The Assessment of e-LMIS Implementation and User Satisfaction for Pharmaceutical Management in Public Health Facilities of the Addis Ababa Regional Health Bureau

By
Sami Tewfik
ID No: GSD/0422/07

Advisor
Shiferaw Mitiku (PhD)

A Thesis Submitted to the Addis Ababa University, School of Commerce, in Partial Fulfillment of the Requirement for the Award of the Degree of Master of Arts in Logistics and Supply Chain Management.

September, 2018
Addis Ababa, Ethiopia

The Assessment of e-LMIS Implementation and User Satisfaction for Pharmaceutical Management in Public Health Facilities of the Addis Ababa Regional Health Bureau

By

Sami Tewfik

ID No: GSD/0422/07

APPROVED BY BOARD OF EXAMINERS

Dean, Graduate Studies_____ Signature_____

Advisor_____Signature_____

External Examiner_____ Signature_____

Internal examiner_____ Signature_____

Declaration

I, Sami Tewfik declared that a thesis entitled with "**The Assessment of e-LMIS Implementation and User Satisfaction for Pharmaceutical Management in Public Health Facilities of the Addis Ababa Regional Health Bureau"** is my original research work and have never been submitted to any other university for any Diploma or Degree. I also declare that all the resources used under this research has been acknowledged clearly.

Name_____

Signature_____

Date_____

Certification

This is to certify that a research under taken by **Sami Tewfik** under my advising entitled with: "**The Assessment of e-LMIS Implementation and User Satisfaction for Pharmaceutical Management in Public Health Facilities of the Addis Ababa Regional Health Bureau"** submitted to the AAU in partial fulfillment of the requirements for the Degree of Master of Arts in Logistics and Supply Chain Management complies with the regulations of the Addis Ababa University and meets the accepted standards with respect to originality and quality.

Name_____

Signature_____

Date_____

Table of Contents

Acknowledgement……..……iii

Abbreviations and Acronyms……..…….……..iv

List of Tables……..…….…v

List of Figures…….…….vi

Abstract……vii

CHAPTER ONE……..……..1

1. Introduction **1**

1.1.Background of the study 1

1.2. Background of the system……..3

1.3.Statement of the problem……..……..……...…….……4

1.4. Research objectives……..…..……5

1.5. Research questions……....……6

1.6. Scope of the study……..……..6

1.7. Delimitation of the study……..……6

1.8. Definition of terms……...……...….....6

1.9. Organization of the study……..…….……...7

CHAPTER TWO **8**

2. Review of Related Literature 8

2.1.Theoretical Literature Review 8

2.2. Empirical Literature Review…….……..…….……15

2.3. Conceptual framework of the study……..…….…..17

2.4. Identified Literature Gaps……..……....19

CHAPTER THREE 20

3. Methods of the study 20

3.1. Description of the study area 20

3.2. Research approach and design……20

3.3. Population and sample design……23

3.4. Data source and type……23

3.5. Data collection procedure……23

3.6. Method of data analysis and presentation……23

3.7. Ethical considerations……27

3.8.Dissemination of results……27

3.9.Validity and reliability of tests……27

CHAPTER FOUR 29

4. Results, Discussion, and Interpretation 29

4.1. Functionality and features of electronic LMIS "HCMIS FE 29

4.2. Demographic characteristics of respondents……35

4.3. System implementation challenges and supports……35

4.4. Data usage in e-LMIS "HCMIS FE" implementing sites……37

4.5. Data quality in e-LMIS "HCMIS FE" implementing sites……43

4.6. User Satisfaction in e-LMIS "HCMIS FE" implementing sites……44

CHAPTER FIVE 57

5. Summary of major finding, Conclusion, and Recommendation……57

5.1. Summary of Major Findings……57

5.2. Conclusion……59

5.3. Recommendation……61

References……64

Annexes……viii

Acknowledgement

I would like to express my deep gratitude to Dr. Shiferaw Mitiku, my advisor, for his guidance, enthusiastic encouragement, and useful critiques of this paper. He has also helped and assisted me in keeping my progress on schedule.

I would like to acknowledge the cooperation and assistance provided by Addis Ababa Regional Health Bureau and Public Hospitals and Management units. My special thanks to Seid Mohammed, Bikilla Dego, Etsub Weldekirkos, and Ephrem Birhanu who have facilitated the data collection process in public health facilities.

Last but not least, I would like to offer my special thanks to my wife Nejmia Mohammed for her patience, continuous support, and encouragement throughout my study.

Sami Tewfik

Abbreviations and Acronyms

DOS	Days Out of Stock
e-LMIS	Electronic Logistics Management Information System
FC	Facilitation Conditions
HCMIS	Health Commodity Management Information System
HCMIS FE	Health Commodity Management Information System, Facility Edition
HCSS	Health Commodity Supply System
HSTP	Health Sector Transformation Plan
IPLS	Integrated Pharmaceutical Logistics System
LMIS	Logistics Management Information System
OIG	Office of Inspector General
OJT	On Job Training
PEPFAR	President's Emergency Fund for AIDS Relief
PFSA	Pharmaceutical Fund and Supply Agency
PLMP	Pharmaceutical Logistics Master Plan
PSTP	Pharmaceutical Sector Transformation Plan
PU	Perceived Usefulness
RRF	Report and Requisition Form
SCM	Supply Chain Management
SOP	Standard Operating Procedure
SQ	System Quality
SS	System Support
US	User Satisfaction
USAID	United States Agency for International Development
WIIFM	What Is In It For Me

List of Tables **Page**

Table 1: Description of dependent and independent variables…….…….….22
Table 2: Constructs measuring system quality…….……..24
Table 3: Construct measuring data use…….……..25
Table 4: Construct measuring information quality……..……...25
Table 5: Construct measuring perceived usefulness……..…….26
Table 6: Construct measuring system support…….……..26
Table 7: Construct measuring facilitation condition……..…….27
Table 8: Construct measuring user satisfaction……..…....27
Table 9: Likert Scale Descriptive Analysis……...……..45
Table 9: Mean and S.D. for Constructs…….……...…..51
Table 10: Reliability - Cronbach's Alpha……...…..……..52
Table 11: VIF and Tolerance Statistics……..…….……52
Table 12: ANOVA……..…….……..53
Table 13: Model Summary……..……..53
Table 14: Linear Regression Result……...……....54
Table 15: Summary of Hypotheses Testing and Findings……...…..54

List of Figures **Page**

Figure 1: Commodity and Information Flow in IPLS (Source: Pharmaceuticals Fund and Supply Agency - PFSA, 2017)……...…….12

Figure 2: Conceptual framework to measure effectiveness of e-LMIS……..…...18

Figure 3: Requisition Business Process Diagram……..……..…29

Figure 4: Receive Business Process Diagram…….……...……31

Figure 5: Storage and Inventory Management Business Process Diagram……..……...32

Figure 6: Issue Business Process Diagram……..……34

Figure 7: Percentage fulfillment of the eLMIS system against the standard…….…..…35

Figure 8: Local ownership……..……...……36

Figure 9: Challenges faced in e-LMIS HCMIS sites……..……37

Figure 10: Use of System Generated Data……..…..……..38

Figure 11: Data Visibility……..…….38

Figure 12: Use of Data for Operational Decision……..…..…39

Figure 13: Use of Data for Inventory Management……..……..…40

Figure 14: Use of Data for Quality Monitoring……..……...…..41

Figure 15: Use of Data for Performance Enhancement…….....42

Figure 16: Use of Data - Summary……..……..…42

Figure 17: Data Quality…….…….43

Figure 18: Proposed e-LMIS assessment model……..…..55

ABSTRACT

The Federal Ministry of Health and Pharmaceutical Fund and Supply Agency (PFSA) in collaboration with development partners have been implementing electronic Logistic Management Information System (eLMIS) – Health Commodity Management Information System (HCMIS), Facility Edition (FE) in more than 800 public health hospitals and health centers. The system is designed to support inventory control, and logistics management information system. The need for continuous improvement to fulfill evolving needs and the system's ability to match the growth in increased commodity through puts will continue to be a challenge. In addition, data contained within eLMIS HCMIS is occasionally unreliable, inconsistent, or incomplete; and data are not used routinely enough for decisionmaking. Last but not least, the system is not linked in real-time to the HCMIS Warehouse (Warehouse Management System at PFSA), so real-time data visibility at the facility level is still a challenge due to internet access and reliability. The purpose of this study is to assess effectiveness of the e-LMIS implementation to optimize pharmaceutical management practices and enhance efficiency at hospitals and health centers under Addis Ababa Regional Health Bureau. Data was collected from sample of 39 users out of 49 mature e-LMIS HCMIS implementing public health facilities in Addis Ababa. Generally, system's ability to give easy access to relevant, customized, and complete logistics information in timely manner (visibility) was good even though the use of system generated data for decision making needs improvement. The study also found that three of the factors: Information quality (β =0.554), perceived usefulness (β=0.377), and system support (β =0.398) had statistically significant and information quality have the strongest predictor for user satisfaction. The eLMIS – HCMIS system requires significant upgrade to fulfill its purpose in the supply chain context but good level of LMIS data visibility for all stakeholders was observed and PFSA stood first. In addition to building the logistics information management systems, creating a data use culture is equally important. Creating and improving data use culture by empowering and training staff to analyze and use data for decision making will be key to improving supply chain performance. Identify the hook or factors that forces data use and quality to enhance use is also equally important. Given that the model only explains 58.1% of the factors that contributed to users satisfaction then in the future studies should focus on adding other factors that will explain more (60% and above) of the factors that contributed to users satisfaction.

Keywords: *eLMIS, user, satisfaction, health, commodities, Ethiopia, HCMIS*

CHAPTER ONE

1. Introduction

The study has assessed the e-LMIS practices and uses in public health facilities Addis Ababa to enhance effectiveness and efficiency of public health supply chain outcomes. This chapter describes the problem statements on the ground which gave rise to the research objectives. In addition scope, delimitation, and limitation will be described.

1.1.Background of the Study

The Federal Ministry of Health (FMOH) has been working to ensure an efficient and high-performing healthcare supply chain that ensures equitable access to affordable medicines for all Ethiopians. The healthcare supply chain in Ethiopia has suffered from weak systems with limited data visibility. This has resulted in wastage, stock outs, and poor health outcomes. To address these challenges, the FMOH initiated a comprehensive supply chain strategic planning process and approved the Pharmaceutical Logistics Master Plan (PLMP) in late 2006 (HCSS Master Plan 2006). Goal of PLMP, which created IPLS, is to improve medicine availability through one single supply chain system for all public health facilities. IPLS is the term applied to the single pharmaceuticals reporting and distribution system based on the overall mandate and scope of the PFSA. It aims to ensure that patients always get pharmaceuticals they need (IPLS SOP, 2017). To help health facilities effectively implement IPLS, PFSA and partners designed various interventions including, designing and implementing electronic- and paper-based logistics management information systems (LMISs). A well-designed, well-operated supply chain is critical to the success of any health system. To ensure essential health commodities are available to the right clients, when they need them, supply chain managers need to have visibility into all functions of the supply chain, such as procurement, warehousing, inventory, distribution, funding, and policy. Some functions can operate independently, which is why a strong logistics management information system (LMIS) is needed. A strong LMIS can ensure data visibility throughout each function, and essential logistics data can be communicated to supply chain managers for decisionmaking. Information is the engine that drives the logistics cycle; without information, the logistics system would not run smoothly (USAID | DELIVER PROJECT, Task Order 4, 2012).

A LMIS is the system of physical- and technology-based records and reports that supply chain workers and managers use to collect, organize, present and use logistics data gathered across all levels of the system. An effective LMIS depends on the right combination of people, processes, and technology (John Snow, Inc., 2017).

The LMIS must leverage technology to manage customers demand for up-to-the-minute, accurate data, which helps to manage product flow better for all levels within the system. Technology enables logisticians to quickly collect the data needed to make informed decisions, which ultimately improves customer service by minimizing losses and stock imbalances while moving public health commodities more efficiently to where they are needed most. LMIS automation or introduction of the eLMIS allows quicker access to aggregate and/ or specific data at their fingertips. Additionally, data is visible to authorized users throughout the requisition/order process, allowing managers to pinpoint where supportive supervision may be necessary to assist their staff (USAID | DELIVER PROJECT, Task Order 4, 2012).

The study described the eLMIS system using LMIS functional requirement list developed by PATH considering the LMIS business processes and associated objectives relevant to the operation of national logistics management system + eLMIS selection guide. This has helped a lot in identifying and clearly describing the value add in relation to data collection and help informed decisions through the decision support systems. In addition it has helped to identify which process in IPLS are covered and are still manual paper system.

Then visibility in terms moving the data up and down the supply chain and horizontally to provide supply chain workers and managers at various levels the right information, of the right quality, at the right time will be evaluated. A paper system moves physical reports; a digital system moves electronic data that are displayed on user interfaces and dashboards or other decision-support systems. Whether paper based or digital, a reporting system must be in place to ensure that information flows correctly and consistently. What data is being shared/how (digital or paper)/for whom/what decision. Data Quality as described as accuracy was also be evaluated quantitatively. In addition, use of data or the decision support decision and action support system for decision making like forecasting/Demand Planning, Inventory Management, Quality improvement, performance management, and Risk management will be evaluated. Or role of reports and informations from the system to enhance informed decision making.

User satisfaction is evaluated to measure the success of HCMIS as it involves gathering perceptions and feelings about the system directly from users (Delone and McLean, 2003; Omary and Kalinga, 2017; Dwivedi *et al*, 2012). User satisfaction is defined as an "effective attitude towards a specific computer application by someone who interacts with the application directly" (Omary and Kalinga, 2017). Measuring user satisfaction becomes especially useful, when the use of an IS is mandatory and the amount of use is not an appropriate indicator of systems success (Dwivedi *et al*, 2012).

Already proven data collection tools from Path, DELIVER's LIAT and LSAT, eLMIS selection Guide, and Delone and McLean's models were customized for the study.

1.2. Background of the system

Addis Ababa is the capital city of Ethiopia with 10 sub cities and 117 Woredas with an area of 540 km^2 and population of 3.43 million (1.81 million female and 1.62 million male) according to 2017 projection (CSA, 2017). During the survey time, Addis Ababa has a total of 56 hospitals (14 government owned hospitals), more than 760 clinics, 96 health centers and more than 720 pharmacies (AACAHB, 2016). Out of the 14 government owned hospitals, five are under the federal ministry of health, six are general hospitals under Addis Ababa city and the other three are army and police hospitals.

IPLS is the term applied to the single pharmaceuticals reporting and distribution system based on the overall mandate and scope of the PFSA. IPLS LMIS helps to collect, organize, and report information to other levels in the system in order to make decisions that govern the logistics system (////). Implementation of LMIS in facilities is twofold; electronic or eLMIS for electronic ready sites, and paper based for non-electronic ready sites.

HCMIS FE (Dagu) is a locally developed eLMIS designed to support inventory control, and logistics management information at public health facilities of Ethiopia. It provides a systematic recordkeeping system for managing health commodities at health facility stores. The system is installed in more than 800 health facilities, including most hospitals and major health centers across Ethiopia. There are 90 eLMIS "HCMIS" facilities and out of which 51 are at early stage of implementation support (practice phase) and 49 are mature sites (4 hospitals and 45 health Centers). Accordingly, census method will be used.

1.3. Statement of the problem

The Ethiopian public health supply chain management system have multiple challenges largely pertaining to the efficiency of the current system, the level of data quality and use, and the availability of adequate numbers of skilled health care workers (HCWs). There is significant wastage and inefficiency due to overstocking (Shewarega *et al*, 2015).

The e-LMIS (HCMIS FE - Dagu) was designed to support inventory control, and logistics management information at service delivery points in IPLS (Ethiopia MIS Fact Sheet, 2017). Even though the system is improving the basic collection and reporting of essential logistics information used for decision making, the need for continuous improvement to fulfill evolving and diversified customer and system requirement in improving the functionality and features is a challenge. In addition, the system's ability to match the growth in increased commodity through puts following the country's public health system expansion will continue to be a challenge (HSTP, 2015 and USAID | DELIVER PROJECT, Task Orders 4 and 7, 2016).

Approximately, there are more than 800 public health facilities using the system on daily basis Ethiopia. While the acceptance of the system is positive, long-term success depends on its continued use which is determined by users' satisfaction with the system. This study examined factors affecting users' satisfaction with eLMIS through developing a research model from the literature and adopting sequential explanatory mixed research design.

Though significant investments have been made to digitalize the Health Commodities Management Information System (HCMIS), data contained within eLMIS HCMIS is occasionally unreliable, inconsistent, or incomplete; and data are not used routinely enough for decisionmaking. Anecdotal information has shown that, the decisions made out of poor data quality result in poor demand planning and supply chain effectiveness and efficiency (USAID | DELIVER PROJECT, Task Orders 4 and 7, 2016). e-LMIS in public health facilities "HCMIS Facility Edition", a desktop module, is not linked in real-time to the HCMIS Warehouse, so real-time data visibility at the facility level is still a challenge due to internet access and reliability (PSPR for PFSA, 2017). Improvements in data use, accessibility, visibility, and transparency, as well as improvements in planning, control, and monitoring and support for quantification, may have contributed for improvement of the supply chain management efficiency in Tanzania (Mwencha *et al*, 2017). As per Ethiopian Information Revolution Road map (2016), the need for organized, accessible, timely,

and accurate data for health decision making has become a growing concern at national and international levels. Quality of care, planning, and decision making is restricted due to deficiency of quality health data.

It is believed that, digitizing the supply chain process will be more appropriate in hospitals than in health centers as hospitals manage more commodities. In the contrary, high workload and in these high volume health facilities might be the obstructive factor for not implementing and utilizing the system as needed.

The decline of funds from donors like President's Emergency Plan for Aids Relief (PEPFAR) really demands utilization of available resource efficiently and this will be impossible to achieve without using up-to-date, accurate data, which helps to manage product flow better for all levels within the system. Technology enables logisticians to quickly collect the data needed to make informed decisions, which ultimately improves customer service by minimizing losses and stock imbalances while moving public health commodities more efficiently to where they are needed most. The recent Global Fund, Office of Inspector General Audit report demands better visibility, quality, and use to enhance system efficiency. The multiplicity of manual and automated systems in procurement and in the supply chain makes it hard to trace medicines, the OIG said. In the audit sample, around 21% and 54%, respectively, of malaria and TB medicines could not be traced (Global Fund Observer, 2017).

1.4. Research objectives

The general objective of the study is to assess effectiveness of the e-LMIS implementation to optimize pharmaceutical management practices and enhance efficiency at hospitals and health centers under Addis Ababa Regional Health Bureau.

1.4.1. Specific objectives

- To assess the electronic LMIS "HCMIS" functionality and features
- To evaluate data usage in e-LMIS "HCMIS" implementing sites
- To measure the LMIS data quality in electronic LMIS "HCMIS" implementing sites
- To compare data use and quality in electronic LMIS, "HCMIS" implementing hospitals and health centers.
- To assess the relationship of HCMIS user satisfaction with system quality, information quality, data use, perceived usefulness, system support, and facilitation condition.

1.5. Research questions

- What are the functionalities and features of the e-LMIS "HCMIS" system?
- How the LMIS data are being used in e-LMIS, "HCMIS" sites?
- How is the LMIS data quality in e-LMIS, "HCMIS" sites?
- How are e-LMIS "HCMIS FE" implementing hospitals as compared to in e-LMIS "HCMIS" implementing health centers or vice versa in LMIS data use and quality?
- What is the relationship HCMIS user satisfaction with system quality, information quality, data use, perceived usefulness, system support, and facilitation condition?

1.6. Scope of the study

The study has evaluated electronic LMIS implementation and use in public health hospitals and health centers in Addis Ababa City administration. HCMIS FE was the system assessed in this study. In addition, user satisfaction was assessed to measure the success of the system. Specifically, the scope of the study will be; eLMIS implementation along with the level of use for decision making, and e-LMIS implementing mature public sector hospitals and health centers under Addis Ababa City Administration will be the facilities to be studied.

1.7. Delimitation of the study

The study will not include PFSA, autonomous agency to avail essential medicines to public health facilities. Public health facilities which are at early stages of implementing HCMIS FE implementation, paper based facilities, and Federal hospital in Addis Ababa, and health posts are not included in the study. Administrative units like Woreda and Region are also not be included.

1.8. Definition of terms

- **Supply Chain Management:** is an integration of key business processes from end user through original suppliers that provide the products, services, and information that add value for customers and other stakeholders (Lambert, Cooper, & Pagh, 1998).
- **Logistics** activities are the operational component of supply chain management, including functions such as quantification, procurement, inventory management, warehousing, transportation and fleet management, and data collection and reporting (John Snow, Inc., 2017).

- **Visibility** is visualizing and moving the data up and down the supply chain and horizontally to provide supply chain workers and managers at various levels the right information, of the right quality, at the right time (John Snow, Inc., 2017).
- **Data Quality** is about completeness, accuracy, and timeliness of reports generated to make informed decision making. It could also be defined in terms of specific step which could be either inbuilt, operational, or implementation support related steps designed to improve LMIS data quality (John Snow, Inc., 2017).
- **Use of information for decision** is system's ability and practice to use the information generated out of the LMIS for strategic and operational supply chain decisions like forecasting/Demand Planning, Inventory Management, Quality improvement, performance management, and Risk management (John Snow, Inc., 2017).

1.9. Organization of the study

The final research paper have the following organization. The first chapter contains background, statement of the problem, research questions, objectives of the study, definition of terms, scope of the study, and delimitation of the study. Chapter two will be review of related theoretical and empirical literatures on basic concepts and principles of SCM, LMIS, country specifically Ethiopia's experiences. Chapter three deals with research design and methodology, sample and sampling technique, sources and tools of data collection, procedures of data collection and method of data analysis. Chapter four covers the findings or results of the study, interpretation of the result and discussion of the result by comparing with the existing literature. The last chapter covers the summary of the findings, conclusion, and recommendation

CHAPTER TWO

2. Review of Related Literature

Literature review is a description of the literature relevant to eLMIS business processes and implementation. It gives an overview of what has been said, who the key writers are, what are the prevailing theories and hypotheses, what questions are being asked, and what methods and methodologies are appropriate and useful. The first part has helped in framing the study in terms of the already existing theories. Whereas, the second part summarizes findings of related studies conducted having consistent and contradictory findings. Finally, identified literature gaps were described.

2.1.Theoretical Literature Review

According to the Council of Supply Chain Management Professionals (CSCMP) (2012),

> *"Supply chain management encompasses the planning and management of all activities involved in sourcing and procurement…and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third party service providers, and customers. In essence, supply chain management integrates supply and demand management within and across companies."*

Logistics activities are the operational component of supply chain management, including functions such as quantification, procurement, inventory management, warehousing, transportation and fleet management, and data collection and reporting (John Snow, Inc., 2017). So in summary, Supply Chain Management (SCM) includes the logistics activities plus the coordination and collaboration of staff, levels, and functions, with the ultimate goal of aligning supply and demand. Supply chain and logistics management is a set of approaches utilized to effectively integrate suppliers, manufacturers, warehouses and stores in order to distribute products and services in the right quantities, to the right locations, and at the right time (Gunasekaran and Ngai, 2003). Cooper *et al* (1993) described that, the adoption supply chain logistics systems has able to lower; the cost of operations and increased reduced order cycle time which increases competitive advantage amongst similar firms. A public health supply chain is a network of interconnected organizations or actors that ensures the availability of health commodities to the people who need them (John Snow, Inc., 2017).

A LMIS is the system of physical- and technology-based records and reports that supply chain workers and managers use to collect, organize, present and use logistics data gathered across all

levels of the system. An effective LMIS depends on the right combination of people, processes, and technology. Skilled people must record, analyze, manage, and use supply chain data at every level. The LMIS must enable efficient business processes and workflows like forecasting, inventory management, distribution planning, reporting and ordering, order fulfillment, temperature monitoring, equipment maintenance, performance monitoring, etc. and incorporate routine data management processes (John Snow, Inc., 2017). LMIS is "a system of records and reports on routine administration, dispensing, consumption, and loss and adjustments data, to support forecasting and distribution of health commodities from central national storage to point of health service delivery" (Bergum *et al*, 2017). Recent developments in ICT have highlighted the need for the development of various systems to facilitate the chain flow and logistics management in many organizations. Such application of ICT in logistics management is called e-logistics (PATH, 2010).

Logistics management information systems (LMIS) play an increasingly critical role in the ability of various countries' Ministries of Health to increase responsiveness of their supply chain, reduce costs, and fulfill people's demand for better quality health services and improved health outcomes through informed decision making and actions (SIAPS, 2014).

And the LMIS must leverage appropriate technology that is feasible to deploy and sustain, and is embraced by users at each level. Most scholars consider Logistics Management Information Systems (LMIS) as the heart of logistics cycle. This is because, supply chain workers and managers gather information about each activity in the system and analyze that information to make informed decisions on logistics operations and coordinate future actions (USAID | DELIVER PROJECT, Task Order 4, 2015). Accurate and completed information reported in a timely manner plays and important role to support decision making and in turn support procurement of adequate quantities of essential medicines, respond to changes in demand, manage inventory levels and minimize thefts, losses and misuse (Yasmin *et al* 2006, Stansfield *et al* 2016). Moreover, quality and timely logistics data enhances accountability of the management of health programs as well as reducing wastage of expensive essential medicines such as antiretroviral (Sanchez *et al*, 2006). Currently there is growing interest in strengthening the collection and reporting of essential logistics information as part of strengthening supply chain systems for essential medicines in developing countries. The reliability, integrity, significance and comparability of information between service delivery points and across regions will be mostly improved through strengthening

logistics data collection, reporting and its subsequent use in supply chain activities (Cibulskis and Hiawalye, 2002). Use of different health information technologies, designed to digitize key supply chain business processes to improve quality of care and efficiency, is expanding in developing and developed countries. Specifically; Dispensing or point-of-service (POS) systems, electronic LMIS (eLMIS) solutions, Warehouse management systems (WMS), Fleeting management systems, Distribution planning systems, Enterprise resource planning (ERP) Barcode technology, and remote temperature monitoring devices are mostly implemented (John Snow, Inc., 2017).

Digitizing the LMIS business process through eLMIS solution improves visibility of supply chain data. And, this in turn improves the supply chain performance and reduces the supply chain costs (Mwencha *et al*, 2017).

The success of a LMIS depends on the interaction of a number of critical factors to ensure smooth design and implementation. These include; contextual factors, technical factors, organizational factors, customization and adaptation, and implementation related factors. The contextual factors is mostly about political will and stewardship. Technical factors are about the information system architecture and system interoperability. Organizational factors include organizational variables needed to maintain and sustain the system. These include; availability of skilled personal, participation of key stakeholders, finance, local ownership through user involvement, and staff motivation/competence/confidence in LMIS tasks. LMIS implementation factors include adherence to guidelines and standard operating procedures, provision of feedback to facilities, staff training, Supportive supervision and monitoring, and adaptation of system functionalities to maintain validity and meet user's needs (Chindove and Medge, 2012).

Many implemented information systems in developing countries tend to fail either totally or partially. The total failure is when the system was procured but never implemented or implemented but immediately abandoned. On the other hand, partial failure is when the system was implemented but the major goals are unattained or in which there are significant undesirable outcomes (Heeks, 2002). Common LMIS challenges that Ministries of Health (MOHs) in low-resource settings face are inadequate technical knowledge and skill sets on how to approach the design and implementation of LMIS that fits supply chain requirements and inadequate resources for structural, resource, and organizational support such as workforce and budget (SIAPS, 2014).

2.1.1. electronic LMIS "HCMIS FE" functionality and features

The PATH/Institute partnership lead the adaptation of what is now called the collaborative requirements development methodology (CRDM) to be applied in the domain of supply chain. The collaborative aspect of CRDM was designed to span the needs of multiple vertical programs for the diverse countries (PATH, 2010).

CRDM is effective in achieving the objective of generating user and system requirements that are understandable, adoptable and useful to stakeholders and managers for acquiring, enhancing, or developing a Logistics Management Information System (LMIS) for any health product. It enables greater clarity and accuracy when communicating the needs of users of information systems to software and system engineers as well as vendors of LMIS applications (PATH, 2010).

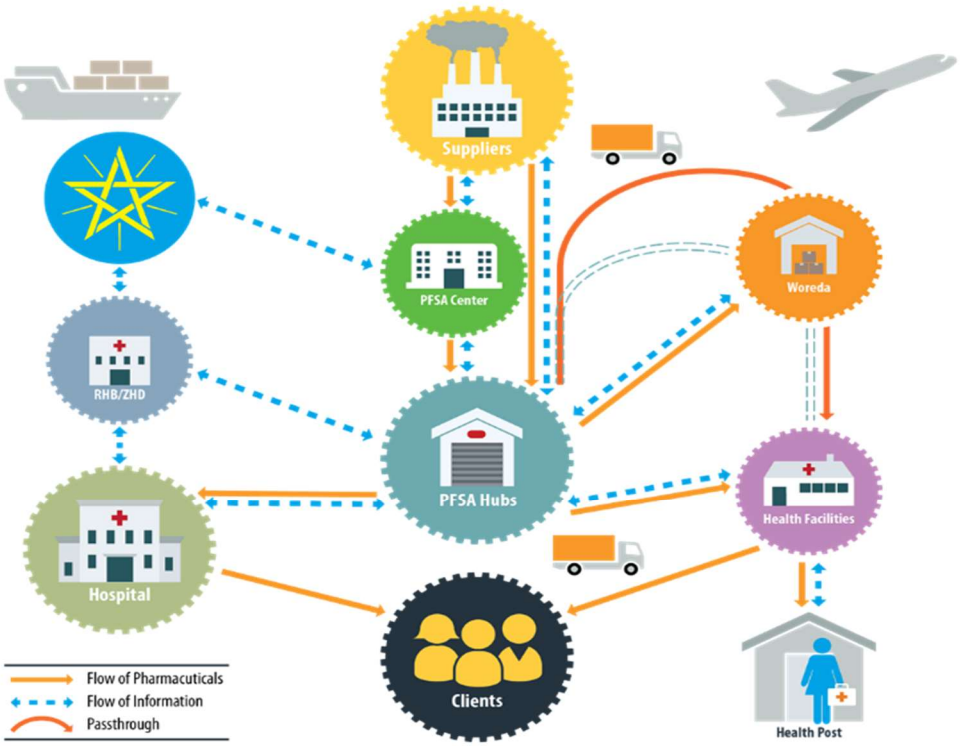
The output of the CRDM for the supply chain domain is a set of 12 business processes, 7 of which were prioritized as most likely to improve the performance of logistics management in countries. These 7 processes were made up of 59 discrete activities that formed the logical work flow to complete each process. A total of 208 specific user and system requirements were determined as necessary and documented. These requirements are now being used by countries to make informed decisions when acquiring commercial or open-source LMIS solutions, evaluating their existing capabilities, or enhancing existing implemented solutions. These requirements enable the LMIS to support: capturing of accurate routine administration, dispensing, and consumption data; real-time, end-to-end logistics management from point of origin to service delivery point; demand forecasting, capacity planning, and modeling based on consumption. This will in turn ensure that adequate quantity and quality of vaccines, essential medicines, and supplies are always available to meet patient demand (PATH, 2010).

Business Processes Contained within the CRDM in the Framework for LMIS are Requisition, Receiving, Storage, Dispatch, Transport, Dispense-General, Dispense-Administer Vaccine, Forecasting, Capacity Planning, Distribution Planning, Contracts & Grants Management, and Procurement (PATH, 2010).

The Ethiopian Integrated Pharmaceutical Logistics System (IPLS) a single pharmaceuticals reporting and distribution system based on the overall mandate and scope of the PFSA. It aims to ensure that patients always get pharmaceuticals they need. The figure below shows product and information flow in IPLS. The purpose of a Logistics Management Information System (LMIS) in IPLS is to collect, organize, and report information to other levels in the system in order to make

decisions that govern the logistics system and ensure that all six rights are fulfilled for each client. The figure below describes commodity and information flow in IPLS (Pharmaceuticals Fund and Supply Agency - PFSA, 2017).

Figure 1: Commodity and Information Flow in IPLS (Source: Pharmaceuticals Fund and Supply Agency - PFSA, 2017).



As per Pharmaceuticals Fund and Supply Agency – PFSA (2017), LMIS Business Processes in IPLS are:

a. **Requisition:** Hospitals and Health Centers use the Report and Requisition Form (RRF) to Report on the quantities of pharmaceuticals used, lost or transferred, and the quantities of stock available and order pharmaceuticals. Facilities send their completed and approved RRF to PFSA until the 10th day of the month following the end of the reporting period.
b. **Receiving:** PFSA delivers pharmaceuticals to Hospitals and Health Centers which have submitted a completed and approved RRF on time. Hospitals and Health Centers receive pharmaceuticals every other month. At the time of delivery, PFSA trucks will wait while

products are counted and verified, to take note of any discrepancies, to obtain proof of delivery (Model 19), to collect signed and sealed PFSA Delivery for the pharmaceuticals shipment. All pharmaceuticals should be received by a store manager before issued to dispensing unites.

c. **Issue:** In order to maintain the quality of the pharmaceuticals, and to better manage the pharmaceuticals in a Health Centre or Hospital, most of the commodities should be stored in the Health Centre or Hospital pharmacy store. Pharmaceuticals should be issued to the service providers (nurses, clinicians, out-patient pharmacies etc.) referred in this document as dispensing units (DUs) at their work area (in the ward, in a clinic, in the dispensary) in small quantities once or more during the month.

So, the most relevant business processes in the CRDMA for facility LMIS here are the first four Requisition, Receiving, Storage, and Dispatch (Issue).

2.1.2. Data usage in e-LMIS

Effective supply chains depend on end-to-end visibility of the right data of the right quality at the right time, in the hands of the right people in the right place, to make the right decision and take the right action. The whole purpose of supply chain maturity is end-to-end visibility of supply and demand data that are used to make decisions and take effective action. Most supply chains begin with a basic set of forms and reports, often manual forms, and then evolve into digital tools to capture, report, analyze, and present supply chain data (John Snow Inc, 2017). Supply Chain Management Information Systems (SCM IS) play an increasingly critical role in the ability of firms to reduce costs and increase the responsiveness of their supply chain (Chopra and Meindl, 2001).

LMIS by definition, is the system of physical- and technology-based records and reports that supply chain workers and managers use to collect, organize, present *and* use logistics data gathered across all levels of the system. So, it has comprehensive setup to facilitate and optimize selection and collection of essential data for use (visibility and use for decision making) (John Snow Inc., 2017).

Visibility is about moving the data up and down the supply chain to provide supply chain workers and managers at various levels the right information, of the right quality, at the right time. A paper system moves physical reports; a digital system moves electronic data that are displayed on user interfaces and dashboards or other decision-support systems. Whether paper based or digital, a

reporting system must be in place to ensure that information flows correctly and consistently. But, Digital LMIS applications can automatically populate report elements, especially if the eLMIS is also used for routine inventory control, and for opening balance, receipts, consumption, losses or adjustments that are recorded with every transaction (John Snow Inc., 2017). The eLMIS is expected to improve data visibility by providing accurate, quality, and timely data (Mwencha *et al*, 2016). The purpose of collecting and reporting data is to use them for decisions and actions. Data can be used for a variety of purposes: routine operations, performance management, continuous improvement, and strategic planning (John Snow Inc., 2017).

2.1.3. e-LMIS Data Quality

The whole purpose of LMIS is to make informed decisions that will improve customer service making quality monitoring and assurance critical. Although data quality is often a challenge, there are specific steps that can be taken to improve the quality of LMIS data. These include; designing and implementing simple and standard tools, human capacity building, incentives and hooks to facilitate reporting, platforms to triangulate reported data with other data sources, and digitalizing the information management processes (John Snow Inc. 2017). Another important factor is data standards since issues such as different facility names in the different system, different reporting periods and different naming conventions for drugs have significant impact on data quality. This could partly be solved with a more service oriented approach to the LMIS architecture (Bergum *et al*, 2017). Although both automated and manual tools can significantly improve the availability of logistics data, automated systems can result in more rapid availability of quality logistics data than manual systems due to real time reporting and in-built system that can detect errors, missing data and simplify data checking (Fraser *et al*, 2005).

2.1.4. User Satisfaction on e-LMIS

User satisfaction is defined as an "effective attitude towards a specific computer application by someone who interacts with the application directly" (Omary and Kalinga, 2017). User satisfaction is the most widely used measurement for the success of information system (Delone and McLean, 1992; Omary and Kalinga, 2017; Cai *et al*, 2017; Xiao and Dasgupta, 2002). It involves gathering perceptions and feelings about the system directly from users (Ives *et al*, 1983). Given the fact that the eLMIS is implemented in a context of developing countries, there is a need to evaluate its success.

2.2. Empirical Literature Review

In Pakistan, web-based cLMIS (Contraceptive LMIS) introduced helped managers, logisticians, and donors have better visibility into the supply chain; they can make better decisions to ensure that products reach the clients who need them. The cLMIS enables authorized users at various locations to enter data and to access cLMIS reports through a web browser. The web-based vLMIS (vaccine LMIS) application has given managers, logisticians, and donors better visibility into the supply chain through a multilevel dashboard based on numerous key performance indicators (KPIs). It helps them make better decisions to ensure that vaccines are available for the population at all supply chain levels (the national, provincial, and district levels). The vLMIS enables authorized users at various locations to enter data and access vLMIS reports through a web browser (USAID | DELIVER PROJECT, 2016).

In Zambia and Tanzania, the central-level, web-based eLMIS interface with the ERP and WMS software used in each country, respectively. They help to process orders for delivery by the Medical Stores Department (MSD) in Tanzania and the Medical Stores Limited (MSL) in Zambia. In Zambia, an offline eLMIS Facility Edition automates stock control cards and daily activity registers in public hospitals and health centers. The system automatically compiles and sends data via a web-based interface to the central eLMIS. The result is a reduced data collection burden on health facility workers and simplified end-of-the-month reporting and requisition process (USAID | DELIVER PROJECT, 2016).

In Nepal, reporting rates for family health programs were improved from 36 per cent in 1995 to 92 per cent in 2005 due to use of specially designed LMIS forms to collect and report logistics data on seven key commodities for the Family Health Program improved reporting rates from 36 per cent in 1995 to 92 per cent in 2005. In addition, the automated system (SILCOM) helped a lot in standardizing and sustaining the availability of logistics information for decision-making.

In Uganda, the automated pharmacy information management system has helped in reducing errors and enhancing quality and relevance of information generated (Ssali and Lyavala, 2009).

In Tanzania, mobile phones, SMS messages and electronic mapping technology were used in a pilot study to strengthen collection and reporting of logistics data on anti-malarial medicines in three districts. There was an average response rate of 95 per cent to SMS request for stock count data (Barrington *et al*, 2010).

Standardization of collection and reporting of logistics data to support decision-making on essential medicine supply can lead to improvements on availability and quality of logistics data and availability of essential medicines (Chindove and Mdege, 2012)

Implementation of Rx Solution (warehouse management software being used at CMS), supply plan decisions that link to procurement, and supply chain performance monitoring that links to government decision makers and donor partners like the Global Fund in Swaziland has helped a lot in improving the ART supply chain performance. That is; LMIS reporting rate increased from 56% to 97% at health facility level; 100% of orders from facilities have been fulfilled using LMIS data; stock-outs of widely consumed key ARVs (more than 85% of patients are using them) were avoided; all patients were able to get three months refill of ARVs according to the country's dispensing protocol (used to get two-weeks refill during shortages); use of LMIS for procurement decisions saved the government close to 6.25 million dollars in unnecessary procurement. In addition, electronic LMIS implementation in Bangladesh had improved data use to make more informed decisions and stock-outs have been reduced. Early warning system (EWS) designed to collect, aggregate and track information on HIV and AIDS commodities across five west African countries has helped a lot in preventing expiries and revising procurement and supply plan decisions to avoid stock outs (SIAPS, 2014).

In Ethiopia, the eLMIS at facility (HCMIS Facility Edition) and the warehouse management system (HCMIS Warehouse) is helping health facilities to improve commodity management, data visibility, and overall performance. The system is user friendly users with various backgrounds, ranging from those with limited computing experience to advanced users and experts can use the system. The HCMIS Warehouse has given managers the ability to oversee and record deliveries and pickups, maintain inventory records, and track inventory location. They can use this detailed information to best manage their inventory at all times. Web-based dashboards add the capability of visualizing the most updated data from all branch distribution locations to enhance decisionmaking. That is; forecasting, resupply, and inventory management decision are being made using data from stock status and demand reports to make decisions. The eLMIS (HCMIS Facility Edition) gives facility manager visibility to every health commodity in their store. Users and managers can react quicker to changes in inventory and make more informed decisions about which products and how much of those products are needed to bring any facility up to adequate

stock quantities, reducing the number and length of stockouts (USAID | DELIVER PROJECT, 2016).

User satisfaction is the most widely used measurement for the success of information system (Delone and McLean, 1992; Omary and Kalinga, 2017; Cai *et al*, 2017; Xiao and Dasgupta, 2002). It involves gathering perceptions and feelings about the system directly from users (Ives et al, 1983). Omary and Kalinga (2017) has found that four of the factors: information quality (β=0.28), system quality (β=-0.21), perceived usefulness (β=0.22), and facilitation conditions (β=0.26) had a significant effect on users' satisfaction with the eLMIS. However, system support did not have a significant effect.

As per Petter *et al* (2008) as described in Dwivedi *et al* (2012); system quality, information quality, service quality, system use, and net benefit had a significant effect on user satisfaction. And, system quality and information quality had the strongest predictor.

Lwoga (2014), in his study on critical success factors for adoption of web-based learning management systems in Tanzania, was found that perceived usefulness was a key determinant of user satisfaction.

P-C Sun *et al* (2008) in his study to investigate the critical factors affecting learners' satisfaction in e-Learning; learner computer anxiety, instructor attitude toward e-Learning, e-Learning course flexibility, e-Learning course quality, perceived usefulness, perceived ease of use, and diversity in assessments were found to be the critical factors affecting learners' perceived satisfaction.

Delone and McLean (2003) in their casual or variance model studies have shown that, system quality and information quality have casual.

Delone and McLean (2003) in their causal or variance model studies have shown that, system quality and information quality have causal relationship with user satisfaction. And, this leads to positive impacts on individual productivity, resulting in organizational productivity improvements.

2.3. Conceptual framework of the study

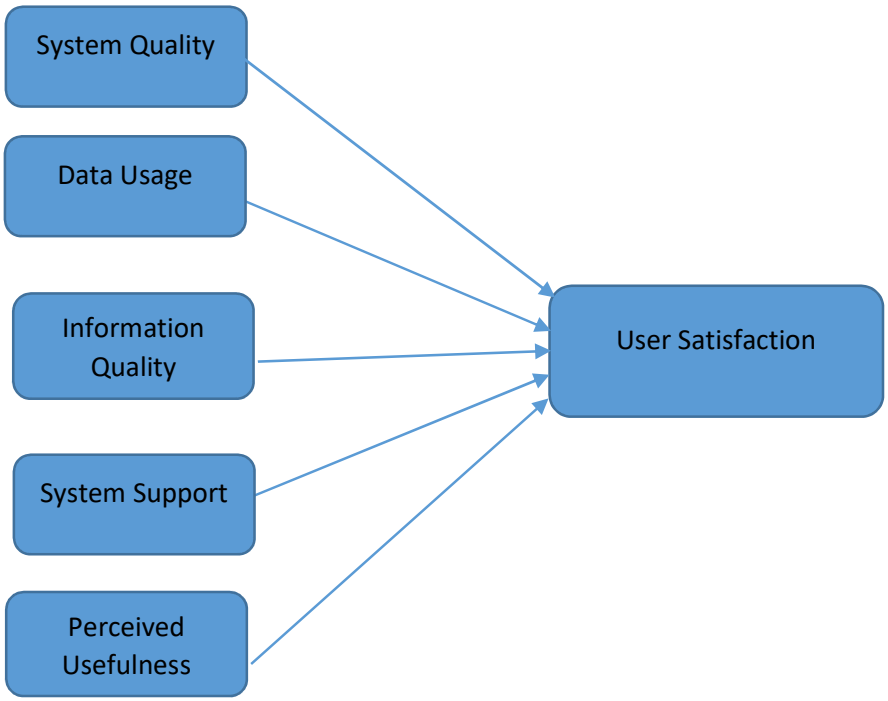
The study started by exploring theoretically, a number of possible factors which were used by other researchers to assess the effectiveness of various information systems. User satisfaction is found to be the most widely used method even though return on investment and information system usage were used to measure success of an information system .

Omary and Kalinga (2017) found five factors and used in assessing the model. After a linear regression, all the factors were found significant except system support which was not significant in contributing to users' satisfaction with eLMIS. Seddon (1997) and DeLone and McLean (2003) explained factors that lead to the user's satisfaction of the information systems namely system quality, information quality, system use, perceived usefulness, and service quality. In addition, Davis (2002) through TAM measures of perceived usefulness and perceived ease of use were effective predictors for the success of an information system.

Mwencha *et al* (2017), constructed the conceptual framework for the management upgrade interventions for eLMIS interventions bring about better supply chain outcomes through its effect on improving reporting and data use (transparency, timeliness, visibility, and accessibility). That is, improved reporting and data use through e-LMIS improves and streamlines the supply chain management practices including forecasting, storage, LMIS, and distribution). Improved and streamlined supply chain management practices bring about better supply chain outcomes.

So, the following conceptual framework was constructed considering the above mentioned models constructed by the above mentioned researchers.

Figure 2: Conceptual framework to measure effectiveness of e-LMIS



Source: Omary and Kalinga, 2017

2.4. Identified Literature Gaps

There are no studies conducted to assess visibility, use, and success of eLMIS interventions in Ethiopian setting. But, the same kind of study conducted in other African and developing countries has helped a lot in framing the methodology for this study. In addition, there are also no studies that comprehensively assessed effectiveness eLMIS in Ethiopia in terms of user satisfaction. But, the same kind of study conducted in Tanzania by Omary and Kalinga (2017) has helped a lot in framing the theoretical framework.

CHAPTER THREE

3. Methods of the study

The methodology of the study have; description of study area, research approach on the specific purpose that the research tries to address, the approach in terms of being qualitative and quantitative, sampling design, data collection as well as analysis, and reliability tests.

3.1. Description of the study area

The study was conducted in Addis Ababa which is the capital city of Ethiopia, seat of African Union and Economic Commission. It is located in the geographic center of the country and covers a landmass of 540 sq. km. It is administratively sub-divided into 10 sub cities. The city has 6 hospitals and 98 health centers. There are 90 eLMIS "HCMIS" facilities and out of which 41 are at early stage of implementation support (practice phase) and 49 are mature sites (6 hospitals and 45 health Centers). The study area was chosen because it is the most accessible area and majority of high volume big hospitals and health centers are available.

3.2. Research approach and design

Explanatory research design was used to assess the relationship of HCMIS user satisfaction (measure of success of information system) with system quality, information quality, data use, perceived usefulness, system support, and facilitation condition. Descriptive study design was used to describe the functionality and features of e-LMIS "HCMIS FE" and to evaluate LMIS data use and quality.

Qualitative approach was used to describe the functionality and features of e-LMIS "HCMIS FE" and evaluate LMIS data use and quality. Most findings were analyzed and summarized quantitatively. The study was exclusively cross sectional, carried out in snap shot. Specifically observation and survey methods was employed. The observation was to describe the e-LMIS through observing and recording system features. The Survey was used to scan and gather data on e-LMIS data use, quality, system quality, information quality, data use, perceived usefulness, system support, facilitation condition, and user satisfaction. Qualitative and numerical data generates from observation and field survey was further used to produce frequencies and descriptive information.

The variables used to describe and explain e-LMIS "HCMIS FE" features and functionalities were activities in the business process framework for LMIS as described in PATH (2010); requisition,

receiving, storage, dispatch, and dispense. In addition the e-LMIS solution was further analyzed using contextual, organizational, technological, customization, and implementation related variables to describe design and implementation related issues.

The study started by exploring theoretically, a number of possible factors which were used by other researchers to assess users' satisfaction in different contexts. An abstract (theoretical) model with factors to be applied in the context of eLMIS was identified which led to the development of an abstract research model as shown in Figure 2. The study proposed six theoretical abstract factors to be used to justify users' satisfaction with eLMIS. These six factors; System Quality, Information Quality, System Support, Perceived Usefulness, and Facilitation Conditions are taken as independent variables expected to have causal relationship with Users Satisfaction as dependent variable. These abstract factors were analyzed and assisted in producing a data collection tool (questionnaire) which was used to test the statistical significance of each factor.

The table below shows matrices describing the independent and dependent variables mentioned above.

Table 1: Description of independent and dependent variables

Abstract Variable	Description
System Quality	• User Interface (UI) • Reliability, adaptability, and performance of the system
System Use	• Visibility • Use of data for decision making
Information Quality	• Timeliness, accuracy, and completeness of data generated out of the system • Accessibility and easiness of the data generated out of the system
Perceived Usefulness	• Adaptability, effectiveness, and efficiency of the supply chain system • Workload
System Support	• Quality of support provided • Mechanism of support • Timeliness of support provided • Sufficiency of support provided • Knowledge of support providers • Impact of the service providers
Facilitation Conditions	• Resources • Knowledge of user • Help to solve problem • User documentation and guideline
User Satisfaction	• Satisfied with the HCMIS function in managing day to day transactions • Satisfied with the inventory management function of HCMIS • Satisfied with the system's output (reports and decision support) • Satisfied with the technical support

Source: Omary and Kilinga, 2017 and Mwencha *et al*, 2017

3.3. Population and Sample Design (Sample size determination technique and sampling technique)

The population of interest of this study were service delivery points implementing eLMIS "HCMIS" including hospitals and health centers. There are 90 eLMIS "HCMIS" facilities and out of which 51 are at early stage of implementation support (practice phase) and 49 are mature sites (4 hospitals and 45 health Centers). Accordingly, census method will be used. However, those 51 facilities which are at the early stages of implementation were excluded due to low availability of data and low use at the early stage of implementation (less than one year). That means, one year of continuous implementation of the system was used as exclusion criteria. The study had a total of 39 respondents (store managers) working in these hospitals and health centers.

3.4. Data source and type

The sources of data for the study were; the eLMIS "HCMIS", health facility records and pharmacy store manager working in the selected 39 health facilities. The primary data was collected by observation, physical inventory, assessment of facility records, and structured interviews with health-facility pharmacy personnel.

3.5. Data collection Procedure

A quantitative questionnaire was prepared and a total of 39 usable responses were obtained. The response rate was 80 percent. Data was collected from August 15 to 30 2018 using standard questionnaire developed and adopted for this purpose.

3.6. Method of Data Analysis and Presentation

3.6.1. Descriptive Analysis

The quantitative data collected was coded, entered and analyzed using SPSS software and statistical tests such as mean, standard deviation, percentage, and frequency were run. Descriptive statistical tools such as graphs, and frequency tables were employed using excel spreadsheet.

3.6.2. Inferential Analysis

Inferential analysis was employed to assess cause and effect relationship between eLMIS user satisfaction and factors affecting user satisfaction. Specifically, linear regression was conducted for independent variables: system quality, information quality, data use, perceived usefulness, system support, and facilitation condition to determine the causal relationship between each

variable on the user's satisfaction. But, the constructs under each independent and dependent variables describing effectiveness of information system were transformed first into continuous variable which combined these individual items into a single mean rating before running the system. Finally, the results were interpreted and was made to provide the results.

The study is making use of metrics of each, with their hypothesis as given by other researchers to understand the essence of each factor as following:

a. **System quality** is concerned with consistency user interface, reliability (bugs in the system), adaptability, and performance of the system. As per Omary and Kalinga (2017) system quality has significant effect on user's satisfaction. Other scholars such as Ardito *et al* (2005) and Islam and Azad (2015) have also reported the same. The hypothesis of this factor is:

- **H1: System Quality has an effect on users' satisfaction with the eLMIS HCMIS**

  Similarly, the proposed instrument to measure the construct is proposed in Table 2

Table 2: Construct measuring system quality

S/No	Construct	Source
I.1.	The information provided by HCMIS is well formatted (laid out and clearly presented)	Omary and Kalinga (2017), Islam and Azad (2015), DeLone and McLean (2003)
I.2.	The HCMIS speed (the time that elapses from the time an activity starts until the results are displayed on the screen or on the printer) is satisfactory	Omary and Kalinga (2017), Islam and Azad (2015), DeLone and McLean (2003)
I.3.	HCMIS is a reliable (e.g. not much failure during operation) logistics management information system	Omary and Kalinga (2017), Islam and Azad (2015), DeLone and McLean (2003)
I.4.	HCMIS can be adapted to a variety of user needs and to changing conditions	Omary and Kalinga (2017), Islam and Azad (2015), DeLone and McLean (2003)
I.5.	HCMIS is easy to learn, manage, and use	Omary and Kalinga (2017), Islam and Azad (2015), DeLone and McLean (2003)

b. **Data use:** Data use in the context this study is described in terms of visibility and use of system generated data for decision. Visibility is visualizing and moving the data up and down the supply chain and horizontally to provide supply chain workers and managers at various levels the right information, of the right quality, at the right time (John Snow, Inc., 2017). Use of information for decision is system's ability and practice to use the information generated out of the LMIS for strategic and operational supply chain decisions like forecasting/Demand Planning, Inventory Management, Quality improvement, performance management, and Risk management (John Snow, Inc., 2017). The hypothesis of this factor is:

- **H2: Data use has an effect on users' satisfaction with the eLMIS HCMIS**

  Similarly, the instrument to measure the construct is proposed in Table 3:

Table 3: Construct measuring data use

S/No	Construct	Source
II. 1	HCMIS provides with all complete set of logistics information needed for reporting and decision making. (Visibility)	John Snow, Inc., 2017
II.2	All HCMIS related logistics information can be accessed with relatively low effort (Visibility)	John Snow, Inc., 2017
II.3	HCMIS enabled to easily produce reports (Visibility)	John Snow, Inc., 2017
II.4	The facility is using the reports and information from the system for operational/strategic decision making	John Snow, Inc., 2017
II.5	The facility is using the reports and information from the system for performance monitoring	John Snow, Inc., 2017
II.6	The facility is using the system to produce reports required by management units at different level	John Snow, Inc., 2017

c. **Data quality** is about completeness, accuracy, and timeliness of reports generated to make informed decision making. It could also be defined in terms of specific step which could be either inbuilt, operational, or implementation support related steps designed to improve LMIS data quality (John Snow, Inc., 2017). The hypothesis of this factor is:

- **H3: Data quality has an effect on users' satisfaction with the eLMIS HCMIS**

  Similarly, the instrument to measure the construct is proposed in Table 4:

Table 4: Construct measuring information quality

S/No	Construct	Source
III.1	The data from HCMIS is timely	John Snow, Inc., 2017
III.2	The data and reports from HCMIS are accurate	John Snow, Inc., 2017
III.3	HCMIS provides sufficient information	John Snow, Inc., 2017
III.4	HCMIS provides information that is easy to understand	John Snow, Inc., 2017
III.5	The reports in HCMIS are available whenever you want to use	John Snow, Inc., 2017

d. **Perceived usefulness** is a perceptual indicator of the degree to which the stakeholder believes that using a particular system has enhanced his or her job performance, or his or her group's or organization performance (Seddon, 1997). In this study, perceived usefulness is related to the degree to which users believe that using the eLMIS will improve facility's supply chain performance (adaptability, effectiveness and efficiency) and minimizing workload. Several scholars have shown that perceived usefulness has significant impacts on user satisfaction in various information systems (P.-C. Sun *et al*, 2011; Omary and Kalinga, 2017; and Lowaga, 2014). Therefore, it was worth to include perceived usefulness as a measure of users' satisfaction with the eLMIS. The hypothesis of this factor is:

- **H4: Perceived usefulness has an effect on users' satisfaction with the eLMIS HCMIS**

The instrument to measure this factor is as shown in Table 5.

Table 5: Construct measuring perceived usefulness

S/No	Construct	Source
VII.1	HCMIS enabled the health facility to improve capacity to manage an increasing volume of commodities (Adaptability)	Omary and Kalinga (2017), Lowaga, 2014
VII.2	HCMIS improved product availability which contributes to improvement in health service coverage and quality of care (Effectiveness)	Omary and Kalinga (2017), Lowaga, 2014
VII.3	HCMIS contributes to efficiency by reducing losses due to overstock and expiry (Efficiency)	Omary and Kalinga (2017), Lowaga, 2014
VII.4	HCMIS had minimized workload by reducing manual work	Omary and Kalinga (2017), Lowaga, 2014

e. **System Support:** USAID funded implementing partner along with the Pharmaceutical Fund and Supply Agency (PFSA) are providing support services to users of eLMIS on their daily operations when they face any challenges. It is expected that users with good support services from the IT Unit are likely to continue using the eLMIS and will have positive perception towards it. Likewise, such services will enable users improve their job performance and be satisfied with the system. According to Delone *et al* (2003), system support service is the measure of the quality of the support services that users receive from the IS department and IT support personnel. System support has found to have a positive impact on users' satisfaction with the system in studies Ssekakubo *et al*, 2012; Lwoga, 2014. The proposed hypothesis is:

- **H5: System Support has an effect on users' satisfaction with the eLMIS**The instrument designed to measure system support is described in constructs in Table 6.

Table 6: Construct measuring system support

S/No	Construct	Source
VI.1	HCMIS support providers provided up to date knowledge and experience related to HCMIS.	DeLone and McLean (2003), Omary and Kalinga (2017)
VI.2	HCMIS support providers provided support in multiple mechanisms (face to face, toll free line, telephone…)	DeLone and McLean (2003), Omary and Kalinga (2017)
VI.3	Technical support provided were timely for all HCMIS related queries and requests.	DeLone and McLean (2003), Omary and Kalinga (2017)
VI.4	Technical supports provided were adequate (number of support provided is sufficient).	DeLone and McLean (2003), Omary and Kalinga (2017)
VI.5	HCMIS technical support provider staffs have adequate knowledge to help me	DeLone and McLean (2003), Omary and Kalinga (2017)
VI.6	Support from HCMIS providers has enhanced my ability to use the system	DeLone and McLean (2003), Omary and Kalinga (2017)

f. **Facilitation Conditions** are like Internet availability, stable power supply, knowledge to use the system which all together have an impact on users' satisfaction with the system. As per Grover (1993) and Saunders *et al* (1992) as it was described in Omary and Kalinga (2017), facilitation conditions and technological issues are key determinants of satisfaction in the perception of users of information system. The proposed hypothesis is:

- **H6: Facilitation condition has an effect on users' satisfaction with the eLMIS.**

The proposed instrument designed to measure facilitation condition is described in constructs in Table 7.

Table 7: Construct measuring facilitation condition

S/No	Construct	Source
VIII.1	I have the resources (e.g. PC, the Internet etc.) necessary to access the eLMIS	Omary and Kalinga (2017)
VIII.2	I have the knowledge necessary to use HCMIS for inventory management	Omary and Kalinga (2017)
VIII.3	A help is available when I get problem in the eLMIS	Omary and Kalinga (2017)
VIII.4	HCMIS has sufficient user documentation (manual or electronic) explanation of what HCMIS does and how to use it	Omary and Kalinga (2017)

g. The proposed instrument designed to measure **user satisfaction** is described in constructs in Table 8.

Table 8: Construct measuring user satisfaction

S/No	Construct	Source
IX.1	I am satisfied with the HCMIS function in managing day to day transactions	Omary and Kalinga (2017)
IX.2	I am satisfied with the inventory management function of HCMIS	Omary and Kalinga (2017)
IX.3	I am satisfied with the system's output (reports and decision support)	Omary and Kalinga (2017)
IX.4	I am satisfied with the technical support	Omary and Kalinga (2017)

3.7. Ethical consideration

The study was first approved by research and ethical committee of Addis Ababa Health Bureau before the study is commenced, then a letter informing the facility administrators was written. There was a high degree of confidentiality during data collection and no name of any health facility and participating subjects were put in the result instead the aggregate result of the facilities and summary results of interviewees were projected.

1.8. Dissemination of Results

Results of the study will be disseminated to Addis Ababa Public Health Research and Emergency Management Core Process.

1.9. Validity and reliability of tests

The research instrument was pre-tested before final administration of questionnaires to the respondents. The pilot study was conducted using questionnaires to interview store managers in HCMIS implementing public health facility. According to Dawson (2009), a pilot study is a small scale preliminary study conducted to evaluate feasibility, time, cost, adverse events, and predict an appropriate sample size and improve the study design prior to performance of a full research scale research study. Reliability analysis was done using Cronbach's Alpha which measures the internal consistency by establishing if certain item within a scale measures the same construct. Cronbach's alpha was calculated by application of SPSS for reliability analysis. The value of the alpha coefficient ranges from 0-1 and may be used to describe the reliability of factors extracted from dichotomous and or multi-pointed formatted questionnaires or scales. A higher value shows a more reliable generated scale. Nunnally (1978) established the Alpha value threshold at 0.7 which the study benchmarked against. Cronbach Alpha was established for every abstract in order to determine if each scale would produce consistent results should the research be done later on.

CHAPTER FOUR

4. Results, Discussion, and Interpretation

This chapter presents study results objective wise along with discussion of the result. These results and discussions were further substantiated with previous findings of the scholars in the area.

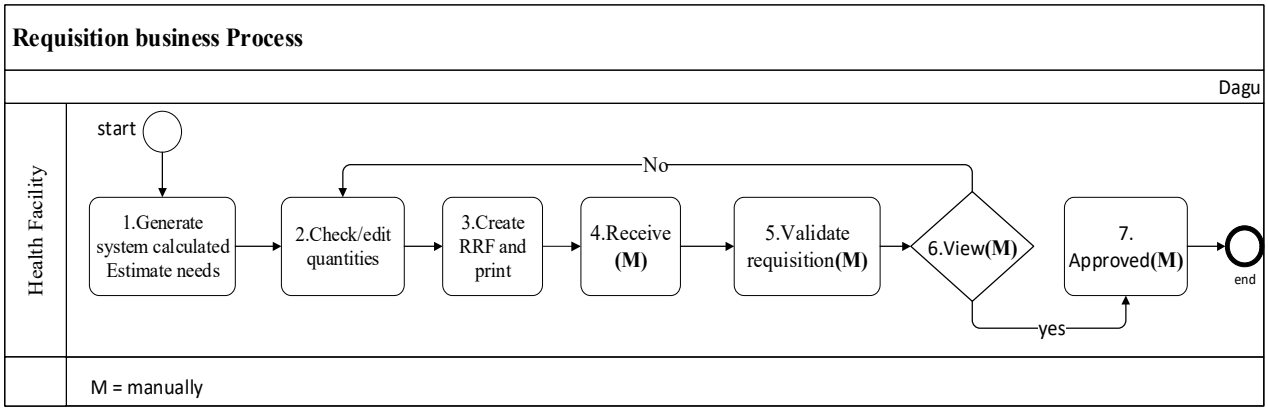
4.1. Functionality and features of electronic LMIS "HCMIS FE" (system audit)

The variables used to describe and explain e-LMIS "HCMIS FE" features and functionalities were activities in the business process framework for LMIS as described in PATH (2010). There are 12 business process included in the framework and the most relevant ones for facility level eLMIS are requisition, receive, storage, issue, and dispense. The eLMIS HCMIS FE implemented in public health facilities does not have features and functionality to manage dispense business process.

a. Requisition Business Process

As per the requirement in PATH 2010, full-fledged eLMIS require eleven core activities within the requisition fulfilled in the automation. Of 9 the system was able to automate 6 core activities (66.7%). The system currently by design doesn't have the capability to transmit and visualize information electronically to upward supply chain tiers. That means, the capability to electronically validate, transmit, delete, approve or reject, and show status of requisition is missing. But, it can easily print the system generated RRF to be manually submitted after being validated and approved by the relevant party. The figure below shows the business process flow within the requisition process.

Figure 3: Requisition Business Process Diagram



Source: Self Depicted

The use case requires the store manager to automatically create requisition using RRF and print this requisition in two copies. The printout will be sent to the facility pharmacy head for validation and the final approval will be by the facility manager. The original copy will be sent to PFSA for resupply and the other goes to WoHO/ZHD/RHB for monitoring.

As per IPLS Report and Requisition Form (RRF) is used by Hospitals and Health Centers to Report on the quantities of pharmaceuticals used, lost or transferred, and the quantities of stock available and order pharmaceuticals. Facilities send their completed and approved RRF to PFSA until the 10th day of the month following the end of the reporting period. The objective is to ensure timely ordering of the right commodities in the right quantity. This is to maintain stock levels within the minimum and maximum thresholds and reduce stock-out and overstock situations. The business process facilitate inventory control and provides tracking mechanisms.

This business process provides the mechanism for calculating and ordering goods for stores at service delivery points. The process is performed with a pull system. Rules and guidelines for estimating the need for stock are based on Maximum level, Days out of Stock (DOS), and the current stock on hand. The system helps to automatically generate the electronic RRF which helps in estimating needs for the coming two months (short term resupply decision using historical demand information, DOS, and Stock on Hand). This will help to ensure timely ordering of the right commodities in the right quantity and shorten order fulfillment time by minimizing time to produce RRF. It has the flexibility to update the requested quantity developed considering other factors and user's judgment.

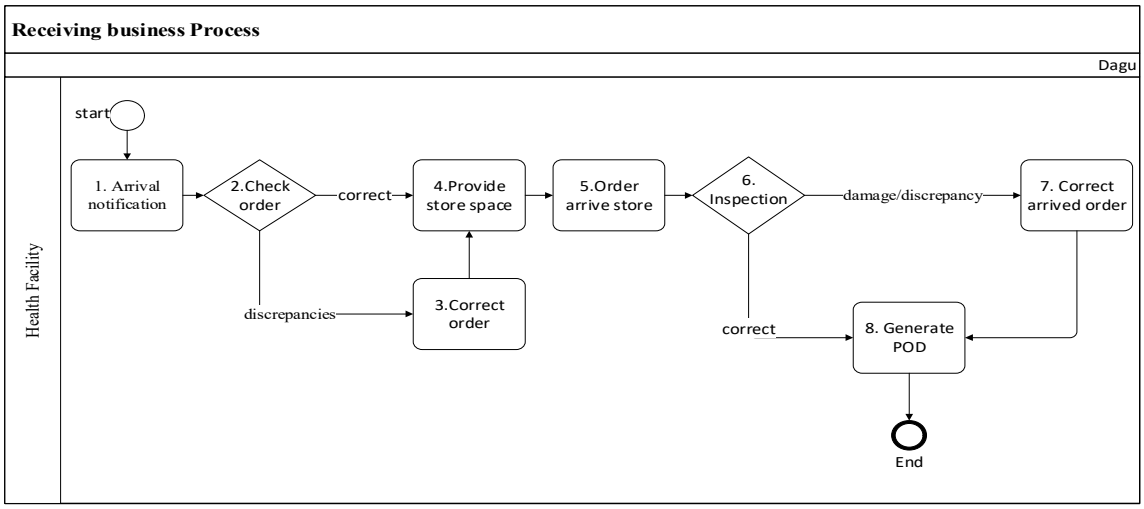
b. Receive Business Process

As per the requirement in PATH 2010, full-fledged eLMIS require eleven core activities within receive business process fulfilled in the automation. Of 8 the system was able to automate only 2 activities (25%). The lack of electronic linkage with the supplier's electronic LMIS system prevented the system to automate additional activities adding value to the business process and in turn improve visibility and supply chain efficiency. The system doesn't have important functionalities like; automatic notification of arrival, mechanisms to take corrective action for discrepancies, storage requirement for arriving consignments, detail of shipment before arrival, and automatic delivery note which all depend on electronic linkage and data synchronization with supplier's eLMIS. The figure below shows the business process flow within the receive process.

Receive log in the system is one of the main data entry point of the system and it is the main duty of the store manager. The system will help to record product information including product name, quantity, unit of issue, pack size, price, batch, and expiry date. These product informations are recorded by supplier, store (Virtual Budget and Health Program Stores), and program (Malaria, HIV, and Family Health).

The system automatically prints Proof of Delivery (Model 19) to be collected by PFSA Deliverer after it was signed and sealed.

Figure 4: Receive Business Process Diagram



Source: Self Depicted

The use case requires store manager to receive verified quantity and quality of product including product name, quantity, unit of issue, pack size, price, batch, and expiry date. These product informations are recorded by supplier, store (Virtual Budget and Health Program Stores), and program (Malaria, HIV, and Family Health).

As per IPLS, most of the time PFSA delivers pharmaceuticals to Hospitals and Health Centers which have submitted a completed and approved RRF on time. Hospitals and Health Centers receive pharmaceuticals every other month. At the time of delivery, PFSA trucks will wait while products are counted and verified, to take note of any discrepancies, to obtain proof of delivery (Model 19), to collect signed and sealed PFSA Delivery for the pharmaceuticals shipment. All pharmaceuticals should be received by a store manager before issued to dispensing unites.

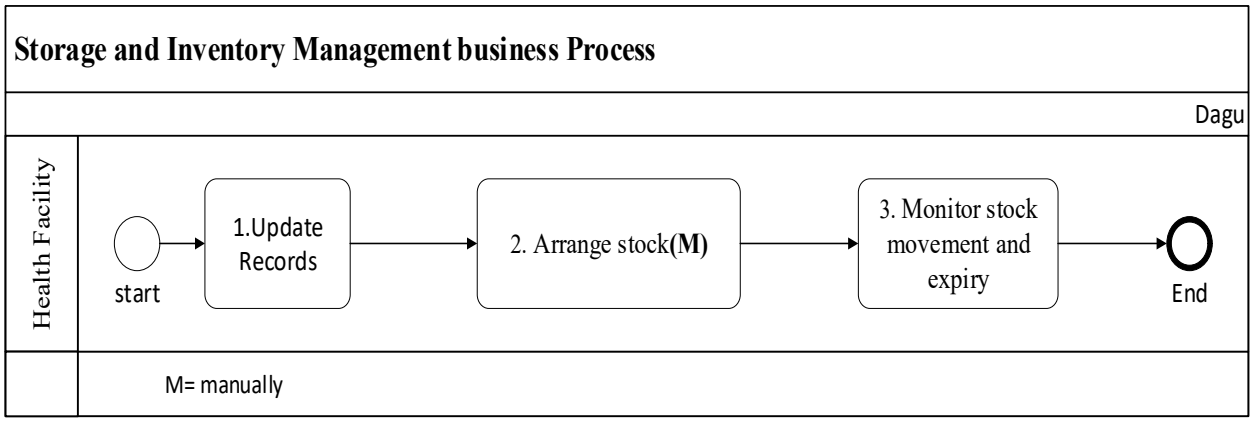
So, automation Objective for this business process will be to receive verified quantity and quality of health commodities into store and determine need for remedial action when necessary. As a

result, commodities coming from suppliers are either accepted or rejected. Those goods that are accepted are placed into stock, and those that are rejected are retained or disposed. Records are updated with appropriate information.

c. Storage and Inventory Management Business Process

As per the requirement in PATH 2010 full-fledged eLMIS require six core activities fulfilled in the automation. Of 6 the system was able to automate 4 (66.7%). The system currently by design doesn't have the capability to monitor stock environment as described as monitoring appropriate temperature and security conditions. In addition, there are no stock status alert and notification system to proactively inform and alert users and decision makers. The figure below shows the business process flow within the storage and inventory management process.

Figure 5: Storage and Inventory Management Business Process Diagram



Source: Self Depicted

The system has well developed stock status/movement monitoring and batch/expiry tracking and monitoring system. Specifically, the system displays informations on stock status (stock outs, overstock, and under stock) using dashboard according to defined Min and Max levels. The stock status report will help to determine current and projected quantities available in the stock. That is, the stock on hand column is the current quantities on hand whereas the MOS shows the projected quantities available in terms of how long the existing stock is going to last with the existing average historical consumption (demand) considering Max/Min IC policy. In addition, the consumption trend report dashboard shows stock movement over time. Most importantly, the near expiry report visualizes and displays information on pending expiries and provides decision support for

redistribution (excess quantities needed to be redistributed to prevent expiry). The system blocks transaction during annual inventory time to maintain data integrity, quality, and accountability.

The use cases requires the store Manager to use the information displayed on stock status and near expiry report to make decision (resupply and/or redistribution) or take action. Pharmacy Head and Facility Head use HCMIS view, reporting engine that visualize important stock information for facility management to use in decision making and monitoring.

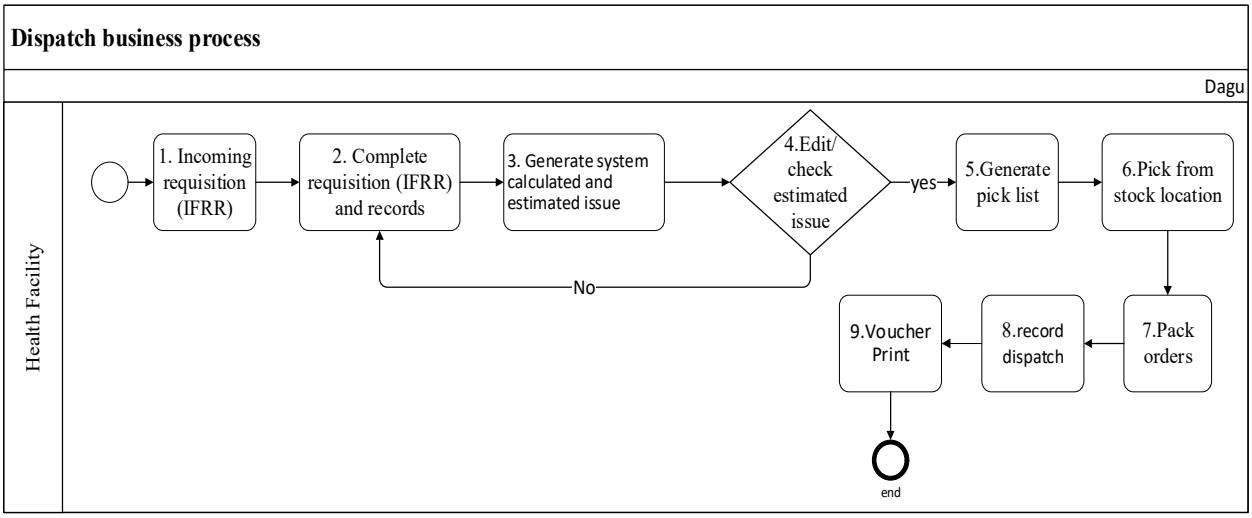
In IPLS this business process include inventory control system to prevent shortages, oversupply, and expiry of pharmaceuticals, and proper storage procedures to ensure that storage facilities protect the shelf life of products, that only high-quality products are issued, and that there is little or no waste due to damaged or expired products. The inventory control system in IPLS is a Forced Ordering Maximum/Minimum inventory control system. This means that all facilities are required to report on a fixed schedule (monthly at health posts, every other month at health centers and hospitals) for all products. In addition, products will be resupplied as soon as possible after report is sent to the respective PFSA hub. In addition, physical count of the products in the storeroom is done to verify that the stock balance found on the Bin Card and the Stock Record Card shows the correct number of usable pharmaceuticals that are available in the storeroom.

The objective of this business process is to maintain chain of custody and appropriate environmental conditions for stock and inventory. Stock should be stored according to the manufacturer's requirements, that is, controlled temperature and/or humidity. Monitoring both stock environment and stock movement facilitate line of sight as well as proper storage which prolongs the life of the goods. Activities in this business are automated so that stock records are accurate and detailed and inventory measures such as stock turnover and under stock situations are alerted appropriately. This would reduce waste/damage and in turn improves supply chain efficiency.

d. Issue Business Process

As per the requirement in PATH 2010, full-fledged eLMIS require eight core activities fulfilled in the automation. Of 8 the system was able to automate 5 (62.5%). Activities including picking from stock locations and packing orders are all manually done. The system doesn't have separate activity recording and confirming dispatch. The assumption here is whatever printed on the pick list will be issued out to respective dispensing units and catchment health posts

Figure 6: Issue Business Process Diagram



Source: Self Depicted

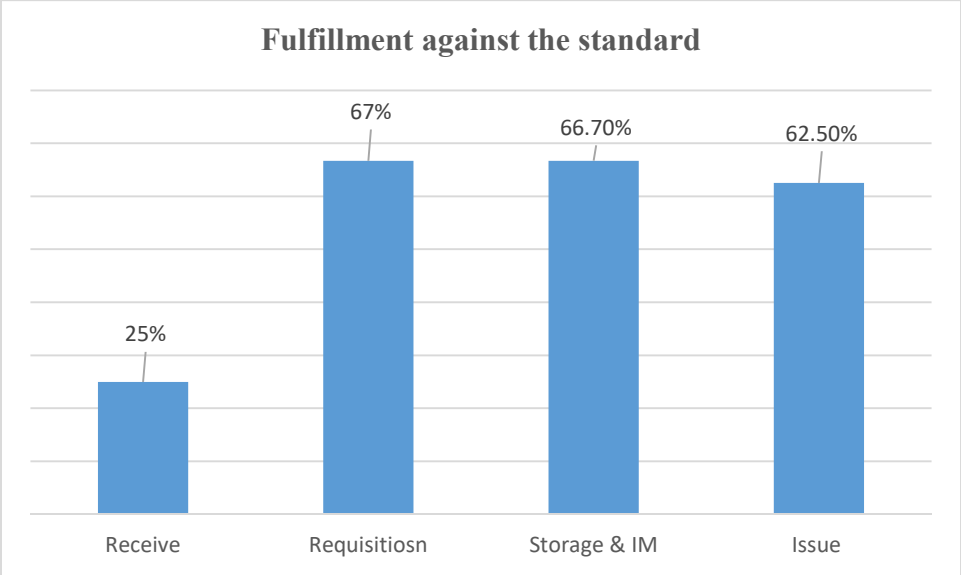
In order to maintain the quality of the pharmaceuticals, and to better manage the pharmaceuticals in a Health Centre or Hospital, most of the commodities should be stored in the Health Centre or Hospital pharmacy store. Pharmaceuticals should be issued to the service providers (nurses, clinicians, out-patient pharmacies etc.) referred in this document as dispensing units (DUs) at their work area (in the ward, in a clinic, in the dispensary) in small quantities once or more during the month.

The Objective of this business process is to issue correct quantity and quality to the right dispensing units and catchment health posts. The system has functionality to process incoming requisitions and calculate the quantity to be refilled considering DU schedule and Min/Max. Then, pick list produced will help to issue products from the specified store by expiry. That is products with shorter expiry will be issued first. The system will automatically update the transaction on the electronic bin card after generating the pick list. It will then print the electronic issue voucher (Model 22) to document the transaction.

Pharmaceuticals used by a facility should be stored in the pharmacy storeroom. When pharmaceuticals are issued from the storeroom to dispensing unit (DU), the dispensing unit (DU) staff will provide essential logistics data on the Internal Facility Report and Resupply Form (IFRR). After completing the report section of the form, the health worker will take the IFRR to the pharmacy to obtain the needed pharmaceuticals. The store manager will enter the information in the report section to determine re-supply quantities and issue the pharmaceuticals. The use case

requires the store manager to enter stock on hand and loss information the system calculates the Required Amount as Pack Quantity and Quantity/Pack. The store manager, Pharmacy Head, and dispensing unit staffs will all sign in their individual section to report, validate, and approve the transaction. The figure below summarizes fulfillment the eLMIS HCMIS system.

Figure 7: Percentage fulfillment of the eLMIS system against the standard



4.2. Demographic characteristics of respondents

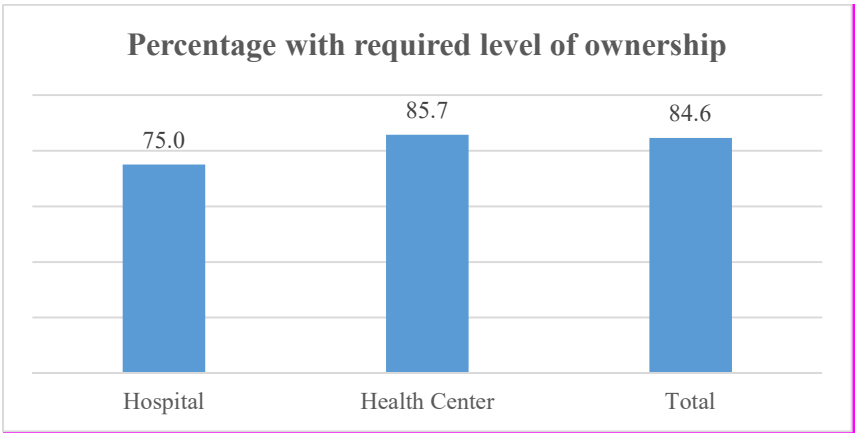
Out of 39 responses, 17 (43.6%) of respondents were males, and 22 (56.4%) were females. The majority of the respondents were from Health Centers 35 (89.7%) and remaining from hospitals 4 (10.3%). Across all health facility types, the majority of the respondents had more than 1 year experience in using the system. In addition, 48.7 % of the respondents had more than 1 year experience whereas 35.9 % had less than 3 months experience, and the remaining 15.4% had 6-12 months of experience.

4.3.System implementation challenges and supports

As per Chindove and Mdenge (2012), local ownership is one of the important factors describing effectiveness of the information system. The study used; including HCMIS support in facility's plan, system follow up by management, planning for consumables, and use of data for decision making as factors describing level of local ownership. Including HCMIS support in the facility's

plan was excluded in the final analysis as 17 (43.6%) of respondents doesn't know if it is included in the plan or not. So, local ownership is fulfilled if at least the two requirements from three is fulfilled. 84.6 % of facilities have the required level of ownership. Level of ownership at Health Canters (85.7%) is way better than hospitals (75%).

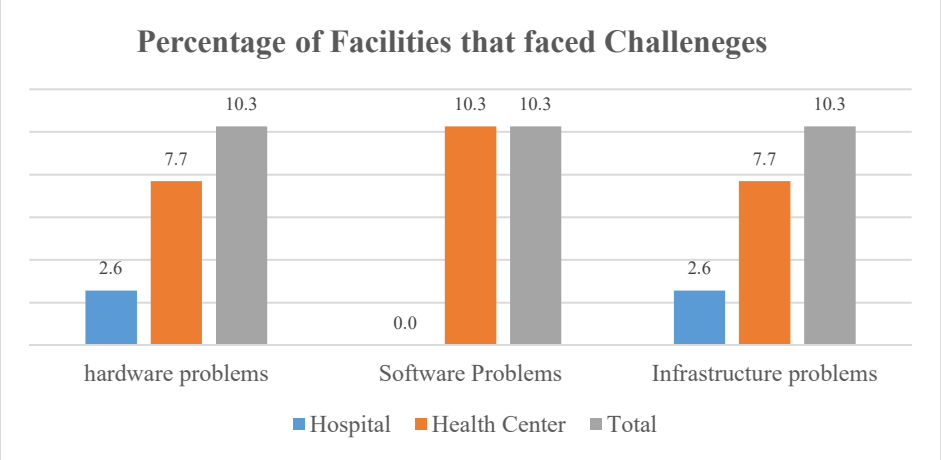
Figure 8: Local ownership



Staff competency is also another factor describing effectiveness of the implemented system. The study assessed in terms of staff's ability to do basic transaction and use the data for action and decision making. All except one professional from one health center believe that, they have the minimum competency required to run the system.

The survey assessed challenges experienced by health facilities in relation to implementation of HCMIS. As can be seen from the figure below; Software, hardware, and infrastructural related challenges (including electric power cuts) were reported in 30.8% of facilities each carrying equal proportion (10.27%). Out of these, proportion of hospitals that faced infrastructure and hardware related challenges were lower (2.56 % for both) and no hospital reported encountering software related challenges. The above mentioned challenges has resulted in system interruption in nine out of ten health centers which was resolved from technical support provided internally by health informatics technicians and externally by PFSA and implementing partners. Frequent power interruption might have caused the software and hardware related challenges. This was more pronounced in health centers as most hospitals have the resource to buy generators and UPS to manage the problem.

Figure 9: Challenges faced in e-LMIS HCMIS sites

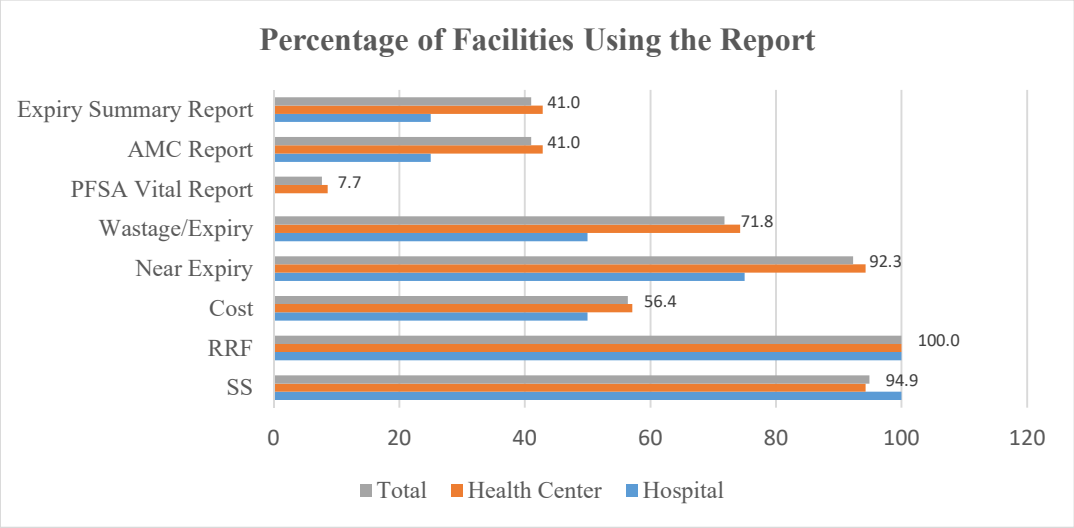


4.4. Data usage in e-LMIS "HCMIS FE" implementing sites

Data usage is described in terms of system's ability to enhance visibility and use of data for decision making. Visibility is described in terms of use and share relevant data for relevant body in timely manner (John Snow Inc., 2017; Mwencha et al, 2017).

HCMIS can generate a variety of reports related to stocks. Respondents were asked which reports they generated and who they shared them with to assess data visibility. As can be seen in the graph below, Stock Status Report (94.9%), RRF (100%), and near expiry (92.3%) are among the most used system generated reports. Whereas, cost (56.4%), Wastage (71.8%), AMC (41.0%), expiry summary (41.0%), and PFSA vital report (7.7%) are among the least used reports from HCMIS. This shows facility's tendency to use the system for proactive demand planning and risk management rather than using it to produce reports going upward. In addition, average percentage of health centers (96.2%) using the three most used reports are higher than hospitals (91.7%). This could be due to the workload in hospitals.

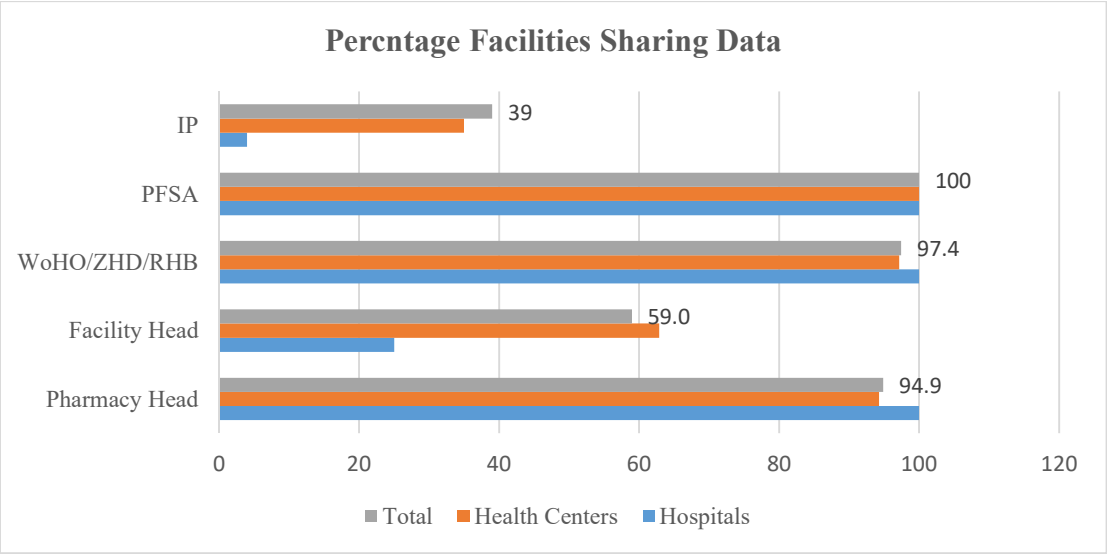
Figure 10: Use of System Generated Data



As can be seen from the figure below, Pharmacy head (94.9%), sub cities (97.4%), and PFSA (100%) have better access to system generated data (essential data from eLMIS HCMIS) for decision making. In addition, the hospitals have better access to reports generated from HCMIS than Health Centers (average of 100 % against 97.1%).

All management units working at different level with the exception of implementing partners access system generated data in the required level of frequency (Quarterly) even though there are significant proportion which access data more regularly. This does not necessarily guarantee use of the data for action even though it is the preliminary step to start using the system generated data.

Figure 11: Data Visibility

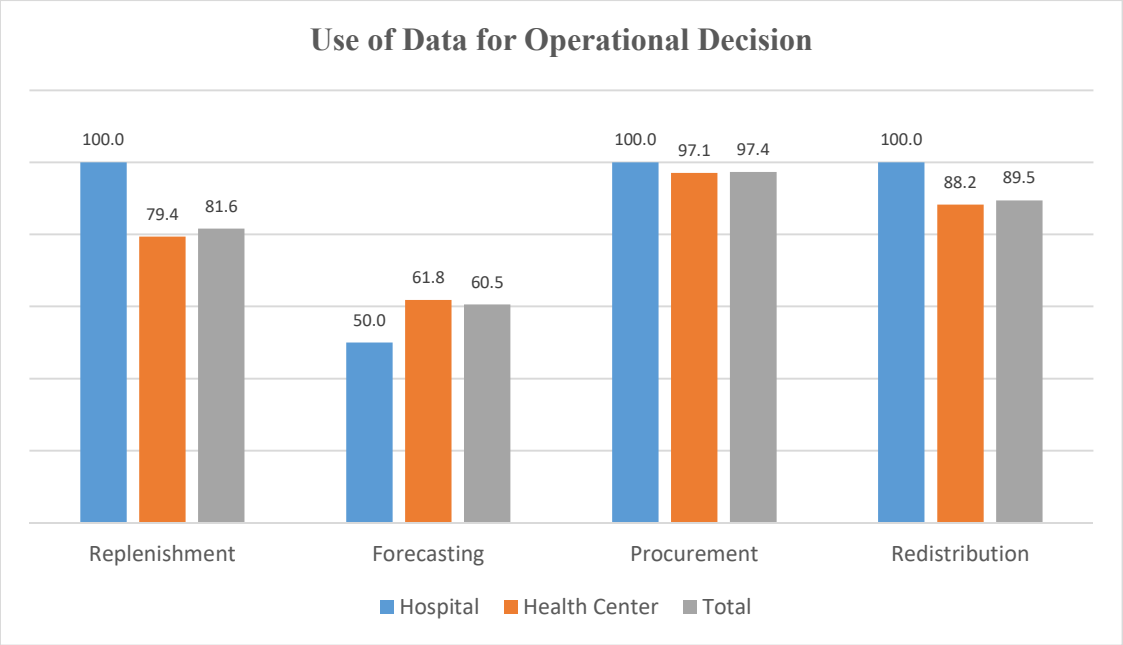


The whole purpose of LMIS is to make informed decisions that will improve customer service making quality monitoring and assurance critical. That is, the purpose of collecting and reporting data is to use them for decisions and actions. Data can be used for a variety of purposes: routine operations, performance management, continuous improvement, and strategic planning (John Snow Inc., 2017).

The hospitals and health centers assessed have reported that they made use of the reports produced from the electronic HCMIS for variety of decision making processes including forecasting/demand planning, monitoring availability/optimal stock management, assessing quality, performance enhancement, and risk management.

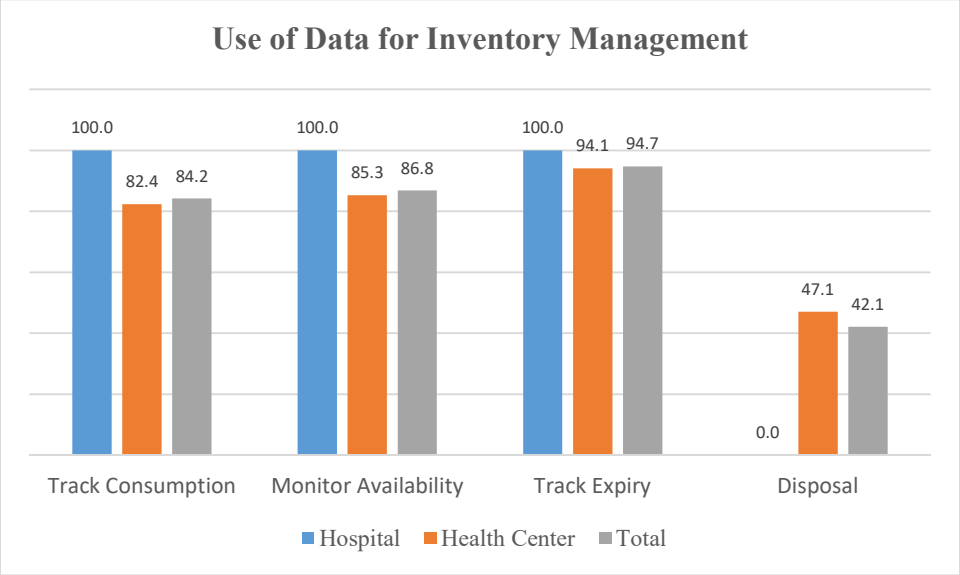
From the four supply chain operational decision areas (replenishment, forecasting, procurement, and redistribution) the system use for all is good except for forecasting. That is, only 60.5% out of the assessed facilities were using the system for forecasting. All hospitals are using the system for replenishment, procurement, and redistribution. But, the use of the system for forecasting (medium and long term demand planning) is very low (50%) even lower than corresponding health centers (61.8%).

Figure 12: Use of Data for Operational Decision



As HCMIS system is an inventory management system designed to manage daily transactions at health facilities, facilities are expected to use the system to manage their inventory. This in turn helps in maintaining effectiveness and efficiency of the supply chain system. As part of inventory management, facilities are mainly expected to monitor demand and availability by; tracking consumption and monitoring availability. In addition, expiry tracking and disposal are part of risk management and efficiency objectives. Use of the system for tracking expiry (94.7%), monitoring availability (86.8%), and tracking consumption (84.2%). Disposal (42.1%) is the least used inventory management area for both hospitals and health centers. Hospitals are better than health centers in use of system for inventory management. This shows transaction volume could be the hook for hospitals to use the system to manage their inventory.

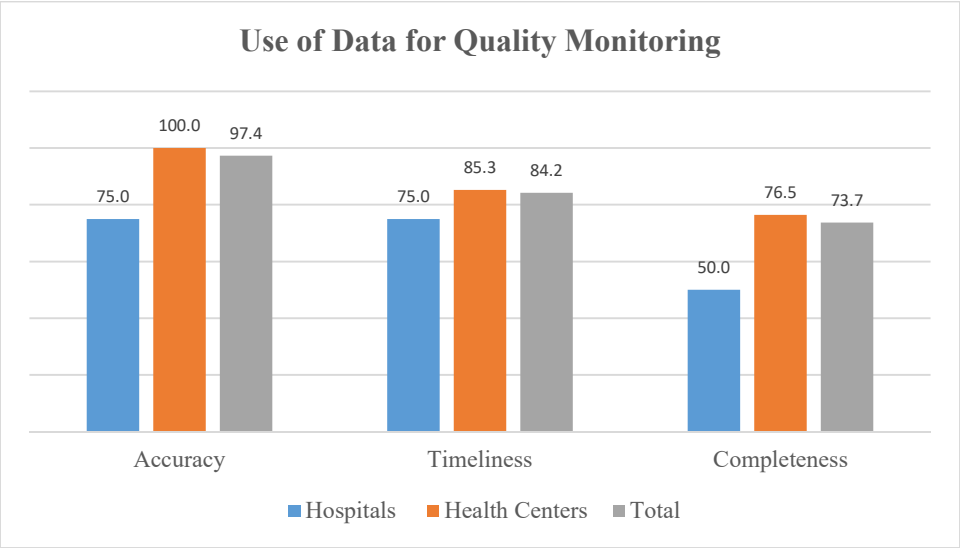
Figure 13: Use of Data for Inventory Management



As described in John Snow Inc. (2017), a digital LMIS can help improve data quality by reducing mathematical errors, highlighting missing information, and facilitating data capture, analysis, reporting, and feedback. In summary, it helps a lot in improving the three LMIS data quality parameters (accuracy, timeliness, and completeness) of LMIS records and reports. For this to happen professionals should consistently monitor accuracy, timeliness, and completeness of the records and reports using different outputs from the system like activity log reports. The use of the

system to monitor data accuracy stood high (97.4%) and the system is used the least for monitoring completeness of system generated LMIS records and reports. In contrary to the expectation health centers are better in using the system for quality monitoring.

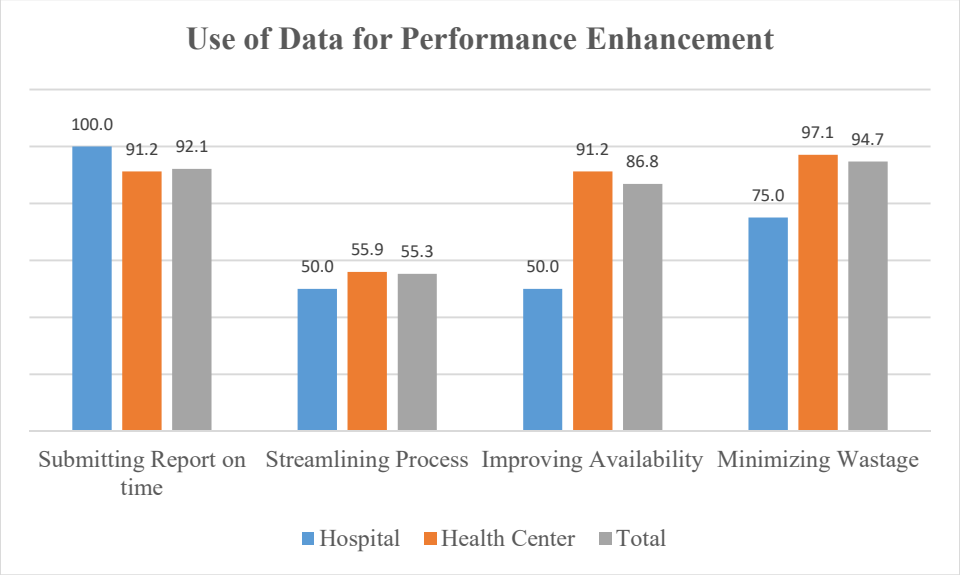
Figure 14: Use of Data for Quality Monitoring



The objectives of all supply chain optimization initiatives including digitalizing are to enhance performance of the system. These could be at process level including; shortening requisition submission and fulfillment times, improving data quality through requisition automation, ensuring data integrity by providing a central data repository, and expanding data visibility through timely reporting. Output level indicators like; minimizing commodity shortages/overages, improving stock management (inventory levels between minimum and maximum), and increasing access to and accuracy of information are also equally important (John Snow Inc., 2017). System's contribution to supply chain performance enhancement were assessed in the HCMIS's ability to improve timely reporting, streamlining process, improving availability, and minimizing wastage. The contribution of automation to improve timely reporting, improving availability, and minimizing wastage seems pretty straight forward. The contribution of automation in streamlining business process might seem tricky as it brings the automation of sub optimal process dilemma (chicken and hen dilemma). But, the already standard process in the system mostly guides the business process to follow the standard proven approach.

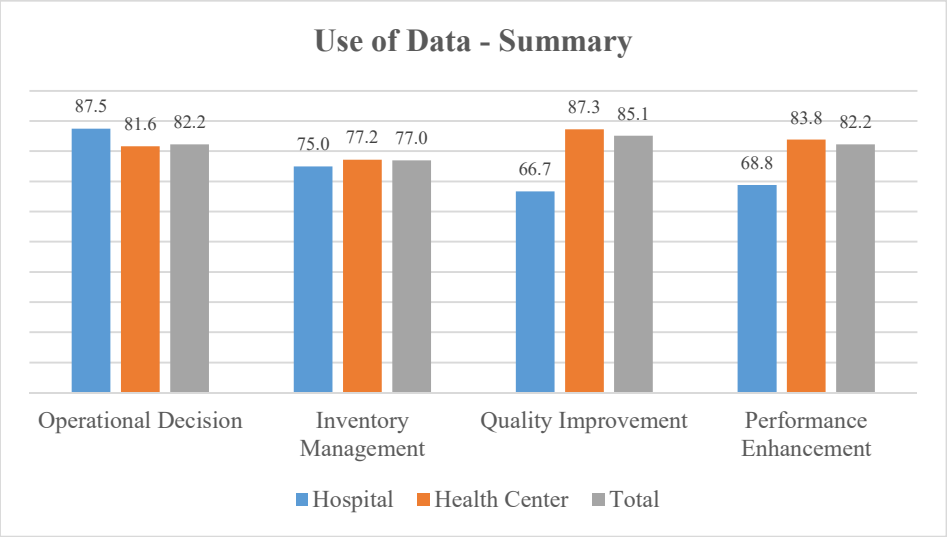
As can be seen in the figure above, wastage minimization and shortening of report submission times were found to be the most use of the system for performance enhancement. As per the respondents, the system helped Health centers more than hospitals in all parameters except in its ability to shortening requisition submission times. This actually makes sense as the volume of commodities managed at hospitals are way more than Health Centers automation will significantly reduce report compilation for large volume facilities. For others it might not be as significant as health centers as availability and wastage are dependent on multiple other supply, demand, and contextual factors.

Figure 15: Use of Data for Performance Monitoring



In summary, taking average of each parameters data use for all with exception of inventory management is above 80% and inventory management was lowest (77.0%). Health centers are better in using data for all except for operational decision where there is better use for hospitals.

Figure 16: Use of Data - Summary

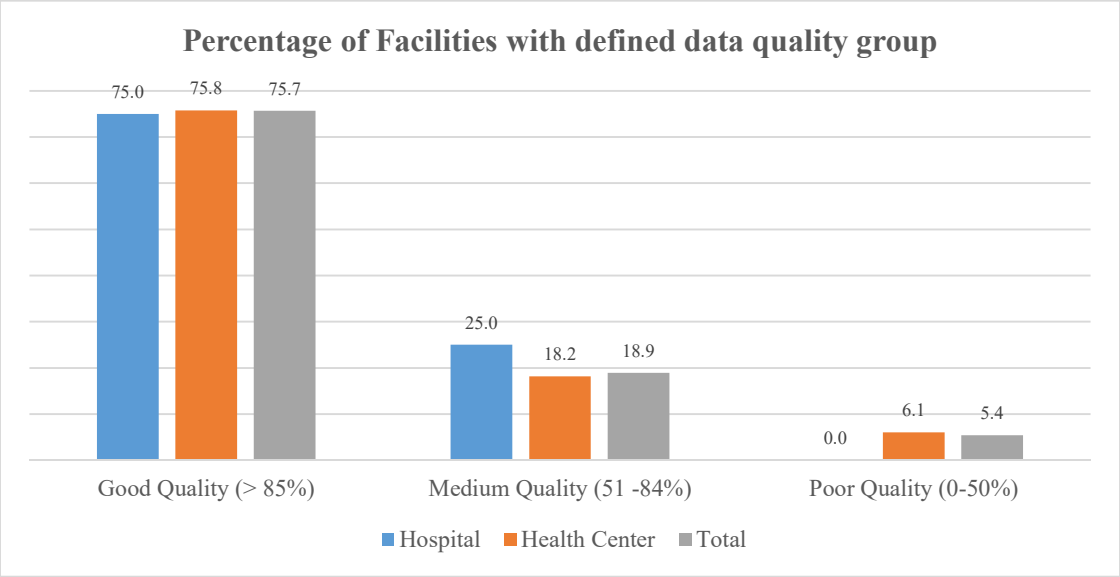


4.5. Data quality in e-LMIS "HCMIS FE" implementing sites

Although both automated and manual tools can significantly improve the availability of logistics data, automated systems can result in more rapid availability of quality logistics data than manual systems due to real time reporting and in-built system that can detect errors, missing data and simplify data checking (Fraser *et al*, 2005).

Data quality at facility was calculated after cross-checking the latest balance of the electronic bin card with the physical count on the day of the visit, for each of the selected tracer products. Then, percentage of data quality for that facility was calculated by dividing total number of product with accurate data quality with the total number of tracer assessed, which is 7. Then, the figures are further grouped into three levels; all facilities with; 0-50% data quality were grouped under poor data quality, 51-84% data quality were grouped under medium data quality, and 85-100% data quality were grouped under good quality. As can be seen from the figure below, three fourths of hospital and health centers assessed have good data quality. The remaining one third of hospitals have medium data quality and 6.1% from the health centers assessed had poor data quality at the time of visit. This has clearly shown the system's contribution in improving accuracy aspect of data quality. This finding coincides with the finding in figure 14 which says, the use of the system to monitor data accuracy stood high (97.4%).

Figure 17: Data Quality



4.6. User Satisfaction in e-LMIS "HCMIS" implementing sites

User satisfaction is defined as an "effective attitude towards a specific computer application by someone who interacts with the application directly" (Omary and Kalinga, 2017). User satisfaction is the most widely used measurement for the success of information system (Delone and McLean, 1992; Omary and Kalinga, 2017; Cai *et al*, 2017; Xiao and Dasgupta, 2002).

4.6.1. Descriptive Analysis

Descriptive statistical tools such as graphs, and frequency tables were employed using excel spreadsheet for independent variables: system quality, information quality, data use, perceived usefulness, system support, and facilitation condition to determine the causal relationship between each variable on the user's satisfaction. Percentage, means and SD of variables were extracted to describe all constructs and variables affecting user satisfaction. The table below shows percentage agreement level for variables under all constructs.

Table 9: Likert Scale Descriptive Analysis

Construct	Type of Facility	Scale					Mean	S.D
		Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree		
System Quality								
SQ1	Hospital	0.0%	0.0%	0.0%	25.0%	0.0%	4.5897	.54858
	HC	0.0%	0.1%	1.1%	1.6%	0.0%		
	Total	0.0%	0.1%	0.9%	1.6%	0.0%		
SQ2	Hospital	0.0%	0.0%	0.0%	75.0%	25.0%	4.2308	1.01207
	HC	2.9%	8.6%	2.9%	34.3%	51.4%		
	Total	2.6%	7.7%	2.6%	38.5%	48.7%		
SQ3	Hospital	0.0%	0.0%	25.0%	50.0%	25.0%	4.3077	.89307
	HC	0.0%	8.6%	2.9%	34.3%	54.3%		
	Total	0.0%	7.7%	5.1%	35.9%	51.3%		
SQ4	Hospital	0.0%	0.0%	0.0%	100.0%	0.0%	4.2308	1.01207
	HC	2.9%	8.6%	2.9%	31.4%	54.3%		
	Total	2.6%	7.7%	2.6%	38.5%	48.7%		
SQ5	Hospital	0.0%	0.0%	0.0%	50.0%	50.0%	4.5641	.68036
	HC	0.0%	0.0%	2.9%	31.4%	65.7%		
	Total	0.0%	0.0%	2.6%	33.3%	64.1%		
Data Use								
Visibility								
DU1	Hospital	0.0%	0.0%	0.0%	50.0%	50.0%	4.6154	.54364
	HC	0.0%	0.0%	2.9%	31.4%	65.7%		
	Total	0.0%	0.0%	2.6%	33.3%	64.1%		
DU2	Hospital	0.0%	0.0%	0.0%	25.0%	75.0%	4.7436	.49831
	HC	0.0%	0.0%	2.9%	20.0%	77.1%		
	Total	0.0%	0.0%	2.6%	20.5%	76.9%		
DU3	Hospital	0.0%	0.0%	0.0%	0.0%	100.0%	4.7949	.46901
	HC	0.0%	0.0%	2.9%	17.1%	80.0%		
	Total	0.0%	0.0%	2.6%	15.4%	82.1%		

Construct	Type of Facility	Scale					Mean	S.D.
		Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree		
DU4	Hospital	0.0%	0.0%	100.0%	0.0%	0.0%	3.6667	.80568
	HC	0.0%	0.0%	48.6%	28.6%	22.9%		
	Total	0.0%	0.0%	53.8%	25.6%	20.5%		
DU5	Hospital	0.0%	0.0%	100.0%	0.0%	0.0%	3.5641	.78790
	HC	0.0%	2.9%	48.6%	31.4%	17.1%		
	Total	0.0%	2.6%	53.8%	28.2%	15.4%		
DU6	Hospital	0.0%	0.0%	100.0%	0.0%	0.0%	3.6667	.86855
	HC	0.0%	2.9%	54.3%	17.1%	28.6%		
	Total	0.0%	2.6%	59.0%	15.4%	25.6%		
Information Quality								
IQ1	Hospital	0.0%	0.0%	0.0%	0.0%	100.0%	4.8974	.38353
	HC	0.0%	0.0%	2.9%	5.7%	91.4%		
	Total	0.0%	0.0%	2.6%	5.1%	92.3%		
IQ2	Hospital	0.0%	25.0%	0.0%	0.0%	75.0%	4.7179	.75911
	HC	0.0%	2.9%	2.9%	8.6%	85.7%		
	Total	0.0%	5.1%	2.6%	7.7%	84.6%		
IQ3	Hospital	0.0%	0.0%	0.0%	25.0%	75.0%	4.7692	.48458
	HC	0.0%	0.0%	2.9%	17.1%	80.0%		
	Total	0.0%	0.0%	2.6%	17.9%	79.5%		
IQ4	Hospital	0.0%	0.0%	0.0%	0.0%	100.0%	4.7692	.58316
	HC	0.0%	2.9%	0.0%	17.1%	80.0%		
	Total	0.0%	2.6%	0.0%	15.4%	82.1%		
IQ5	Hospital	0.0%	0.0%	0.0%	0.0%	100.0%	4.7692	.48458
	HC	0.0%	0.0%	2.9%	20.0%	77.1%		
	Total	0.0%	0.0%	2.6%	17.9%	79.5%		
Perceived Usefulness								
PU1	Hospital	0.0%	0.0%	0.0%	75.0%	25.0%	4.4872	.55592
	HC	0.0%	0.0%	2.9%	42.9%	54.3%		
	Total	0.0%	0.0%	2.6%	46.2%	51.3%		
PU2	Hospital	0.0%	0.0%	25.0%	25.0%	50.0%	4.5385	.60027
	HC	0.0%	0.0%	2.9%	22.9%	74.3%		
	Total	0.0%	0.0%	5.1%	23.1%	71.8%		
PU3	Hospital	0.0%	0.0%	0.0%	100.0%	0.0%	4.6667	.57735
	HC	0.0%	0.0%	5.7%	28.6%	65.7%		
	Total	0.0%	0.0%	5.1%	35.9%	59.0%		
PU4	Hospital	0.0%	25.0%	0.0%	0.0%	75.0%	4.2564	1.01872
	HC	0.0%	11.4%	2.9%	34.3%	51.4%		
	Total	0.0%	12.8%	2.6%	30.8%	53.8%		

Construct	Type of Facility	Scale					Mean	S.D.
		Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree		
System Support								
SSP1	Hospital	0.0%	0.0%	75.0%	0.0%	25.0%	4.4615	.75555
	HC	0.0%	0.0%	8.6%	25.7%	65.7%		
	Total	0.0%	0.0%	15.4%	23.1%	61.5%		
SSP2	Hospital	0.0%	0.0%	25.0%	75.0%	0.0%	4.4359	.59802
	HC	0.0%	0.0%	2.9%	42.9%	54.3%		
	Total	0.0%	0.0%	5.1%	46.2%	48.7%		
SSP3	Hospital	0.0%	25.0%	75.0%	0.0%	0.0%	3.8718	1.03057
	HC	0.0%	8.6%	22.9%	28.6%	40.0%		
	Total	0.0%	10.3%	28.2%	25.6%	35.9%		
SSP4	Hospital	0.0%	0.0%	75.0%	25.0%	0.0%	3.5641	1.23106
	HC	5.7%	20.0%	14.3%	28.6%	31.4%		
	Total	5.1%	17.9%	20.5%	28.2%	28.2%		
SSP5	Hospital	0.0%	25.0%	25.0%	50.0%	0.0%	4.3077	.89307
	HC	0.0%	2.9%	11.4%	25.7%	60.0%		
	Total	0.0%	5.1%	12.8%	28.2%	53.8%		
SSP6	Hospital	0.0%	25.0%	25.0%	50.0%	0.0%	4.2308	.93080
	HC	0.0%	5.7%	8.6%	31.4%	54.3%		
	Total	0.0%	7.7%	10.3%	33.3%	48.7%		
Facilitation Condition								
FC1	Hospital	25.0%	75.0%	0.0%	0.0%	0.0%	3.0000	1.37649
	HC	8.6%	40.0%	0.0%	31.4%	20.0%		
	Total	10.3%	43.6%	0.0%	28.2%	17.9%		
FC2	Hospital	0.0%	0.0%	0.0%	25.0%	75.0%	4.6410	.53740
	HC	0.0%	0.0%	2.9%	31.4%	65.7%		
	Total	0.0%	0.0%	2.6%	30.8%	66.7%		
FC3	Hospital	0.0%	0.0%	0.0%	100.0%	0.0%	3.7949	1.21784
	HC	5.7%	17.1%	8.6%	31.4%	37.1%		
	Total	5.1%	15.4%	7.7%	38.5%	33.3%		
FC4	Hospital	0.0%	50.0%	0.0%	50.0%	0.0%	3.7949	1.28103
	HC	5.7%	14.3%	8.6%	28.6%	42.9%		
	Total	5.1%	17.9%	7.7%	30.8%	38.5%		
User Satisfaction								
US1	Hospital	0.0%	0.0%	0.0%	50.0%	50.0%	4.5897	.84970
	HC	2.9%	2.9%	0.0%	20.0%	74.3%		
	Total	2.6%	2.6%	0.0%	23.1%	71.8%		
US2	Hospital	0.0%	0.0%	0.0%	75.0%	25.0%	4.7179	.55954
	HC	0.0%	0.0%	5.7%	11.4%	82.9%		
	Total	0.0%	0.0%	5.1%	17.9%	76.9%		
US3	Hospital	25.0%	0.0%	0.0%	50.0%	25.0%	4.6667	.66227
	HC	0.0%	2.9%	0.0%	17.1%	80.0%		
	Total	2.6%	2.6%	0.0%	20.5%	74.4%		
US4	Hospital	0.0%	25.0%	25.0%	50.0%	0.0%	4.2821	.88700
	HC	2.9%	0.0%	2.9%	42.9%	51.4%		
	Total	2.6%	2.6%	5.1%	43.6%	46.2%		

a. System Quality

System quality about User Interface (UI), reliability, adaptability, and performance of the system or the software with minimal interruption (Omari and Kilinga, 2017).

Majority (more than 85%) respondents ranked highly to all constructs under system quality. 97.4 % and 94.9% of respondents were at least agree on the fact that the information on the system is well formatted and HCMIS is easy to learn respectively. 87.2% of respondent were satisfied with (at least agree) on the speed, reliability, and adaptability of the system. The consistency of user interface and well formatted information from the system has made learning and management easy (user friendly). Relatively higher proportion of respondents are not satisfied on the speed, reliability (bugs and stability), and adaptability of the system. Specially, speed and reliability is an issue in the recently introduced version with additional features. Whereas, adaptability is in relation to the new system introduced by FMOH to enhance accountability of medicines in public health facilities.

b. Data Use

Data use includes visibility and use of data for decision making (Mwencha *et al*, 2017). The whole purpose of LMIS is to make informed decisions that will improve customer service making quality monitoring and assurance critical. That is, the purpose of collecting and reporting data is to use them for decisions and actions. Data can be used for a variety of purposes: routine operations, performance management, continuous improvement, and strategic planning (John Snow Inc., 2017).

As can be seen from the table above significant proportion of respondents at least agree on the system's ability to enhance visibility, system ability to give easy access to relevant, customized, and complete logistics information in timely manner. But, use of that data for operational/strategic decisions, performance monitoring, and producing report stood at 41%, 43.6%, and 46.1% respectively.

c. Information Quality

System attributes describing system quality include timeliness, accuracy, and completeness of data generated out of the system. In addition, accessibility and easiness of the data generated out of the system was also another variable used to describe system quality (John Snow Inc., 2017; Omary and Kilinga, 2017). DeLone and McLean (2003) also revealed that information quality and system quality are significant predictors of users' satisfaction.

Findings on information quality as measured in terms of timeliness, accuracy, and completeness was excellent. More than 90% of respondent at least agree that, the system provide accurate, complete, sufficient, and relevant information through reports and dashboard interfaces. This finding coincides with finding on data quality in the earlier section

d. Perceived Usefulness

Perceived usefulness is about the system's contribution in enhancing adaptability, effectiveness, and efficiency of the supply chain system and minimizing professionals' workload. Omary (2017) and Lwoga (2014) has shown that perceived usefulness had a significant effect on users' satisfaction with the information system implemented showing effectiveness.

As per the table above, more than 90% at least agree on all perceived usefulness of the system except minimizing workload, which is 84.2 %. That is, around 16% of facilities didn't agree that, HCMIS helped in minimizing commodity management workload. Even though, the system was supposed to minimize workload the issue in these 16% facilities could be related to change management, process and infrastructure related challenges.

e. System Support

USAID funded implementing partner along with the Pharmaceutical Fund and Supply Agency (PFSA) are providing support services to users of eLMIS on their daily operations when they face any challenges. It is expected that users with good support services from the IT Unit are likely to continue using the eLMIS and will have positive perception towards it. Likewise, such services will enable users improve their job performance and be satisfied with the system. According to Delone et al. (2003), system support service is the measure of the quality of the support services that users receive from the IS department and IT support personnel. System support has found to have a positive impact on users' satisfaction with the system in studies Ssekakubo et al, 2012; Lwoga, 2014.

As can be seen from the table above, majority of respondents (82%) believed that technical support providers have the required knowledge and skill and this has helped them to enhance their ability to manage the system (82%). Only 56.4% and 61.5% of respondents believe that they get adequate and timely support respectively. That is significant proportion of respondents are not satisfied with frequency and timeliness of support provided from system support providers.

f. Facilitation Conditions

Facilitation issues are factors like resources needed to effectively run the system, supporting documents like user documentation and guidelines, availability of help on demand, and knowledge to use. As per Grover (1993) and Saunders et al (1992) as it was described in Omary and Kalinga (2017), facilitation conditions and technological issues are key determinants of satisfaction in the perception of users of information system.

Overall knowledge to use the system has the highest level of agreement with 97.5% of respondents ranking highly to this construct. This finding is in line with the finding in system quality which is, the consistency of user interface and well formatted information from the system has made learning and management easy (user friendly). In contrary resources needed to run the system has the lowest level of agreement with only 46.1% of ranking highly (agree and strongly agree) to this construct. These results were reflections of unreliable electric power supply and internet connectivity in the country.

Facilitation condition intended to capacitate the human resource, availability of help and user documentation and guideline, had the second highest level of agreement with 71.8% of respondents ranking highly to availability of help and 69.3% ranking highly to availability and utilization of user documentation and guidelines. The finding in the availability of help is in line with the finding in the system support variable which is, only 56.4% and 61.5% of respondents believe that they get adequate and timely support respectively. In addition, HCMIS user guideline was given in hard and soft copy at the early stage of implementation but poor skill and job transfer upon turnover has affected this construct. Recommendation, digitalizing the HCMIS user guideline as part of the help menu.

g. User Satisfaction

User satisfaction for system's output, inventory management, and managing day to day activity was excellent. That is, around 95% respondents ranked highly to these constructs. But, user satisfaction for technical support provided was lower, which is 89.8 % ranked highly to these constructs. Linking this to the findings in system support in the section above, the lower level of agreement for adequacy (56.4%) and timeliness of technical support provided (61.5%) might have contributed to the relatively lower agreement for user satisfaction on the technical support provided. All in all, users' satisfaction towards the system is good and this is good indication on the effectiveness of the system

4.6.2. Inferential analysis

a. Mean of Variables

Mean of variables were extracted to enable exploration of the existence and importance of the dependent and independent variables. Making use of the Likert scale from strongly disagree (1) to strongly agree (5), as shown in Table 9, all factors were highly ranked (that is strongly agreed). The measure used sum and a mean value, whereby if obtained factors is more than or equal to 3.2 then the level of agreement with the statements measuring a certain variable is high. If it is less than or equal to then the level of agreement with the statements measuring a certain variable is low.

Table 10: Mean and S.D. of Constructs

	Mean	Std. Deviation
System Quality	4.3846	.52792
Data Use	4.1752	.47132
Information Quality	4.7846	.43136
Perceived Usefulness	4.4872	.52550
Facilitation Conditions	3.8077	.81407
User Satisfaction	4.5641	.58971
N = 39		

b. Research Reliability

Cronbach's Alpha was used to measure the reliability of the instruments. Based on SPSS results, the Cronbach's alpha coefficient of 34 items was 0.922. The instrument was reliable as the value of Cronbach's alpha was more than 0.70 as suggested for the basic research. The result of Cronbach's alpha was furthermore evaluated by testing the internal consistency of the items. From the six constructs, the values ranged from 0.684 to 0.873 as shown in Table 10.

As per Tavakol and Dennnick (2011), a rule of thumb for interpreting alpha for dichotomous questions or Likert scale questions for checking internal consistency is; excellent for alpha $\geq$ 0.9, good for alpha between 0.8 (including) and 0.9, acceptable for alpha between 0.7 (including) and 0.8, questionable for alpha between 0.6 (including) and 0.7, poor for alpha value between 0.5 (including) and 0.6, and unacceptable for alpha value less than 0.5. As can be seen from the table below internal consistency as described by Cronbach's alpha is good for data use, information quality, system support, and user satisfaction. Whereas the value for perceived usefulness and

facilitation condition is within acceptable range. And, the value for system quality is in questionable range. No construct is in poor and unacceptable range.

Table 11: Reliability - Cronbach's Alpha

S/No	Construct	Cronbach's Alpha
1.	System Quality	0.602
2.	Data Use	0.782
3.	Information Quality	0.838
4.	Perceived Usefulness	0.718
5.	Facilitation conditions	0.666
6.	System Support	0.844
7.	User Satisfaction	0.792

c. Research Model Summary

Multiple linear regression analysis was used to test the proposed model. However, to meet the assumptions of regression analysis, Variance Inflation Factor (VIF) and Tolerance statistics were extracted to ensure the absence of high correlation between independent variables (Multi-Collinearity). Table 11 shows variance inflation and Tolerance for each factor. As it can be seen, VIF value for all independent variables was less than 10 ranging from 1.616 to 2.698 and allowed variation (Tolerance) for each independent variable was more than 0.2 ranged from 0.371 to 0.619 which indicates the absence of high correlation between independent variables. It has also passed normality from normal P-P plot regression standardized residual (refer annex). Homoscedacity (independence of error) – ZRESID against ZRPED plot is also shown in the annex. Therefore, the data met the assumption of linear regression analysis which was used to test the proposed model.

Table 12: VIF and Tolerance Statistics

Model	Collinearity Statistics	
	Tolerance	VIF
System Quality	.461	2.169
Data Use	.496	2.016
Information Quality	.619	1.616
Perceived Usefulness	.600	1.667
System Support	.371	2.698
Facilitation Condition	.387	2.582
Dependent Variable: User Satisfaction		

Six factors from the proposed research model were subjected to linear regression analysis to measure the success of the model and predict the causal relationship between the factors and users'

satisfaction towards eLMIS, HCMIS. As can be seen from the table below, using enter method, a significant model emerged: F (9.784) = 13.215, p < 0.0005.

Table 13: ANOVA

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	8.553	6	1.425	9.784	.000[b]
Residual	4.662	32	.146		
Total	13.215	38			

a. Dependent Variable: User Satisfaction

b. Predictors: (Constant), Facilitation Condition, Information Quality, Perceived Usefulness, Data Use, System Quality, System Support

As can be seen from the table below, six factors for assessing users' satisfaction with eLMIS were subjected to linear regression analysis and found that model variables statistically significantly predicted users' satisfaction by 58.1% (R square 0.581) of variance. This means 41.9% of the variance in users' satisfaction cannot be explained by variables proposed in this model. Future research can explore more factors that can be included in the research model to be able to explain user satisfaction with eLMIS, HCMIS. Table 13 shows a summary of the research model, where SE is the Standard Error of the Estimates.

Table 14: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.804[a]	.647	.581	.38169

a. Predictors: (Constant), Facilitation Condition, Information Quality, Perceived Usefulness, Data Use, System Quality, System Support

d. Hypothesis Testing

Linear regression analysis was conducted to test the hypotheses and determine the structure of the proposed research model. Table 15 below shows linear regression results

Table 15: Linear Regression Result

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	-.627	.786		-.798	.431
System Quality	-.262	.173	-.235	-1.520	.138
Data Use	-.103	.187	-.082	-.551	.586
Information Quality	.757	.182	.554	4.151	.000
Perceived Usefulness	.423	.152	.377	2.783	.009
System Support	.337	.146	.398	2.305	.028
Facilitation Condition	-.039	.122	-.054	-.321	.750
a. Dependent Variable: User Satisfaction					

Table 16 below is a summary of predictive factors in terms of beta values for each hypothesis obtained from linear regression analysis along with the significant results.

Table 16: Summary of Hypotheses Testing and Findings

Hypothesis	Results	Conclusion
Hypothesis 1: SQ-->US	Yes: Significant (Beta=-0.235, p<0.05)	Not Supported
Hypothesis 2: DU-->US	Yes: Significant (Beta=-0.82, p<0.05)	Not Supported
Hypothesis 3: IQ--->US	Yes: Significant (Beta=0.554, p<0.05)	Supported
Hypothesis 4: PU--->US	Yes: Significant (Beta=0.377, p<0.05)	Supported
Hypothesis 5: SS--->US	Yes: Significant (Beta=0.398, p<0.05)	Supported
Hypothesis 6: FC--->US	Yes: Significant (Beta=-0.54, p<0.05)	Not Supported

As can be seen from the table above, the results showed that among the six hypotheses three hypothesis (H1, H2, and H6) were not significant ($p > 0.05$).That is: system quality, data use, and facilitation conditions failed to be a significant predictors of users' satisfaction. This implies that these users' satisfaction could not be explained by these three factors. As per the findings in the descriptive section; unreliable electric power supply and internet connectivity in the country and access to standard user guidelines, relatively low satisfaction with reliability/speed/adaptability, and poor use of data for decision making might have resulted in this.

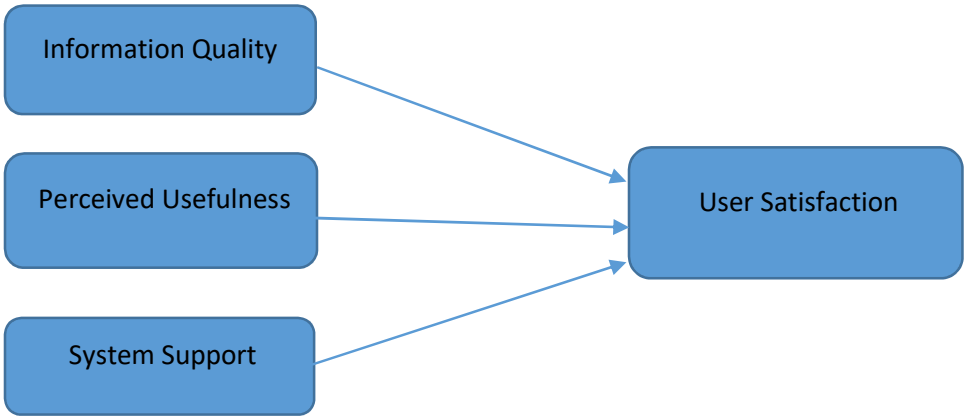
As can be seen from table 15; information quality ($\beta = 0.554$), perceived usefulness ($\beta = 0.377$), and system support ($\beta = 0.398$) were statistically significant and information quality have the strongest predictor. This study has exact similarity with other researches like Sedon (2017) as described in

Omary (2017) who has shown that; information quality, perceived usefulness, and system support are significant predictors of users' satisfaction. Omary 2017 has also shown that: information quality (β=0.28), system quality (β=-0.21), perceived usefulness (β=0.22), and facilitation conditions (β=0.26) had a significant effect on users' satisfaction with the eLMIS in Tanzania. DeLone and McLean (2003) also revealed that information quality and system quality are significant predictors of users' satisfaction. In summary; the system's ability to provide accurate, complete, and timely data for decision making was the major factors that brought user satisfaction. The finding in figure 17 showing percentage of data quality reinforces the finding in here. In addition, perceived usefulness of the system in enhancing supply chain performance (effectiveness, efficiency, and adaptability) is also another factor that has contributed to user satisfaction. Last but not least, adequate and timely technical support given in multiple mechanisms was also another factor that significantly contributed to user satisfaction.

e. Final eLMIS HCMIS Assessment Model

According to hypothesis testing and significant level, the eLMIS HCMIS proposed model was revised by removing three paths which were not significant, this was the relationship between system quality, data use, and facilitation conditions and users' satisfaction. The relationship between information quality, perceived usefulness, system support, and user satisfaction were found significant. The final eLMIS HCMIS evaluation research model was shown in Figure 25.

Figure 25: Proposed e-LMIS assessment model



Source: Self Depicted

In summary, information quality (β =0.554), perceived usefulness (β=0.377), and system support (β =0.398) were statistically significant and information quality have the strongest predictor. The model equation is:

US = - 0.627 + 0.554 IQ + 0.377 PU + 0.398 SS

CHAPTER FIVE

5. Summary of major finding, Conclusion, and Recommendation

This chapter presents summary of major findings objective wise along with concluding remarks based on individual findings. In addition, recommendations based on findings in specific objective areas were presented.

5.1. Summary of Major Findings

- The eLMIS HCMIS system automated 66.7%, 25%, 66.7%, and 62.5% of the core activities within requisition, receive, storage and inventory management, and issue business processes respectively that are required to be automated in facility full-fledged eLMIS platform.
- 84.6 % of facilities have the required level of ownership with level of ownership at Health Canters (85.7%) exceeding hospitals (75%).
- Software, hardware, and infrastructural related challenges (including electric power cuts) were reported in 30.8% of facilities each carrying equal proportion (10.27%). Out of these, proportion of hospitals that faced infrastructure and hardware related challenges were lower (2.56 % for both) and no hospital reported encountering software related challenges.
- Stock Status Report (94.9%), RRF (100%), and near expiry (92.3%) are among the most used system generated reports. Whereas, cost (56.4%), Wastage (71.8%), AMC (41.0%), expiry summary (41.0%), and PFSA vital report (7.7%) are among the least used reports from HCMIS. In addition, average percentage of health centers (96.2%) using the three most used reports are higher than hospitals (91.7%).
- Pharmacy head (94.9%), Sub-cities (97.4%), and PFSA (100%) have better access to system generated data (essential data from eLMIS HCMIS) for decision making. In addition, the hospital pharmacy head, Sub-Cities/RHBs, and PFSA have better access to reports generated from HCMIS than Health Centers (average of 100 % against 97.1%).
- Data use for decision making and action with exception of inventory management is above 80% and inventory management was lowest (77.0%). Health centers are better in using data for all except for operational decision where there is better use for hospitals. Three fourths of hospital and health centers assessed have good data quality. The remaining one third of hospitals have medium data quality and 6.1% from the health centers assessed had poor data quality at the time of visit.

- System Quality: Majority (more than 85%) respondents ranked highly to all constructs under system quality. 97.4 % and 94.9% of respondents were at least agree on the fact that the information on the system is well formatted and HCMIS is easy to learn respectively. 87.2% of respondent were satisfied with (at least agree) on the speed, reliability, and adaptability of the system.
- Data Use: Significant proportion (97.5%) of respondents at least agree on the system's ability to enhance visibility or system ability to give easy access to relevant, customized, and complete logistics information in timely manner. But, use of that data for operational/strategic decisions, performance monitoring, and producing report stood at 41%, 43.6%, and 46.1% respectively.
- Information quality: More than 90% of respondent at least agree that, the system provide accurate, complete, sufficient, and relevant information through reports and dashboard interfaces.
- Perceived usefulness: More than 90% of respondents at least agree on all perceived usefulness of the system except minimizing workload, which is 84.2 %. That is, around 16% of facilities didn't agree that, HCMIS helped in minimizing commodity management workload.
- System Support: Majority of respondents (82%) believed that technical support providers have the required knowledge and skill and this has helped them to enhance their ability to manage the system (82%). Only 56.4% and 61.5% of respondents believe that they get adequate and timely support respectively.
- Facilitation Conditions: Overall knowledge to use the system has the highest level of agreement with 97.5% of respondents ranking highly to this construct. In contrary resources needed to run the system has the lowest level of agreement with only 46.1% of ranking highly (agree and strongly agree) to this construct. The average percentage considering all four parameters was 71.2%.
- Six factors for assessing users' satisfaction with eLMIS were subjected to linear regression analysis and found that model variables statistically significantly predicted users' satisfaction by 58.1%.
- Information quality (β =0.554), perceived usefulness (β=0.377), and system support (β =0.398) were statistically significant and information quality have the strongest predictor for user satisfaction.

5.2. Conclusion

The eLMIS – HCMIS system is good as internal inventory management tool but requires significant upgrade to fulfill its purpose in the supply chain context. As per John Snow, Inc. (2017), public health supply chain is a network of interconnected organizations or actors that ensures the availability of health commodities to the people who need them. That means

Local ownership is good but practitioners specifically store manager engagement during planning and resource allocation is low.

The intensive technical support and OJT provided by relevant bodies might have paid off as almost all professionals believe that they have the required level of competency to manage the system comfortably.

Significant proportion of health centers experienced hardware, software, and infrastructure related challenges in relation to implementation of HCMIS. The above mentioned challenges has resulted in system interruption in nine out of ten health centers which was resolved from technical support provided internally by health informatics technicians and externally by PFSA and implementing partners. Frequent power interruption might have caused the software and hardware related challenges.

Good level of LMIS data visibility for all stakeholders was observed and PFSA stood first. “No data No product” motto might have brought better visibility and data sharing practice unlike other supply chain partners.

Data availability alone is not enough for supply chains to perform and get critical health products into the hands of clients. In addition to building robust information systems, creating a data use culture is equally important.

Data quality in eLMIS sites was good as digital LMIS can help improve data quality by reducing mathematical errors, highlighting missing information, and facilitating data capture, analysis, reporting, and feedback. In addition, good use of the system to monitor data quality could have contributed to the improved data quality.

The study proposed and validated a model and relevant metrics that used in evaluating user’s satisfaction with eLMIS in Addis Ababa. The model was an outcome of an intensive literature review of different models proposed by different authors for the assessment of information systems. Six factors were found and used in assessing the model. After a linear regression; information quality, perceived usefulness, and system support were statistically significant and

information quality have the strongest predictor for user satisfaction. But, system quality, data use, and facilitation condition were not statistically significant and hence were removed from a proposed research model and only remained with three independent factors.

5.3. Recommendations

a. System Upgrade:

- Electronic transmission of requisition after getting the requisition validated and approved electronically. The electronic linkage needs to have the capability to show status of requisition after it was submitted.
- Linking suppliers and facility eLMIS electronically and upgrade the system with additional features like automatic arrival notification, discrepancy management, storage space requirement, advanced shipment notification, and discrepancy report.
- Feature to monitor stock environment or to help monitor appropriate temperature and security conditions.
- Stock status alert and notification system to proactively inform and alert users and decision makers based on inventory control policies and supply chain performance management targets.
- System enhancement to automate feedback reports from management and performance based incentive schemes to motivate lower level staffs to report quality report on time.
- Introducing bar codes to facilitate transaction and data entry to optimize commodity management and improve data quality. That is, bar coding will optimize and simplify commodity transactions, movement, and data quality by facilitating data capture from paper reports and commodities using bar code scanners.
- An integrated dashboard platform for management units at different level that will help to triangulate and validate data reported by comparing it with historical data or with data derived from other sources, e.g., a HMIS. The advantage is twofold; it improves data quality and use.
- Enhancing use of system generated data for forecasting (long term demand planning) by facilitating seamless information share between existing systems coupled with decision support features.
- Technology intervention coupled with training to further enhance use of the system for quality monitoring. This will be done by extracting quality monitoring indicators to be visualized using customized dashboard platforms to relevant management units.
- System upgrade to filter important custom reports for individual groups along SOPs. These SOPs need to include basics on data analytics and guidelines to use different custom report.

- Updating the system to enhance speed, reliability, and adaptability especially in high volume facilities with many transactions.

b. Infrastructure, Process and Change Management

- Facilities need to engage practitioners (store managers) in planning and resource allocation to enhance motivation and ownership. This means most facilities do have the capacity to maintain and sustain the system with minimal internal and external support
- Solar installations to obtain solar energy from photovoltaic systems (PV) to support the routine use of information systems for reporting in health centers which do not afford to buy and run generators.
- Identifying the hook (What In It For Me- WIIFM factors) for data visibility and use and enforcing further through training, monitoring, and performance based incentive schemes. WIIFM factor for woreda could be efficiency or waste minimization whereas, availability could be the WIIFM factor for other groups. For example if professionals really understood that quality data is the basis for every decision they will start to meticulously plan to consistently monitor accuracy, timeliness, and completeness of the records and reports using different outputs from the system like activity log reports.
- Creating and improving data use culture by empowering and training staff to analyze and use data for decision making will be key to improving supply chain performance. This seeks a deeper understanding of people's desires within program-specific contexts and results in prototype solutions that are geared to addressing needs and shifting behaviors. There is also a need to take into account the complex environments and systems within which people work.
- SOPs that guide use of system generated data along with capacity building and training to access and use the data for decision making. This SOP should include roles and responsibilities, processes, and job aids to use system generated data.

c. User Satisfaction

- The proposed model to evaluate user's satisfaction of eLMIS is expected to be used by Ministry of Health, PFSA, Supply chain stakeholders and implementing partners in Ethiopia as it typically represents many situations facing health commodities supply chain in Sub-Saharan countries. The study is requesting future studies to validate the model and its instrument using a cross-sectional survey involving large numbers of eLMIS users from different institutions in

different parts of the country. Furthermore, given that the model only explains 58.1% of the factors that contributed to users satisfaction then in the future studies should focus on adding other factors that will explain more (60% and above) of the factors that contributed to users satisfaction.

References

Aidspan (2017), "Global Fund Observer – GFO", Newsletter, Issue 326.

Ardito C, Costabile MF, Marsico MDe (2005), "An approach to usability evaluation of e-learning applications", Universal Access in the Information Society, vol. 4, no. 3, 270–283. Available from http://doi.org/10.1007/s10209-005-0008-6.

Barrington J., O.Wereko-Brobby, P. Ward, W. Mwafongo and S. Kungulwe (2010), "SMS for life: A pilot project to improve anti-malarial drug supply management in rural Tanzania using standard technology", Malaria Journal, 9, 298: 1–9.

Beamon, B.M. (1998), "Supply Chain Design and Analysis: Models and Methods", International Journal of Production Economics, vol. 5, no. 5, 281-294.

Bergum BI. (2017), "Architectural Patterns in the Medical Commodity Supply Chain in developing countries: A Collective Case Study of Uganda and Tanzania", Reprosentralen, University of Oslo, http://www.duo.uio.no/

Bossert T.J., D.M. Bowser, J.K. Amenyah (2007), "Is decentralization good for logistics systems? Evidence on essential medicine logistics in Ghana and Guatemala. Health Policy and Planning", 22 (2), 73–82.

Cai S, Jun M, Pham L (2007), "End-user computing Satisfaction and its key dimensions: An exploratory study", Southwest decision sciences Institute, 725–734.

Chindove, S., Mdege, N.D. (2012), "Logistics Data Collection and Reporting for Essential Medicines in Developing Countries: A Review", Journal of Health Management, 14(4), 397–408.

Chopra, S., Meindl, P. (2001), "Supply Chain Management: Strategy, Planning, and Operation", Prentice-Hall, Inc, Upper Saddle River, NJ.

Cibulskis, R.E and G. Hiawalye (2002), "Information systems for health sector monitoring in Papua New Guinea". Bulletin of the World Health Organization, 80 (9), 752–58.

Cooper MC, Ellram LM (1993), "Characteristics of supply chain management and the implications for purchasing and logistics strategy", International Journal of Logistics Management, vol. 4, no. 2, 13–24. Available from http://doi.org/10.1108/09574099310804957

Cox, A. (2004), "The art of the possible: relationship management in power regimes and supply chains", Supply Chain Management: An International Journal, vol. 9, no. 5, 346-56.

DeLone WH and McLean ER (1992), “Information systems success - the quest for a dependent variable”, Information Systems Research, vol. 3, no.1, 60–95. Available from http://doi.org/10.1287/isre.3.1.60

Doll W, Torkzadeh G, (1989), “A discrepancy model of end-user computing involvement”, Management Science, vol. 35, no. 10, 1151–1171.

Ethiopia, Federal Ministry of Health – FMOH (2016), “Information Revolution Road Map”.

Federal Ministry of Health – FMOH (2006), “Health Commodity Supply System /HCSS/ Master Plan Executive Summary.

Fraser, H.S.F., D. Jazayeri and K. Kempton (2004), “An information system and medical record to support HIV treatment in rural Haiti”, British Medical Journal, 329, 1142–46.

Fraser, H.S.F., P. Biondich, D. Moodley, S. Choi, B.W. Mamlin and P.B. Szolovits (2005), “Implementing electronic medical records systems in developing countries. Informatics in Primary Care”, 13, 83–95.

Gunasekaran A, Ngai EWT (2004), “Information systems in supply chain integration and management”, European Journal of Operational Research, vol. 159, no. 2 SPEC., 269–295. Available from http://doi.org/10.1016/j.ejor.2003.08.016.

Heeks R. (2002), “Information systems and developing countries: failure, success, and local Improvisations”, The Information Society, vol. 18, no. 2. 101–112. Available from http://doi.org/10.1080/01972240290075039.

Islam N, Azad N (2015), “Satisfaction and continuance with a learning management system”, The International Journal of Information and Learning Technology, vol. 32, no. 2, 109–123.

John Snow, Inc. (2017), “The Supply Chain Manager’s Handbook: A Practical Guide to the Management of Health Commodities”. Arlington, Va.: John Snow, Inc.

Lambert, D.M., Cooper, M.C., Pagh J.D. (1998), "Supply Chain Management: Implementation Issues and Research Opportunities", The International Journal of Logistics Management, vol. 9, no. 2, 1 – 20.

Lwoga E. (2014), “Critical success factors for adoption of web-based learning management systems in Tanzania”, International Journal of Education and Development Using Information and Communication Technology (IJEDICT), vol. 10, no. 1, 4–21.

Mwencha, M., Rosen, J.E., Spisak, E., Watson, E., Kisoka, N., Mberesero, H. (2017), "Upgrading Supply Chain Management Systems to Improve Availability of Medicines in Tanzania: Evaluation of Performance and Cost Effects", Journal of Global Health: Science and Practice.

Omary, Z.D., Kalinga, E.A. (2017), "Assessing Users' Satisfaction with Tanzanians' Public Health Supply Chain Electronic Logistics Management Information System", Journal of Health Informatics in Developing Countries, vol.11, no.2. Available from http://www.jhidc.org//.

Nunnally, J. C. (1978), "Psychometric theory", New York, McGraw-Hill, 2nd Edition.

PATH (2010), "Common Requirements for Logistics Management Information System".

Pharmaceuticals Fund and Supply Agency (2017), "Standard operating procedure manual for the integrated pharmaceutical logistics system in health facilities of Ethiopia", 3rd Edition.

Pharmaceuticals Fund and Supply Agency (2017), "Pharmaceuticals Supply Process Reengineering for Pharmaceuticals Fund and Supply Agency", Addis Ababa, Ethiopia.

SCC (2010), "Supply Chain Operations Reference (SCOR) model: Overview", Version 10.0, Supply Chain Council Inc., info@supply-chain.org.

Shewarega, Abiy, Paul Dowling, Welelaw Necho, Sami Tewfik, and Yared Yiegezu (2015), "Ethiopia: National Survey of the Integrated Pharmaceutical Logistics System", Arlington, Va.: USAID | DELIVER PROJECT, Task Order 4, and Pharmaceuticals Fund and Supply Agency (PFSA).

Tavakol, M., Dennick, R. (2011), "Making Sense of Cronbach's Alpha". International Journal of Medical Education, vol. 2, 53-55.

USAID | DELIVER PROJECT, Task Order 4 (2015), "eLMIS selection guide: electronically managing your supply chain information" Arlington.

USAID | DELIVER Project [n.d.], Computerizing Logistics Management Information Systems: A Program Manager's Guide, Retrieved from http://iaphl.org/resources/publications/computerizing-lmis_prgmmanager-guide/ on March 27, 2018.

USAID | DELIVER PROJECT, Task Order 4 and 7 (2016), "USAID | DELIVER PROJECT, Ethiopia" Arlington, Va: USAID | DELIVER PROJECT, Task Orders 4 and 7.

Wu J, Tsai RJ, Chen CC, Wu Y (2006), “An Integrative Model to Predict the Continuance Use of Electronic Learning Systems: Hints for Teaching Authors”, The Electric Journal of E-Learning, vol. 5, no. 2, p. 287.

Xiao L, Dasgupta S (2002), “Measurement of User Satisfaction with Web-Based Information Systems”, Eighth Americas Conference on Information Systems, 1149–1155.

Annexes

Annex 1: Data Collection Tool

Part I: Questionnaire for Facility Survey

Informed Consent
Introduce yourself and ask facility store manager to introduce him/herself. Good day. My name is _____. We are conducting a survey regarding to assess effectiveness of the e-LMIS implementation to optimize pharmaceutical management practices and enhance efficiency at the Addis Ababa Regional Health Bureau We will be visiting all matured eLMIS implementing public health facilities in Addis Ababa. The objectives of the survey are to; assess the electronic LMIS "HCMIS FE" functionality and features, evaluate data usage in e-LMIS "HCMIS FE" implementing sites, measure the LMIS data quality in electronic LMIS "HCMIS FE" implementing sites, compare data use and quality in electronic LMIS, "HCMIS FE" implementing hospitals and health centers, and assess the relationship between improved data use and quality with supply chain effectiveness and efficiency as described as improved availability and minimized wastage respectively. The assessment is done in Partial Fulfillment of the Requirement for the Award of the Degree of Master of Arts in Logistics and Supply Chain Management. We would like to ask the store manager and/or pharmacy head a series of questions about the products and supplies available at this facility. In addition, we would be assessing end users' perception on use of HCMIS eLMIS. We would also be checking data quality by comparing physical count against ending balance in the system. Do you have any questions? Sami Tewfik samidedu@gmail.com May I begin the interview now? RESPONDENT AGREES TO BE INTERVIEWED . . . . . 1 ⟶ CONTINUETHE INTERVIEW RESPONDENT DOES NOT AGREE TO BE INTERVIEWED . . . . . 2 ⟶ END THE INTERVIEW

Information about Interview	
Date: Interviewer name(s): _____ Position: _____ Gender: M / F	DAY MONTH YEAR ☐☐ ☐☐ ☐☐☐☐

b. System implementation use, challenges, and support received

S/NO	Questions	Response	Code
1	How long have you been using HCMIS anywhere (the respondent)?	< 3month	1
		3-6months	2
		6-12 months	3
		>1 year	4
2	Did you face HCMIS interruption during the past six months, anytime?	Yes	1
		No	2
3	What were the major challenges encountered in using HCMIS during the past six months?	Hardware problems/breakdowns (e.g. computer, RAM, power, hard disk failure, etc.)	1
		Software problems (e.g. system crashes, doesn't have specific functionalities)	3
		Infrastructure problems – loss of electricity	4
		No challenge at all	5
4	If yes, How was the problem fixed?	I fixed the problem	1
		Received support from Health Information Technicians (HIT) in the facility.	2
		Sought support from PFSA or supply chain partners	3

		Through HCMIS call center (tall free line)	4
		Not fixed	5
I.	Local Ownership		
1	Is HCMIS support included in facility's plan? (Confirm)	Yes	1
		No	2
2	Does the management follow the system implementation?	Yes	1
		No	2
3	Does the facility provide and plan for consumable resources (paper, cartridge, UPS, and generator) needed to run the system?	Yes	1
		No	2
4	Does the manager use data for decision making?	Yes	1
		No	2
II.	Competence		
1	Do you think you can operate the system (transaction) by yourself?	Yes	1
		No	2
2	Do you have the capacity to use the data from the system?	Yes	1
		No	2
3	Do you have the capacity to use system generated data for decision making?	Yes	1
		No	2

c. Visibility

S/NO	Questions	Response	Code
1	Which reports do you usually produce using HCMIS? (MULTIPLE RESPONSE)	Stock status	1
		RRF	2
		Cost/price	3
		Near expiry	4
		Wastage/expiry	5
		PFSA Vital Report	6
		AMC Report	7
		Expiry Summary Report	8
		Other (Specify	9
2	Which relevant bodies are accessing these reports? (MULTIPLE RESPONSE)	Pharmacy head/supply officer	1
		Facility head	2
		Woreda/Zone/RHB/FMoH	3
		PFSA	4
		Implementing Partners	5
3	If yes, how are they accessing these reports?		
3a	Pharmacy head/supply officer	Manual from report printouts	1
		Online via LAN or email attachments	2

3b	Facility head	Manual from report printouts	1
		Online via LAN or email attachments	2
3c	Woreda/Zone/RHB/FMoH	Manual from report printouts	1
		Online via LAN or email attachments	2
3d	PFSA	Manual from report printouts	1
		Online via LAN or email attachments	2
3e	Implementing Partners	Manual from report printouts	1
		Online via LAN or email attachments	2

4	How often are you sharing or them accessing these reports?					
		2-3 weeks	Every month	Quarterly	Semi annually	Annually
4a	Pharmacy head/supply officer					
4b	Facility head					
4c	Woreda/Zone/RHB/FMoH					
4d	PFSA					
4e	Implementing Partners					

d. Use of data for decision making

Which decisions/actions do you make using HCMIS reports?			
1	Operational Decisions	Replenishment	1
		Order fulfillment	2
		Forecasting or demand planning	3
		Procurement	4
		Redistribution	5
2	Inventory Management	Track Consumption	1
		Monitor availability and optimal stock management	2
		Track expiry and near expiry	3
		Disposal of expired products	4
3	Quality Improvement	Monitoring accuracy	1
		Monitoring timeliness	2
		Monitoring completeness	3
4	Performance Enhancement	Submitting data on time and in full (Order fulfillment time)	1
		Streamline internal process	2
		Enhancing availability and adequacy	3
		Minimizing wastage	4

e. Data quality

S/No	Product	Balance on electronic Bin Card	Physical count
1	RHZE (Rifampicin + Isoniazid + Pyrazinamide + Ethambutol) + RH (Rifampicin + Isoniazid) - (150mg+75mg+400mg+275mg) of 6x28 tablets + (150mg+75mg) of 12x28 Tablets		
2	Medroxyprogesterone Acetate - 150mg/ml in 1ml, Injection		
3	Implant 68mg implant (Implanon)		
4	Lamivudine/Zidovudine/Nevirapine (30mg + 60mg + 50mg) of 60 tablets		
5	TDF/Lamivudine/Effavirenz (300mg + 150mg + 600mg) of 30 tablets		
6	Nevirapine 10mg/ml oral suspension		
7	Artemether – Lumafantrine (6X4)		

f. End user perception of eLMIS HCMIS

S/No	Statement	Strongly disagree	disagree	Neither Agree nor disagree	Agree	Strongly Agree
		1	2	3	4	5
I.	**System Quality (UI, reliability, adaptability, and performance)**					
1	The information provided by HCMIS is well formatted (laid out and clearly presented)					
2	The HCMIS speed (the time that elapses from the time an activity starts until the results are displayed on the screen or on the printer) is satisfactory					
3	HCMIS is a reliable (e.g. not much failure during operation) logistics management information system					
4	HCMIS can be adapted to a variety of user needs and to changing conditions					
5	HCMIS is easy to learn, manage, and use					
II.	**Data use**					
II.a.	**Visibility**					
1	HCMIS provides with all complete set of logistics information needed for reporting and decision making. (Visibility)					
2	All HCMIS related logistics information can be accessed with relatively low effort (Visibility)					

3	HCMIS enabled to easily produce reports (Visibility)					
II.b. Use of data for decision making and actions						
1	The facility is using the reports and information from the system for operational/strategic decision making					
2	The facility is using the reports and information from the system for performance monitoring					
3	The facility is using the system to produce reports required by management units at different level					
III. Information Quality						
1	The data from HCMIS is timely					
2	The data and reports from HCMIS are accurate					
3	HCMIS provides sufficient information					
4	HCMIS provides information that is easy to understand					
5	The reports in HCMIS are available whenever you want to use					
IV. Perceived Usefulness						
1	HCMIS enabled the health facility to improve capacity to manage an increasing volume of commodities (Adaptability)					
2	HCMIS improved product availability which contributes to improvement in health service coverage and quality of care (Effectiveness)					
3	HCMIS contributes to efficiency by reducing losses due to overstock and expiry (Efficiency)					
4	HCMIS had minimized workload by reducing manual work					
V. System Support						
1	HCMIS support providers provided up to date knowledge and experience related to HCMIS.					
2	HCMIS support providers provided support in multiple mechanisms (face to face, toll free line, telephone,…)					
3	Technical support provided were timely for all HCMIS related queries and requests.					
4	Technical supports provided were adequate (number of support provided is sufficient).					
5	HCMIS technical support provider staffs have adequate knowledge to help me					
6	Support from HCMIS providers has enhanced my ability to use the system					
VI. Facilitation Condition						
1	I have the resources (e.g. PC, UPS, Printer, and Accessories) necessary to access HCMIS					
2	I have the knowledge necessary to use HCMIS for inventory management					
3	A help is available when I get problem in the eLMIS					

4	HCMIS has sufficient user documentation (manual or electronic) explanation of what HCMIS does and how to use it					
VII. User Satisfaction						
1	I am satisfied with the HCMIS function in managing day to day transactions					
2	I am satisfied with the inventory management function of HCMIS					
3	I am satisfied with the system's output (reports and decision support)					
4	I am satisfied with the technical support					

Part II. Functionality and Features

a. System Audit

1. Describe the health commodity requisition, receive, issue, and dispatch business process in public hospitals and health centers as per the standard in IPLS? (Use the activities in the table below)
2. Which among the following activities in the table below within the requisition, receive, issue, and dispatch business processes are automated in the eLMIS – HCMIS and which are not?
3. And, if yes describe how the process in general and the activities in specific are automated along with use cases (responsible actor and responsibility in the specific business process?

	Yes…1 No…2	If yes, how?
1. Requisition business Process		
1.1. Does the system help estimate needs?		
1.2. Does the system determine current/projected quantities available?		
1.3. Does the system issue requisition?		
1.4. Does the system has the functionality to update facility reports and requisition information?		
1.5. Can the system validate requisition?		
1.6. Can the system transmit requisitions?		

1.7. Can the system print requisitions?		
1.8. Does the system has the functionality allowing deletion of requisition?		
1.9. Does the system has functionality allowing validation of requisition?		
1.10. Does the system has capability to show status of requisition? (view)		
1.11. Does the system has the functionality to approve and reject requisitions?		
2. **Receiving business Process**		
2.1. Does the system has automatic notification of arrival?		
2.2. Does the system has mechanisms to take corrective action for discrepancies?		
2.3. Does the system provide information on storage space requirement for arriving consignment?		
• View storage and product handling requirements		
• Enters storage and product handling requirements		
2.4. Does the system provide details of shipment for store manager before receipt? …. View dispatch notification		
2.5. Does the system allow inspection of shipment before arrival (damage/discrepancy)?		
2.6. Does the system automatically receives delivery note? Is it live synch from supplier?		
2.7. Does the system record receipt?		
2.8. Does the system automatically generates proof of delivery (POD)? And sends live POD to Supplier?		

3. **Storage and Inventory Management business Process**		
3.1. Does the system has functionality to release into stock?		
3.2. Does the system has functionality to monitor stock environment? … appropriate temp and security condition		
3.3. Does the system has functionality to monitor stock movement and expiry?		
• View on stock status alerts and notifications		
• View on consumption trend, near expiry, and expiry.		
3.4. Does the system has functionality to update records? Update stock levels		
3.5. Does the system determine current/projected quantities (MOS) available?		
4. **Dispatch business process**		
4.1. Does the system has functionality to process incoming requisition?		
4.2. Does the system has functionality to allocate stock?		
4.3. Does the system has functionality to create pick list?		
4.4. Does the system has functionality to pick from stock location?		
4.5. Does the system has functionality to update bin cards?		
4.6. Does the system has functionality to pack orders?		
4.7. Does the system has functionality to document for delivery?		
4.8. Does the system has functionality to record dispatch?		

b. **To explain eLMIS design and implementation, and functionality/features**

1. Contextual, Technical, Organizational, Customization/Adaptation related factors affecting implementation.

1.1. To be assessed through document review and interview with system developers and analysts working at higher level.

   a. Contextual Factors: How is the system institutionalization (is it incorporated in governments and regional plan)? (Document Review)
   b. Technical Factors: Is the system interoperable with other electronic MIS platforms? (Developers).
   c. Customization: Describe efforts in customization and adaptation to respond to changing and evolving customer requirements? (Developers and Analysts).
   d. Describe the implementation model and strategy of HCMIS FE?
   e. Describe the resources and cost elements required to maintain the system? (to calculate TCO)

1.2. To be assessed through interview of facility level store manager

Annex 2: e-LMIS Platforms in Ethiopia

The eLMIS in Ethiopia include five platforms implemented at different level of the supply chain tier.

1. HCMIS Warehouse Edition (Vitas) is a locally developed, open source, custom software platform designed to support warehouse management, inventory control, and logistics management information. It is used to control inventory, from receipt to issue, and manage movement and storage in PFSA center and hub warehouses. The system is installed in all PFSA central store locations all hubs (18 locations).
2. HCMIS FE (Dagu) is a locally developed, open source, custom software platform designed to support inventory control, and logistics management information at service delivery points. It provides a systematic recordkeeping system for managing health commodities at health facility stores. Dagu is installed in more than 750 health facilities, including most hospitals and major health centers across Ethiopia.
3. Fanos is an online tool that makes PFSA supply chain data accessible in real time through the visual presentation of selected supply chain indicators. It is complimented by a mobile Android app that provides access to the same data via a smartphone. Fanos is being used at all PFSA central stores locations and all hubs (18 locations).
4. i-Import is an open source, online application developed for the Food, Medicine and Health Care Administration and Control Authority of Ethiopia (FMHACA) which allows importers to apply for and receive permits to import medicines online and FMHACA staff to manage these applications online. I-Import is now being used by FMHACA and PFSA
5. mBrana is an open source mobile software platform designed to manage inventory – from receipt to issue.

Annex 3: List of Health Facilities Assessed

S/No	Name of Health Center	Sub City
1	Addis Hiwot Health Center	Gulelle
2	Addis ketema W3 Health Center	Addis Ketema
3	Addis ketema W7 Health Center	Addis Ketema
4	Alembank Health Center	Kolfe Keranio
5	Arada Health Center	Arada
6	Baeta Health Center	Arada
7	Beleteshachew Health Center	Lideta
8	Bole 17 Health Center	Bole
9	Bole 17/2 0 Health Center	Bole
10	Chefe Health Center	Yeka
11	Dilfre Health Center	Bole
12	Entoto No.1 Health Center	Yeka
13	Gergi Health Center	Bole
14	Goro Health Center	Bole
15	Gotera Masalecha Health Center	Kirkos
16	Gutomeda Health Center	Gulelle
17	Hidasse Health Center	Gulelle
18	Hiwot Amba Health Center	Kirkos
19	Janmeda Health Center	Arada
20	Kassanchis Health Center	Kirkos
21	Kirkos Health Center	Kirkos
22	Kolfe Woreda 9 Health Center	Kolfe Keranio
23	Kotebe Health Center	Yeka
24	Lideta Health Center	Lideta
25	Maichew Health Center	Gulelle
26	Minilik Hospital	
27	Nifas Silk Lafto Woreda 06 Health Center	Nifas Silk Lafto
28	Nifas Silk Lafto Woreda 03 Health Center	Nifas Silk Lafto
29	Nifas Silk Lafto Woreda 06 Health Center	Nifas Silk Lafto
30	Nifas Silk Lafto Woreda 09 Health Center	Nifas Silk Lafto
31	Nifas Silk Lafto Woreda 12 Health Center	Nifas Silk Lafto
32	Philipos Health Center	Kolfe Keranio
33	Ras Desta Hospital	
34	Saris Health Center	A/Kality
35	Shiromeda Health Center	Gulelle
36	Teklehaimanot Health Center	Lideta
37	Tirunesh Beijing Hospital	
38	Yeka Health Center	Yeka
39	Zewditu Hospital	

Annex 4: Statistical Output from SPSS

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
TypeofFacility * c2aInventoryManagementTrackConsumption	39	100.0%	0	0.0%	39	100.0%
TypeofFacility * c2bInventoryManagementMonitoravailability	39	100.0%	0	0.0%	39	100.0%
TypeofFacility * c2cInventoryManagementTrackexpiry	39	100.0%	0	0.0%	39	100.0%
TypeofFacility * c2dInventoryManagementDisposal	39	100.0%	0	0.0%	39	100.0%

TypeofFacility * c2aInventoryManagementTrackConsumption Crosstabulation

Count

		c2aInventoryManagementTrackConsumption			Total
		Yes	No	Missing	
TypeofFacility	Hospital	4	0	0	4
	Health Center	28	6	1	35
Total		32	6	1	39

TypeofFacility * c2bInventoryManagementMonitoravailability Crosstabulation

Count

		c2bInventoryManagementMonitoravailability			Total
		Yes	No	Missing	
TypeofFacility	Hospital	4	0	0	4
	Health Center	29	5	1	35
Total		33	5	1	39

Count

		c2cInventoryManagementTrackexpiry			Total
		Yes	No	Missing	
TypeofFacility	Hospital	4	0	0	4
	Health Center	32	2	1	35
Total		36	2	1	39

TypeofFacility * c2dInventoryManagementDisposal Crosstabulation

Count

		c2dInventoryManagementDisposal			Total
		Yes	No	Missing	
TypeofFacility	Hospital	0	4	0	4
	Health Center	16	18	1	35
Total		16	22	1	39

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
TypeofFacility * c3aQualityImprovementAccuracy	39	100.0%	0	0.0%	39	100.0%
TypeofFacility * c3bQualityImprovementTimeliness	39	100.0%	0	0.0%	39	100.0%
TypeofFacility * c3cQualityIImprovementCompletness	39	100.0%	0	0.0%	39	100.0%

TypeofFacility * c3aQualityImprovementAccuracy Crosstabulation

Count

		c3aQualityImprovementAccuracy			Total
		Yes	No	Missing	
TypeofFacility	Hospital	3	1	0	4
	Health Center	34	0	1	35
Total		37	1	1	39

TypeofFacility * c3bQualityImprovementTimeliness Crosstabulation

Count

		c3bQualityImprovementTimeliness			Total
		Yes	No	Missing	
TypeofFacility	Hospital	3	1	0	4
	Health Center	29	5	1	35
Total		32	6	1	39

TypeofFacility * c3cQualityIImprovementCompletness Crosstabulation

Count

		c3cQualityIImprovementCompletness			Total
		Yes	No	Missing	
TypeofFacility	Hospital	2	2	0	4
	Health Center	26	8	1	35
Total		28	10	1	39

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
TypeofFacility * b1WhichreportStockStatus	39	100.0%	0	0.0%	39	100.0%
TypeofFacility * b1WhichreportRRF	39	100.0%	0	0.0%	39	100.0%
TypeofFacility * b1WhichreportCostprice	39	100.0%	0	0.0%	39	100.0%
TypeofFacility * b1WhichreportNearexpiry	39	100.0%	0	0.0%	39	100.0%
TypeofFacility * b1WhichreportWastageexpiry	39	100.0%	0	0.0%	39	100.0%
TypeofFacility * b1WhichreportPFSAVitalReport	39	100.0%	0	0.0%	39	100.0%
TypeofFacility * b1WhichreportAMCReport	39	100.0%	0	0.0%	39	100.0%
TypeofFacility * b1WhichreportExpirySummaryReport	39	100.0%	0	0.0%	39	100.0%

Count

		b1WhichreportStockStatus		Total
		Yes	No	
TypeofFacility	Hospital	4	0	4
	Health Center	33	2	35
Total		37	2	39

TypeofFacility * b1WhichreportRRF Crosstabulation

Count

		b1WhichreportRRF	Total
		Yes	
TypeofFacility	Hospital	4	4
	Health Center	35	35
Total		39	39

TypeofFacility * b1WhichreportCostprice Crosstabulation

Count

		b1WhichreportCostprice		Total
		Yes	No	
TypeofFacility	Hospital	2	2	4
	Health Center	20	15	35
Total		22	17	39

TypeofFacility * b1WhichreportNearexpiry Crosstabulation

Count

		b1WhichreportNearexpiry		Total
		Yes	No	
TypeofFacility	Hospital	3	1	4
	Health Center	33	2	35
Total		36	3	39

TypeofFacility * b1WhichreportWastageexpiry Crosstabulation

Count

		b1WhichreportWastageexpiry		Total
		Yes	No	
TypeofFacility	Hospital	2	2	4
	Health Center	26	9	35
Total		28	11	39

TypeofFacility * b1WhichreportPFSAVitalReport Crosstabulation

Count

		b1WhichreportPFSAVitalReport		Total
		Yes	No	
TypeofFacility	Hospital	0	4	4
	Health Center	3	32	35
Total		3	36	39

TypeofFacility * b1WhichreportAMCReport Crosstabulation

Count

		b1WhichreportAMCReport		Total
		Yes	No	
TypeofFacility	Hospital	1	3	4
	Health Center	15	20	35
Total		16	23	39

TypeofFacility * b1WhichreportExpirySummaryReport Crosstabulation

Count

		b1WhichreportExpirySummaryReport		Total
		Yes	No	
TypeofFacility	Hospital	1	3	4
	Health Center	15	20	35
Total		16	23	39

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
TypeofFacility * b3.3aPharmacyHead	39	100.0%	0	0.0%	39	100.0%
TypeofFacility * b3.3bFacilityHead	39	100.0%	0	0.0%	39	100.0%
TypeofFacility * b3.3cWOZORHBFMOH	39	100.0%	0	0.0%	39	100.0%
TypeofFacility * b3.3dPFSA	39	100.0%	0	0.0%	39	100.0%
TypeofFacility * b3.3eIP	39	100.0%	0	0.0%	39	100.0%

TypeofFacility * b3.3aPharmacyHead Crosstabulation

Count

		b3.3aPharmacyHead		Total
		Manual from Report Printouts	NA	
TypeofFacility	Hospital	4	0	4
	Health Center	34	1	35
Total		38	1	39

TypeofFacility * b3.3bFacilityHead Crosstabulation

Count

		b3.3bFacilityHead			Total
		Manual from Report Printouts	Online via LAN or email attachments	NA	
TypeofFacility	Hospital	0	0	4	4
	Health Center	22	2	11	35
Total		22	2	15	39

TypeofFacility * b3.3cWOZORHBFMOH Crosstabulation

Count

		b3.3cWOZORHBFMOH		Total
		Manual from Report Printouts	Online via LAN or email attachments	
TypeofFacility	Hospital	4	0	4
	Health Center	32	3	35
Total		36	3	39

TypeofFacility * b3.3dPFSA Crosstabulation

Count

		b3.3dPFSA	Total
		Manual from Report Printouts	
TypeofFacility	Hospital	4	4
	Health Center	35	35
Total		39	39

TypeofFacility * b3.3eIP Crosstabulation

Count

		b3.3eIP			Total
		Manual from Report Printouts	Online via LAN or email attachments	NA	
TypeofFacility	Hospital	0	0	4	4
	Health Center	11	5	19	35
Total		11	5	23	39

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
TypeofFacility * b2WhichrelevantbodyPharmacyHead	39	100.0%	0	0.0%	39	100.0%
TypeofFacility * b2whichrelevantbodyFacilityHead	39	100.0%	0	0.0%	39	100.0%
TypeofFacility * b2whichrelevantbodyWoZORHBFMOH	39	100.0%	0	0.0%	39	100.0%
TypeofFacility * b2whichrelevantbodyIP	39	100.0%	0	0.0%	39	100.0%
TypeofFacility * b2whichrelevantbodyPFSA	39	100.0%	0	0.0%	39	100.0%

TypeofFacility * b2WhichrelevantbodyPharmacyHead Crosstabulation

Count

		b2WhichrelevantbodyPharmacyHead		Total
		Yes	No	
TypeofFacility	Hospital	4	0	4
	Health Center	33	2	35
Total		37	2	39

TypeofFacility * b2whichrelevantbodyFacilityHead Crosstabulation

Count

		b2whichrelevantbodyFacilityHead		Total
		Yes	No	
TypeofFacility	Hospital	1	3	4
	Health Center	22	13	35
Total		23	16	39

TypeofFacility * b2whichrelevantbodyWoZORHBFMOH Crosstabulation

Count

		b2whichrelevantbodyWoZORHBFMOH		Total
		Yes	No	
TypeofFacility	Hospital	4	0	4
	Health Center	34	1	35
Total		38	1	39

TypeofFacility * b2whichrelevantbodyIP Crosstabulation

Count

		b2whichrelevantbodyIP		Total
		Yes	No	
TypeofFacility	Hospital	0	4	4
	Health Center	11	24	35
Total		11	28	39

TypeofFacility * b2whichrelevantbodyPFSA Crosstabulation

Count

		b2whichrelevantbodyPFSA	Total
		Yes	
TypeofFacility	Hospital	4	4
	Health Center	35	35
Total		39	39

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
TypeofFacility * DataUse	39	100.0%	0	0.0%	39	100.0%

Count

		DataUse										Total
		3.00	3.50	3.67	3.83	4.00	4.33	4.50	4.67	4.83	5.00	
TypeofFacility	Hospital	0	0	1	1	2	0	0	0	0	0	4
	Health Center	1	2	2	2	12	4	4	2	2	4	35
Total		1	2	3	3	14	4	4	2	2	4	39

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
TypeofFacility * InformationQuality	39	100.0%	0	0.0%	39	100.0%

TypeofFacility * InformationQuality Crosstabulation

Count

		InformationQuality							Total
		2.80	4.00	4.20	4.40	4.60	4.80	5.00	
Typeof Facility	Hospital	0	0	1	0	0	0	3	4
	Health Center	1	2	0	2	3	5	22	35
Total		1	2	1	2	3	5	25	39

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
TypeofFacility * InformationQuality	39	100.0%	0	0.0%	39	100.0%
TypeofFacility * PerceivedUsefulness	39	100.0%	0	0.0%	39	100.0%
TypeofFacility * FacilitationConditions	39	100.0%	0	0.0%	39	100.0%
TypeofFacility * UserSatisfaction	39	100.0%	0	0.0%	39	100.0%

TypeofFacility * InformationQuality Crosstabulation

Count

		InformationQuality							Total
		2.80	4.00	4.20	4.40	4.60	4.80	5.00	
Typeof Facility	Hospital	0	0	1	0	0	0	3	4
	Health Center	1	2	0	2	3	5	22	35
Total		1	2	1	2	3	5	25	39

TypeofFacility * PerceivedUsefulness Crosstabulation

Count

		PerceivedUsefulness							Total
		2.75	3.25	4.00	4.25	4.50	4.75	5.00	
TypeofFacility	Hospital	0	1	0	1	1	1	0	4
	Health Center	1	1	3	6	8	5	11	35
Total		1	2	3	7	9	6	11	39

TypeofFacility * FacilitationConditions Crosstabulation

Count

		FacilitationConditions											Total
		2.50	2.75	3.00	3.25	3.50	3.75	4.00	4.25	4.50	4.75	5.00	
TypeofFacility	Hospital	0	0	1	1	1	1	0	0	0	0	0	4
	Health Center	2	2	5	4	3	3	2	1	2	6	5	35
Total		2	2	6	5	4	4	2	1	2	6	5	39

TypeofFacility * UserSatisfaction Crosstabulation

Count

		UserSatisfaction								Total
		2.00	3.50	3.75	4.00	4.25	4.50	4.75	5.00	
Typeof Facility	Hospital	0	1	2	0	0	0	1	0	4
	Health Center	1	0	0	3	3	3	12	13	35
Total		1	1	2	3	3	3	13	13	39

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
SystemQuality	39	3.00	5.00	4.3846	.52792
DataUse	39	3.00	5.00	4.1752	.47132
InformationQuality	39	2.80	5.00	4.7846	.43136
PerceivedUsefulness	39	2.75	5.00	4.4872	.52550
FacilitationConditions	39	2.50	5.00	3.8077	.81407
UserSatisfaction	39	2.00	5.00	4.5641	.58971
Valid N (listwise)	39				

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
TypeofFacility * a2HCMISInterruption	39	100.0%	0	0.0%	39	100.0%

TypeofFacility * a2HCMISInterruption Crosstabulation

Count

		a2HCMISInterruption		Total
		Yes	No	
TypeofFacility	Hospital	0	4	4
	Health Center	9	26	35
Total		9	30	39

TypeofFacility * c4bPerformanceEnhancementStreamlineprocess Crosstabulation

Count

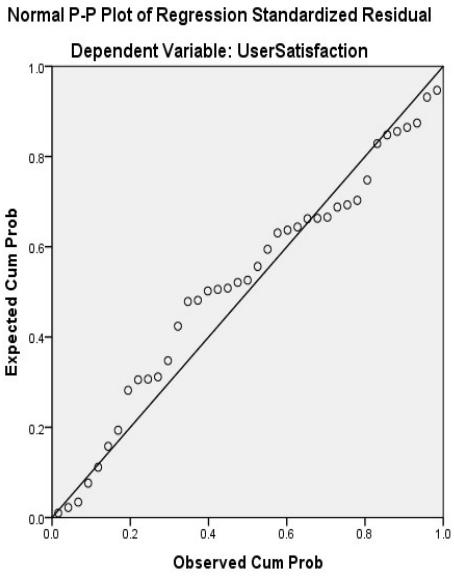
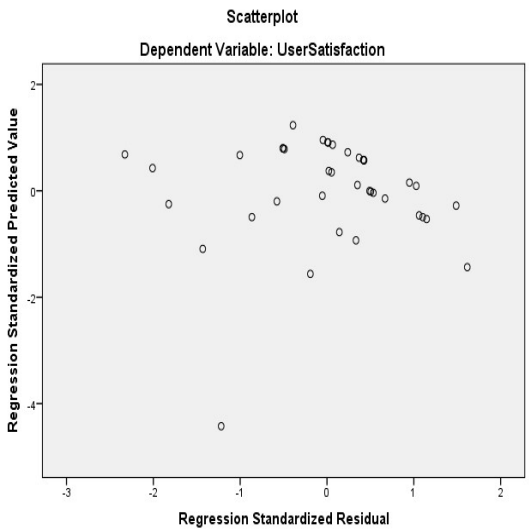
		c4bPerformanceEnhancementStreamlineprocess			Total
		Yes	No	Missing	
TypeofFacility	Hospital	2	2	0	4
	Health Center	19	15	1	35
Total		21	17	1	39

TypeofFacility * c4cPerformanceEnhancementEnhancingavailability Crosstabulation

Count

		c4cPerformanceEnhancementEnhancingavailability			Total
		Yes	No	Missing	
TypeofFacility	Hospital	2	2	0	4
	Health Center	31	3	1	35
Total		33	5	1	39

TypeofFacility * c4dPerformanceEnhancementMinimizingwastage Crosstabulation

Count

		c4dPerformanceEnhancementMinimizingwastage			Total
		Yes	No	Missing	
TypeofFacility	Hospital	3	1	0	4
	Health Center	33	1	1	35
Total		36	2	1	39