efficient and high performing healthcare supply chain that will ensure equitable access to affordable medicines for all Ethiopians. In past years, significant progress has been made, although various challenges remain an inadequate supply of quality and affordable essential pharmaceuticals, poor storage conditions, and weak stock management resulted in high levels of waste and stockouts. The Expanded Program on Immunization started in Ethiopia in 1980 with the aim of reducing mortality and morbidity of children and mothers from vaccine preventable diseases. During the inception of EPI the objective was to increase immunization coverage by 10 % annually but this target has not been realized even after three decades. Immunization services are being rendered in most of the health facilities and in outreach and mobile services for the community residing beyond 5KM from the static health facilities. In the routine EPI program the traditional six antigens are being given in both the public and private services. Starting in 2007, pentavalent formulation, DPT-HepB-Hib was introduced into the routine immunization program thus increasing the number of total antigens given to infants to eight (DPT-HepB-Hib, BCG, OPV and measles). In addition, 10 valent pneumococcal vaccine was introduced in the October 2011 and increased the total number of antigens in the routine immunization programme to nine. Rota (FMOH, 2013).

For years, staff at the regional, woreda, and health facility staff collected vaccine supplies from the level above. The journey from the facility to the warehouse can take a day or longer on tough-to-navigate roads, and trips were frequently made more than once a month to ensure sufficient supply of vaccine when mothers arrived with their infants. Now, Pharmaceuticals Fund and Supply Agency (PFSA) is delivering vaccines from the central cold room to their regional hubs, and then to the zones and/or woreda (district) level using refrigerated trucks. Distributing vaccines to numerous sites presents a logistical challenge. system have been responsible for picking up vaccine supplies from warehouses and transporting them back to their locations using cold boxes or vaccine carriers to maintain a safe temperature. Vaccines were distributed through a complex supply chain involving no fewer than six levels. Starting in 2014, the responsibility for the routine vaccine supply chain began transitioning from the FMOH to the PFSA, an autonomous FMOH agency responsible for the entire essential medicine supply chain. This shift consolidated the national vaccine supply chain with the supply chain for essential medicines and vaccines used for campaigns, creating potential efficiencies but also bringing new challenges. PFSA was managing distribution of vaccine for campaigns before the vaccine transition. By May 2015, three of the 14 Hubs began to manage vaccine for routine immunization as well. The hubs now receive vaccines in refrigerated trucks each quarter, and are delivering vaccines to lower levels of the system (JSI, 2015a).

Figure 1: The transition of vaccine supply chain

Source: World Health Organization http://apps.who.int/immunization_monitoring, 2015

2.7 Cold chain equipment in Ethiopia

National level cold chain equipment inventories were carried In Ethiopia with the objective of identifying the status of cold chain equipment in the country. The 2002 inventory shows that 35% of equipment was not functional, 83% of the functional equipments were aged 10 and above 14% of the functional equipments were sub-standard equipment. By the end of 2004, there was only one cold room of about 75 meter cube in internal volume. By the end of 2005, there were five regional cold rooms in three regions of the country, with a total 150 meter cube internal volume. By mid-June 2006, nine additional cold rooms were provided at different regions of the country. A cold room was provided in Tigray, Nekemt, Bahir Dar, Awassa, Dukem, Dire Dawa and Afar.The 2013 inventory result revels 20,660 refrigerators/freezers were available at different level of health structure (health post, clinic, health centre and hospital, woreda, zone and region). About 62% of the refrigerators/freezers at health facility level and 64% of refrigerators/freezers at administrative level (woreda to region) were functional during the inventory (FMOH, 2015).

Studies indicate that there is a real weakness in the cold chain system in Ethiopia, which could compromise the potency of the vaccines and the general quality of the immunization services (Berhane & Demissie, 2000; FMOH, 2013, 2015). A study done in urban and rural health centers of Ethiopia showed that 32.8% of the health institutions used to collect vaccines at intervals longer than a month. Completely melted ice packs during transportation of vaccines were encountered by only three (4.5%) centers. A complete record of the vaccines stock and up-to-date refrigerator temperature records taken twice a day were observed in 38 (59.4%) and 37 (57.8%) of the 64 functional immunization centers, respectively. In four of the rural centers, there was no thermometer to regulate the temperature of the refrigerator, and among those found having any, seven were reading outside the recommended temperature of 0 to +8°C for vaccine holding refrigerators. Vaccine storage in the refrigerator was observed to be improper in 47 (73.4%) of the functioning 64 centers (Berhane & Demissie, 2000).

Today's vaccine management is becoming more complicated, as national immunization programmes prepare to provide protection against 2.5 times as many diseases, administer three times as many doses per person, store and transport four times more vaccine volume per fully immunized person, increase six-fold the spending on vaccines to fully immunize one person and serve a global target population size that has doubled. It is clear that immunization programmes in developing countries such as Ethiopia face severe challenges (WHO, 2014c).

Vaccine management is a major challenge currently of concern within Ethiopia. As the FMOH highlighted a number of areas improved significantly, such as vaccine arrival, cold storage, vaccine vial monitor use, and proper use of multi-dose open vial policy. However, it also identified continued gaps in vaccine wastage control, stock management, effective vaccine delivery, and vaccine storage temperature. The high level of vaccine wastage, and poor utilization of available policies and equipment such as VVM (Vaccine Vial Monitors), and/or MDVP (Multi-Dose Vial Policy) have also highlighted the need for better vaccine management practices. Adverse events due to inappropriate vaccine distribution practices are, partly, also believed to effect negatively on vaccine management (FMOH, 2013).

Immunization is well accepted as one of the most cost-effective of all health interventions. In most of the prior work this important constraint is either neglected or not given much importance while generating the optimized supply route. In advent of new and improved vaccines introduced daily, the logistics systems must be strengthened and optimized.

2.8 Availability of vaccine in health facilities

As (Adida, Dey, & Mamani, 2013) mentioned the two main reasons of why it is difficult to reach optimum level of vaccine coverage are emergence of operational issues on the supply side and negative network effects on consumption side. These two reasons are needed to be dealt with to achieve the optimized solution for vaccine supply. There are many constraints which need to be considered in vaccine distribution planning, like (Zaffran et al., 2013) mentioned some current issues include: Effect of vaccine schedules and presentations on cold chain volume requirements, vaccine transporting with maintain cold chain, immunization related information systems, technical capacity for vaccine supply chain and Vaccine cost and wastage.

These issues need to be addressed in order to keep logistic systems with pace with growing immunization programs. According to the researchers from the World Health Organization WHO and PATH, the vaccine volume requirements compared to the available capacity exceeds by 25 percent (PATH., 2008).

2.9 Conceptual framework

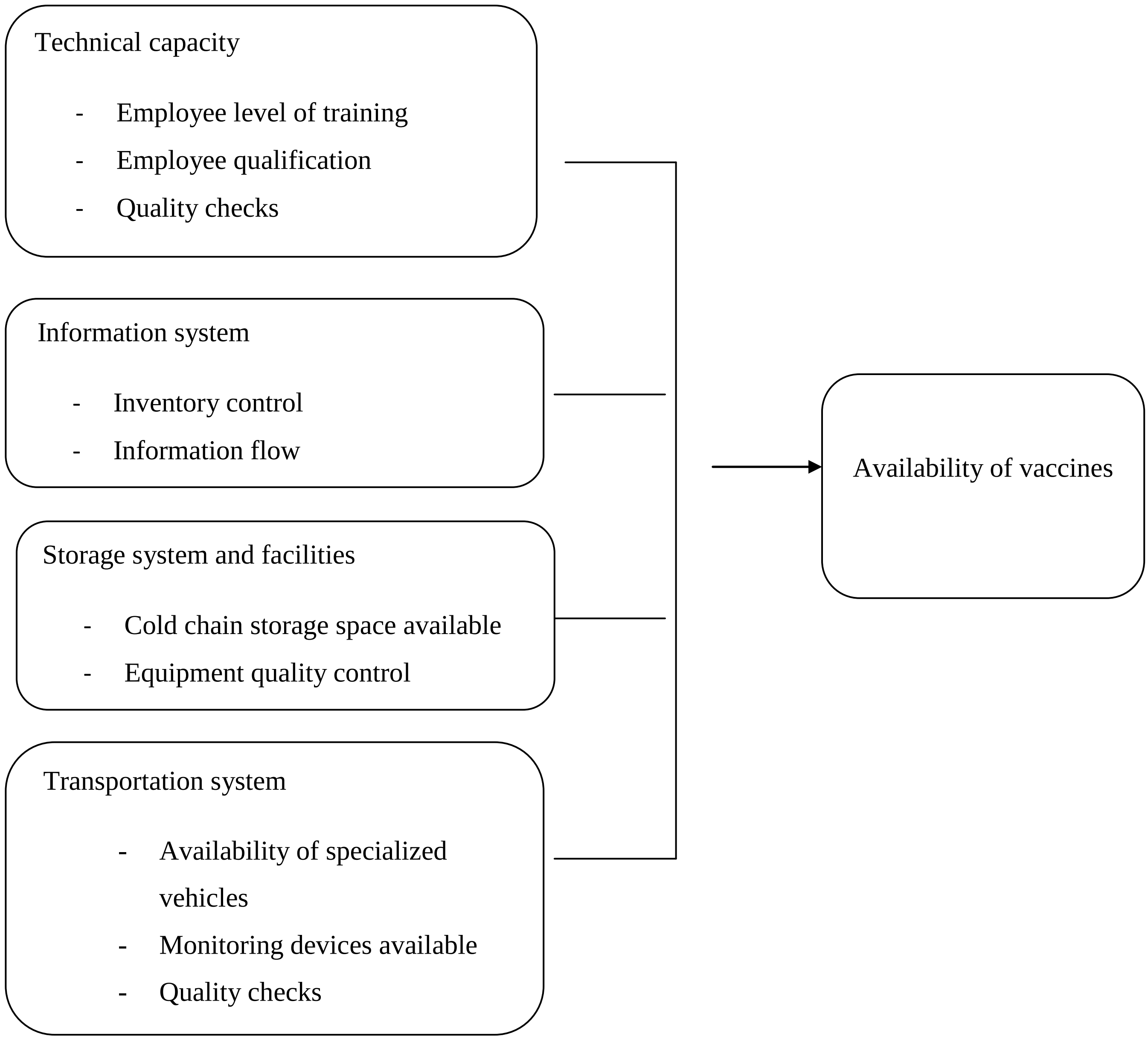


Figure 2: Conceptual Framework

Source: Own work adapted from (Njuguna, Mairura, & Ombui, 2015).

In order to answer the research question of the study, the researcher identified the following hypotheses:

Hypothesis 1: Storage system has a significantly positive effect on availability of vaccine in the health centers under city administration of Addis Ababa.

Hypothesis 2: Distribution system has a significantly positive effect on availability of vaccine in the centers under city administration of Addis Ababa.

Hypothesis 3: Technical capacity has a significantly positive effect on availability of vaccine in the health centers under city administration of Addis Ababa.

Hypothesis 4: Information system has a significantly positive effect on availability of vaccine in the health centers of Addis Ababa.

3 Chapter Three: Research Methodology

This chapter deals how the research was conducted to achieve the objectives of the study. It consists of the research design, method of data collection, sampling design, data collection instrument and method of data analysis.

3.1 Research Design

This study adopted a quantitative methodology with explanatory study design to generate answers to the research questions. This research design was preferred because it seeks to establish cause and effect relationships from sample of people who have been selected to represent a defined population, but without experimental manipulation (Burns & Burns, 2008). The data was collected all at the same time (or within a short time frame). So that, it can be considered as a cross-sectional design was used to collect data on relevant variables.

3.2 Study Setting

The Study was conducted in Addis Ababa. Addis Ababa is the capital city of Ethiopia. It is the largest city in Ethiopia, with a population of 3,384,569 according to the 2007 population census with annual growth rate of 3.8% (BoFED, 2009). According to Addis Ababa City Administration Health Bureau, in Addis Ababa there are 103 health centers which are owned by Ethiopian government. And among those 103 health centers 86 are fully functional and the rest 17 of them are under construction and not fully operational (AACAHB, 2012).

3.3 Sample Design

3.3.1 Population

A population can be defined as all people or items (unit of analysis) with the characteristics that one wishes to study. The unit of analysis may be a person, individual, organization, country, object, or any other entity that researchers wish to draw scientific inferences about (Kelley, Clark, Brown, & Sitzia, 2003). Accordingly, the population of this research consists of all public health centers in Addis Ababa.

3.3.2 Sample Size

To determine the sample size for selecting health centers in this study the researcher employed a sample determination formula developed by Cochran in 1963.

$$n_o = \frac{Z^2 pq}{e^2}$$

Where n_0 is the sample size, Z^2 is the abscissa of the normal curve that cuts off an area α at the tails (1 – α) equals the desired confidence level, e is the desired level of precision, p is the estimated proportion of an attribute that is present in the population, and q is 1-p. Therefore in

this research

$$n_0 = \frac{1.96^2 * (0.5)*(0.5)}{(0.05)2} = 384.16\text{~}385$$

Since the population is small then the sample size can be reduced slightly. This is because a given sample size provides proportionately more information for a small population than for a large population. The sample size (n_0) can be adjusted using the following formula.

$$n = 385/ (1+ ((385-1)/86)) = 70.45\text{~}71$$

Therefore, using the formula, the sample size of the study with 95 confidence level and 0.5 level of variability is calculated to be 71.

3.3.3 Sampling Technique

Probability sampling (or representative sampling) is most commonly associated with survey-based research strategies where you need to make inferences from your sample about a population to answer research question(s) or to meet the research objectives (Saunders, 2011). For that reason, simple random sampling was used to select samples from the study population. After determining sample size, the researcher used a random number table (Appendix 3) to get the random numbers for the selected participants list of this research. The sampling frame (complete list of all of 86 functional health centers) was found from Addis Ababa City administration Health Bureau. According to random number table the researcher selected 71 health centers from the list to be included in this study.

3.4 Sources and tools for data collection

Data was collected from vaccines in-charges personnel or vaccination focal person. For the study, questionnaire is used as the research instrument. The questionnaire consists of 3 parts with five point Likert scale and is divided into 4 parts as follows: The first part of the questionnaire is the demographic information of the respondents. Queries about personal information of the sample such as gender, age, education and profession were included. The second part of the questionnaire is cold chain management practices of the health centers questions about storage distribution, information systems and the technical capacity of the health centers regarding cold chain management were included in this part. In the third part, questions about the availability of vaccine in the health centers were included.

3.5 Procedures of data collection

The procedure for the data that will be collected using questionnaires is, first the respondents will be communicated to get their consent. Once their consent is obtained, the prepared questionnaires will be distributed to each participant by appreciating their participation and devoting their precious time for the research. Finally, questionnaires will be collected by checking the completeness of the data.

3.6 Pre-testing of tools

All data collecting instruments should be pretested to check the usability of the data gathered (Kothari, 2004). A research tool should be tested on a pilot sample of members of the target population. This process will allow the researcher to identify whether respondents understand the questions and instructions, and whether the meaning of questions is the same for all respondents. Where closed questions are used, piloting will highlight whether sufficient response categories are available, and whether any questions are systematically missed by respondents (Kelley et al., 2003). Pretest is of paramount importance, Hence, for this study, the data collection tool was pretested at 4 different centers which will not be included in the sample. This assisted the researcher to check the clarity, validity, ambiguity and readability of the statements and questions and to get a feedback on leading questions and to know the time that is needed to complete the questionnaire. Through conducting the pilot, the researcher spotted some vocabularies which were difficult to the participants and recognized as they were somehow vague. Data collecting tools was modified accordingly upon completing the pre test.

3.7 Reliability and Validity

The purpose of this stage is to describe on the reliability of the measuring tools employed in this research. This is important because reliability shows whether or not an instrument's measures are free from errors, thus yielding reliable outcomes. The most common technique used in the literature to assess the scale's reliability and stability is use of the Chronbach Alpha Statistics, which identifies to what extent items hang together as one set. Low Chronbach alpha values mean the items do not capture the same construct, but high values of Chronbach Alpha indicates the items very well measure and reflect the construct. Ideally , Chronbach Alpha should be over 0.70 to produce a reliable scale (Burns & Burns, 2008). Accordingly, internal reliability of a 43 item scale was assessed using the Cronbach alpha technique. The scale produced an alpha of 0.886, this is highly acceptable.

3.8 Method of Data Analysis

The data of this study was analyzed by computer through package software (SPSS: Statistical Package for Social Sciences), version 16.0.

Statistical methods employed were:

- The demographic background information of the respondents was analyzed and presented using descriptive statistics in form of frequency and percentage.
- To assess the cold chain management practices and availability of vaccines measures of descriptive statistics in form of Mean and Standard Deviation were used.
- To determine the relationship between cold chain management practices and availability of vaccines correlation analysis was used in form of Pierson's correlation coefficient to investigate the relation between variables.

- The effect of cold chain management practices on availability of vaccines was analyzed and presented using regression analysis.
- The scoring of questionnaire was analyzed by using five-points rating scale or five–Likert scales.

3.9 Ethical clearance

Any survey should be conducted in an ethical manner and one that accords with best research practice. Two important ethical issues to adhere to when conducting a survey are confidentiality and informed consent (Kelley et al., 2003). In this study Permission was sought from each sub-city health offices. The sub-city health offices wrote support letter for health centers that are included in the study. Consent was sought from participants before enrolling them into the study. The consent form is appended in (appendix 1). The information that was collected from this research project was kept confidential.

4 Chapter Four: Data Presentation, Analysis and Discussion

This chapter presents the data analysis, the research findings (results) and based on the results the researcher gives some interpretation of the results. This chapter includes the general characteristics or the demographic profile presented by descriptive statistics. As an aside, correlation analysis is used to indicate the relationship between the variables. Finally, the results of multiple regression will presented in order to estimate the value of availability of vaccine from independent variables and analyzed here in this chapter.

4.1 Response rate

A total of 71 questionnaires were administered to governmental health centers in Addis Ababa, out of which 62 were completely filled and returned. The remaining 9 questionnaires were not collected due to refusal to give response for the questionnaires. This gave a response rate of 87.32%.According to Mugenda the statistically significant response rate for analysis should be at least 50% (Mugenda & Mugenda, 2003). Hence, the response rate can be considered adequate for this study.

4.2 Demographic characteristics of the participants

The study sought to determine the general characteristics or the demographic profile of the study participants' by using five variables that were exhibited in table 2, and they were analyzed in frequency statistics accordingly.

Table 1: Demographic characteristics of study participants

Variables	Response items	Frequency	Percentage
Gender	Male	13	21.0
	Female	49	79.0
	Total	62	100
Age	< 25 years	21	33.9
	26-34 years	27	43.5
	34-44 years	9	14.5
	45-54 years	5	8.1
	>45 years	-	-
	Total	62	100
Educational background	Certificate	-	-
	Diploma	20	32.3
	First degree	42	67.7
	MSc/MA degree	-	-
	Total	62	100
Profession	Pharmacist	1	1.6
	Health officer	13	21.0
	Nurse	45	72.6
	Other	3	4.8
	Total	62	100
Experience in current job	1-5 Years	50	80.6
	6-10 Years	12	19.4
	11-15 Years	-	-
	Over 15 Years	-	-
	Total	62	100

Table 1 indicates that 13 (21 %) of the respondents were male while 49 (79%) were female. This simply indicates that the dominance of females in managing vaccines in the health centers.

As indicated in the same table, the age range of the majority respondents were between 26 to 34 years, which occupied 27(43.5 %).The respondents who were under 25 years old were accounted for the second place which took 21(33.9%). Age of the remaining respondents fall between 34 to 44 and 45 to 54 which accounts for 9(14.5%) and 5 (8.1%) respectively.

The majority 50 (80.6%) had experience of 1 to 5 years. 12 (19.4%) of the respondents had 6 to 10 years of experience. Unfortunately there was no respondent who has 11 and more years of experience in this job. But in general the data implies the respondents had a reasonable experience in their job which enables them to evaluate the vaccine cold chain management and availability of vaccines in the health centers.

From the given 62 respondents, 42 (67.7%) and 20 (32.3%) have had First degree and diploma respectively. The majority 45 (72.6%) of them were nurses. 13(21%) of the respondents were health officers. Only 1(1.6%) of the respondents was pharmacist. The remaining 3 (4.8%) claimed that their profession is other than mentioned. From these data, it is possible to conclude that most of the respondents have the required understanding of the objective of the study in general and the items of the questionnaire in particular which definitely can be taken as a positive factor towards the quality of the study.

4.3 Descriptive statistics

Respondents were asked to rate the cold chain management and availability of vaccines in the health centers on a five-point likert type scale ranging from 1 being strongly disagree to 5 strongly agree. The mean statistical value approaching were based on the following assumptions: if the mean value is between [0 to 1.5) this implies the respondents strongly disagreed, if the mean value is between [1.50 to 2.50) it indicates the respondents disagreed, the mean value between [2.50 to 3.50) indicates the respondents were neutral, the mean value between [3.50 to 4.50) implies the respondents agreed and a mean value 4.50 and above shows the respondents strongly agreed (Burns & Burns, 2008). Accordingly, the mean scores have been computed for all components of the independent variables and the dependent variable by equally weighting the mean scores of all the items under each dimension. The average mean results together with their respective variables was separately presented, analyzed and interpreted as follows.

4.3.1 Storage system

Table 2: mean score of storage system

No	Items	N	Mean	S.D
1	Special storage area available for vaccines in the health facility.	62	4.21	0.75
2	There is enough vaccine storage space.	62	3.05	1.65
3	The vaccines are stacked properly inside the refrigerator	62	2.69	1.33
4	Storage equipments are fully functional.	62	3.97	0.79
5	There is different storage equipment for different kinds of vaccines.	62	1.32	0.54
6	Storage equipments are regularly checked for compliance.	62	3.94	1.04
7	SOPs are available to ensure proper vaccine storage.	62	3.08	1.67
8	Existing SOPs are followed to ensure proper storage.	62	2.69	1.41
9	There is any type of temperature monitoring devices in use.	62	4.32	0.83
10	Temperature record readings remains between *2-8^{o}C.*	62	3.58	1.12
	Storage system	62	3.28	0.72

Source: Survey Data (2016)

Table 2 illustrates that the respondents disagreed on having different storage equipment for different kinds of vaccines in their health center (mean=1.32, s.d=0.54). They agreed on availability of Special storage area for vaccines (mean=4.21, s.d=0.75), Storage equipments are fully functional (mean=3.97, s.d=0.79). Storage equipments are regularly checked for compliance (mean=3.94, s.d=1.04). There is any type of temperature monitoring devices in use. (mean=4.32, s.d=0.83).Temperature record readings remains between 2-8^{o}C (mean=3.58, s.d=1.12). The respondents preferred to stay neutral on the other questions asked about the storage system.

From this study, it was possible to determine that the storage condition of vaccines in the health centers of Addis Ababa is not excellent to ensure safety and availability of cold chain items.

4.3.2 Distribution system

Table 3: Mean scores of distribution system

No	Items	N	Mean	S.D
1	There are special vehicles for transportation of vaccines	62	2.40	1.25
2	There are enough cold boxes for transportation of vaccines	62	1.91	1.09
3	Appropriate mode of transportation is used	62	3.03	1.03
4	There is temperature monitoring system during transportation	62	2.56	1.30
5	Temperature readings remain between 2 to 8^0c during transportation	62	2.93	1.07
6	Vaccine collection schedule time table is available	62	4.34	0.60
7	Delivery is done within recommended timelines	62	3.55	1.17
8	SOPs are available to ensure proper transport condition	62	2.45	1.13
9	SOPs are followed to ensure proper transport conditions	62	2.47	1.13
	Distribution system	62	2.86	0.62

Source: Survey Data (2016)

Table 3 indicates that, the respondents disagreed on availability of special vehicles for transportation of vaccines (mean=2.40, s.d=1.25), enough cold boxes for transportation of vaccine (mean=1.91, s.d=1.09), SOPs are available to ensure proper transport condition (mean=2.45, s.d=1.13) and SOPs are followed to ensure proper transport conditions (mean=2.47, s.d=1.13). In contrast, the respondents agreed on Vaccine collection schedule time table is available (mean=4.34, s.d=0.60), Delivery is done within recommended timelines (mean=3.55, s.d=1.17). The respondents were neutral on the other questions asked about the distribution system of vaccines.

On average the respondents were neutral to having proper distribution systems. This means there is a chance of cold chain items being damage during transportation because specialized vehicles and cold chain boxes should be used to transport cold chain products and be fitted with monitoring devices.

4.3.3 Technical capacity

Table 4: Mean score of technical capacity

No	Items	N	Mean	S.D
1	Staffs who handle cold chain items are specifically trained.	62	3.40	1.36
2	Enough training provided for the staff on vaccine distribution system.	62	2.55	1.07
3	There are enough employees to handle maintenance of equipments.	62	1.92	0.89
4	There are enough employees to handle the demand.	62	2.43	1.35
5	Equipments are regularly serviced to avoid breakdown and ensure compliance.	62	3.11	1.29
6	There is reliable electric power supply.	62	1.91	0.81
7	There is enough equipment to handle demand.	62	2.81	1.24
8	There is a power backup to ensure constant power supply for equipment.	62	2.97	1.23
9	Quality checks are done to ensure compliance with cold chain supply regulations.	62	3.09	1.33
	Technical capacity	62	2.68	0.64

Source: Survey Data (2016)

Table 4 illustrates that the respondents disagreed on, There are enough employees to handle maintenance of equipments (mean=1.92, s.d=0.89), There are enough employees to handle the demand (mean=2.43, s.d=1.35) and There is reliable electric power supply (mean=1.91, s.d=0.81). As we can see from the table above the respondents were neutral on other questions.

This means that the technically capacity of health centers in Addis Ababa in terms of employee competence in monitoring storage and transport conditions as well as on quality checks , calibration of equipment, handling of the systems, is not sufficient to handle cold chain items.

4.3.4 Information system

Table 5: mean score of information system

No	Items	N	Mean	S.D
1	The facility has proper vaccine forecasting.	62	3.77	1.28
2	Consumption reports are regularly prepared and reported.	62	4.66	0..47
3	Vaccine stock balance and physical count of sample vaccine are equal.	62	3.43	1.31
4	Vaccine requisition forms are used for ordering vaccine.	62	4.50	0.671
5	SOPs are available to Insure proper information system.	62	3.38	1.37
6	SOPs are followed to ensure proper information system.	62	3.32	1.33
7	There is adequate inventory control system.	62	3.58	1.18
8	Vaccine wastage reports are regularly prepared and reported.	62	4.20	0.94
	Information system	62	3.87	0.73

Source: Survey Data (2016)

Based on table 5, the respondents agreed on all statements about the information system except Vaccine stock balance and physical count of sample vaccine are equal(mean=3.43, s.d=1.31), SOPs are available to Insure proper information system. (mean=3.38, s.d=1.37) and SOPs are followed to ensure proper information system (mean=3.32, s.d=1.33) to which they were neutral.

The study reveals that information system practiced are agreeable in the health centers. Proper information system along the cold chain system is crucial in ensuring availability of vaccines (WHO, 2014c).

4.3.5 Availability of vaccines

Table 6: mean score of availability of vaccines

No		N	Mean	S.D
1	There is adequate quantity of vaccine for the supply period	62	3.81	0.99
2	There is adequate buffer stock of vaccine for the supply period	62	2.77	1.32
	Availability of vaccine	62	3.29	0.66

Source: Survey Data (2016)

The above table shows that the respondents agreed on there is adequate quantity of vaccine for the supply period (mean=3.81,s.d=0.99)and they were neutral on There is adequate buffer stock of vaccine for the supply period (mean=2.77,s.d=1.32).

On average the respondents were neutral on availability of vaccine in their health centers.

4.4 Correlation Analysis

A set of Pearson correlations were computed to determine if there were any significant relationships between the variables. The main focus of this section being on the overall relationship between the dependent and independent variables in table 7, Correlation coefficient of Pearson was applied to study the relation between constructs. According to (Burns & Burns, 2008) correlation Values between 0 and 0.3 (0 and -0.3) indicate a weak positive (negative) linear relationship via a shaky linear rule, Values between 0.3 and 0.7 (0.3 and -0.7) indicate a moderate positive (negative) linear relationship and values between 0.7 and 1.0 (-0.7 and -1.0) indicate a strong positive (negative) linear relationship via a firm linear rule. Therefore, in this study all correlation results are interpreted in light of this rule.

Table 7: Interrelation Matrix among cold chain management and availability of vaccines

		Storage system	Distribution system	Information system	Technical capacity	Availability of vaccine
Storage system	Pearson Correlation	1	.508**	.477**	.271*	.527**
	Sig. (2-tailed)		.000	.000	.033	.000
Distribution system	Pearson Correlation		1	.448**	.392**	.575**
	Sig. (2-tailed)			.000	.002	.000
Information system	Pearson Correlation			1	.241	.407**
	Sig. (2-tailed)				.059	.001
Technical capacity	Pearson Correlation				1	.307*
	Sig. (2-tailed)					.015
Availability of vaccine	Pearson Correlation					1
	Sig. (2-tailed)					

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Source: Survey Data (2016)

Storage system And Distribution system:

In the above table we can see the relationship between the Storage system and distribution system. The value of correlation is 0.508. The Correlation is significant at the 0.01 level. This shows that there is a moderate positive relationship between the Storage system and distribution system.

Storage system and Information system: As it is stated in the above table, the value of correlation Storage system and Information system is 0.477and the Correlation is significant at the 0.01 level. This indicates that these two variables have a moderate positive relationship.

Storage system and technical capacity: The above table revels that, the value of correlation between Storage system and technical capacity 0.271and the Correlation is significant at the 0.05 level. This indicates a weak positive relationship between the two variables.

Storage system and availability of vaccine: In the above table we can see the relationship between the Storage system and availability of vaccine. The value of correlation is 0.527 which is significant at the 0.01 level. This shows that there is a moderate positive relationship between Storage system and availability of vaccine.

Distribution system and Information system: As we can see from the above table the value of correlation of distribution system and information system is 0.448 that is significant at the 0.01 level. This shows that there is a moderate positive relationship between the two variables.

Distribution system and Technical capacity: In the above table we can see the relationship between the Distribution system and Technical capacity. The value of correlation is 0.392 which is significant at the 0.01 level. This shows that there is a moderate positive relationship.

Distribution system and availability of vaccine: In the above table we can see the relationship between the Distribution system and availability of vaccine. The value of correlation is 0.392 which is significant at the 0.01 level which shows that there is a moderate positive relationship.

Information system and technical capacity: The value of correlation between information system and technical capacity is 0.241. As the above table indicates this correlation is not significant.

Information system and availability of vaccine: In the above table we can see the relationship between Information system and availability of vaccine. The value of correlation is 0.407 which is significant at the 0.01 level. This shows there is a moderate positive relationship between information system and availability of vaccine.

Technical capacity and availability of vaccine: In the above table we can see the relationship between the Technical capacity and availability of vaccine. The value of correlation is 0.307 which is significant at the 0.05 level .This shows that there is a moderate positive relationship.

4.5 Regression analysis of study variables

A standard multiple regression was performed between availability of vaccine as the dependent variable and Storage system Transportation system Technical capacity and Information system as independent variables.

Table 8: Model Summary of Availability of vaccine

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.644[a]	.415	.374	.44694

a. Predictors: (Constant), Information system, Technical capacity, Storage system, Distribution system

Source: Survey Data (2016)

The result of multiple regressions displayed in table 9 model summery shows a highly significant relationship ($p < .001$) between the dependent variable and the linier combination of the predictor variables as indicated by multiple R (0.644).The coefficient of determination (R Square) is a measure of how good a prediction of the criterion variable we can made by knowing the predictor variables. Accordingly, 41.5% of the variation in the dependent variable was explained by the set of mentioned independent variables. However, R-squared measures the proportion of the variation in the dependent variable explained by independent variables, irrespective of how well they are correlated to the dependent variable. This isn't a desirable property of a goodness-of-fit statistic. Conversely, adjusted R-squared provides an adjustment to the R-squared statistic such that an independent variable that has a correlation to dependent variable increases adjusted R-squared and any variable without a strong correlation will make adjusted R-squared decrease. Therefore, to see the success of our model in the real world adjusted R-squared is more preferred than R-squared (Burns & Burns, 2008). According to adjusted R-squared, the variation explained by the regression of dependent variable on the combined effect of all the predictor variables is 37.4%.

Table 9: ANOVA result for dependent Variable Availability of vaccine

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	8.086	4	2.021	10.119	.000[a]
	Residual	11.386	57	.200		
	Total	19.472	61			

a. Predictors: (Constant), Information system, Technical capacity, Storage system, Distribution system

Source: Survey Data (2016)

In the ANOVA table we have the F value of 10.119 which is significant with p > .001. This informs us that the four independent variables taken together as a set are significantly related to the dependent variable. The F critical at 5% level of significance is 0.2. Since F calculated 10.119 is greater than the thus show that the model is significant.

Table 10: Coefficients of Availability of vaccine

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.163	.369		3.149	.003
	Storage system	.213	.096	.278	2.227	.030
	Distribution system	.368	.128	.366	2.872	.006
	Technical capacity	.054	.091	.065	.591	.557
	Information system	.072	.091	.095	.788	.434

Source: Survey Data (2016)

The Coefficients table reveals that the dependent variables distribution system (t =2.872, p=.006) and Storage system (t =2.227, p = .030) were found to uniquely and significantly contribute to the prediction of availability of vaccines. These significance levels tell us that two variables uniquely contribute to the regression equation there by making a significant contribution to the prediction, but the other independent variables namely; Information system and technical capacity have insignificant relationship with availability of vaccines.

The objective of the regression in this study is to find such an equation that could be used to find the effect of predictors on dependent variable. The specified regression equation takes the following form:

$$Y = 1.163 + 0.213X1 + 0.368X2 + 0.054X3 + 0.072X4 + e$$

Where Y= availability of vaccine, X1= Storage system; X2= Distribution system; X3 =Technical capacity; X4= Information system and e = the residual amount.

The regression equation above shows that, by taking all factors into account constant at zero, the availability of vaccines in the health centers will have a value of 1.163. And the findings presented also show that taking all other independent variables at zero, a unit increase in information system would lead to a 0. 072 increase in the availability of vaccines; a unit increase in technical capacity would lead to a 0. 054 increase in the availability of vaccines; a unit increase in distribution system would lead to a 0.368 increase in the availability of vaccines and a unit increase in storage system would lead to a 0.213 increase in the availability of vaccines.

Table11: Collinearity Statistics

Model	Tolerance	VIF
Storage system	.660	1.514
Distribution system	.632	1.584
Technical capacity	.837	1.195
Information system	.713	1.402

Source: Survey Data (2016)

According to (Burns & Burns, 2008) high correlations of 0.90 and above implies the two variables are measuring the same variance and will over-inflate R. Therefore only one of the two is needed. The Variance Inflation Factor (VIF) measures the impact of collinearity among the dependent variables in a multiple regression model on the precision of estimation. Typically a VIF value greater than 10.0 is of concern. Since, the maximum value of VIF is 1.584 and the minimum one is 1.195, multicolinearity is not the problem of this model and intercorrelations are not sufficiently high to cause concern. On the other hand, tolerance below 0.1 indicates a serious problem and below 0.2 indicates a potential problem. The tolerances of the variables are ranges between 0.837 and 0.632. The data satisfied the assumptions of multicollinearity, normality of residuals, and homoscedasticity while no outliers were identified.

The hypothesis and research question were set conducted in order to answer the research questions. The summary of the findings are presented on table 13.

Table 12: Hypothesis testing

Hypothesis	Result	Reason
H0: Storage system has no significantly positive effect on availability of vaccine in health centers under Addis Ababa city administration health bureau. H1. Storage system has a significantly positive effect on availability of vaccine in the health centers under Addis Ababa city administration health bureau.	H0:Rejected H1:Accepted	ß=0.213 $p<0.05$
H0: Distribution system has no significantly positive effect on availability of vaccine in the health centers under Addis Ababa city administration health bureau. H1. Distribution system has a significantly positive effect on availability of vaccine in the health centers under Addis Ababa city administration health bureau.	H0: Rejected H1: Accepted	ß=0.368 $p<0.05$
H0: Technical capacity has no significantly positive effect on availability of vaccine in the health centers under Addis Ababa city administration health bureau. H1. Technical capacity has a significantly positive effect on availability of vaccine in the health centers under Addis Ababa city administration health bureau.	H0: Fail to Reject H1: Rejected	ß=.054 $p>0.05$
H0: Information system has no significantly positive effect on availability of vaccine in the health centers under Addis Ababa city administration health bureau. H1. Information system has a significantly positive effect on availability of vaccine in the health centers under Addis Ababa city administration health bureau.	H0: Fail to Reject H1: Rejected	ß=0.072 $p>0.05$

Source: Survey Data (2016)

4.6 Discussion

This part presents detailed discussions pertaining to the research study. The results of the present study are discussed in line with the basic questions raised in chapter one. It also provides possible explanations for the results presented on the above.

From this study, it was possible to determine that vaccines are not being stored carefully to ensure optimal potency. Vaccines should be stored at all times, beginning at the factory where they are manufactured and at every stage until the moment they are given to children and mothers. Excess heat or cold will reduce the vaccine potency (strength), increasing the risk that vaccines will be discarded. The storage condition of vaccines in the health centers of Addis Ababa is not excellent to ensure safety and availability of cold chain items. Control of storage conditions and temperature is essential in maintaining the quality of cold chain items and in helping to protect patients from sub-standard or ineffective medicines that may result from inadequate storage control (WHO, 2015a). The respondents in this study agreed on availability of Special storage area for vaccines in their health facility, even if they stayed neutral on adequacy of the storage space and they disagreed that vaccines were stacked properly inside the refrigerator. This result is Similar to a study done in Cost region, Tanzania which revealed that, Standard vaccine refrigerators were found in most of the healthcare centers visited but assessment of good arrangement practices of vaccines revealed that only half of all visited healthcare facilities and stores had good arrangement practices (Makuru, 2012). A study from Pakistan reported that vaccine Storage facilities had massive over stacking and improper placement of products (USAID|Deliverproject, 2015). Therefore, even if the vaccines were potent on arrival at the health institutions, their potency could easily be compromised because of lack of proper monitoring of the storage system. Vaccines should be stored carefully between +2ºC and +8ºC at all times, from the factory where they are manufactured until they are used in order to increase availability of vaccines and to maximize the resulting efficacy of immunization as observed in this study and others elsewhere (Njuguna et al., 2015; Zaffran et al., 2013).

The distribution of vaccines from the Sub-city vaccine stores to health centers was not as recommended. The main causes of poor distribution system were shortage of special vehicles and cold boxes for transportation of vaccines. Simultaneously SOPs were not followed to ensure proper distribution conditions. Similar study conducted in Coast region, Tanzania shows that the main cause of delay in delivery of vaccines to the health centers was shortage or lack of transport to distribute the vaccine. As it is indicted in similar study lack of reliable transport at district level contributes to shortage of vaccines at health facility level (Makuru, 2012)). Lack of means of transport from districts level to lower level could result in healthcare workers using public transport to transport vaccine carrier to their facilities. This is dangerous as public transport take long time and the temperature in the carrier may change because of the length of the time. Training is a very important constraint which needs to be considered to improve the vaccine distribution plan. People involved in transportation and supply of vaccines need to be trained and have knowledge of cold chain and how to handle breakage of cold chain. Without pre-requisite knowledge of how to handle vaccines being transported can seriously affect the vaccine potency which in turn can result in wastage of vaccines and thus, increase in their price (Immunization & Biologicals, 2004).

In the present study the respondents claimed that the training provided for the staff on vaccine cold chain management was not enough. The other problem identified in this study was capacity of employees to handle the demand and maintenance of equipments. This result is supported by other studies done in different countries. In Tanzania, a study showed that in the last 3 years of the study majority of respondents were not attended any training on storage, distribution and handling procedures of vaccines (Makuru, 2012). A study done on cold chain management knowledge and practices in primary health care facilities in Niassa, Mozambique indicated that 60% of the health workers had no pre- service training in vaccine storage and handling (de Timóteo Mavimbe & Bjune, 2007). According to study done on pharmaceutical distributors in Nairobi County 41% of respondents have absolutely no special training in cold chain (Njuguna et al., 2015). This means that most organizations are not technically capable to handle cold chain items and ensure their safety. (Samant et al., 2007) showed generator facility in 65% of public health centers .This is in contrast to the present study, where the respondents disagreed on having backup to ensure constant power supply for equipments in their health centers. Similar results were reported from India where Vaccine Cold Chain in Urban Health Centers of Western India shows that only 30% of the health centers had either a working inverter or a generator (Naik et al., 2013). Respondents in the present study were neutral on having their cold chain equipment checked and serviced to avoid breakdown this comparatively a better result when compared to results reported from Kenya where 52% of the respondents strongly disagree on this issue (Njuguna et al., 2015).

It was positive point to note that the respondents agreed on almost all items of the information system. Unlike the findings in this study effective Vaccine Management (EVM) Analysis done by WHO in 75 countries revealed that with a few exceptions, information systems are weak at each level in each region. The same study illustrates more than a third of vaccine storage facilities do not monitor vaccine wastage(WHO, 2014b).

Storage and distribution systems were found to have positive and significant effect on availability of vaccine in the health centers. Various weaknesses on storage and distribution systems have been underlined from other studies as a major risk factor associated with limited availability of vaccines(Bell et al., 2001; Health & Council, 2008; Okwo-Bele, 2015).

Some key interventions including constant supervision, training of professionals in charge, promoting access to existing guidelines and making available cold chain tools have been identified to reduce these gaps (WHO, 2014c).

5 Chapter Five: Summary, Conclusions and Recommendations

This chapter provides the summary of major findings, conclusions and recommendation of the study.

5.1 Summary of findings

In this study, the researcher looked for the cold chain management practice and availability of vaccines in governmental health centers in Addis Ababa. The study also indicated the relationship that exists between cold chain management practice and availability of vaccines. In order to achieve these objectives, data were collected from the cold chain responsible personnel in the health centers.

From the demographic characteristics of respondents', the majorities (79%) were female participants and the remaining (21%) was male. Besides, age range of the majority respondents were between 26 to 34 years, which occupied 27(43.5 %). In cognizant to their educational level, the participants had a minimum of certificate and it is possible to say they are/were educated. Coming to profession and work experience of the respondents, they had adequate of both which reasonably increase the validity (as a whole the quality) of this research.

In descriptive statistics the results show that the respondents agreed on Information system. On the other hand the respondents preferred to stay neutral on the Storage system, transportation system and technical capacity of the health centers.

The result shows that all the variables are correlated each other after the detailed analyses of the data it's conclude that the most of the variables are moderate positively correlated. There is significant association between the independent variables storage system and distribution system with the dependent variable availability of vaccines. Other variables were found to be insignificantly associated with availability of vaccines in governmental health centers of Addis Ababa.

5.2 Conclusion

In this study, the major determinant factors identified were cold chain management practices based on cold chain responsible personals' response which comprises of four components;

storage system distribution system, technical capacity and information system. Besides, their effect on the availability of vaccines was studied. Three main research questions were developed and addressed in this research.

Unfortunately, all the components of cold chain management practices were rated average except information system. In other words, cold chain management practices in the health centers were not excellent in ensuring the availability of vaccines.

Based on the analysis made on availability of vaccines in the health centers, respondents were neutral in rating the availability of vaccines in their health centers. This doesn't guarantee the service is in line with the recommendation of guidelines and could hinder the immunization services of the health centers.

Storage system and distribution system were found to have a positive and significant effect on availability of vaccines .based on the findings of the study it will not be unwise to conclude that distribution and storage system in the cold chain management should be improved so as to bring a change in the availability of vaccines in the health centers.

5.3 Recommendations

Based on the findings of the study, the researcher suggested the following points as plausible commendations which if adopted would lead to efficient and effective cold chain management.

Storage conditions for cold chain items need to be closely monitored and improved so that the safety of vaccines is guaranteed in having fully functional and enough storage facilities. FMOH Need to strengthen supportive supervision at lower healthcare facilities delivery site so as to improve proper vaccine storage. More storage freezers need be purchased since there is lack of enough vaccine storage space storage in the health centers to maintain the required temperature during storage. In the health facilities, Staffs who handle cold chain items should strictly follow SOP'S.

The transport systems for cold chain items need to be improved so that the safety of cold chain items is guaranteed in having fully functional and enough vehicles for transport of cold chain items. The transition of vaccine supply chain responsibility from the Federal Ministry of Health to the Pharmaceuticals Fund and Supply Agency should be facilitated since it was found to bring huge benefit in Mekele and Bahirdar hubs where the transition took place (JSI, 2015b). PFSA should implement direct vaccine distribution to health facilities through branch hubs in the country in order to achieve this PFSA has to strengthen its transportation capacity to handle direct vaccine distribution to health facilities with special vehicles, additional cold boxes and correct temperature monitoring device for cold chain transport.

One of the major challenges identified was erratic power supply. FMOH should ensure that all health facilities need to have adequate contingencies for light offs. Special training is required for all personnel involved in cold chain sensitivity of cold chain items and hence improves their understanding and competency in handling cold chain pharmaceuticals to ensure their safety. All equipments also need to be properly calibrated and up to standard as recommended by regulatory bodies. SOPs in place should be updated and strictly followed since; one of the challenges identified was the poor adherence and implementation. WHO cold chain management systems (GDP, GSP, etc) could also be adopted in order to adhere to some standard as recommended by regulatory bodies.

This study indicates the information system in the management of cold chain is considerable. It will be further strengthen if the Standard operating procedures would be followed. Taking lesson from Mekele, FMOH, doners and PFSA should work together to implement a better information system in Addis Ababa through electronic databases such as Health Commodities Management Information System (HCMIS).

5.4 Suggestion for Further Study

The present study used only public health centers in Addis Ababa; future studies should consider expanding their scope to include private health facilities and other governmental health facilities. Further studies related to the cold chain management practices can be conducted especially on vaccine wastage rates to find out actual vaccine wastage and comparative studies between public and private facilities can be done.

Reference

AACAHB. (2012). Addis Ababa city administration health bureau, yeka sub-city Retrieved Feb 9, 2016, from http://www.aahb.gov.et/index.php/facilities-and-services/health-centers/yeka-sub-city

Acu, F., Adedeji, A., Esan, J., & Odusanya, O. (1996). Live viral vaccine potency: an index for assessing the cold chain system. *Public health, 110*(6), 325-330.

Adida, E., Dey, D., & Mamani, H. (2013). Operational issues and network effects in vaccine markets. *European Journal of Operational Research, 231*(2), 414-427.

Afsar, A., & Kartoğlu, Ü. (2006). Vaccine stock management: Guidelines for immunization and vaccine store managers. *Geneva: World Health Organization*.

Association, P. D. (2007). Guidance for temperature-controlled medicinal products: maintaining the quality of temperature-sensitive medicinal products through the transportation environment. *PDA journal of pharmaceutical science and technology/PDA, 61*(2 Suppl TR 39), 2.

Bell, K. N., Hogue, C. J., Manning, C., & Kendal, A. P. (2001). Risk factors for improper vaccine storage and handling in private provider offices. *Pediatrics, 107*(6), e100-e100.

Belsey, M. J., de Lima, B., Pavlou, A. K., & Savopoulos, J. W. (2006). Influenza vaccines. *Nature Reviews Drug Discovery, 5*(3), 183-184.

Berhane, Y., & Demissie, M. (2000). Cold chain status at immunisation centres in Ethiopia. *East African medical journal, 77*(9).

Blue, L. (2008). Why Don't Adults Get Vaccinated. *Time, January, 24*.

BoFED, A. A. (2009). *Socio-Economic Profile of Addis Ababa For the Year 2004 E.C/2011/12G.C Policy Study and Analysis Sub Process*.

Burns, R., & Burns, R. (2008). *Business Research Methods and Statistics Using SPSS*: SAGE Publications Ltd.

CDC. (2014). Vaccine Storage& Handling Toolkit May 2014 Retrieved Jan27, 2016, from http://www.cdc.gov/vaccines/recs/storage/toolkit/

CommonwealthofAustralia. (2013). National Vaccine Storage Guidelines: Strive for 5.

David Wolking, U. D. O. H. I. a. t. P. O. H. C. (2013). PREDICT One Health Consortium 2013. Guide for Implementing a Cold Chain for Safe Sample Transport and Storage. Retrieved Jan 27, 2016, from http://www.vetmed.ucdavis.edu/ohi/predict/PREDICT_Publications.cfm#Protocols

de Timóteo Mavimbe, J. C., & Bjune, G. (2007). Cold chain management: knowledge and practices in primary health care facilities in Niassa, Mozambique. *Ethiopian Journal of Health Development, 21*(2), 130-135.

Deo, S., & Corbett, C. J. (2009). Cournot competition under yield uncertainty: The case of the US influenza vaccine market. *Manufacturing & Service Operations Management, 11*(4), 563-576.

FMOH. (2013). *Vaccine Management Training Manual for EPI Coordinators and Focal Persons*.

FMOH. (2015). *Ethiopia national expanded programme on comprehensive multi year plan 2016 - 2020*.

Gazmararian, J. A., Oster, N. V., Green, D. C., Schuessler, L., Howell, K., Davis, J., . . . Warburton, S. W. (2002). Vaccine storage practices in primary care physician offices: assessment and intervention. *American journal of preventive medicine, 23*(4), 246-253.

Guichard, S., Hymbaugh, K., Burkholder, B., Diorditsa, S., Navarro, C., Ahmed, S., & Rahman, M. M. (2010). Vaccine wastage in Bangladesh. *Vaccine, 28*(3), 858-863.

Health, N., & Council, M. R. (2008). *The Australian immunisation handbook*: NHMRC.

Immunization, W. D. o., & Biologicals. (2004). *Immunization in practice: A practical guide for health staff*: World Health Organization.

JSI. (2015a). From Supply Chain Analysis to Action: Delivering Vaccines in Ethiopia.

JSI. (2015b). Transition.

Kartoğlu, Ü. (2012). Temperature sensitivity of the diphtheria containing vaccines.

Kartoglu, U., & Milstien, J. (2014). Tools and approaches to ensure quality of vaccines throughout the cold chain. *Expert review of vaccines, 13*(7), 843-854.

Katz, M. L., & Shapiro, C. (1985). Network externalities, competition, and compatibility. *The American economic review, 75*(3), 424-440.

Kaufmann, J. R., Miller, R., & Cheyne, J. (2011). Vaccine supply chains need to be better funded and strengthened, or lives will be at risk. *Health Affairs, 30*(6), 1113-1121.

Kelley, K., Clark, B., Brown, V., & Sitzia, J. (2003). Good practice in the conduct and reporting of survey research. *International Journal for Quality in Health Care, 15*(3), 261-266.

Kohli, P. (2008). Fruits and Vegetables Post-Harvest Care: The Basics. *PDF). CrossTree techno-visors*.

Kothari, C. R. (2004). *Research methodology: Methods and techniques*: New Age International.

Lala, K. R., & VVM, V. V. M. (2003). Thermostability of Vaccines Mrudula K. Lala. *Indian pediatrics, 40*, 311-319.

Lloyd, J. (1999). Technologies for vaccine delivery in the 21^ st century: A white paper of WHO, UNICEF, USAID and PATH: WHO/ATT/TECHNET. 99.

Lydon, P., Raubenheimer, T., Arnot-Krüger, M., & Zaffran, M. (2015). Outsourcing vaccine logistics to the private sector: The evidence and lessons learned from the Western Cape Province in South-Africa. *Vaccine*.

Makuru, M. (2012). *Assessement of vaccines distribution system in public healthcare facilities in coast region, Tanzania* Degree of Master of Science.

Matthias, D. M., Robertson, J., Garrison, M. M., Newland, S., & Nelson, C. (2007). Freezing temperatures in the vaccine cold chain: a systematic literature review. *Vaccine, 25*(20), 3980-3986.

Maurice, J. M., & Davey, S. (2009). *State of the World's Vaccines and Immunization*: World Health Organization.

Miller, N., & Harris, M. (1994). Are childhood immunization programmes in Australia at risk? Investigation of the cold chain in the Northern Territory. *Bulletin of the World Health Organization, 72*(3), 401.

MOH. (2012). Immunization Retrieved Feb,4, 2016, from http://www.moh.gov.et/immunization

Mugenda, M., & Mugenda, A. (2003). Research Methods in Education: Quantitative and Qualitative Approach, Nairobi: Acts press.

Naik, A. K., Rupani, M. P., & Bansal, R. (2013). Evaluation of vaccine cold chain in urban health centers of municipal corporation of surat city, Western India. *International journal of preventive medicine, 4*(12), 1395.

Nelson, C., Froes, P., Van Dyck, A. M., Chavarría, J., Boda, E., Coca, A., . . . Lima, H. (2007). Monitoring temperatures in the vaccine cold chain in Bolivia. *Vaccine, 25*(3), 433-437.

Nelson, C. M., Wibisono, H., Purwanto, H., Mansyur, I., Moniaga, V., & Widjaya, A. (2004). Hepatitis B vaccine freezing in the Indonesian cold chain: evidence and solutions. *Bulletin of the World Health Organization, 82*(2), 99-105.

Njuguna, M. W., Mairura, C. J., & Ombui, K. (2015). Influence of Cold Chain Supply Logistics on the Safety of Vaccines. A Case of Pharmaceutical Distributors in Nairobi County.

Okwo-Bele, D. J.-M. (2015). Together we can close the immunization gap Retrieved Jan,19, 2016, from http://www.who.int/mediacentre/commentaries/vaccine-preventable-diseases/en/

PATH. (2008). Landscape Analysis Analysis of EVSM Indicators.

Samant, Y., Lanjewar, H., Parker, D., Block, L., Tomar, G. S., & Stein, B. (2007). Evaluation of the cold-chain for oral polio vaccine in a rural district of India. *Public health reports*, 112-121.

Saunders, M. N. (2011). *Research methods for business students, 5/e*: Pearson Education India.

Taylor, J. (2001). Recommendations on the control and monitoring of storage and transportation temperatures of medicinal products. *THE PHARMACEUTICAL JOURNAL, 267*(28), 128-131.

USAID|Deliverproject. (2015). *EPI Reforms at the Federal Stores: Optimizing Supply Chain Practices for Better Governance and Accountability*. Arlington.

WHO. (2005). Monitoring vaccine wastage at country level: Guidelines for programme managers.

WHO. (2008). Training for Mid-Level Managers: Cold Chain, Vaccines and Safe-Injection Equipment Management. *Geneva (Switzerland): WHO*.

WHO. (2011). Technical Report Series 961. Annex 9: Model guidance for the storage and transport of time-and temperature-sensitive pharmaceutical products.

WHO. (2014a). 2014 assessment report of the global vaccine action planstrategic advisory group of experts on immunization. Retrieved 30/12/2015 http://www.who.int/immunization/global_vaccine_action_plan/SAGE_DoV_GVAP_Assessment_report_2014_English.pdf.

WHO. (2014b). Effective Vaccine Management (EVM) Global Data Analysis 2010-2013

WHO. (2014c). *Immunization supply chain and logistics - a neglected but essential system for national immunization programmes*. Geneva, Switzerland.

WHO. (2015a). How to monitor temperatures in the vaccine supply chain.

WHO. (2015b). Vaccines Retrieved Jan,27, 2016, from http://www.who.int/topics/vaccines/en/

Woodyard, E., Woodyard, L., & Alto, W. A. (1995). Vaccine storage in the physician's office: a community study. *The Journal of the American Board of Family Practice, 8*(2), 91-94.

Yadav, P., Stapleton, O., & Van Wassenhove, L. (2013). Learning from coca-cola. *Stanford Soc Innov Rev, Winter*.

Zaffran, M., Vandelaer, J., Kristensen, D., Melgaard, B., Yadav, P., Antwi-Agyei, K., & Lasher, H. (2013). The imperative for stronger vaccine supply and logistics systems. *Vaccine, 31*, B73-B80.

Appendix 1: Consent form

ADDIS ABABA UNIVERSITY SCHOOL OF COMMERCE

DEPARTMENT OF LOGISTICS AND SUPPLY CHAIN MANAGEMEN

Greetings!

My name is Tiya Bacha. I am conducting a study on the effect of cold chain distribution system on the vaccine availability in governmental health centers for the partial fulfillment of master's degree in logistics and supply chain management in Addis Ababa University, School of commerce. The information that will be collect from this research project will be kept confidential. Taking part in this study you will contribute towards alleviating the problem of poor vaccines distribution system and availability. If you are willing to participate in our project, you need to understand and sign the Consent form. Then, you will be asked to give your response to the data collectors. If you have any question you can contact following individual and you may ask at any time you want.

Tiya Bacha Bulcha: Addis Ababa University

Tel: +251 911- 192670

E-mail: tiyab21@gmail.com

--------------------------------	-------------------------	----------------------
Name	Signature	Date

Appendix 2: Questionnaire

Questionnaire on Effect of cold chain distribution system on availability of vaccine

Questionnaire No:_______________ Date: _______________________________

PART1: Demographic characteristics of respondents

The general attributes of respondents (i.e. you) are given below. Please tick (□) in the box that exactly expresses you.

1. Gender:

□ Male □ Female

2. Age:

□ <26 yrs □ 26-34yrs □ 35-44yrs 4□ 5-54yrs □ >54yrs

3. Educational Background :

□ Certificate □ Diploma □ BA/Bsc □ BA/Msc Other Specify_______________

4. Experience in the job:

□ <1yr □ 1-3 yrs □ 4-6yrs □ 7-8yrs □ > 9 yrs

5. Professional of in-charge/coordinator/ immunization focal person of the facility cold chain

□ Pharmacist □ Health officer □ Nurse/midwife other Specify ________________

6. How many years have you been employed in this Health Facility?

□ 1-5 Years □ 6-10 Years □ 11-15 Years □ Over 15 Years

Part two: vaccine distribution system

Please rate to what extent you agree on the following vaccine distribution system components are applicable to your organization. The scale below will be applicable: 1 – Strongly disagree 2 – Disagree 3- Neither agree nor disagree 4- Agree 5 – Strongly agree

No	Storage system and facility	1	2	3	4	5
1	Special storage area available for vaccines in the health facility.					
2	There is enough vaccine storage space.					
3	The vaccines are stacked properly inside the refrigerator					
4	Storage equipments are fully functional.					

5	There is different storage equipment for different kinds of vaccines.					
6	Storage equipments are regularly checked for compliance.					
7	SOPs are available to ensure proper vaccine storage.					
8	Existing SOPs are followed to ensure proper storage.					
9	There is any type of temperature monitoring devices in use.					
10	Temperature record readings remains between *2-8^{o}C*					
No	Transportation system	1	2	3	4	5
1	There are special vehicles for transportation of cold chain items.					
2	There are enough Containers to meet demand for distribution.					
3	Appropriate mode of transportation is used					
4	There is temperature monitoring system during transportation.					
5	Temperature readings remain between 2-8^{o}Cduring transportation.					
6	Vaccine collection schedule time table is available.					
7	Delivery is done within recommended timelines.					
8	SOPs are available to ensure proper transport conditions.					
9	SOPs are followed to ensure proper transport conditions.					
No	Technical capacity	1	2	3	4	5
1	Staffs who handle cold chain items are specifically trained.					

2	Enough training provided for the staff on vaccine distribution system.					
3	There are enough employees to handle maintenance of equipments.					
4	Enough employees to handle the demand.					
5	Equipment are regularly checked and serviced to avoid breakdown and ensure compliance.					
6	There is enough equipment to handle demand.					
7	There is reliable electric power supply.					
8	There is a power backup to ensure constant power supply for equipment.					
9	Quality checks are done to ensure compliance with cold chain supply regulations.					
No	Information system	1	2	3	4	5
1	The facility has proper vaccine forecasting.					
2	Consumption reports are regularly prepared and reported to the appropriate organization.					
3	Vaccine stock balance and physical count of sample vaccine are equal.					
4	Vaccine requisition forms are used for ordering vaccine.					
5	SOPs are available to ensure proper Information system.					
6	SOPs are followed to ensure proper Information system.					

7	There is adequate inventory control system in the health facility					
8	Vaccine wastage reports are regularly prepared and reported to the appropriate organization					

Part three: Availability of vaccine

No	Availability of vaccine	1	2	3	4	5
1	There is adequate quantity of vaccine for the supply period					
2	There is adequate buffer stock of vaccine for the supply period					

Appendix 3: Data output SPSS

Regression

Variables Entered/Removed[b]

Model	Variables Entered	Variables Removed	Method
1	Information system, Technical capacity, Storage system, Distribution system[a]	.	Enter

a. All requested variables entered.

b. Dependent Variable: Availability of vaccine

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.644[a]	.415	.374	.44694

a. Predictors: (Constant), Information system, Technical capacity, Storage system, Distribution system

b. Dependent Variable: Availability of vaccine

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	8.086	4	2.021	10.119	.000[a]
	Residual	11.386	57	.200		
	Total	19.472	61			

a. Predictors: (Constant), Information system, Technical capacity, Storage system, Distribution system

b. Dependent Variable: Availability of vaccine

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			Correlations			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	1.163	.369		3.149	.003					
	Storage system	.213	.096	.278	2.227	.030	.527	.283	.226	.660	1.514
	Distribution system	.368	.128	.366	2.872	.006	.575	.356	.291	.632	1.584
	Technical capacity	.054	.091	.065	.591	.557	.307	.078	.060	.837	1.195
	Information system	.072	.091	.095	.788	.434	.407	.104	.080	.713	1.402

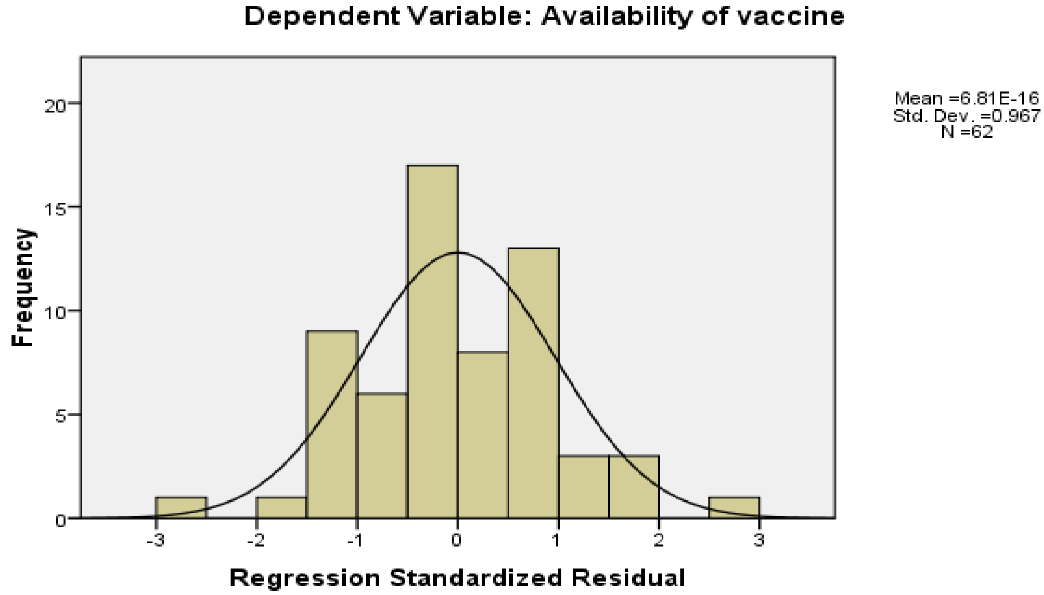
a. Dependent Variable: Availability of vaccine

Collinearity Diagnostics[a]

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions				
				(Constant)	Storage system	Distribution system	Technical capacity	Information system
1	1	4.898	1.000	.00	.00	.00	.00	.00
	2	.042	10.794	.00	.12	.00	.82	.07
	3	.024	14.321	.23	.68	.01	.04	.24
	4	.019	16.077	.05	.10	.74	.13	.35
	5	.017	16.821	.73	.10	.25	.01	.34

a. Dependent Variable: Availability of vaccine

Histogram



Scatterplot