PERFORMANCE EVALUATION AND CONCEPTUAL MODEL DEVELOPMENT FOR HEALTH COMMODITIES' LOGISTICS MANAGEMENT INFORMATION SYSTEM (LMIS): THE CASE OF AMHARA REGION, ETHIOPIA

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Performance Evaluation and Conceptual Model Development for Health Commodities' Logistics Management Information System (LMIS): The Case of Amhara Region, Ethiopia

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Declaration

This is to certify that the dissertation prepared by Zelalem Tilahun Mekonen, entitled, Performance Evaluation and Conceptual Model Development for Health Commodities' Logistics Management Information System (LMIS): The Case of Amhara Region, Ethiopia and submitted in partial fulfilment of the requirements for the Degree of Doctor of Philosophy (PhD) in Social and Administrative Pharmacy, complies with the regulations of the University and meets the accepted standards for originality and quality.

Signed by the Examining Committee:

External Examiner: ________________________Signature_______________Date____________

Internal Examiner: ________________________Signature_______________Date_____________

Advisor: ________________________Signature________________Date____________

Advisor: ________________________Signature________________Date____________

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Chair of the Department

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Dedication

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Original Papers

This PhD dissertation is based on the six papers listed below;

I) Mekonen ZT, Cho DJ, Nadeem SP, Garza-Reyes JA, Fenta TG. Vaccine Logistics Management Information System at Public Health Facilities in Amhara Region, Ethiopia: A Performance Evaluation. *Healthc Inform Res*. 2024;30(4):375-386. doi:10.4258/HIR.2024.30.4.375

II) Mekonen ZT, Cho DJ, Fenta TG. Logistics Management Information System (LMIS) for Health Commodities at Public Health Facilities in Amhara National Regional State of Ethiopia: A Data Quality Evaluation Survey. *J Multidiscip Healthc*. 2025; Volume 18:255-266. doi:10.2147/JMDH.S498995

III) Mekonen ZT, Cho DJ, Cheikhrouhou N, Blanchet K, Fenta TG. End Users' Perspective of Digital Logistics Management Information System (eLMIS) Performance at Public Health Facilities of Amhara Region, Ethiopia. *INQUIRY: The Journal of Health Care Organization, Provision, and Financing.2025;* 62. Doi:10.1177/00469580251319086.

IV) Mekonen ZT, Cho DJ, Fenta TG. Health commodities logistics management information system performance at public health facilities of Amhara region, Ethiopia. *Frontiers in Public Health*. 2025; 13. Doi:10.3389/FPUBH.2025.1545429.

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VI) Mekonen ZT, Cho DJ, Fenta TG. Developing a Conceptual Model for the Performance of Health Commodities LMIS in Public Health Facilities of the Amhara Region, Ethiopia: A Grounded Theory-Based Qualitative Study (Manuscript Prepared)

Papers Presented in Conferences

I) Mekonen ZT, Cho DJ, Nadeem SP, Garza-Reyes JA, Fenta TG. Vaccine Logistics Management Information System at Public Health Facilities in Amhara Region, Ethiopia: *4th African Conference on Operations and Supply Chain Management (ACOSCM)*, 27-28, July 2022, Crowne Plaza Hotel, Nairobi, Kenya

II) Mekonen ZT, Cho DJ, Nadeem SP, Garza-Reyes JA, Fenta TG. Vaccine Logistics Management Information System at Public Health Facilities in Amhara Region, Ethiopia: *International Conference on Vaccine & Vaccination*, November 18-19, 2024, Hilton Zurich Airport, Switzerland.

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List of Abbreviations and Acronyms

APTS – Auditable Pharmaceutical Transactions and Services

BIN – Bin Card

CI – Confidence Interval

DHIS2 – District Health Information System 2

DIS – Drug Information Service

DTC – Drug and Therapeutics Committee

EDT – Electronic Dispensing Tool

eHA – Ethiopian eHealth Architecture

eLMIS – Electronic Logistics Management Information System

EPSS – Ethiopian Pharmaceutical Supply Service

ERP – Enterprise Resource Planning

FESC – Facility Electronic Stock Card

FMOH – Federal Ministry of Health

GAVI – Global Alliance for Vaccines and Immunization

HCP – Health Care Provider

HCMIS – Health Commodity Management Information System

HMIS – Health Management Information System

HIS – Health Information System

IFRR – Internal Facility Reporting and Requisition Form

ICD – International Classification of Diseases

ICT – Information and Communication Technology

ICT – Information and Communication Technologies

IPLS – Integrated Pharmaceutical Logistics System

LMICs – Low- and Middle-Income Countries

LMIS – Logistics Management Information System

LIAT – Logistics Indicators Assessment Tool

LSAT – Logistics System Assessment Tool

M&E – Monitoring and Evaluation

PFSA – Pharmaceutical Fund and Supply Agency

RDF – Revolving Drug Fund

SDGs – Sustainable Development Goals

TAM-Technology Acceptance Model

UHC – Universal Health Coverage

UN – United Nations

USAID – United States Agency for International Development

VLMIS – Vaccine Logistics Management Information System

VRF – Vaccine Request Form

WHO – World Health Organization

WoHO – Woreda Health Office

Glossary of Terms

- **Bin Card:** A record-keeping tool used for inventory management and stock control of individual items in a store
- **Data quality**: It is an assessment of LMIS data's fitness to serve its purpose in terms of health supply chain data completeness, timeliness, legality, legibility, and accuracy.
- **Digital LMIS (eLMIS)**: The health facility version of HCMIS, comprising Dagu 1.0 as the latest version and Dagu 2.0 as the advanced version, is tailored for health commodities inventory management and LMIS within health facilities. Dagu 2.0 is connected to Vitas and Fanos and has more integration and interoperability with the other supply chain information systems in EPSS and facilities.
- **End Users' Perspective**: The evaluation of the facility-version digital LMIS system by individuals who directly interact with and utilize the software. The evaluation captures users' experiences, satisfaction, and perceived effectiveness of the digital LMIS in various aspects of the system, including its interoperability, functionality, integration, and data quality.
- **Health Commodities Logistics Management Information System**. It is a system designed to manage and oversee the flow of information along with the flow of health commodities across the healthcare system.
- **Health Commodity Management Information System (HCMIS)**: It is digital LMIS used to manage inventory and LMIS in public healthcare system of Ethiopia and having four versions including **Fanos** (an online real-time supply chain LMIS in EPSS), **Vitas** (open-source software for warehouse, inventory and LMIS at EPSS central and hub warehouses), **mBrana** (open-source mobile software platform designed to manage Vaccine LMIS), and **Dagu** (an open-source software designed to manage health commodities' inventory and LMIS at health facilities).
- **HPMMR (Health Post Monthly Report and Resupply Form)**: The LMIS tool that enables health posts to report their consumption and request resupply of health commodities from health centers
- **IFRR (Internal Facility Reporting and Requisition Form)**: LMIS tool that facilitates the requisition and redistribution of health commodities within health facilities and is utilized by both health centers and hospitals

- **Model 19/Health**: It is a serially registered official financial transaction tool used in health facilities to receive health commodities from suppliers
- **Model 22/Health**: It is a serially registered official financial transaction tool used in health facilities for issuing health commodities for health facilities and different units
- **RRF (Report and Requisition Form)**: It is a LMIS tool that allows health centers and hospitals to report consumption and request resupply of health commodities from Woreda or Ethiopian Pharmaceutical Supply Service (EPSS) hubs
- **RRF (Report and Requisition Form)**: This LMIS tool allows health centers and hospitals to report consumption and request resupply of health commodities
- **Stock Card:** It is a record-keeping tool similar to a bin card, but it includes additional data elements such as price, which are used for inventory management in a store.
- **Performance Evaluation:** A systematic process of assessing the effectiveness, efficiency, and quality of the LMIS within health facilities. This includes measuring key indicators such as data accuracy, completeness, timeliness of reporting, system usability, user satisfaction, and overall LMIS performance in supporting inventory management, decision-making, and supply chain efficiency
- **Conceptual Model:** A theoretical framework that illustrates the relationships and interactions among systemic, operational, and contextual factors influencing LMIS performance in public health facilities. It operationalizes key constructs such as systemic capacity, infrastructure, human resources, data quality, and external environment, defining how these elements interact to affect LMIS functionality, data utilization, and ultimately, health commodities availability.

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Abstract

Introduction: Access to essential medicines remains a major global health challenge, especially in low- and middle-income countries like Ethiopia, where weak health supply chains and fragmented Logistics Management Information Systems hinder timely, equitable delivery of life-saving health commodities. Despite international and national efforts to improve supply chain performance, challenges persist, including poor data quality, inadequate infrastructure, limited interoperability, and lack of standardized performance evaluation frameworks for LMIS. These issues undermine informed decision-making, cause stockouts, and compromise service delivery.

Objective: This study aimed to evaluate the performance of LMIS in public health facilities in the Amhara Region and developing conceptual model

Methods: This study employed institution based concurrent mixed-methods design, grounded in a pragmatic paradigm, to assess the performance of the LMIS in the Amhara Region of Ethiopia. Quantitative data were gathered through surveys and document reviews, while qualitative data were obtained through in-depth interviews, utilizing a grounded theory approach to develop a conceptual model. The study focused on health professionals involved in supply chain management across 102 public health facilities. Multi-stage stratified random sampling was used to select facilities, and data collection tools were adapted from established frameworks. To ensure data quality, pre-testing, training, and data triangulation were conducted. Quantitative data were analyzed using SPSS, and qualitative data were processed using grounded theory techniques with MAXQDA software. Ethical approval was granted, and informed consent was obtained from all participants.

Findings: In this study, significant infrastructure challenges were identified, notably inconsistent power supply and limited internet connectivity, only 42.2% of facilities had internet access. While the Internal Facility Report and Requisition Form (IFRR) and the Report and Requisition Form (RRF) were widely used, other LMIS tools and digital systems saw lower levels of utilization. Regular written feedback from higher levels was received by only 37.3% of facilities.

Data quality assessments using seven tracer medicines revealed varying levels of inventory accuracy, with mean physical and electronic accuracy rates of 74.7% and 70.6%, respectively. The RRF exhibited high completeness at 90.2%, but lower performance in terms of legality (77.2%) and accuracy (76%). Utilization of the 15 vaccine LMIS forms was limited, with availability and usage rates at 44.1% and 40.5%, respectively. Vaccine inventory accuracy was suboptimal, averaging 58.3%. Accuracy of vaccine requisition reports differed between urban and rural areas, averaging 73.4% and 69.6%, respectively. Among the 37 facilities using digital LMIS, 75.7% had functional systems. The average frequency of use for digital dashboard components was 3.13 out of 4, while end-user performance ratings for the eLMIS averaged 3.21 out of 5 (64.2%). LMIS performance varied significantly based on factors such as organizational support, user experience, and internet access ($P < 0.05$). The health supply chain professionals perceived that LMIS tools are user-friendly and helpful for stock management. However, key challenges included inadequate digitalization, limited system interoperability, and weak infrastructure. Manual tools, particularly Model 22/H and 19/H, were preferred over stock cards, which were considered less efficient. The developed conceptual model for LMIS performance identified critical factors affecting LMIS performance, including budget limitations, data quality concerns, workforce training gaps, and implementation barriers. It also recognized contextual factors such as government support, infrastructure availability, public health emergencies, and security conditions. To improve LMIS effectiveness and support evidence-based decision-making, the model recommended strategies such as digital innovation, system integration, workforce capacity building, and enhanced implementation support.

Conclusion: The evaluation of the health commodities LMIS in Amhara Region's public health facilities revealed that while standard LMIS forms and reporting tools are widely used, several critical challenges persist. The major challenges were unreliable power supply, poor internet connectivity, and limited digital infrastructure. Data quality issues were prominent, with significant discrepancies between physical and electronic inventory records, as well as fluctuations in the completeness, legality, and accuracy of reports. The vaccine LMIS system was particularly weak, characterized by inconsistent use of recording forms, lack of digital systems, and a shortage of trained personnel. Digital LMIS tools showed moderate performance, but their effectiveness was uneven, influenced by organizational support, user experience, and internet access. Broader challenges like poor system integration, lack of data backup, and limited

interoperability remain unresolved. The conceptual model developed using grounded theory offers a structured framework for improving LMIS performance and is recommended for pilot implementation and further validation to support the development of measurable KPIs for ongoing monitoring and evaluation of health commodities LMIS.

Key Words: LMIS, Performance Evaluation, Data Quality, Digital LMIS, Vaccine LMIS, Conceptual Model, health Facilities

Chapter One: Introduction

1.1 Background

Access to essential medicines remains one of the most pressing global health challenges, particularly in low- and middle-income countries (LMICs), where preventable and treatable diseases continue to cause significant morbidity and mortality due to inadequate availability of affordable, life-saving health commodities (WHO, 2010; Dowling and Yap, 2014; Stevens and Huys, 2017). Ensuring equitable access to essential medicines, medical devices, vaccines, and diagnostics is a core element of the right to health, as affirmed by international declarations and human rights conventions (United Nations, 1966; Hogerzeil, 2006).

Moreover, it is integral to the realization of Sustainable Development Goal 3, which aims to "ensure healthy lives and promote well-being for all at all ages (Bissell, Perrin and Beran, 2016; Dyea and Acharyab, 2017; Perehudoff, Alexandrov and Hogerzeil, 2019). In the same way, the World Health Organization (WHO) also recognized the equitable access of essential medical products, vaccines and technologies as one building block for the health system of any country (WHO, 2010).

Despite all these global commitments, approximately one-third of the world's population and half of the population in Sub-Saharan countries does not have a regular access to full and effective lifesaving essential medicines (Evans and Boerma, 2009; Stevens and Huys, 2017; 't Hoen *et al.*, 2018; Roth *et al.*, 2018). In LMICs, medicines can constitute 25-70% of total healthcare expenditure compared to less than 10% in high-income countries with the majority of costs typically paid out-of-pocket by individuals (Ozawa *et al.*, 2019; WHO, 2019).

These access barriers are exacerbated not only by economic constraints but also by structural inefficiencies within health systems, particularly in the pharmaceutical supply chain (Yadav, 2015a). The structure of the supply chain system in most low-income countries is mapped in parallel with the administrative structure of the country. This results multiple tiers of stock holding, stock allocation, stock shortage, information system and decision making in the health system which makes the supply chain system more complex and inefficient (Yadav, 2015a, 2016; Lugada, Komakech, *et al.*, 2022).

A well-functioning health supply chain system is a critical component of the health care system for the delivery of essential of medicines, vaccines, contraceptives and other products (Khlie and Abouabdellah, 2016; Global Fund, 2019). Effective supply chain systems covering drug selection, forecasting, procurement, inventory and warehouse management, distribution, rational drug use, and reverse logistics rely heavily on real-time, accurate, and reliable logistics information (USAID Deliver, 2011; Khlie and Abouabdellah, 2016; FMOH, 2020b).

However, in many LMICs, including Ethiopia, fragmented supply chains and weak logistics management information systems impede the consistent availability of health commodities. To address these challenges, Logistics Management Information Systems (LMIS) have been implemented to collect, manage, and disseminate data critical to the functioning of health supply chain system (PATH, 2010). A robust LMIS enables health managers to make informed decisions, improve forecasting, enhance supply planning, and optimize procurement and distribution processes (WHO, 2010; Global Fund, 2019). The lack of quality logistics data can lead to distortions along the supply chain, such as the bullwhip effect causing excessive inventory, inaccurate forecasting, production inefficiencies, and increased costs (Metters, 1997; Herlyn, 2014a).

Ethiopia's introduction of the Integrated Pharmaceutical Logistics System (IPLS), supported by a digital LMIS backbone, has led to measurable improvements in supply chain performance and access to medicines (USAID, 2010; PFSA, 2015; EPSA, 2019). The IPLS is designed to streamline logistics data collection, ensure a two-way flow of information across all levels of the health system, and support evidence-based decisions (PFSA, 2017).

Nevertheless, several implementation challenges persist, including overreliance on paper-based reporting, limited availability of LMIS tools, poor infrastructure such as electricity, internet, and ICT equipment, low data quality, staff skill gaps, and inadequate supportive supervision, all of which hinder effective decision-making and supply chain efficiency (Endeshaw *et al.*, 2020; Hailu, Ahmed and Yimer, 2020; Alemu *et al.*, 2021; Bekele and Anbessa, 2021; Tefera, Yihunie and Bekele, 2021). In addition, gaps in the design and standardization of LMIS, along with the absence of standard performance evaluation frameworks, are undermining the efficiency of the health commodities supply chain and slowing the progress of health service delivery (PATH, 2010; FMOH, 2024a; Tilahun *et al.*, 2025).

Therefore, addressing these ongoing gaps necessitates a systematic evaluation of the existing LMIS and the development of a conceptual model tailored for public health facilities. This study is both timely and essential to inform strategic enhancements in the health supply chain system.

1.2 Statement of the Problem

Access to essential medicines and health commodities is a fundamental human right and a cornerstone of universal health coverage. It plays a pivotal role in improving health outcomes, promoting equity, and fostering socioeconomic development (Hogerzeil, 2006; WHO, 2010; Perehudoff, 2020). Despite global and national commitments, many low- and middle-income (LMICs) countries, including Ethiopia, continue to face persistent challenges in ensuring equitable, reliable, and timely access to life-saving health commodities (Stevens and Huys, 2017; Roth *et al.*, 2018). These challenges are rooted in complex and systemic inefficiencies across the health supply chain, particularly in the LMIS, which is central to effective supply chain operations (Yadav, 2015a; Ozawa *et al.*, 2019).

A well-functioning LMIS is vital for real-time data collection, forecasting, procurement planning, inventory management, and the distribution of health commodities. When implemented effectively, LMIS enhances visibility across the supply chain, reduces wastage, prevents stockouts, and ensures the continuous availability of critical medical products at service delivery points (Herlyn, 2014b; Khlie and Abouabdellah, 2016).

Ethiopia has made notable progress in adopting LMIS tools, including the implementation of electronic LMIS (eLMIS) systems as part of national health system strengthening efforts (FMOH, 2016, 2021a). However, significant implementation gaps persist, including the continued reliance on paper-based records, inadequate ICT infrastructure, unstable internet connectivity, and frequent power interruptions, all of which collectively hinder timely data entry, accurate reporting, and effective decision-making (USAID, 2019; FMOH, 2020b; Alemu *et al.*, 2021; FMOH, 2024b). Furthermore, human resource challenges such as inadequate technical training, high staff turnover, and low digital literacy further compromise the functionality and utilization of LMIS platforms (Endeshaw *et al.*, 2020; Hailu, Ahmed and Yimer, 2020).

In addition, the coexistence of multiple, often non-interoperable digital and manual systems has led to fragmented data management, duplication of efforts, and inefficiencies in monitoring and decision-making processes (Chikumba, 2009; Chircu, Sultanow and Saraswat, 2014; Yadav, 2017; FMOH, 2020b).

A further critical weakness in Ethiopia's health system is the absence of standardized frameworks and performance evaluation systems to assess the functionality and effectiveness of LMIS. This lack of structured evaluation inhibits systematic monitoring, delays the identification of performance gaps, and prevents timely corrective actions, ultimately limiting the scalability, sustainability, and integration of LMIS within the broader health information system (PATH, 2010; FMOH, 2024b, 2024a)

Experiences from other countries such as Tanzania, Malawi, and Bangladesh demonstrate that integrated and well-evaluated LMIS platforms, when supported by robust infrastructure, standardized protocols, and continuous assessments, significantly enhance logistics performance and improve health outcomes (Zhang, Goh and Meng, 2011; ANDERSSON S *et al.*, 2013; Lee, Kim and Kim, 2014). In contrast, Ethiopia's fragmented LMIS systems and lack of standardization continue to impede effective implementation and limit the potential of digital health solutions to scale successfully (Desale *et al.*, 2013; PFSA, 2015; Tiye and Gudeta, 2018).

Given these ongoing challenges and the critical role of LMIS in strengthening health system performance and service delivery, there is a clear and urgent need for a comprehensive, context-specific evaluation of existing LMIS platforms in Ethiopia. This evaluation should include not only technical performance but also human resource capacity, infrastructure adequacy, system interoperability, and data integration. Furthermore, there is a pressing need to develop a conceptual model to guide the design, implementation, and ongoing performance assessment of LMIS in public health facilities. Therefore, this study aims to systematically evaluate the current performance of LMIS in the Amhara Region and to develop a practical conceptual model that can inform national policy, strengthen system effectiveness, and support the broader goal of ensuring equitable access to essential medicines and improved health outcomes in Ethiopia.

1.3 Rational of the Study

Ensuring reliable access to essential medicines remains a cornerstone of achieving universal health coverage, particularly in LMICs such as Ethiopia (WHO, 2019). However, persistent challenges within the public health supply chain continue to impede the timely and consistent availability of medical products. These challenges not only compromise patient outcomes but also burden the overall healthcare delivery system. A central factor in these issues is the suboptimal performance of the LMIS, which plays a crucial role in enabling informed decision-making within the health supply chain. Despite its intended purpose, the LMIS in Ethiopia faces numerous systemic and implementation-related obstacles (FMOH, 2021a). Additionally, the absence of standardized evaluation frameworks for assessing LMIS performance hinders consistent monitoring, delays the identification of performance gaps, and limits the system's capacity to support a resilient and responsive healthcare system.

The Amhara Region, one of Ethiopia's most populous and having topographically difficult areas, presents a particularly relevant setting for examining these issues. The region has faced substantial healthcare delivery challenges while also demonstrating early adoption of several LMIS tools and LMIS related initiatives, including the IPLS, APTS, HCMIS (Dagu and mBrana) (PFSA, 2015; Fenta, 2016). A detailed investigation of LMIS implementation in this region can offer valuable insights into both the enabling factors and the barriers that influence LMIS performance.

This study is motivated by the urgent need to address existing gaps in both academic knowledge and policy implementation. Previous research and national evaluations have typically focused on context-specific elements of LMIS, without undertaking a comprehensive, system-level assessment (PFSA, 2015; EPSA, 2019). There is a pressing need for an integrated and evidence-based evaluation that examines LMIS performance across various dimensions, including technical capacity, organizational structure, infrastructure readiness, and human resource availability.

In response to this need, the study is guided by two primary objectives. The first is to conduct a comprehensive evaluation of LMIS implementation in the Amhara Region, with particular attention to how existing systems are functioning within public health facilities. The second objective is to use the findings from this evaluation to develop a conceptual model that will support the effective design, implementation, integration, and continuous performance monitoring of LMIS in public health facilities. The anticipated outcomes of this research are expected to contribute meaningfully to academic discourse for LMIS in resource-limited settings. More importantly, the findings aim to offer practical guidance to policymakers and stakeholders, including the Federal Ministry of Health, the Ethiopian Pharmaceutical Supply Service, and regional health bureaus, as they strive for more effective strategic planning and operational interventions. The conceptual model developed through this study is envisioned as a practical tool to support the ongoing implementation and performance evaluation of LMIS, thereby advancing national efforts to strengthen the health system and improve equitable access to essential medicines.

1.4 Scope of the Study

This study focuses on evaluating the LMIS for health commodities within public health facilities in the Amhara Region of Ethiopia. Geographically, the study is confined to the Amhara Region, one of the largest and most populous regions in the country where health system challenges such as inadequate access to essential medicines and services are particularly pronounced. The scope encompasses all levels of public health facilities within the region, excluding health posts, in order to provide a comprehensive assessment of LMIS performance across the public health facilities. The study targets key stakeholders involved in the supply chain, including healthcare providers, supply chain managers, EPI logistics officers, and other professionals responsible for the procurement, storage, and distribution of health commodities.

A variety of LMIS tools currently used in these facilities were examined to assess their implementation performance and operational challenges. A mixed-methods approach employed, integrating both qualitative and quantitative data collection methods to ensure a holistic understanding of LMIS implementation, utilization, and performance.

While the study aims to generate in-depth insights into LMIS in the Amhara Region, it acknowledges potential limitations in the generalizability of the findings to other regions of Ethiopia or to other low- and middle-income countries, due to differences in the health system and infrastructural contexts. By clearly defining its geographical and institutional boundaries, target population, and methodological approach, the study provides a focused yet comprehensive analysis aimed at informing policy decisions and system improvements.

1.5 Significance of the Study

This study addresses critical gaps in the LMIS for health commodities in Ethiopia, with a particular focus on the Amhara Region. By examining region-specific issues and requirements, the research contributes to a deeper understanding of LMIS performance in the Ethiopian context. The findings will provide valuable insights into the strengths and weaknesses of current LMIS implementation, thereby supporting evidence-based decision-making by policymakers and health managers to enhance supply chain efficiency.

A key contribution of this study is the development of a conceptual model for evaluating LMIS performance. This model aims to establish standardized performance metrics that are essential for the continuous improvement of LMIS and the overall efficiency of the health supply chain. Furthermore, the proposed model lays the groundwork for future digital transformation and policy implementation by offering a system-based approach to LMIS assessment and improvement.

In addition, the research highlights LMIS tools features and requirements for an effective LMIS, which can inform the design of capacity-building initiatives and training programs for health sector personnel. Although the study focuses on the Amhara Region, its findings have broader relevance for other regions in Ethiopia and for LMICs facing similar LMIS challenges. Overall, this study is expected to advance both academic understanding and practical application of LMIS in health facilities. It will support the Federal Ministry of Health, the Ethiopian Pharmaceutical Supply Service, Regional Health Bureaus, and other stakeholders in the design, implementation, and performance evaluation of LMIS in health facilities, ultimately contributing to improved access to essential health commodities and enhanced health outcomes.

1.6 Structure of the Dissertation

The dissertation starts with title page followed by declaration, acknowledgements, dedication, list of original papers, papers presented at conferences, table of contents, list of abbreviations and acronyms, glossary of terms, list of tables, list of figures, list of annexes, and an abstract. Chapter one, the introduction, sets the context by presenting the background of the study, identifying the problem, outlining the rationale, defining the scope, highlighting the significance, and explaining the structure of the dissertation. Chapter two presents the literature review, which explores the evolution of logistics and supply chain management, the role of information systems in healthcare, and specifically examines the LMIS for health commodities in the Ethiopian healthcare system. It also introduces the theoretical, conceptual, and research frameworks. Chapter three outlines the general and specific objectives of the study along with the key research questions. Chapter four, the methodology, discusses the philosophical assumptions and details the research design, study area, population, sampling methods, data collection tools and procedures, data quality assurance, analysis techniques, and ethical considerations. Chapter five presents the key findings, including general information about respondents, LMIS infrastructure and initiatives, reporting and data quality, and performance evaluations of both vaccine and digital LMIS systems, concluding in a proposed conceptual model for improving LMIS performance. Chapter six offers a discussion of the findings, identifies the strengths and limitations of the study, and discusses practical and policy implications. Finally, chapter seven concludes the dissertation by summarizing the main findings, offering recommendations, and proposing directions for further research. The references section provides a comprehensive list of all cited sources, and the annexes include supporting materials and appended research papers.

Chapter Two: Literature Review

2.1. Evolution of Logistics and Supply Chain Management

The term "Logistics" and defined use of it dates back to the 18th century, 1st defined and used in the military operation (Samal, 2019). Over time, the theoretical and practical evolution of logistics gave rise to the concept of Supply Chain Management (SCM), which emerged as broader paradigm influencing various business functions (Mukhamedjanova, 2020). The term SCM was first emerged in 1980s as it was first published in financial times magazine (Jones, Cope and Budden, 2009). Despite its growing relevance, scholars initially disagreed on the relationship between logistics and SCM. According to Larson and Halldorsson (2004), four perspectives emerged regarding their connection: the traditionalist (viewing SCM as a subset of logistics), relabeling (renaming logistics to SCM), unionist (treat logistics as a part of SCM) and inter-sectionist (considering both as independent disciplines having inter-sectional role) (Larson and Halldorsson, 2004). Trough time, the unionist and inter-sectionist perspective got more attention due to the fact that SCM becomes more border concept and interlinked with logistics activities (Habib, 2014).

As a newly evolving paradigm, there is no universally accepted definition that distinctly differentiates logistics from supply chain management (Figure 1). The American Council of Logistics Management defines logistic as " *the process of planning, implementing, and controlling the efficient, effective flow and storage of goods, services, and related information from point of origin to point of consumption for the purpose of conforming to customer requirements"* (Samal, 2019).

Likewise, the Council of Supply Chain Management Professionals (CSCMP) defines supply chain management as *"the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. It includes all of the logistics management activities as well as manufacturing operations, and it drives coordination of processes and activities with and across marketing, sales, product design, finance and information technology*" (Bodhankar and Rangari, 2016).

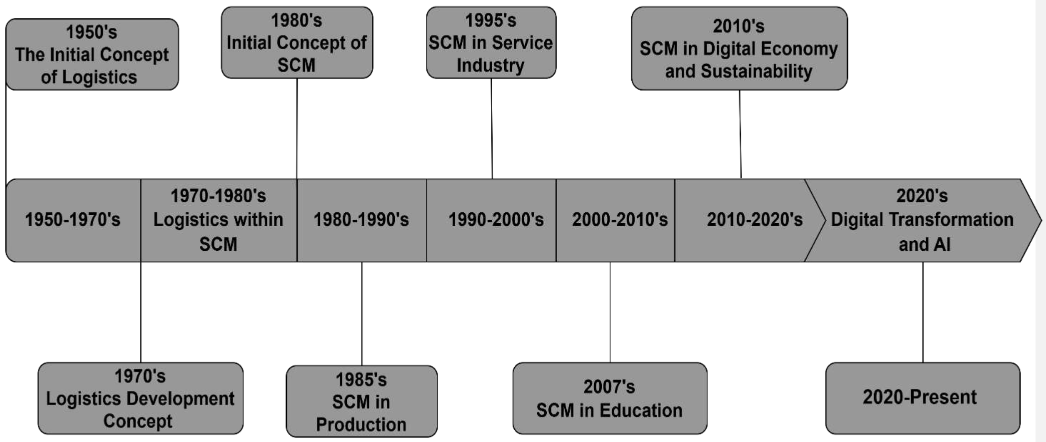

Figure 1: Evolutionary timeline for Logistics and supply chain management; Adopted and modified from (Habib and Jungthirapanich, 2008; Habib, 2011; Cui Jun-Ying et al., 2024).

2.2. Health Commodities' Supply Chain System

The supply chain system for health commodities is a critical component of the health care system, directly impacting access to essential medicines, vaccines, contraceptives and medical technologies (WHO, 2010; Khlie and Abouabdellah, 2016). Ensuring equitable and uninterrupted access to these life-saving products is a key determinant for health system performance and population health outcomes (Global Fund, 2019; Lugada, Ochola, *et al.*, 2022). A well-functioning health supply chain is fundamental for maintaining service delivery, improving patient outcomes, and building system resilience, particularly in resource-constrained settings (USAID, 2011; Ottih, Cussen and Mustafa, 2018).

The main purpose of the healthcare supply chain is to deliver the right product to the right customer, in the right quantity, in the right condition, to the right place, at the right time, and for the right affordable cost, often referred to as the "seven rights of logistics (Clark and Barraclough, 2010; Roark, 2011; Mathew *et al.*, 2013). Achieving this objective is essential to delivering a high standard of care and optimizing resource utilization (Mathew *et al.*, 2013).

However, healthcare supply chains are inherently complex systems, often managing a wide array of products, each with unique storage, handling, and distribution requirements. They involve multiple stakeholders including manufacturers, procurers, distributors, regulators, and service providers who must coordinate across different levels of the health system (Burns, 2002; Clark and Barraclough, 2010; Khlie and Abouabdellah, 2016; Choudrie *et al.*, 2017). The involvement of government institutions, development partners, insurance schemes, and private actors adds further layers of complexity (Mathew *et al.*, 2013).

In low-income countries, particularly in Sub-Saharan Africa, supply chains are often fragmented and unreliable, resulting in frequent stockouts and delayed service delivery (Annan and Amagon, 2013; Yadav, 2015a). These inefficiencies are commonly linked to weak integration of logistics functions, limited data visibility, and inadequate coordination between public and private stakeholders (USAID, 2011; Khlie and Abouabdellah, 2016).

Typically, health commodities supply chain system in these contexts follow the administrative structure of the country. Governments usually oversee procurement and distribution through Central Medical Stores (CMS) and public-sector transport systems(Yadav, 2015a). For example, Ghana's public health system employs a three-tier system in which regional health administrations manage regional medical stores that supply health facilities within their catchment areas. Teaching and referral hospitals, however, are authorized to procure directly from suppliers with approval from the Ministry of Health (Annan and Amagon, 2013). While multi-tiered systems can bring proximity-based advantages, they may also create bottlenecks, resource duplication, and coordination challenges. On the other hand, streamlined systems with fewer tiers can reduce delays, minimize wastage, and enhance responsiveness (Yadav, 2015b).

To guide the development of resilient supply systems, the World Health Organization (WHO) proposed a generic model of the health supply chain structure for low- and middle-income countries (Figure 2), which maps commodity flow across various levels of the health system (Yadav, 2015b) (Figure 2).

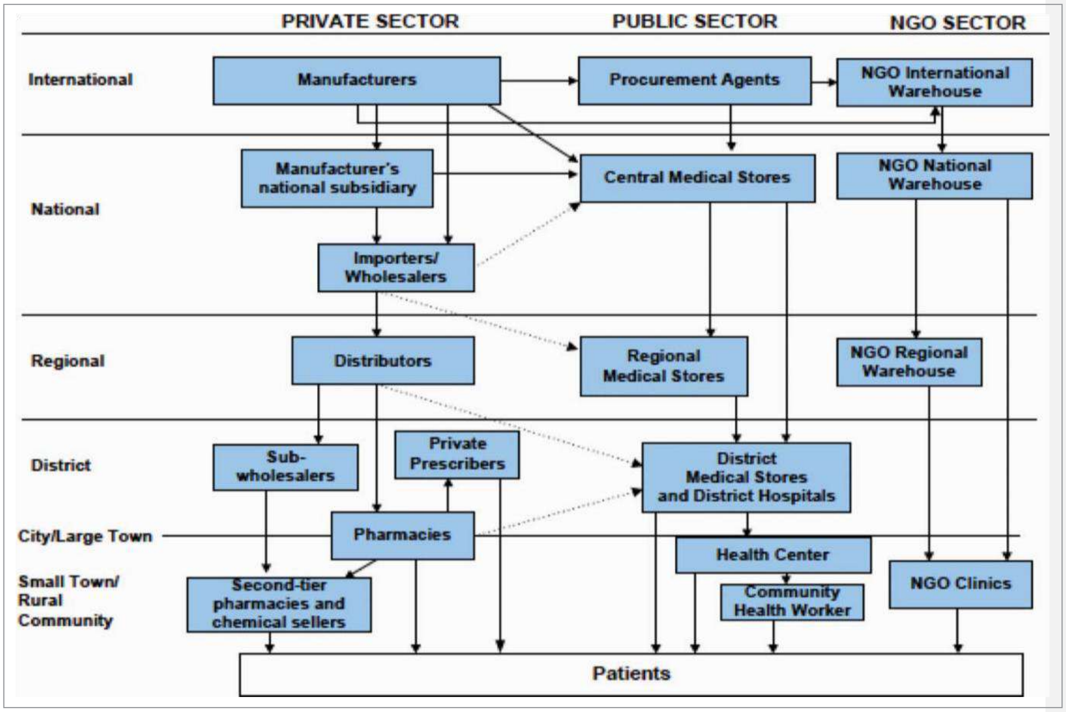

Figure 2:Structure of Health Product Supply Chain in Developing Countries (©WHO, 2015)

Further, the USAID Supply Chain Evolution Model outlines four stages of development for public health supply chain systems including; Ad hoc (unstructured), organized, integrated, and extended. Most developing countries are currently in the integration stage, wherein ministries of health and logistics management units coordinate health commodity flows across programs and partners. In the extension stage, supply chain management evolves to include institutionalized collaboration with the private sector, enhanced automation, and broader system-wide visibility (USAID, 2011; Yadav, 2015a) (Figure 3).

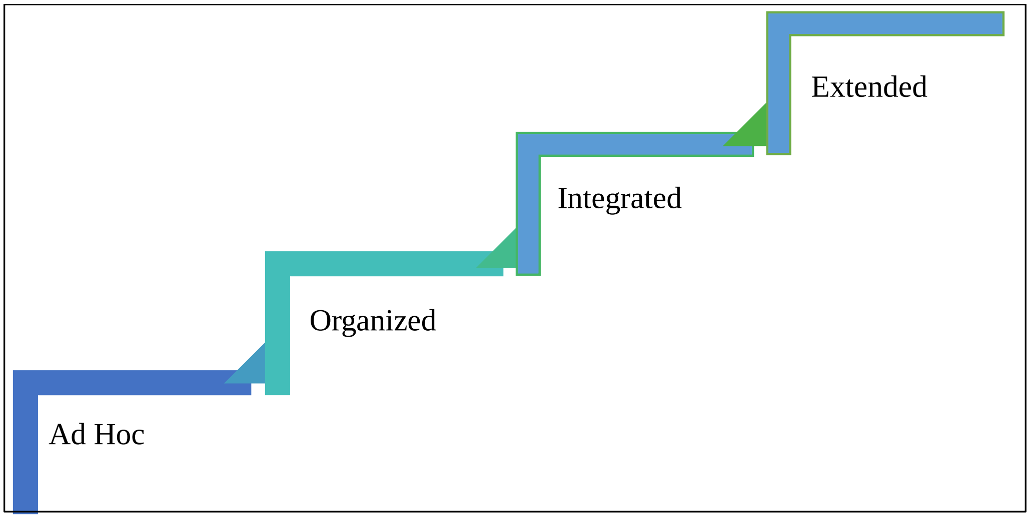

Figure 3:Supply Chain Evolution Model for Developing Countries' Public Health System; Adopted from; (USAID, 2011)

Overall, consistent availability of affordable, high-quality health commodities is both a health system goal and a governance challenge. Strengthening healthcare supply chain management capacity, digitalizing supply chain operations, and fostering public-private partnerships are increasingly recognized as strategic priorities for achieving Universal Health Coverage (UHC) and Sustainable Development Goals (SDGs) (WHO, 2017b; Witter *et al.*, 2019; Chemonics International, 2021).

2.3. Health Commodities' Supply Chain in Ethiopian Healthcare System

The Ethiopian health care system operates under a decentralized three tier structure composed of primary, secondary, and tertiary-levels health care. The Primary Health Care Unit (PHCU) forms the foundational level and includes health posts, health centers, and primary hospitals. General hospitals are categorized under the second tier of the health care system used as a referral center for primary hospitals. The third tier consists of a specialized hospital that serves as a referral center for general hospitals (FMOH, 2021a) (Figure 4).

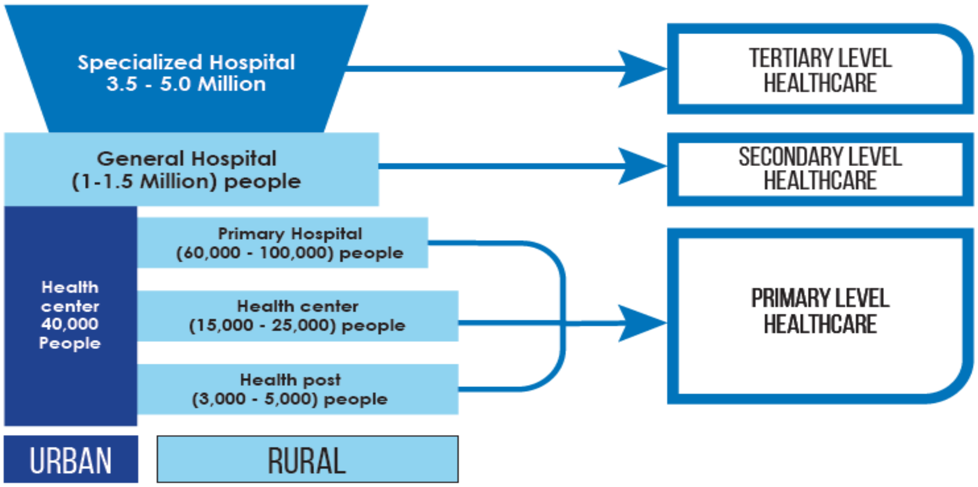

Figure 4:Ethiopian Three-tier Healthcare System (© Ministry of Health-Ethiopia, 2021)

Among the key agencies supporting the Ethiopian Ministry of Health is the Ethiopian Pharmaceutical Supply Service (EPSS), previously known as PFSA and EPSA. Revamped after the 2006 approval of the Pharmaceutical Logistics Master Plan (PLMP), EPSS is tasked with ensuring a consistent and cost-effective supply of quality-assured medicines and medical supplies by overseeing their procurement, storage, and distribution to public health facilities across the country (FDRE, 2007). To further streamline and integrate supply chain operations, EPSS introduced the Integrated Pharmaceutical Logistics System (IPLS) in 2010. This system manages both program-specific commodities and Revolving Drug Fund (RDF) items, enabling demand-driven procurement, distribution, inventory management and logistics management information system (Dowling, 2017; PFSA, 2017; FMOH, 2020b).

Currently, the EPSS has 19 hubs, having warehouses and perform inventory management and distribution activities for public health facilities. The agency envisions becoming the most responsive and efficient pharmaceutical supply chain organization in Africa by 2030. EPSS has an annual procurement capacity exceeding 1 billion USD, sourcing pharmaceuticals and medical supplies from both local and international suppliers (EPSS, 2020; FMOH, 2020a). Although public-private partnership mechanisms remain limited, private sector actors contribute significantly to the supply chain through importation, local manufacturing, and distribution efforts (United Nations, 2014; PFSA, 2017; FMOH, 2020b; Chemonics International, 2021).

Despite significant progress in Ethiopia's public health supply chain over the past decade, several challenges continue to impede the achievement of the EPSS's strategic objectives. According to the 2024 FMOH Performance Report, the overall forecast accuracy stood at 64.8%, which is below the target of 75% set for the year (FMOH, 2024a).

Multiple studies on the implementation of the IPLS have identified persistent issues, including its partial implementation across health facilities, frequent stock-outs, high levels of wastage, the absence of standardized recording formats, poor data quality, limited integration of Logistics Management Information Systems, lack of data visibility, and minimal digitalization of logistics information (PFSA, 2015; Shewarega Abiy, Paul Dowling, Welelaw Necho, Sami Tewfik, 2015; Hailu, Ahmed and Yimer, 2020; Tamirat *et al.*, 2020; Alemu *et al.*, 2021; Tefera, Yihunie and Bekele, 2021).

2.4. Role of Information System in Healthcare Supply Chain

Effective and timely use of health and logistics information is critical for transforming healthcare systems, particularly in low- and middle-income countries (LMICs) where resources are limited, and supply chains are complex. Decision-making at all levels of the health system is only as effective as the quality of information that supports it (Abouzahr and Boerma, 2005; Stansfield *et al.*, 2006; Mutale *et al.*, 2013).

The World Health Organization (WHO) identifies the health information system as one of the six essential building blocks of a well-functioning health system, underpinning evidence-based planning, monitoring, and service delivery (WHO, 2010) (Figure 5).

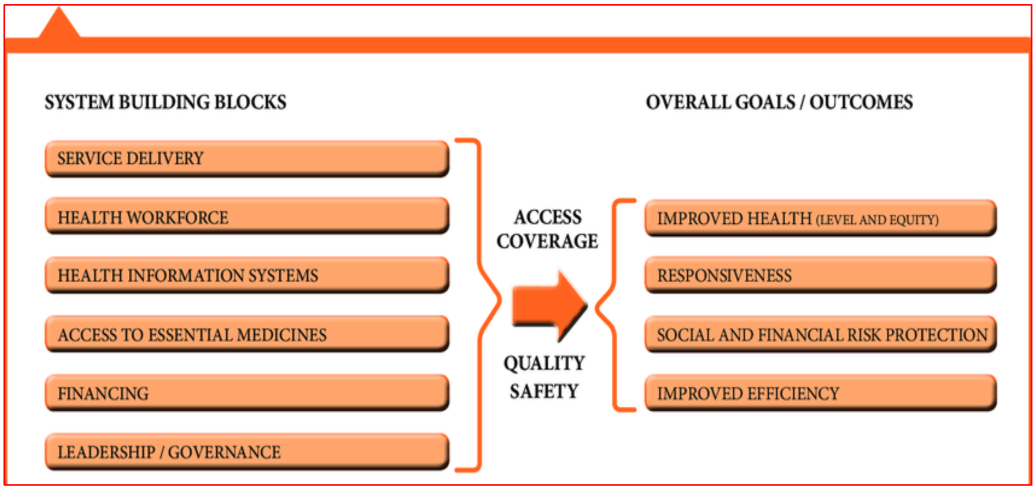

Figure 5:The six building blocks of health system ; Adopted from (WHO, 2010).

A robust health information system (HIS) has four core functions: data generation, data compilation, analysis and synthesis, and communication and use by decision-makers. At the 2015 Summit on the Measurement and Accountability for Results in Health, organizations including the World Bank, USAID, and WHO issued a “Five-Point Call to Action” urging all countries to invest in health information and statistical systems to achieve better health outcomes by 2030 (World Bank Group, USAID and WHO, 2015).

Despite broad recognition of its importance, data collected from health facilities in LMICs often suffer from poor quality marked by incompleteness, lack of timeliness, inaccuracy, and poor representativeness thus undermining its use in decision-making (Rowe, 2009; Mustafa *et al.*, 2016; Getachew, Erkalo and Garedew, 2022). Beyond the technical design of information systems, effective implementation requires leadership commitment, institutional ownership, and a culture of data use for continuous improvement (Chaulagai *et al.*, 2005).

The Logistics Management Information System serves as a critical interface between HIS and supply chain management, functioning as the backbone of an effective healthcare supply chain system (USAID Deliver, 2011). It supports essential activities such as forecasting, procurement, inventory control, and the efficient use of medicines and supplies. A well-designed LMIS captures critical data, including stock levels, consumption rates, and requisitions, facilitating informed decision-making that improves health commodity availability and service delivery (USAID Deliver, 2011; Choudrie *et al.*, 2017; Mabirizi *et al.*, 2018). The LMIS can be manual (paper-based), semi-computerized, or fully computerized (Chikumba, 2009).

To fully harness the transformative potential of information systems in healthcare supply chains, it is imperative to prioritize interoperability, data governance, and capacity building at all levels of the system (Abouzahr and Boerma, 2005; WHO, 2010; Mutale *et al.*, 2013). Strengthening LMIS within the broader HIS framework requires not only investment in infrastructure and digital tools but also sustained training and support for personnel who manage and utilize data (Chaulagai *et al.*, 2005; USAID Deliver, 2011).

As healthcare systems in LMICs increasingly face both routine and emergency supply chain challenges, a data-driven approach becomes essential for ensuring resilience, equity, and efficiency (Choudrie *et al.*, 2017; Mabirizi *et al.*, 2018). Ultimately, enhancing evidence-based decision-making through strong information systems is essential for achieving universal health coverage and improving health outcomes for all populations (WHO, 2010; World Bank Group, USAID and WHO, 2015; Manyazewal, 2017)

2.5. Health Commodities' LMIS in Ethiopian Healthcare System

The Health Information Revolution was one of the four key transformation agendas in Ethiopia's first Health Sector Transformation Plan (HSTP-I), and it remains a core focus among the five transformation agendas of HSTP-II. This agenda emphasizes improving data quality, specifically accuracy, completeness, and timeliness while also strengthening integration and interoperability of health information systems, and fostering a culture of evidence-based decision-making (FMOH, 2021a).

Ethiopia's journey toward enhancing health information utilization began with the implementation of the Health Management Information System (HMIS), which was used for over decades and helped initiate a culture of data use. In November 2019, the country advanced to a digital platform known as the District Health Information System 2 (DHIS2), which was customized to the Ethiopian context. This cloud-based system was rolled out across public health facilities and partially implemented in the private health sector (FMOH, 2020a, 2021a, 2024b).

In 2016, the FMOH developed the national eHealth Architecture (eHA) as part of the broader information revolution roadmap. The eHA aims to streamline resource utilization, prevent duplication of efforts, and enable data access and integration. Despite these intentions, full implementation is still forthcoming. The HSTP-II continues to highlight key strategic priorities, including enhancing data quality and usage, ensuring interoperability among eHealth applications, integrating datasets, and promoting performance monitoring and data sharing (FMOH, 2016, 2020a, 2021b) (Figure 6).

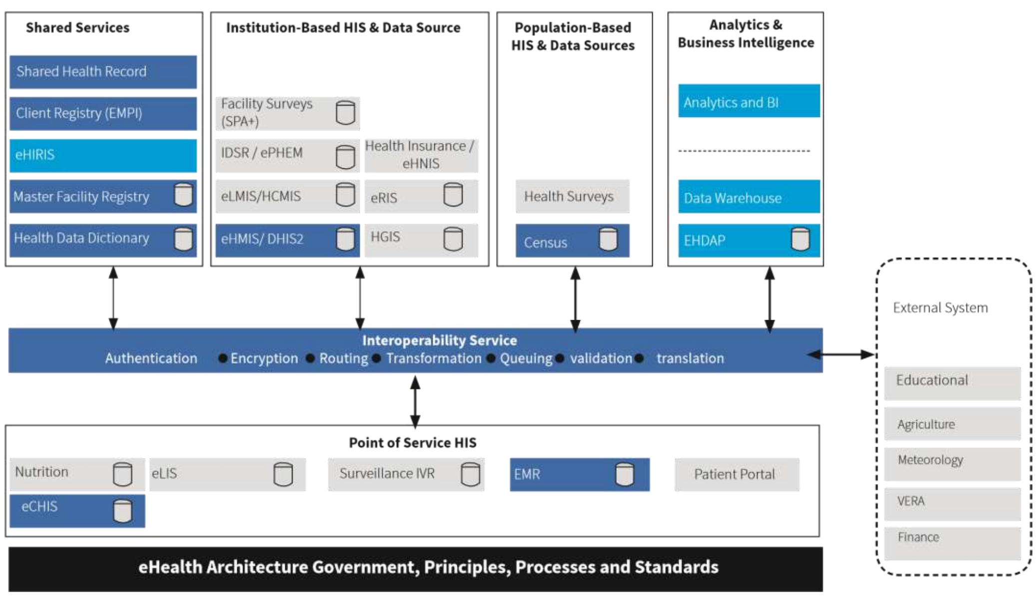

Figure 6: Ethiopian eHealth Architecture (eHA); Adopted from (FMOH, 2016)

Despite these all efforts in the health system, data quality in the routine health information system remains a significant challenge(FMOH, 2021a, 2024b). In a recent study conducted in Harari Region, the good quality data in HMIS was found to be 51.35% (95% CI, 44.6-58.1) which was less than the national target recommended for LMICs (80%) (WHO, 2017a; Shama *et al.*, 2021).

The IPLS implemented in EPSS and public health facilities encompasses three core functions: the LMIS, inventory control, and pharmaceutical storage. The purpose of LMIS is to collect, organize, and report information to inform decision-making across all levels of the health system. All sectors involved in the health commodities' supply chain system are interconnected with logistics activities and information sharing. The overall logistics management information system also includes a mechanism for providing feedback to lower level facilities from upper level facilities and offices (PATH, 2010; USAID, 2010; PFSA, 2017) (Figure 7).

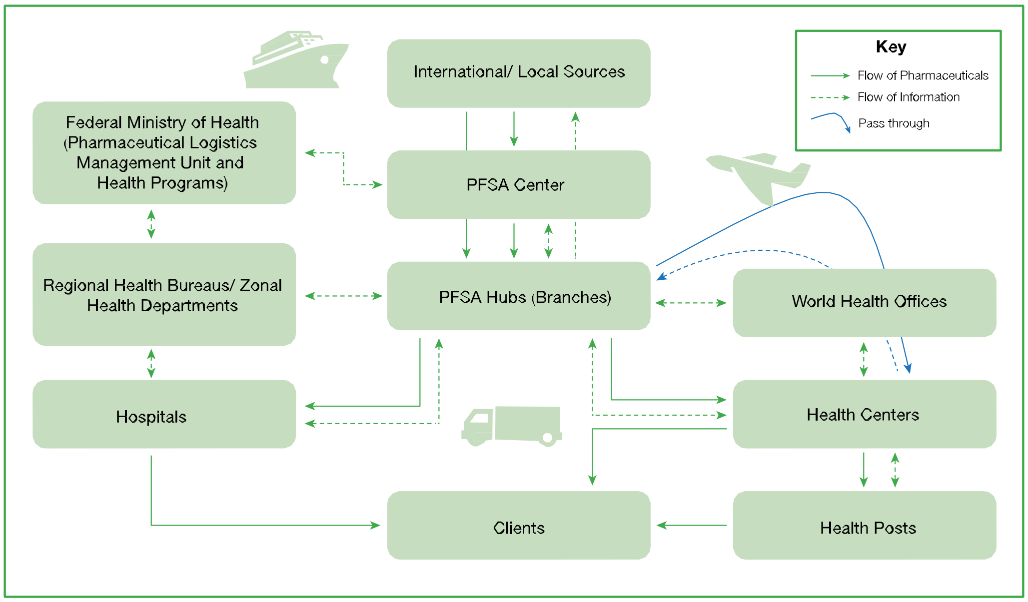

Figure 7:Flow of Pharmaceuticals and LMIS in the IPLS: Adopted from (PFSA, 2017)

Despite efforts by the health system to implement the IPLS and LMIS, several studies have highlighted persistent systemic challenges in Ethiopia's health commodities LMIS at health facilities. These challenges include partial implementation of the LMIS, insufficient supply of LMIS forms, inadequate infrastructure such as electricity, internet, and computers (Shewarega Abiy, Paul Dowling, Welelaw Necho, Sami Tewfik, 2015; Dowling, 2017; Alemu *et al.*, 2021); shortage of staffs (Fenta, 2017); challenges in LMIS interoperability with other systems (Taddesse, 2015); poor data quality (PFSA, 2015; Damtie, Ibrahim and Yikna, 2020; Bekele and Anbessa, 2021); lack of end to end data visibility (Dowling, 2017; FMOH, 2020a); poor digital information governance system (FMOH, 2024b); gaps in training and staff commitment (Nigusie, 2017; Tiye and Gudeta, 2018; Tefera, Yihunie and Bekele, 2021); lack of adequate supportive supervision and timely feedback from higher levels (Tefera, Yihunie and Bekele, 2021).

2.6. Health Commodities' LMIS Design and Requirements

A well-designed LMIS is crucial for efficient health supply chain management, especially in resource-limited settings. As health systems grow more complex, LMIS plays a key role in enhancing logistics visibility, efficiency, and responsiveness. Its development demands a multidisciplinary approach that blends software architecture with healthcare workflows and contextual needs. This synthesis outlines core architectural and design principles for building resilient health information systems (PATH, 2010).

Tummers and his colleagues highlighted the importance of clearly defining features, sub-features, and stakeholder roles during the architectural design of health information system. Stakeholder engagement is central to this process, as it ensures that the design reflects the real-world experiences and needs of users, including healthcare providers, system administrators, and policymakers (Tummers *et al.*, 2021). Complementing this, (Richardson, 2006) emphasized that healthcare information systems must prioritize privacy, accountability, data quality, ease of use, portability, and compliance with legal and ethical standards. Additionally, they should be minimally intrusive, support diverse user groups, and foster ongoing innovation.

The World Health Organization has emphasized that a strong health information system should be comprehensive, functional, adaptable, scalable, and resilient, particularly in low-resource settings where healthcare systems must be able to respond flexibly to evolving needs and challenges. This is echoed in several WHO reports and frameworks, including the Health Metrics Network (HMN) Framework and the WHO Digital Health Strategy (MEASURE Evaluation, 2018a; WHO, 2021b).

In the context of LMIS, the architecture must be designed with a thorough understanding of the healthcare ecosystem. This involves identifying challenges and opportunities, mapping workflows and processes, and documenting the roles and requirements of individuals involved in data creation and usage. An LMIS should not only store data but also facilitate real-time use and analysis as a core function (PATH, 2010; Tummers *et al.*, 2021).

Key data elements in an LMIS include stock on hand, losses, adjustments, consumption rates, demand forecasts, issues, shipment status, and cost data. Visibility of this information across the supply chain supports evidence-based decision-making, ensuring timely availability of essential health commodities (UNDP, 2025).

USAID (2011) further specifies that LMIS design should incorporate architectural domains such as data types, units of measurement, record and reporting structures, responsible actors, frequency and channels of reporting, and standardized forms. Moreover, data validation, approval workflows, and the degree of automation are critical aspects that determine the efficiency and reliability of the system (USAID Deliver, 2011).

Beyond these fundamentals, the issues of end to end data visibility, governance, integration within the larger health information system architecture, interoperability, and data quality are fundamental features for modern LMIS architecture (Hara *et al.*, 2017). Data quality is a multifaceted concept that cannot easily measured with binary dimension rather it needs to consider each dimension of quality (O'Hagan *et al.*, 2017).

The digitization of LMIS design through integrated digital platforms is crucial for optimizing health commodity management. These platforms automate data collection, validation, storage, and reporting, reducing errors and increasing real-time visibility, which is especially valuable in decentralized health systems (Global Fund, 2019). A well-designed LMIS must balance technical sophistication with usability, focusing on data quality, interoperability, user-centered design, and governance. Such systems improve efficiency, decision-making, and health outcomes, making the development of robust LMIS platforms a strategic necessity for modern health systems (Nicodemus *et al.*, no date; Richardson, 2006; Global Fund and GAVI, 2019).

2.7. Digitization of Health Commodities' LMIS

As health programs grow in size and complexity, digital tools become increasingly important for ensuring real-time data visibility, accuracy, and responsiveness. The integration of Information and Communication Technologies (ICT) into supply chains has significantly enhanced operational agility, reduced human error, and improved data-driven decision-making (Closs, Goldsby and Clinton, 1997; Yadav, 2015a; García-Alcaraz *et al.*, 2017). The automation of LMIS has brought significant transformation to supply chain operations. Electronic LMIS (eLMIS) platforms facilitate rapid data collection, aggregation, analysis, and transmission, ensuring end-to-end visibility throughout the supply chain (USAID | DELIVER PROJECT, 2012; Global Fund, 2019).

Namibia has effectively implemented various eLMIS tools to improve health commodity management and visibility. These include the Electronic Dispensing Tool (EDT) for ART data at facilities, the EDT National Database for centralized data aggregation, the Facility Electronic Stock Card (FESC) for stock control, SYSPRO ERP software for inventory and order management, and a web-based Pharmaceutical Management Information Dashboard for visualizing key pharmaceutical data (Mabirizi *et al.*, 2018).

Similarly, Tanzania implemented an integrated eLMIS that greatly improved vaccine availability compared to previous paper and Excel-based systems. The digital system significantly reduced vaccine stock-outs over time, demonstrating the benefits of digitization for supply chain performance (Gilbert *et al.*, 2020).

In Ethiopia, as part of the IPLS implementation initiative, a digital LMIS known as the Health Commodities Management Information System (HCMIS) was developed and implemented locally. HCMIS includes various versions tailored for vaccines, health facilities, and EPSS, offering real-time access to supply data from EPSS distribution hubs and health facilities (USAID Deliver Project, 2014; Dowling, 2017). It is one of the digital tools highlighted in the eHA of the health information revolution map (FMOH, 2016).

Nevertheless, serval studies reveal persistent challenges affecting HCMIS functionality, including unreliable internet connectivity, skill gaps among end users, poor data quality, and limited system use for decision-making (Desale *et al.*, 2013; PFSA, 2015; Dowling, 2017; Tewfik, 2018; Bekele and Anbessa, 2021). A recent study in health facilities of Addis Ababa found that the overall data quality of HCMIS was 66.61%. The average utilization of all the regular reports was found to be 39.17% (Endeshaw *et al.*, 2020). Although facilities used HCMIS for recording logistics activities, the system lacked integration and interoperability with HMIS and other health information platforms (Taddesse, 2015; Endeshaw *et al.*, 2020; FMOH, 2020a).

As part of a solution, the EPSS is currently implementing a comprehensive Enterprise Resource Planning (ERP) system to modernize its supply chain operations, replacing previously implemented digital systems. The initiative is designed to strengthen interdepartmental coordination, optimize inventory management, and enable data-driven decision-making through real-time, end-to-end data visibility (EPSS, 2020, 2023; FMOH, 2024b). However, the integration of the eLMIS used in health facilities with the ERP system deployed at EPSS hubs remains an unresolved issue. Addressing this gap requires coordinated action and substantial investment to ensure a fully integrated and efficient national eLMIS (USAID Delievr Project, 2015; Snow, 2017).

Despite ongoing efforts by LMICs, including Ethiopia, to digitize the LMIS for health commodities, several challenges persist. These include weaknesses in software development project management, limited adoption of information technology best practices, inadequate infrastructure, low digital literacy and competency among health workers, and poor interoperability with other national health information systems. Additionally, gaps in governance and concerns about the long-term sustainability of electronic LMIS within the healthcare system remain significant barriers to effective implementation. (PATH, 2010; John Snow Inc., 2017; Global Fund, 2019; FMOH, 2020a, 2024b).

To design an effective digital solution for LMIS, it is crucial to consider the scale of IT capabilities, including infrastructure, business expertise, relationship resources, and human resources. The process of designing and implementing a digital LMIS requires careful project planning based on demand, identification of fundamental requirements, thorough piloting, deployment, ongoing support, and ensuring the system's long-term sustainability (Figure 8) (USAID | DELIVER PROJECT, 2012; Bakan and Sekkeli, 2017)

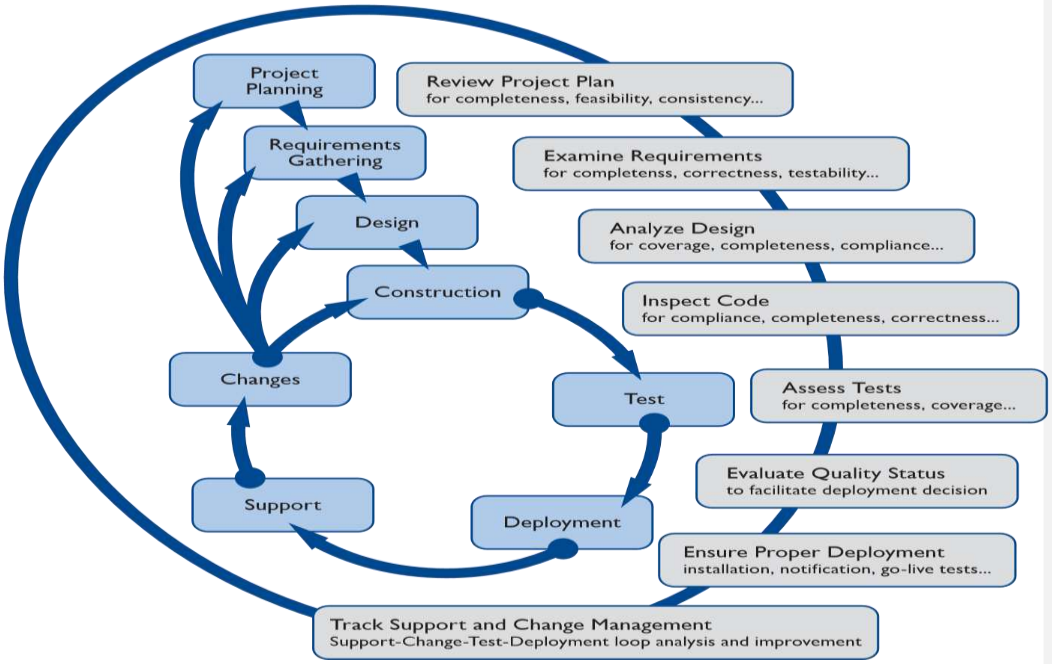

Figure 8:Software development life cycle for LMIS digitalization; Adopted from (USAID | DELIVER PROJECT, 2012)

2.8. Performance Evaluation of LMIS

Performance assessment is vital for strengthening public health systems by identifying strengths, diagnosing weaknesses, and guiding improvements (Mierau *et al.*, 2024). Health system performance assessment is a comprehensive yet complex process due to the diverse data sources, stakeholders, and dynamic contexts (Papanicolas *et al.*, 2024). Evidence-based decision-making is key to enhancing health outcomes and service quality. To support this, evolving frameworks for assessing health system performance like those by Murray and Frenk (2000) guide countries in adapting to changing health need (Murray and Frenk, 2000; WHO, 2007).

A Health Information System (HIS) is a vital component of any health system, supporting performance evaluation, strategic planning, and policy-making. The WHO's Health Metrics Network (HMN) Framework outlines key elements of a functional HIS, such as system resources, indicators, data sources, and mechanisms for data use (WHO, 2008b)**.** However, standardized methods to assess HIS performance and data quality remain limited (WHO, 2008a)

To address this, MEASURE Evaluation (2018) proposed four key tools including Semi-Structured Interview Guide, the Self-Assessment Survey, the Group Assessment Tool, and the Site Visit Checklist to evaluate and enhance data use across health systems, fostering evidence-based decision-making (MEASURE Evaluation, 2018b).

A vital subcomponent of HIS is the Logistics Management Information System, which supports the management of health commodities supply chain system. Although general HIS performance frameworks exist, a standardized and comprehensive framework for evaluating LMIS remains underdeveloped. Currently, widely used tools for LMIS evaluation include the Logistics Indicators Assessment Tool (LIAT) and the Logistics System Assessment Tool (LSAT), developed by the USAID (USAID Deliver Project, 2008, 2011). Although Ethiopia has recently developed a monitoring and evaluation framework for its supply chain system, it does not include a specific framework for evaluating the performance of the LMIS. As a result, LMIS performance assessment remains unsupported by a standardized, guiding framework across the healthcare system (FMOH, 2019).

Evaluating the performance of the LMIS is essential for effective medical supply management and informed decision-making. Common performance indicators include system availability, data quality (accuracy, completeness, timeliness, consistency, and validity), reporting rates, user satisfaction, and the adequacy of training and supervision (Greenwell and Salentine, 2018; MEASURE Evaluation, 2018b). These indicators provide critical insights into LMIS functionality and its contribution to the broader health system.

Multiple studies have highlighted various factors that influence LMIS performance; facility-related issues, such as inadequate infrastructure and insufficient resources (Dowling, 2017; EPSA, 2019; Alemu *et al.*, 2021); personnel-related challenges, including limited training, low motivation, skill gaps, resistance to change, and high staff turnover (Yadav, 2015b; Nigusie, 2017; Tiye and Gudeta, 2018; Tefera, Yihunie and Bekele, 2021); the technical design, usability, reliability, and data quality of the LMIS (Taddesse, 2015) (PATH, 2010; PFSA, 2015; Taddesse, 2015; Damtie, Ibrahim and Yikna, 2020; Bekele and Anbessa, 2021); organizational support, effective supply chain coordination, and strong implementation strategies are essential for maintaining LMIS functionality (FMOH, 2024b).

Despite the importance of LMIS in supporting supply chain management and public health outcomes, no comprehensive conceptual framework exists for evaluating LMIS performance in health facilities. Therefore, beyond assessing existing systems, there is an urgent need to standardize performance evaluation tools and develop a robust framework tailored to LMIS. This will enable consistent assessments, benchmarking, and long-term improvements in health commodity management systems.

2.9. Theoretical Framework

Several theoretical frameworks are suitable to underpin the investigation, especially considering its concurrent mixed-methods design and emphasis on both system performance and model development of this study. The following frameworks provide relevant lenses through which the various dimensions of LMIS performance can be assessed and interpreted.

2.9.1. Health System Framework

Understanding the performance of LMIS within health systems requires a comprehensive and systemic perspective, particularly one grounded in the WHIO health system framework. This framework outlines six essential building blocks including service delivery, health workforce, health information systems, medical products and technologies, leadership and governance, and health financing (WHO, 2010). These interdependent components offer a structured lens through which to analyze how the broader health system context affects LMIS performance and, ultimately, health service outcomes. In LMICs, the functionality and effectiveness of LMIS are deeply influenced by the strength and integration of these six building blocks (Ummah, 2019; FMOH, 2020b). Effective LMIS implementation relies on adequately trained health personnel, robust and interoperable information infrastructure, sound governance mechanisms, and sustainable financing arrangements (Murray and Frenk, 2000; Manyazewal, 2017; WHO, 2021b). This interdependence underscores that LMIS strengthening should not be approached as a standalone intervention. Rather, it should be embedded within a holistic strategy that considers the mutual reinforcement among the health system’s building blocks (FMOH, 2024b; Piquer-Martinez *et al.*, 2024).

2.9.2. Information Systems Success Model (DeLone & McLean)

The DeLone and McLean Information Systems Success Model (1992, updated in 2003) provides a comprehensive framework for evaluating the performance and effectiveness of information systems, including LMIS. The model delineates six interrelated success dimensions including system quality, information quality, service quality, use, user satisfaction, and net benefits (DeLone and McLean, 2003). The success of LMIS can be assessed using six key dimensions, including system quality (ease of use, reliability, and infrastructure), information quality (data accuracy, completeness, and relevance), service quality (technical support and supervision), user engagement (use or intention to use), user satisfaction (perceived usability and usefulness), and net benefits (improved inventory management and reduced stockouts), all of which serve as indicators of the overall effectiveness of the system (Adams, Nelson and Todd, 1992; DeLone and McLean, 2003; Petter, DeLone and McLean, 2008). The DeLone and McLean model provides a comprehensive framework for evaluating LMIS performance by linking system quality, data accuracy, user satisfaction, and perceived benefits. It supports a context-sensitive, pragmatic, mixed-methods approach to identify gaps and guide interventions, helping to explain what works, why, and under what conditions within the diverse settings of health facilities (Delone and Mclean, 2003; Petter, DeLone and McLean, 2008; Piquer-Martinez *et al.*, 2024).

2.9.3. Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM), developed by Davis (1989), is a theoretical framework that explains how users accept and use new technologies, focusing on two key factors: perceived usefulness (PU) and perceived ease of use (PEOU) (Davis, 1989). Perceived usefulness is the extent to which a user believes that using a system will improve their job performance, while perceived ease of use refers to the degree to which the user expects the system to be effortless to use (Kalayou, Endehabtu and Tilahun, 2020; Zhu *et al.*, 2025)

TAM is instrumental in evaluating user satisfaction, system functionality, and usage frequency, particularly by examining how perceived usefulness and ease of use influence digital LMIS adoption. It also accounts for external variables like organizational support and user technical competence, which shape these perceptions. TAM thus aids in identifying behavioral factors that affect system uptake and continuity, informing improvements in usability, training, and design (Davis, 1989; Khafit and Puspaningtyas, 2021). In this study, TAM is used to assess health supply chain professionals' acceptance of digital LMIS platforms like Dagu 1.0 and 2.0, based on perceived benefits (e.g., improved inventory control and reporting) and system user-friendliness (Rahimi *et al.*, 2018; Khafit and Puspaningtyas, 2021).

2.9.4. Grounded Theory Analysis

Grounded Theory, as introduced by Glaser and Strauss (1967), served as the central methodological and analytical framework guiding the development of the conceptual model. This inductive and iterative approach enabled the construction of theory directly from stakeholder narratives, ensuring both contextual relevance and empirical grounding (Glaser, B. G., Strauss, 1967; Corbin and Strauss, 2008). To support theory construction at a higher analytical level, Strauss and Corbin (1990) introduced the coding paradigm, a structured analytical tool that examines the relationships among causal conditions, context, intervening conditions, action/interaction strategies, and consequences, thereby facilitating a deeper understanding of the core phenomenon (Corbin and Strauss, 2015; Vollstedt and Rezat, 2019). Additionally, the Gioia methodology was used to visually structure the data, enhancing analytical rigor and transparency in tracing how raw data evolved into theoretical constructs (Gioia, Corley and Hamilton, 2013). Although traditional Grounded Theory favors theoretical sampling and iterative data collection, this study effectively adapted the approach through transparent reflexivity, re-analysis of existing data, and the use of secondary sources to ensure conceptual richness and theoretical saturation (Corbin and Strauss, 2015). These strategies contributed to the development of a grounded, context-specific conceptual model for evaluating LMIS performance.

2.10. Conceptual Framework

The conceptual framework for this study was developed through an extensive literature review and focuses on key factors affecting LMIS performance in public health facilities. The conceptual framework for this study identifies four interrelated domains influencing LMIS performance.~~It comprises four domains~~: (1) health system-related factors (e.g., structure, workforce, training, leadership), (2) LMIS functional requirements (e.g., stock management, data reporting), (3) data quality dimensions (e.g., accuracy, timeliness), and (4) ICT-related features (e.g., system integration, sustainability). ~~These elements collectively inform the evaluation and improvement of LMIS performance in public health facilities~~ These dimensions systematically informed the development of research questions, selection of variables, and data collection tools for the intended objectives aimed at assessing the performance evaluation of LMIS in health facilities. For the development of the conceptual model, although this framework guided tool development, an additional framework, the coding paradigm was also considered to inform the qualitative data analysis framework (Figure 9).

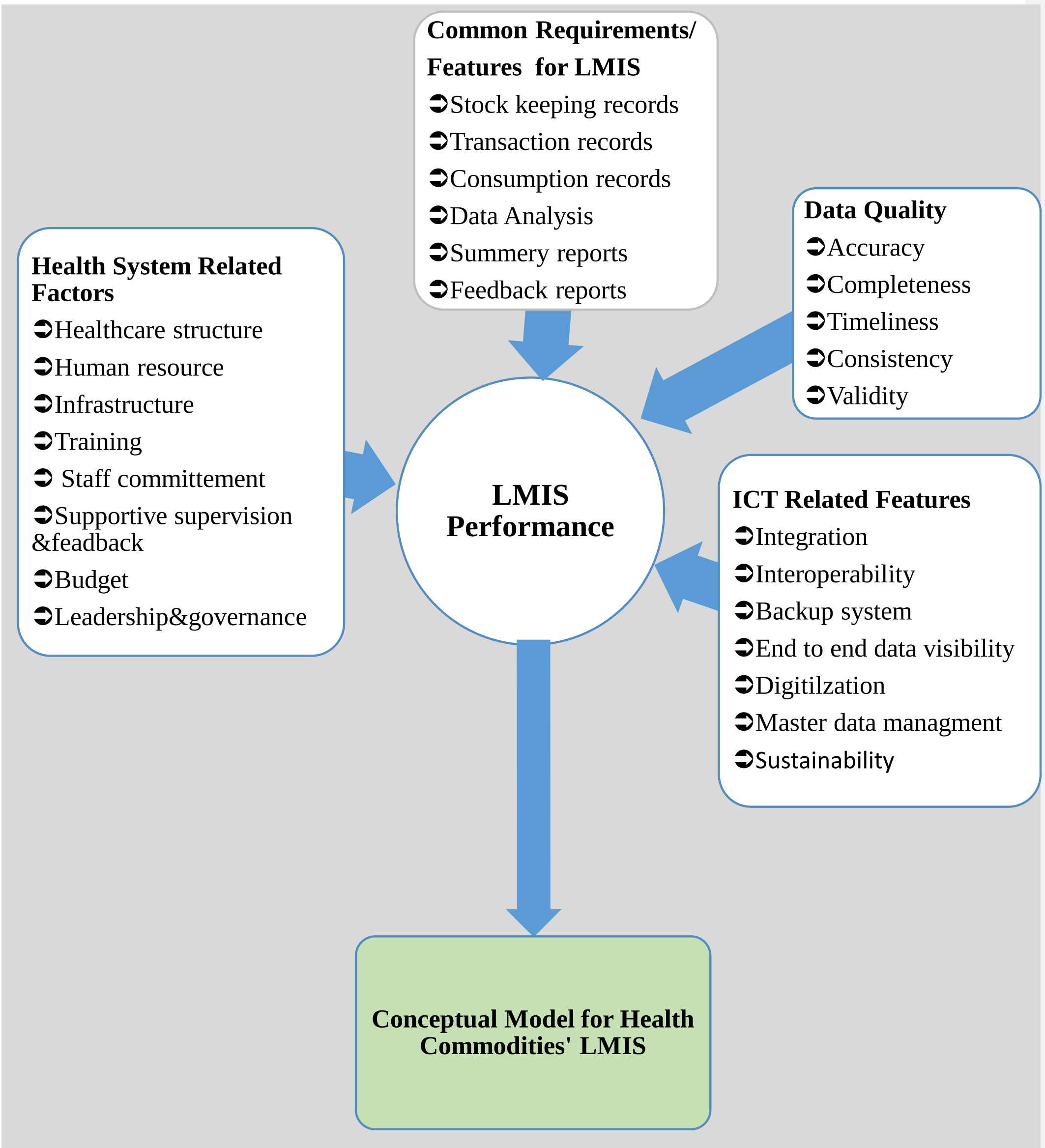

Figure 9:Conceptual framework for LMIS performance and conceptual model development

Chapter Three: Objectives and Research Questions

3.1. General Objective

- To conduct a performance evaluation and develop a conceptual model for the Health Commodities Logistics Management Information System (LMIS) in public health facilities of the Amhara region

3.2. Specific Objectives

- To assess the current status of health commodities' logistics management information system in the public health facilities of Amhara region
- To identify the strengths and weaknesses of health commodities' logistics management information systems implemented in the Public Health System of Amhara region
- To evaluate the Vaccines Logistics Management Information System at Public Health Facilities in Amhara Region
- To evaluate the performance of Digital Logistics Management Information System (eLMIS) Performance at Public Health Facilities of Amhara Region, Ethiopia
- To evaluate the requirements and features of health commodities logistics management information system tools used in public health facilities of the Amhara region.
- To develop a conceptual model for health commodities' logistics management information system performance in public health facilities of Amhara region

3.3. Research Questions

This research project aims to evaluate the existing health commodities' logistics management information systems implemented in the public health facilities of Amhara Region. Besides, a conceptual model will be developed based on the findings. To achieve the aim of this study, the following research questions are defined;

- What is the current status of the health commodities' Logistics Management Information System (LMIS) in public health facilities of the Amhara Region?
- What operational strengths and functional gaps exist in the logistics management information systems implemented in public health facilities of the Amhara Region?

- How is the Vaccines Logistics Management Information System (VLMIS) performing in public health facilities of the Amhara Region?
- What is the level of performance of the Digital Logistics Management Information System (eLMIS) in public health facilities of the Amhara Region?
- What are the system requirements, user needs, and key functional features of the logistics management information system tools used in public health facilities of the Amhara Region?
- What conceptual model can be developed to enhance the performance of health commodities' LMIS in public health facilities of the Amhara Region?

Chapter Four: Methodology

4.1. Philosophical Assumption

Philosophical assumptions provide the foundation for research by shaping how reality is understood (ontology), how knowledge is acquired (epistemology), the role of values (axiology), and the methodological choices that follow (Creswell and Poth, 2018). These assumptions influence every aspect of a study, from research design to data interpretation. In evaluating the performance of the LMIS and developing a conceptual model, this study adopts a pragmatic paradigm, integrating elements of positivism, constructivism, and critical theory to effectively address a complex, real-world problem.

Ontologically, the study embraces a pluralistic view of reality. From a positivist stance, LMIS performance metrics such as inventory accuracy, reporting rates, and stock-out frequencies are treated as objective realities that can be measured quantitatively (Guba and Lincoln, 1994). Simultaneously, constructivist ontology is acknowledged, recognizing that health supply chain professionals' experiences, perceptions, and contextual factors such as institutional culture and resource constraints shape how the LMIS operates in practice (Schwartz-Shea and Yanow, 2012). This dual ontological stance is essential to capture both the tangible and intangible elements influencing LMIS performance.

Epistemologically, the study values both empirical measurement and interpretive understanding. Positivist epistemology supports the use of structured instruments and statistical tools to collect verifiable data (Creswell, 2003, 2007), while interpretivism guides the exploration of subjective experiences and social contexts through qualitative interviews (Denzin and Lincoln, 2004). Additionally, a critical epistemological lens draws attention to issues systemic barriers that may influence LMIS performance, especially in low-resource settings (Kincheloe and Mclaren, 2011). This blended approach ensures that knowledge generated is not only accurate and reliable but also socially and contextually informed.

Axiologically, the research acknowledges the role of values in the research inquiry process. While quantitative approaches strive for objectivity, qualitative methods recognize that the researcher's background, engagement with participants, and contextual understanding inevitably influence data interpretation (Creswell and Poth, 2018). A value-laden perspective, therefore, enhances reflexivity and ethical sensitivity in the research process, particularly when approaching the experts in health supply chain in the respective health facilities.

Methodologically, the study employs a concurrent mixed-methods design, reflecting its pragmatic orientation. Quantitative methods provide structured evaluation of system performance using measurable indicators, while qualitative methods, particularly grounded theory support an in-depth investigation into the operational and contextual realities affecting LMIS implementation (Creswell, 2003; Corbin J and Strauss A, 2015). Grounded theory, originally developed by Glaser and Strauss (1967), is a systematic and iterative approach to building theory from qualitative data. Though it has evolved across positivist, post-positivist, and constructivist paradigms (Charmaz, 2015), it remains a powerful tool for conceptual model development in complex systems (Qureshi and Ünlü, 2020).

Given the dual focus of this study on quantitatively evaluating LMIS performance and qualitatively developing a conceptual model, the pragmatic paradigm emerges as the most appropriate philosophical foundation. Pragmatism is not confined to any single philosophical tradition; instead, it emphasizes practical solutions and methodological flexibility to effectively address complex research problems (Tashakkori and Charles, 1998; Creswell and Clark, 2011; Shrestha and Giri, 2021). This approach supports methodological pluralism, enabling the integration of structured surveys to assess LMIS performance alongside grounded theory-based interviews that explore system challenges and user experiences (Johnson and Onwuegbuzie, 2004).

Pragmatism accommodates both objective measurement and subjective interpretation, making it particularly suitable for research that seeks to produce actionable and context-sensitive insights (Morgan, 2007). Although positivism, post-positivism, and constructivism each offer valuable perspectives, pragmatism is the most suitable philosophical approach for this study as it focuses on practical, evidence-based solutions to improve LMIS performance. It bridges theory and practice, enabling contextually relevant interventions that support sustainable health system improvements (Biesta, 2015; Patton, 2015, 2023).

4.2. Methods

4.2.1. Study Area

Ethiopia, the second most populous country in Africa and the 12th in the world, is administratively divided into 12 regional states and two city administrations. This study was conducted in the Amhara National Regional State, the second most populous region in the country, from March 1-31, 2022. The region lies in the northwestern part of Ethiopia, with Bahir Dar, its capital city, located approximately 565 kilometers from Addis Ababa.

Administratively, Amhara is subdivided into 12 zones (Awi, West Gojjam, East Gojjam, South Gondar, West Gondar, Central Gondar, North Gondar, Oromiya Special Zone, South Wollo, North Wollo, North Shewa, and Waghimera), three city administrations (Bahir Dar, Dessie, and Gondar), and 166 woredas (districts). As of 2021, the region had a total of 5,775 functional health facilities, including 87 public hospitals, 873 public health centers, 3,565 health posts, six private hospitals, and 1,244 private clinics.

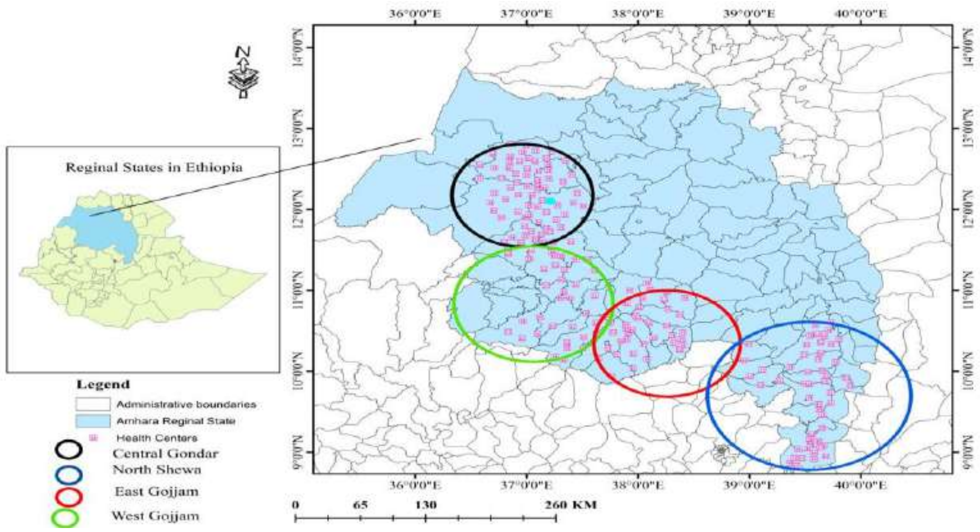

Figure 10: Map of selected public health facilities for the study in Amhara Region, March 2022

The Amhara Region was purposefully selected for this study due to its pioneering role in the implementation of key pharmacy service and health supply chain initiatives. It was the first region in Ethiopia to introduce and incubate services such as Auditable Pharmaceutical Transactions and Services (APTS), Clinical Pharmacy Services, and Drug Information Services. Furthermore, major supply chain management systems including the Integrated Pharmaceutical Logistics System (IPLS), the Health Commodity Management Information System (HCMIS), and mBrana (electronic LMIS) were implemented in the region during the first phase of national implementation.

These early and comprehensive implementations of various LMIS-related packages make the Amhara Region an ideal study area for evaluating the Logistics Management Information System. The evaluation of LMIS in this region will provide valuable insights that can inform the development of a conceptual model, grounded in a comprehensive understanding of system performance and the identification of both best practices and operational challenges. Given the maturity of its health programs and its strategic importance, the study in this region will offer valuable insights into the performance, successes, and challenges of LMIS, especially in resource-intensive evaluations where nationwide coverage is not feasible. Moreover, the findings will support system improvements in other regions which are at the early stage of LMIS implementation. This approach is strongly recommended in program and system evaluations, particularly when planning to scale up or improve similar systems at the national level (Papanicolas I, Rajan D, Karanikolos M, Soucat A, 2022).

The health commodities supply system and distribution in the region are managed through four Ethiopian Pharmaceutical Supply Service hubs: Bahir Dar Hub, Gondar Hub, Dessie Hub, and Addis Ababa Branch 2 Hub. However, health facilities supplied by the Dessie Hub were excluded from the study, as the majority of these facilities were destroyed during the northern conflict.

According to the 2020 national health workforce update by the Federal Ministry of Health (FMOH), the region had a total of 61,477 health professionals. This includes 11,154 nurses, 8,781 health extension workers, 4,212 pharmacy professionals, 3,365 health officers, 2,815 laboratory professionals, 1,710 physicians, 1,073 health IT professionals, 356 anesthesia professionals, and 155 biomedical professionals (FMOH, 2020c)

4.2.2.Study design

This study employed an institution-based concurrent mixed-exploratory methods design, conducted in the Amhara National Regional State, Ethiopia. Both quantitative and qualitative data were collected simultaneously to provide a comprehensive understanding of the LMIS performance. While the data collection occurred concurrently, the qualitative component followed a grounded theory approach, utilizing in-depth interviews to inform the development of a conceptual model (Glaser, B. G., Strauss, 1967).

4.2.3. Source population

The source population for this study includes all public health facilities in the Amhara Region, health professionals involved in managing health commodities supply chains, and all manual and digital LMIS platforms implemented in the region. The quantitative survey targeted pharmacy heads, supply chain coordinators and officers, outpatient pharmacy coordinators, store managers, and cold chain logistics managers.

For the qualitative component, a purposive sampling approach was used to selected individuals in key leadership and supply chain coordination roles, including health facility heads, medical directors, chief executive officers, pharmacy heads, store managers, and supply chain coordinators from woreda health offices. This was intended to capture critical insights into the challenges, perceptions, and effective practices influencing LMIS performance and overall supply chain efficiency, ultimately informing the development of a conceptual model to strengthen the health commodities supply chain system.

4.2.4. Study Population

The study population included selected public health facilities in the Amhara region and health professionals involved in managing the health commodities supply chain system within these facilities. Participants comprised pharmacy heads, supply chain coordinators, supply chain

Formatted: Space Before: 0 pt, After: 8 pt officers, store managers, outpatient pharmacy coordinators, and EPI focal persons responsible for vaccine management. Manual and digital Logistics Management Information System platforms implemented across multiple zones were also considered. Additionally, individuals in leadership and decision-making roles such as health facility heads, medical directors, chief executive officers, and supply chain management coordinators from woreda health offices were included to provide broader insights to the LMIS performance. The participants for both the qualitative and quantitative surveys were selected based on their day-to-day involvement in supply chain management, LMIS-related activities, and decision-making processes. However, professionals involved in patient care, immunization, and dispensing were not included, as their primary focus is on patient-related services rather than supply chain operations.

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4.2.5. Sampling Procedure

For this study, public health facilities across all zonal administrations were considered for sampling, except those located in areas with significant security concerns. Specifically, six zonal administrations were excluded from the study for two primary reasons. First, the majority of health facilities in Waghimra, North Wollo, South Wollo, and the Oromia Special Zone had been severely damaged due to conflict, resulting damage to LMIS documentation and the looting of health commodities in health facilities. Second, ongoing security issues in West Gondar, North Gondar, Waghimra, and North Wollo Zones made data collection infeasible during the study period. Despite partial damage to some facilities, North Shewa and South Gondar Zones were included in the final sampling process.

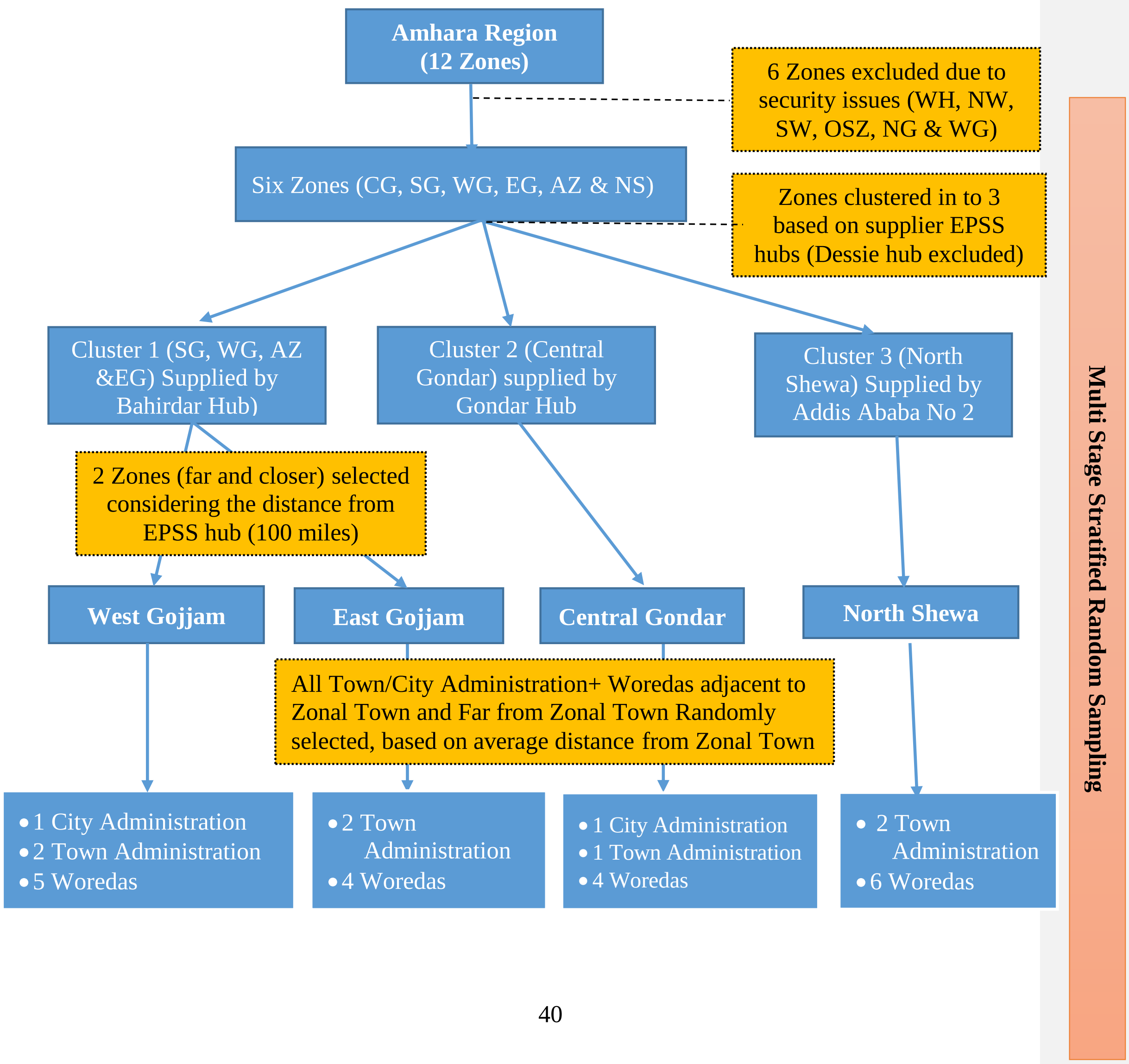
To select the health facilities for the study, a multi-stage stratified random sampling method was employed, using proportional allocation based on the number of facilities. Initially, public health facilities were stratified by zone and categorized by level of facilities, which included referral hospitals, general hospitals, primary hospitals, and health centers. Health Posts were excluded for two key reasons: they handle only a limited range of tracer medicines and do not use the standard LMIS platforms implemented in higher-level facilities. Instead, Health Posts rely on a single reporting format, the Health Post Monthly Reporting and Requisition Form (HPMRR), which is submitted to the corresponding Health Centers for reporting and resupply.

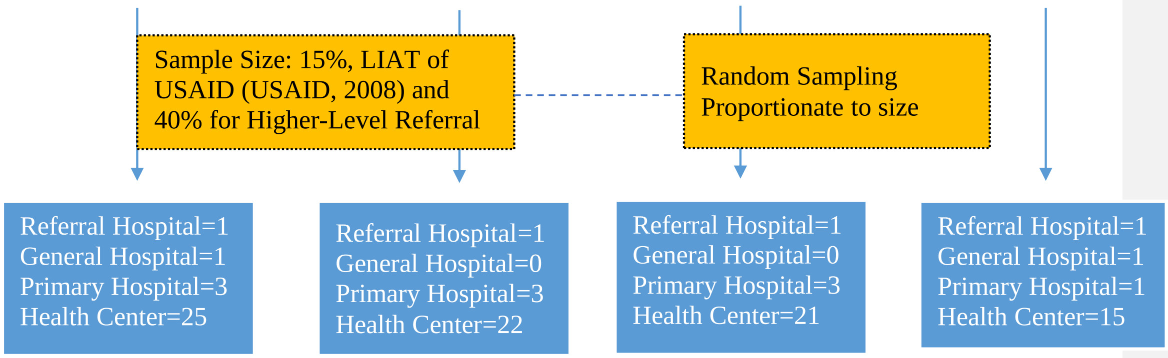
The six selected zones were further grouped into three clusters based on the Ethiopian Pharmaceutical Supply Service (EPSS) hubs responsible for supplying health commodities:

- **Cluster 1**: Central Gondar (supplied by the Gondar hub)
- **Cluster 2**: South Gondar, East Gojjam, Awi Zone, and West Gojjam (supplied by the Bahir Dar hub)
- **Cluster 3**: North Shewa (supplied by Addis Ababa hub 2 and the Dessie hub)

Both Zones from Cluster 1 and Cluster 3 were automatically included in the study. From Cluster 2, two zones were selected based on distance from the Bahir Dar hub, as distance is a key factor influencing supply chain efficiency and LMIS performance. Facilities in South Gondar, Awi Zone, and some parts of West Gojjam are situated at an average distance of around 100 miles from the hub, whereas facilities in East Gojjam are located more than 100 miles away. Therefore, West Gojjam (the closest) and East Gojjam (the farthest) were selected to ensure variation in geographic accessibility. In each of the selected zones, woredas were stratified based on their distance from the zonal town administration. To capture logistical and geographic variations, the nearest and farthest woredas were selected from each zone, based on their average distance from the zonal town administration. Facilities in Bahir Dar and Gondar city administrations were included in the surrounding catchment zones for stratification purposes. However, Dessie city administration and the Dessie hub were excluded due to extensive damage of health facilities and the hub.

Following the USAID Logistics Indicators Assessment Tool (LIAT) recommendation for pharmaceutical logistics assessments, 15% of eligible facilities were selected for inclusion in the study (USAID | DELIVER PROJECT, 2008). Sample sizes for each zone and woreda were allocated proportionally, and health facilities were randomly selected within each woreda using the Research Randomizer online tool. In cases where the calculated sample size resulted in a fractional value, the number was rounded up to the nearest whole number. Finally, a total of 102 facilities were selected, comprising 5 referral hospitals, 4 general hospitals, 10 primary hospitals, and 83 health centers.


Amhara Region
(12 Zones)
6 Zones excluded due to security issues (WH, NW, SW, OSZ, NG & WG)
Six Zones (CG, SG, WG, EG, AZ & NS)
Zones clustered in to 3 based on supplier EPSS hubs (Dessie hub excluded)
Cluster 1 (SG, WG, AZ &EG) Supplied by Bahirdar Hub)
Cluster 2 (Central Gondar) supplied by Gondar Hub
Cluster 3 (North Shewa) Supplied by Addis Ababa No 2
2 Zones (far and closer) selected considering the distance from EPSS hub (100 miles)
West Gojjam
East Gojjam
Central Gondar
North Shewa
All Town/City Administration+ Woredas adjacent to Zonal Town and Far from Zonal Town Randomly selected, based on average distance from Zonal Town
1 City Administration
2 Town Administration
5 Woredas
2 Town Administration
4 Woredas
1 City Administration
1 Town Administration
4 Woredas
2 Town Administration
6 Woredas
Multi Stage Stratified Random Sampling



***WH-Wagihimara, NW-Zorth Wollo, SW-South Wollo, OSZ-Oromia Special Zone, NG-North Gondar, SW-West Gondar. AZ-Awi Zone, SG-South Gondar**

Figure 11:Multi-Stage Stratified Sampling of Health facilities for the study

A full census was conducted of all health professionals engaged in the management of health commodities and LMIS for the quantitative, interviewer-administered survey. These professionals included pharmacy coordinators, supply chain officers, outpatient pharmacy coordinators, store managers, and focal persons for the Expanded Program on Immunization (EPI) or cold chain officers. For the qualitative in-depth interviews, participants included medical directors, health center heads, pharmacy heads, chief executive officers, and woreda-level health supply chain coordinators.

4.2.6.Inclusion and Exclusion Criteria

4.2.6.1.Inclusion Criteria

- All Zonal Administrations
- All public health facilities that have been functional for more than one year
- All health professionals related with health supply chain management system in the facility and Woreda Health Office
- All Manual/digital logistics management information systems implemented in more than one Zonal Administrations

4.2.6.2.Exclusion Criteria

- Health facilities located in conflict-affected areas or those with security issues during the study period

- Health Posts
- Manual and digital information management tools used for services other than health commodities
- Participants who were not accessible at the time of the survey

4.2.7.Data Collection Methods

4.2.7.1. Data Collection Tools

For quantitative data collection, various data abstraction checklists and interviewer-administered questionnaires were utilized. These tools were adapted from the Logistics Indicator Assessment Tool (LIAT) and the Logistics System Assessment Tool (LSAT) developed by USAID, the Federal Ministry of Health's Supply Chain Monitoring and Evaluation Framework, the Amhara Regional Health Bureau's supportive supervision checklist, and other relevant literature sources (Annex 1-VI) (USAID Deliver Project, 2008, 2011; FMOH, 2019). For qualitative data collection, guiding questions with probing points were employed to conduct in-depth interviews with key informants (Annex-VII).

4.2.7.2.Data Collectors

A total of 12 pharmacists were recruited for data collection. These included postgraduate students in Health Supply Chain Management at Addis Ababa University, lecturers from various universities, and health system experts holding a master's degree. To ensure familiarity with the data collection tools, a two-day intensive training was provided by the principal investigator and the primary supervisor of the project. The overall data collection process was coordinated by the principal investigator, in collaboration with a senior public health expert and PhD student familiar with the health system in the study area, under the overall supervision of the primary supervisor. Key informant interviews were conducted by the principal investigator and data collectors with prior experience in qualitative research.

4.2.8.Data Collection Procedures

Data collection procedure employed a combination of structured data abstraction checklists, interviewer-administered questionnaires, observations, and in-depth interviews. Quantitative data were gathered through document reviews, structured interviews, and physical observations conducted by well-trained and experienced data collectors. Responsible personnel in each department assisted in identifying and locating relevant documents. Data were extracted from various LMIS recording tools, including Bin card, stock recording card, Model 19/H, Model 22/H, RRF, IFRR, HPMRR, vaccine ledger books, VRF reports, quarterly monitoring and evaluation reports, and vaccine temperature recording chart ~~and other relevant LMIS tools~~. The other LMIS tools were checked only for the physical availability and utilization. In addition, physical counts of selected vaccines in refrigerators and tracer medicines on store shelves were conducted to assess inventory accuracy.

For interviewer-administered data collection, a structured questionnaire comprising closed-ended, partially open-ended, and Likert-scale items was used. The questionnaire was structured into distinct sections, each tailored to engage experts based on their specific roles and responsibilities related to overall LMIS performance, vaccine-specific LMIS, and digital LMIS.

For qualitative data collection, open-ended guiding questions with probing points were used in in-depth interviews with key informants. Grounded in a theoretical sampling approach, these interviews began with broader questions on supply chain performance and progressively focused on the Logistics Management Information System (LMIS), exploring its strengths, weaknesses, challenges, and opportunities for improvement. The English version of the data abstraction and questionnaire were utilized for quantitative data collection, while the Amharic version was employed for qualitative data collection. All interviews were audio-recorded with participants' consent to ensure the accuracy and depth of the qualitative data collected.

4.2.9. Data Quality Assurance

To ensure the validity and reliability of the data, a rigorous quality assurance process was implemented. A data triangulation technique was employed, incorporating multiple sources and methods, including document reviews, structured observations, interviews, and in-depth qualitative interviews to enhance the credibility of the findings. Data collection tools were adapted from both national and international reputable sources. These tools were face-validated by ten experts in the field and pre-tested in three health facilities (one hospital and two health centers). Feedback from the pre-test was used to make necessary amendments, improving clarity, relevance, and internal consistency. Moreover, based on pre-test findings, the data collection method was modified from self-administered to interviewer-administered to further enhance data quality.

Additionally, reliability and validity tests were conducted, yielding strong Cronbach's alpha values across various sections of the questionnaires (0.755, 0.861, 0.950, 0.987, and 0.963), all of which indicate acceptable internal consistency. Data collectors participated in a comprehensive two-day training to ensure standardized and consistent administration of the tools. The study adhered to the STROBE guidelines for observational study design, as outlined by the EQUATOR Network (Elm et al., 2008).

During the initial days of fieldwork, supervisors reviewed audio recordings of the interviews and provided feedback to interviewers, focusing on refining their probing techniques and improving consistency. The interviews followed a theoretical sampling approach, were audio-recorded with participants' consent, and subsequently transcribed. Transcripts were shared with selected participants for verification to ensure the accurate representation of their views. In addition, expert validation was carried out throughout each step of the qualitative data analysis using MAXQDA software. An experienced researcher, co-investigator of this study reviewed the coding process, category development, and emerging themes to ensure consistency, credibility, and alignment with the study objectives

4.2.10. Reflexivity

The principal investigator, a pharmacist with experience at both federal and facility levels of the healthcare system, led the study. The interview team consisted of pharmacists with extensive health system experience and at least a master's degree in health supply chain management or related fields. All interviewers possessed in-depth knowledge of LMIS implementation challenges. Aware of the potential for bias in qualitative research, the team engaged in reflexivity by critically examining their own experiences, assumptions, and professional backgrounds. Prior to data collection, they discussed their roles to ensure clarity and transparency. This reflexive approach aimed to minimize unconscious bias and maintain the authenticity of participants'

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responses. The principal investigator conducted transcription, coding, and analysis, approaching the data with openness to ensure the findings reflected the lived experiences of key informants rather than personal preconceptions.

~~4.2.10.~~4.2.11. Data Analysis, Interpretation and Dissemination

The quantitative data were first reviewed for completeness and internal consistency. Then, the data were entered into Epi Info Version 7 for initial processing and exported to SPSS Version 23.0 for enhanced data management and analysis. The data underwent cleaning, with variables sorted and any missing entries cross-checked. Descriptive statistics were summarized using tables and graphs, and bivariate analysis was conducted for selected variables. A p-value of <0.05 was considered indicative of a statistically significant association.

The qualitative data were carefully reviewed, and the audio recordings of the interviews were systematically coded. Following this, the recordings were transcribed into English to ensure accuracy and consistency. The resulting transcripts were then imported into MAXQDA (version 24.4.1), a software tool for computer-assisted qualitative and mixed methods data analysis (Rädiker, 2023). The qualitative analysis followed a grounded theory approach, beginning with open coding, followed by axial coding to explore patterns and relationships among the identified codes. The final step, selective coding, involved systematically relating these categories and refining them into a conceptual model.

The grounded theory analysis followed an iterative process of coding, with continuous comparison and refinement of categories. This approach allowed for the identification of factors influencing LMIS performance and supported the development of a comprehensive conceptual model for public health facilities. The analysis ensured that all relevant data were considered, guided by the "all is data" principle, which treats any information encountered during the study as potentially relevant.~~ The sample size of 83 participants aligned with Creswell's (2007) recommendations (Creswell, 2007)~~. Although data collection occurred at a single time point without iterative rounds, theoretical saturation was pursued by maximizing the sample size and monitoring for the emergence of new concepts. Eighty-three participants were interviewed, exceeding Creswell’s (2007) and Khan’s (2014) recommended sample ranges. In the absence of iterative interviews, capturing rich, in-depth data during a single interaction was critical (Birks and Mills, 2011; Corbin and Strauss, 2015). Although no new insights emerged beyond the transcripts of 50 participants, the larger sample enabled the identification of well-represented concepts articulated from diverse perspectives as well as enrich the contextual depth. A data structure was used to visualize the identified categories, illustrating the progression from raw data to categories, an essential element in demonstrating rigor in qualitative research. This method of analysis adhered to Strauss and Corbin's (1990) coding paradigm, providing a structured framework for examining relationships between categories and concepts (Corbin J and Strauss A, 2015). By systematically linking causal conditions, context, intervening conditions, action/interaction strategies, and consequences, this approach enhanced the depth and precision of the conceptual model.

~~4.2.11.~~4.2.12. Ethical Consideration

The research proposal was reviewed and approved by the Ethical Review Committee of the School of Pharmacy (Protocol No: ERB/SOP/399/14/2022), and subsequently by the Institutional Review Board of the College of Health Sciences, Addis Ababa University (Protocol No: 007/22/SoP). Following IRB approval, a formal letter was issued by the Department of Pharmaceutics and Social Pharmacy to the Amhara Public Health Institute to obtain ethical clearance from the regional research ethics review board. Upon receiving regional approval, permission letters were obtained from the Amhara Public Health Institute to conduct the study in the respective Zones, Woredas, and Health Facilities. Support letters were also issued to the Zonal Health Departments, followed by the respective Woreda Health Offices, to facilitate the conduct of the research in public health facilities (Annex VIII).

The purpose of the study was clearly explained to all participants. Verbal informed consent was obtained after participants fully understood the information provided. All interviews and discussions were audio-recorded with participants' permission. To ensure confidentiality, no individual identifiers were included in the data collection, and all data were analyzed in aggregate. Additionally, qualitative findings from key informant interviews were shared with some of the respective participants for validation and approval.

Chapter Five: Key Findings

5.1 Introduction

The results are organized into several sections: Section 5.2 provides general information about the surveyed health facilities and key respondents; Section 5.3 discusses LMIS-related infrastructure and initiatives, including physical resources and supply chain activities; Section 5.4 addresses LMIS reporting and feedback mechanisms; Section 5.5 evaluates LMIS data quality, focusing on inventory and reporting accuracy; Section 5.6 assesses Vaccine LMIS (vLMIS) performance, infrastructure, and data management; Section 5.7 examines Digital LMIS (eLMIS) implementation, usage, and user perceptions; Section 5.8 evaluates LMIS tools features and system requirements, highlighting usability and integration issues; and Section 5.9 presents a conceptual model illustrating how systemic, contextual, and operational factors influence LMIS and supply chain performance, emphasizing areas for targeted improvement.

5.2 General Information

A total of 102 health facilities were included in the LMIS performance assessment. Of these, 96 EPI focal persons participated in the evaluation of vaccine-related LMIS, 150 supply chain experts assessed the features and requirements of LMIS tools, 27 end users participated in the digital LMIS evaluation, and 83 key informants were interviewed for the development of a conceptual model.

5.2.1. Overview of Surveyed Health Facilities

A total of 102 public health facilities were surveyed in this study, with 58.8% situated in rural areas. The majority of these were health centers (84.3%), followed by primary hospitals (9.8%). ~~(Figure 9).~~

The facilities were spread across four zonal administrations: West Gojjam (29.4%), East Gojjam (25.5%), North Shewa (23.5%), and Central Gondar (21.6%). The study covered 19 rural woredas and 9 urban (city and town) administrations. On average, the surveyed facilities were located 11.98 ± 9.56 kilometers from the woreda town and 63.13 ± 60.7 kilometers from the zonal town. The mean distance from the regional capital was 149.58 ± 146 kilometers, while the average distance from the Ethiopian Pharmaceutical Supply Service (EPSS) hub was 96.6 ± 82.5 kilometers. The average duration of service of these facilities was 19.4 ± 16.9 years. Each facility was linked, on average, to 4.9 ± 2.07 lower-level health facilities through the referral system

5.2.2. Profile of EPI Focal Persons

Out of the 102 public health facilities included in the study, VLMIS data were collected from 99 facilities. Two facilities had not yet initiated EPI services, and one had suspended services after being converted into a COVID-19 treatment center. Among the 99 facilities assessed for VLMIS performance, 98 had designated EPI focal persons responsible for managing the vaccine supply chain. A total of 96 EPI focal persons were interviewed. The mean age of respondents was 28.97 ± 4.21 years. More than half were female nurses 51 (53.1%). Regarding academic qualifications, 36 (37.5%) held bachelor's degrees, while 60 (62.5%) held diplomas. On average, respondents had 6.9 ± 4.03 years of overall professional experience, including 2.1 ± 1.54 years specifically serving as EPI focal persons. Their mean experience in other pharmaceutical supply chain-related activities was 0.3 ± 0.87 years.

5.2.3. Profile of Digital LMIS End Users

Out of the 102 public health facilities included in the study, only 37 had implemented a digital Logistics Management Information System (LMIS). With the exception of four facilities, 33 (89.2%) were located in urban areas. Among these, 16 (43.2%) had installed Dagu 1.0, while the remaining 21 (56.8%) had installed Dagu 2.0. Of the 37 facilities that implemented the eLMIS, only 27 eligible eLMIS end users were available and interviewed using an interviewer-administered questionnaire. Two-thirds of the respondents were male, and all were pharmacy professionals. The majority held bachelor's degrees (66.7%), while the remaining respondents were diploma holders.

5.2.4. Profile of Experts for LMIS tools Evaluation

A total of 150 healthcare professionals were included in the evaluation of LMIS tools, revealing a predominantly young and male workforce. Among the participants, 74.7% were under the age of 30, and 68.7% were male. Most respondents were pharmacy professionals (99.3%), primarily working in health centers (68.7%) and urban areas (56%). The majority held diplomas (73.3%), while 25.3% held bachelor's degrees and only 1.3% had master's degrees. Most participants served as pharmacy heads (44.7%) or store managers (41.3%). A substantial proportion (70%) reported having less than five years of experience in healthcare supply chain management, and 53.3% had less than five years of overall professional work experience.

5.2.5. Profile of Key Informants for Conceptual Model Development

A total of 83 key informants were interviewed for the qualitative study. The majority of participants (80.72%) were working in health centers, while the rest were from primary hospitals (10.84%) and Woreda Health Offices (8.43%). The average age of participants was 31.35 years, ranging from 25 to 39 years, with the vast majority being male (96.39%). In terms of profession, Health Officers constituted the largest group (43.37%), followed by Nurses (25.30%), Pharmacists (20.48%), Midwives (6.02%), and Medical Doctors (4.82%). Regarding educational background, most participants (80.72%) held a bachelor's degree, while others had diplomas (10.84%), master's degrees (7.23%), or medical specialty qualifications (1.20%). The majority of participants (69.88%) held Health Center Head positions. Others served as Pharmacy Heads (10.84%), Woreda Supply Chain Management Coordinators (9.64%), Chief Executive Officers (7.23%), and Medical Directors (2.41%). On average, participants had 7.87 years of professional experience, ranging from 3 to 15 years, and an average of 2.61 years in their current position, with a range of 0.5 to 9 years.5

5.3. LMIS Related Infrastructures and Initiatives

5.3.1. LMIS Related Infrastructure

Among the surveyed 102 health facilities, 98 (96.1%) had an electric power supply on the day of the visit, but 28 (28.6%) experienced interruptions on the same day. Backup generators were available in 63 (61.8%) of the facilities. Internet access was available in 42.2% of facilities, but only 58.1% of these had access in the pharmacy department, using mainly wireless (55.8%) and broadband (44.2%) connections. Half of the facilities lacked dedicated computers for supply chain and LMIS activities, while the other half had at least one computer. Additionally, 61.8% of facilities had budgets allocated for printing and duplicating LMIS formats.

5.3.2. LMIS Related Initiatives

Health facilities had an average of 7.05 ± 6.07 dispensaries. The average number of pharmacy personnel present during the visit was 5.36 ± 8, ranging from 1 to 56 per facility. Only 62 (60.8%) facilities had a designated health commodities supply chain management coordinator. On average, 1.65 ± 1.34 professionals (95% CI [1.38, 1.91]) were assigned to supply chain activities. The average number of finance professionals assigned to supply chain tasks was 0.95 ± 2.44 (95% CI [0.43, 1.48]). Most facilities (81.4%) received supplies directly from EPSS hubs, mainly Bahir Dar (54.9%), Addis Ababa (23.5%), and Gondar (21.6%). The most implemented services were IPLS (96.1%), DTC (92.1%), and ART (50%), while DIS (30.4%), APTS (18.6%), and clinical pharmacy (10.8%) were least practiced.

5.3.3. Availability, Utilization, and Supply of LMIS forms

The availability and utilization of LMIS forms varied significantly across healthcare facilities. IFRR and RRF were the most available and utilized, present in 99% and 98% of facilities, respectively. Bin Cards were available in 96.1% and used in 89.8% of facilities. In contrast, the HCMIS Guide/Manual had the lowest availability (18.6%), though it was used in 84.2% of those facilities. Stock Record Cards were available in only 27.5% of facilities but had a 92.9% utilization rate in the facilities where it was available.

At 19 APTS sites, Cash Sales Tickets, Daily Summary Sheets, and Sales Ticket Pad Registers had 100% availability and utilization. The Free Registration Book had the lowest availability (89.5%). Most APTS forms had sufficient supply for three or more months. Similarly, among 51 ART sites, the ART Monthly Activity Report and ART Register were available in 98% of facilities, while the EDT form had the lowest availability (17.6%). These disparities in form availability and use contribute to data quality challenges and undermine the overall performance of LMIS, ultimately affecting supply chain efficiency and the consistent availability of health commodities.

5.4. LMIS Reporting and Feedback

Most health facilities (75.5%) submitted LMIS reports to Woreda Health Offices (WoHO), with others reporting to EPSS (60.8%), Zonal Health Departments (15.7%), and the Regional Health Bureau (2.9%). Reports were mainly transported via public transport (48%), facility vehicles (37.3%), and private vehicles (20.6%). However, only 37.3% of facilities received written feedback, primarily from WoHO (76.3%). Supportive supervision on LMIS and supply chain was reported by 71.6% of facilities in the past year, mainly from WoHO (52.1%) and Zonal Departments (31.5%). This support enhanced logistics practices such as APTS, DAGU, DIS, DTC, IFRR, bin cards, RRF, data quantification, and stock management.

5.5. LMIS Data Quality

The assessment of data quality for the LMIS focused on inventory and reporting accuracy of seven key tracer medicines associated with significant public health programs. The study analyzed data from 88 facilities using bin cards and found significant inconsistencies in update rates, ranging from 39.8% for Oxytocin Injection to 68.2% for RHZE/RH. Notably, Oxytocin Injection exhibited the largest physical inventory discrepancy at 26.3%, while other medicines like TDF/3TC/DTG and Artemether + Lumefantrine had lower discrepancies. Electronic inventory records also demonstrated variations, particularly with RHZE/RH, TDF/3TC/DTG, and Artemether + Lumefantrine. Overall, physical inventory accuracy averaged 74.7%, while electronic accuracy was slightly lower at 70.6%, indicating challenges in inventory data quality for both systems.

Of 102 facilities, 100 used the Report and Requisition Form (RRF) for bi-monthly reporting. Among 600 reports reviewed, 82% and 94% of the most recent two submissions had recorded reporting dates. Timely submission within 10 days was generally high, with 67% to 79% submitted within 5 days, and 7% to 16% within 6 to 10 days. Only a few reports were submitted late. Non-submission rates ranged from 6% to 18%, highlighting areas for improvement in timeliness of reporting.

The RRFs showed over 90% completeness for six of the seven tracer medicines. However, reports for TDF/3TC/DTG were consistently below 70%, averaging 65.7%. Overall, the mean completeness across all tracer medicines was 90.2%, indicating strong performance with some gaps. The legality of the RRF reports was assessed across five data components, showing an overall increase over time. The "who prepared the report" component peaked at 97% in the second period and dropped to 81% in the sixth. "Who approved the report" varied from 83% in the second period to 74% in the sixth. Verification rates declined from 66% to 53%, and the presence of an official stamp and cover letter followed similar patterns, with the highest rates in the earlier periods and the lowest in the sixth. The overall average legality of the RRF was 77.2%.

Illegible items were present in the RRFs across all reporting periods. Of the 100 health facilities using RRFs, the percentage of facilities with illegible RRFs ranged from 19% in the second period to 31% in the sixth period. The average percentage of illegible items per report varied from 2.8% in the fifth period to 6.4% in the first period. The accuracy of the RRF reports was evaluated using eight key data components essential for resupply decisions. The highest accuracy was recorded for Amoxicillin 250 mg dispersible tablets (81.1%), while the lowest was for Oxytocin Injection (68.5%). Among the data components, “verified calculated consumption” had the highest accuracy (88.9%), and “ending balance on RRF vs. bin card” had the lowest (46.4%). The overall average accuracy across all tracer medicines and components was 76%, indicating moderate reliability with areas needing improvement.

5.6. Vaccine LMIS (vLMIS) Performance

Vaccine LMIS data were collected from 99 of 102 targeted facilities, excluding two that had not yet initiated EPI services and one that was repurposed for COVID-19 care. A majority of facilities (68.7%) lacked dedicated vaccine storage rooms, using shared immunization department spaces instead; all operated manual VLMIS with no digital systems, though each had at least one functional refrigerator. The presence of functional temperature monitoring devices was high (93.9%), and temperature recording charts were available in 89.5% of cases. However, only 82.8% of facilities consistently documented fridge temperatures in accordance with WHO recommendations. The availability and utilization of VLMIS forms were relatively low, averaging 44.1% and 40.5%, respectively. While the Vaccine Request Form (VRF) was widely available (97%) and most facilities had a three-month supply (93.9%), essential stock-keeping forms like the Bin Card and Stock Card were nearly absent.

Regarding data quality, the average inventory accuracy rate for tracer vaccines (Penta, BCG, and Measles) was 58.3%, with only half of the facilities updating their stock ledger prior to the visit. Based on one year of monthly VRF reporting data, 44 (44.4%) facilities did not submit a VRF report in the latest (12th) reporting period. While 65.7% of facilities submitted their reports on time in the most recent period, only 41.4% met the deadline in the latest period, indicating a decline in timeliness over time.

Completeness of VRF data was relatively high, at 88.4% for urban and 87.8% for rural forms, though specific data items like "doses discarded" and "vaccinations given in the last supply period" had lower completeness rates. Accuracy scores were moderate, with urban VRF at 73.4% and rural at 69.6%, though several key data elements had accuracy rates below 60%.

Of the EPI focal persons surveyed, 76% reported receiving supportive supervision for vaccine supply chain and VLMIS issues, with 34.2% receiving it in the past month. The supervision primarily addressed vaccine management, reporting, and data quality, resulting in improvements in these areas. However, only 34.4% received written feedback from higher institutions, mostly from the Woreda Health Office, with 57.6% receiving feedback in the last three months.

Reflections from EPI focal persons revealed key challenges in VLMIS implementation, including cold chain and power supply issues, poor forecasting, workforce shortages, inadequate infrastructure, weak support systems, and limited digital tools. They recommended strengthening cold chain management, ensuring reliable power, expanding resources and staffing, improving training and digitalization, and enhancing supervision, coordination, and transport systems.

5.7. Digital LMIS (eLMIS) Performance

Out of 102 public health facilities, only 37 (36.3%) implemented digital LMIS, 43.2% with Dagu 1.0 and 56.8% with Dagu 2.0. Just 67.6% had dedicated eLMIS computers (Mean = 2.4±2.77). Installations were mainly in store departments, with limited setup in dispensaries or administrative offices. Infrastructure support for eLMIS included electricity (78.4%), computers (67.6%), internet (59.5%), generators (56.8%), and data backup systems (40.5%). At the time of the visit, eLMIS was functional in 28 (75.7%) health facilities. The RRF was integrated in 27 (73%) facilities, while Model 19/Health and Model 22/Health transaction tools were integrated in 18 (48.6%) facilities.

The facility version of HCMIS (Dagu) includes four main Dashlets: Activity Log (5 sub-Dashlets), Transaction (2), Reports (15), and Summary Reports (5). A 27-item, 4-point Likert scale tool (Cronbach's Alpha = 0.94) was used to assess end users' usage frequency, yielding an overall average rating of 3.13 ± 0.67. The Activity Log Dashlet showed the highest usage among all Dashlets (mean = 3.43 ± 0.49). Within it, "Receive" (3.93 ± 0.27) and "Issue" (3.96 ± 0.19) were the most frequently used features, while "Stock Transfer" was the least used (mean = 2.78 ± 1.09).

The mean frequency of use for the transaction Dashlets was 3.08 ± 1.35 for Model 19/H and 3.04 ± 1.40 for Model 22/H. The overall mean usage rating for the Report Dashlet was 3.00 ± 0.78. Among its sub-Dashlets, the electronic bin card was the most frequently used (mean = 3.63 ± 0.88), while HPMMR was the least used (mean = 2.04 ± 1.43).

The overall mean frequency of use for the Summary Report Dashlet was 3.25 ± 0.96. Among its sub-Dashlets, the stock expiry summary was the most frequently used (mean = 3.41 ± 0.97), while the cost summary was the least used (mean = 3.07 ± 1.14). Respondents also suggested enhancements to the digital LMIS dashboard, including features such as an alarm for expired items, database synchronization (for Dagu 1.0), and options to add/delete items, specify unit of items, model numbers, and apply price markups.

End users evaluated the facility-version digital LMIS (Dagu) using a 34-item, 5-point Likert scale tool (Cronbach's Alpha = 0.82) to assess system performance, satisfaction, and effectiveness. The highest-rated item was "Dagu benefits/improves facility LMIS performance" (mean = 4.60 ± 0.50), while the lowest was "The database is linked with higher levels with real-time end-to-end data visibility" (mean = 1.74 ± 0.98).

The overall average performance score was 3.21±0.43. Users showed stronger agreement on performance aspects related to organizational support (mean = 3.42±0.5), and the weakest agreement on technical skills (mean = 2.53±0.96).

There was a significant mean difference in the frequency of use of transaction Dashlets between Dagu 2.0 (Mean = 3.63) and Dagu 1.0 (Mean = 1.93) with a P-value of 0.02. Additionally, a significant difference was found in the frequency of use of transaction Dashlets across geographical locations. The mean frequency in North Shewa Zone (Mean = 4.0) was significantly higher than in West Gojjam (Mean = 1.67), with a P-value of 0.009.

A significant mean difference was also observed in end users' agreement on the digital LMIS performance in terms of health system and organizational support across different versions. Furthermore, end users with internet access reported significantly better performance in technical skills compared to those without internet access (Table).

Table: Bivariate and Multivariate analysis variables on the performance of Digital LMIS in public health facilities of Amhara Region, Ethiopia; March 2022

Item Group	Variable	Mean	Comparison Group	P-Value
Health System Support	Dagu Version	2.50	Dagu 1,0	0.039
		3.28	Dagu 2.0	
Organizational Support	Internet Access	3.58	Yes	0.01
		3.07	No	
Technical Skill	Internet Access	2.78	Yes	0.021
		2.03	No	
Organizational Support	Experience (≤5 Years)	3.27	6-10 Years	0.995
			>=11 Years	0.012
	Experience (6-10 Years)	3.29	<=5 Years	0.995
			>=11 Years	0.014
	Experience (≥11 Years)	4.00	<=5 Years	0.012
			6-10 Years	0.014

5.8. Evaluation of LMIS tools Features and Requirements

Health supply chain management professionals provided detailed insights into LMIS implementation using a 23-item, five-point Likert scale tool. In terms of LMIS implementation, the system was generally viewed as user-friendly (3.87), effective for stock analysis (3.80), and supported by strong staff commitment (3.77). However, key challenges included weak data backup (2.60), limited digitalization (2.37), and poor end-to-end data visibility (2.01). While data collection formats were mostly adequate, integration (3.09) and interoperability (2.93) with broader health systems remained suboptimal. Gaps were also noted in professional training (2.35 ± 1.13) and feedback from higher administrative levels (2.35 ± 1.16).

Regarding the LMIS performance, the facility-specific LMIS performance was rated slightly higher (3.01 ± 0.78) than the overall public health system (2.78 ± 0.94). Initiatives like APTS (3.42 ± 1.88), Dagu-2 (3.43 ± 1.86), and IPLS (3.36 ± 0.79) were seen as beneficial for LMIS. While staff commitment remained strong (3.41 ± 0.88), management (2.97 ± 0.96) and supervisory support (2.38 ± 0.99) were rated lower. Ongoing concerns included integration (2.83 ± 0.95), interoperability (2.43 ± 1.06), and infrastructure readiness (2.40 ± 1.00).

Across various LMIS tools, experts consistently emphasized the high importance of core data elements, with importance scores exceeding 4.6. However, the frequency of usage of these elements often lagged behind their perceived importance. In Bin Cards, over 90% of respondents reported regular use of basic data such as product name and dosage form. However, the use of more advanced indicators such as average monthly consumption (2.52) and emergency order point (3.29) was markedly lower. A similar pattern was observed with Stock Cards. Basic items like dosage form were moderately used (2.54 ± 1.45), while advanced indicators such as minimum stock level (MSL) (2.00 ± 1.17), EOP (2.09 ± 1.24), and AMC (2.00 ± 1.24) were underutilized despite their high importance ratings (ranging from 4.1 to 4.4). In IFRRs, commonly recorded elements included Item Name (3.98 ± 0.18) and Quantity Received (3.97 ± 0.21). Conversely, data points like Remarks (3.68 ± 0.73) and MSL (3.72 ± 0.74) were less consistently documented. In RRFs, essential items such as Beginning Balance and Ending Balance were recorded with near-perfect frequency (4.00), and their importance was similarly rated highly (4.83-4.86). However, elements such as "Products with Less than Six Months Shelf Life" had the lowest recording frequency (3.37 ± 1.05). For Model 22/H forms, frequently documented items included Date (3.99 ± 1.00), Receiver Name (3.98 ± 0.14), and Quantity Issued (3.98 ± 0.14), while Drug Code (3.10 ± 1.25) and Total Selling Price (3.38 ± 1.15) were recorded less frequently. In Model 19/H forms, Quantity Received (3.97 ± 0.17) and Total Cost (3.94 ± 0.28) were consistently documented, but Drug Code (3.17 ± 1.18) showed lower utilization.

Among manual LMIS tools, Model 22/H (4.48), Model 19/H (4.44), and the RRF (4.61) were perceived as the most user-friendly, while the Stock Card was viewed as the least convenient (3.63). The RRF (4.61) and Model 22/H (4.59) forms scored highest in the inclusion of essential data items. Data aggregation and reporting functions were generally well-regarded across tools. Uniformity was highest in the RRF (4.37), while consistency with other records peaked in Model 22/H (4.36). However, IFRR (3.96) and RRF (3.91) exhibited relatively higher error rates. In terms of time consumption, the Stock Card was rated the most labor-intensive (3.04), whereas Model 19/H was considered the most time-efficient (3.83).

Digital LMIS tools were generally preferred over manual systems, particularly for efficiency and error reduction. The Bin Card was rated as the most user-friendly digital tool (4.81), followed by the Stock Card (4.70), while Model 22/H received the lowest usability score among digital tools (4.61). The IFRR scored highest for inclusion of data elements (4.75), aggregation (4.87), and reporting capabilities (4.88). It also performed best in terms of uniformity (4.68) and consistency (4.66). Error rates were lowest in the Bin Card and IFRR tools (both 4.70). Time efficiency was generally higher across digital tools, with the Bin Card being the most time-saving (4.47). However, integration and interoperability remained weak, particularly for the Model 19/H and 22/H digital tools (both 3.67).

5.9. Conceptual Model for LMIS Performance

The performance of the health commodities supply chain (HCSC) in public health facilities of the Amhara Region is shaped by a complex interaction of systemic, contextual, and operational factors. A grounded theory analysis using MAXQDA, guided by the Corbin and Strauss framework, identified interrelated causal, contextual, and intervening conditions that influence access to essential commodities, wastage reduction, and service delivery.

Causal conditions include limited capacity within the EPSS marked by low fill rates, delayed deliveries, near-expiry stock, and mismatches between supply and demand. These issues lead to frequent stockouts and reliance on costlier, less reliable private suppliers. Inefficiencies in the LMIS such as manual data entry, inaccurate reporting, and limited data visibility further undermine inventory control and demand forecasting.

Contextual challenges including inadequate budgets, bureaucratic procurement processes, and limited political commitment significantly impede efforts to reform the supply chain system. These issues are compounded by the expansion of the Community-Based Health Insurance (CBHI) scheme, which has increased service demand without guaranteeing timely financial reimbursements to health facilities. Additionally, broader macroeconomic pressures such as inflation, coupled with infrastructural deficiencies and regional insecurity including ongoing conflict and a high number of internally displaced persons further destabilize supply chains and compromise the continuity of healthcare service delivery.

Intervening factors include weak LMIS performance, limited digital integration, fragmented reporting, and poor monitoring systems. Human resource shortages, high turnover, inadequate training, and resistance to new technologies reduce system adaptability. A lack of policy advocacy and coordination across sectors also hinders sustainable change.

Addressing these challenges requires integrated strategies, including digitalizing the LMIS to enhance data accuracy and inventory control, optimizing stock management, upgrading infrastructure, and strengthening the health workforce. These must be supported by policy reforms in procurement, budgeting, and public-private partnerships to enable long-term improvements. When effectively implemented, such measures can significantly improve supply chain performance ensuring timely, equitable access to health commodities, reducing wastage, and enhancing healthcare delivery. This, in turn, fosters staff motivation, operational efficiency, and a reinforcing cycle of continuous improvement, with sustainable progress relying on coordinated reforms across systems, infrastructure, policy, financing, and human resources.

Similar to the health commodities supply chain, the performance of the Logistics Management Information System (LMIS) in the Amhara Region is shaped by a complex interaction of causal, contextual, and intervening factors. Causal challenges primarily stem from systemic limitations, including inconsistent data recording practices, the parallel use of manual and digital systems, and the absence of standardized reporting tools and formats such as the RRF, HPMMR, and IFRR. These technical deficiencies are compounded by weak data governance, inadequate human resource capacity, and limited financial investment in digital infrastructure and workforce development. Moreover, the fragmented implementation of key initiatives such as APTS, DTC, and integrated digital platforms reflects a lack of strategic coordination and alignment.

Contextual factors further constrain LMIS functionality includes; infrastructural challenges, including unreliable electricity, limited ICT capacity, inadequate transportation networks, and insufficient storage facilities. Geographic inaccessibility and seasonal disruptions further hinder system operations. Security concerns including armed conflict, public health emergencies, and large-scale displacement exacerbate operational difficulties by diverting critical resources and disrupting routine service delivery. While government and development partner support exist, inconsistent engagement and variable funding hinder the continuity and long-term sustainability of LMIS initiatives.

Intervening conditions such as workforce availability and performance significantly mediate these challenges. Persistent shortages of trained personnel, ongoing skill gaps, low motivation, and resistance to adopting new technologies hinder effective LMIS use. Additionally, institutional support, limited supervision, and the absence of structured performance feedback mechanisms constrain adaptability and accountability. Nonetheless, targeted interventions such as structured training programs, ongoing professional development, and regular audits can enhance workforce capacity, improve data quality, and strengthen overall system resilience.

To address these multifaceted challenges, the conceptual model underscores the importance of digitizing and integrating LMIS platforms (e.g., Dagu-2) to standardize data collection, improve real-time inventory visibility, and enhance reporting efficiency. These efforts must be supported by investments in digital infrastructure, including reliable internet access, hardware provision, and ICT training. Strengthening institutional support through increased funding, robust supervision frameworks, and effective stakeholder coordination is essential. Furthermore, sustained workforce development through continuous training, mentorship, and performance incentives alongside the institutionalization of regular monitoring and feedback mechanisms, is critical for achieving long-term improvements.

When implemented effectively, these strategies are expected to significantly improve LMIS performance by enhancing data accuracy, transparency, and accountability. Access to real-time, high-quality data will enable evidence-based decision-making, optimize resource allocation, and ensure the timely and equitable distribution of essential health commodities. Ultimately, these improvements will contribute to a more resilient health system and better public health outcomes.

Chapter Six: Discussion and Implication of the Study

6.1 Discussion

This comprehensive evaluation of health commodities LMIS in public health facilities of the Amhara Region reveals a complex landscape marked by commendable progress, persistent challenges, and opportunities for improvement. A reliable infrastructure is essential for the effective functioning of LMIS in health facilities. Although 96.1% of facilities had operational electricity, a substantial number experienced recurrent power outages, and only 61.8% had functional backup generators, revealing systemic vulnerabilities that compromise LMIS operations, including electronic data transmission and timely report submission (PFSA, 2015; EPSA, 2019). Furthermore, only 42.2% of the facilities had internet access, which often did not extend to pharmacy departments, limiting the optimal use of digital LMIS. These constraints mirror findings in Addis Ababa which underscored weak internet infrastructure as a barrier to effective digital LMIS in Ethiopia (Endeshaw *et al.*, 2020). The shortage of dedicated computers hampers real-time data reporting and diminishes the potential benefits of digital systems like the HCMIS (Dagu) platforms, as documented in similar settings (Snow, 2017; EPSA, 2019; Alemu *et al.*, 2021). Improving power reliability and ICT infrastructure is essential to enabling real-time data entry and seamless digital operations (USAID | DELIVER PROJECT, 2012; WHO, 2021b, 2024)

In parallel, human resource constraints remain a critical challenge. On average, only 1.65 professionals were responsible for managing supply chain activities per facility, and 39.28% of facilities lacked designated supply chain coordinators. This shortage undermines effective oversight and accountability and aligns with previous studies that highlight persistent gaps in the availability of skilled supply chain personnel (Tiye and Gudeta, 2018; Bilal *et al.*, 2019).

A major challenge identified is the inconsistent availability and use of standard LMIS tools. While forms like IFRR and RRF are widely used, other LMIS tools barely available which is consistent with studies in Ethiopia (Mekonnen, Worku and Tefera, 2024). In the VLMIS context, the mean utilization rate of 15 intended LMIS tools stood at only 40.5%, with poor use of essential tools like bin cards. This low availability and tool utilization impacts inventory visibility and decision-making (Pk and Mirza, 2015; Gilbert *et al.*, 2020).

Despite 75.5% of facilities regularly submitting reports to Woreda Health Offices, only 37.3% received written feedback, and 71.6% reported receiving supportive supervision within the past year. These findings reflect broader challenges related to weak communication and accountability mechanisms in LMIS operations, consistent with studies conducted in Northwest Ethiopia and elsewhere (Tiye and Gudeta, 2018; Gemechu *et al.*, 2021). The lack of structured feedback and supervisory engagement hinders data-driven decision-making and weakens the progress of health facilities. Additionally, even though reporting practices are widely adopted, there remains a notable disconnect between data submission and the practical use of feedback to inform decisions an issue also identified by (Damtie, Ibrahim and Yikna, 2020; Endeshaw *et al.*, 2020). This underutilization of data severely compromises the supply chain's responsiveness and efficiency.

There is a notable gap in the data quality of the health commodities LMIS in the study area. The mean physical and electronic inventory accuracy rates for tracer medicines were 74.7% and 70.6%, respectively. Significant discrepancies were observed in critical medicines, such as Oxytocin Injection, which had the highest error margin (26.3% ± 98.9), indicating serious gaps in inventory management. These inaccuracies can lead to stockouts, particularly of life-saving medicines—thereby adversely affecting maternal and neonatal health outcomes (Omo-emmanuel *et al.*, 2017; Global Fund and GAVI, 2019). Compared to other regions, the Amhara Region's inventory accuracy was moderate: higher than West Wollega (52.45%) (Kebede and Tilahun, 2021) but lower than Addis Ababa (90.6%) (Gemechu *et al.*, 2021)and South West Ethiopia (87%) (Bekele and Anbessa, 2021). This variation is largely attributed to workforce shortages, the absence of robust digital systems, and the burdens of manual record-keeping, which hinder timely updates and reconciliation (PFSA, 2015; Damtie, Ibrahim and Yikna, 2020; Kebede and Tilahun, 2021).

In the case of the VLMIS, the mean inventory accuracy for tracer vaccines (Penta, BCG, Measles) was only 58.3%, reflecting underutilization of stock ledgers and irregular data updates. The digital gap in the VLMIS system compounded by inconsistent supervision and a lack of ICT tools negatively impacted inventory accuracy and demand forecasting (WHO, 2021a; Lopes *et al.*, 2022)

The data quality of RRFs evaluated across multiple dimensions revealed critical concerns. While the IPLS guideline mandates timely submission of RRFs, analysis of six previous reporting periods showed a non-submission rate ranging from 6% to 18%. Although this aligns with findings from Bahir Dar EPSS (75.6%) (Tessema and Tilahun, 2022), it surpasses the performance reported in SNNPR (56.7%) and Gambella (64%) (Damtie, Ibrahim and Yikna, 2020; Boche, Temam and Kebede, 2022). These delays can significantly hinder procurement planning and resupply effectiveness, contributing to both stockouts and overstocking, each of which compromises patient care.

Moreover, while the overall data completeness rate for RRFs was 90.2%, completeness for specific ART medicines such as TDF/3TC/DTG was notably lower (65.7%), suggesting reduced attention to donor-supported programs. Similarly, RRF legality had a mean score of 77.2%, yet systemic gaps in documentation integrity remain a critical concern, reflecting weak accountability for stock transactions. The legibility of reports also poses a challenge, with illegible entries ranging from 2.8% to 6.4%, further emphasizing the need for digital reporting tools (WHO, 2024; Yadav, 2024). The overall RRF accuracy rate was 76%, which, while higher than that of West Oromia (37.1%) and Northwest Ethiopia (59.5%) (Alemu *et al.*, 2021; Kebede and Tilahun, 2021), remains below that of South West Ethiopia (84.6%) (Bekele, Kumsa and Ayalew, 2022). Enhancing accuracy will require the digitization of LMIS, capacity-building for supply chain staff, and consistent supportive supervision to ensure that reports reflect real-time stock realities (Kasaye *et al.*, 2024; Yadav, 2024). Meanwhile, performance on the quarterly monitoring and evaluation (M&E) framework introduced for pharmaceutical logistics was weak, only 45 out of 102 facilities adhered to submission schedules.

The evaluation of the VLMIS also revealed critical gaps in cold chain management and data quality. Only 68.7% of facilities had dedicated vaccine storage rooms, and although 93.9% of refrigerators were equipped with temperature monitors, approximately 17% of facilities did not regularly record temperatures, violating WHO recommendation (WHO, 2021a). This jeopardizes cold chain integrity and compromises vaccine potency. The average VLMIS tools utilization rate was 40.5%, with the VRF being more commonly used than bin cards or stock cards, reflecting similar challenges reported in Uganda and Northwest Ethiopia (Nsubuga *et al.*, 2018; Madebo *et al.*, 2021). Inventory data quality for vaccines was poor, with an average accuracy of 58.3% across three tracer vaccines. Major contributing factors included shortages of recording formats, limited staff training, and poor data visibility, as documented also in other studies (Weledesenbet, 2020; Lopes *et al.*, 2022).

The timeliness of VRF reporting was also suboptimal, with only 65.7% and 41.4% of facilities submitting timely reports over the last two reporting periods, an issue that could potentially disrupt vaccine availability (FMOH, 2020a; Gilbert *et al.*, 2020). Data completeness and accuracy also varied between urban and rural settings: urban facilities reported an average completeness of 88.4% and accuracy of 73.4%, while rural counterparts recorded slightly lower figures (87.8% completeness and 69.6% accuracy). All facilities relied on manual VLMIS systems, and the absence of digitalization was cited as a major barrier to improving data quality, echoing findings from studies in Tanzania and Ethiopia (Gilbert *et al.*, 2020; Fritz, Herrick and Gilbert, 2021). Additionally, vaccine supply chains are often managed by personnel without formal pre-service training in immunization logistics, further compounding system inefficiencies.

With regard to digital LMIS, only three-quarters of facilities had the digital system (Dagu) installed. However, system usage was hindered by persistent challenges related to electricity reliability, inadequate ICT infrastructure, and dependence on external technical support (Tewfik, 2018; Endeshaw *et al.*, 2020). This has posed a challenge to the ownership of the digital system, as it is a donor-driven project, which directly affects the system's sustainability. While overall Dashlet usage was relatively high (78.3%), critical tools such as the Report Dashlet had the lowest utilization rates, suggesting technical limitations or capacity-related barriers. Many facilities had not yet integrated essential Dashlets for transaction tracking and reporting, undermining the LMIS's core objective of enabling streamlined, data-driven decision-making (WHO, 2024; Yadav, 2024). End-user perceptions of the digital system were generally positive, particularly regarding benefits such as enhanced data visibility and reduced reporting errors. Nonetheless, challenges with integration and interoperability remain significant (FMOH, 2016, 2020a). Variations in digital LMIS performance were strongly influenced by internet access and software version upgrades, underscoring the need for continuous infrastructure development, capacity-building initiatives, and sustained technical support to enhance system adoption and functionality (DHA, 2021; FMOH, 2024b). Lessons from countries such as Namibia, Tanzania, and Guinea demonstrate that strategic digital transformation, when integrated with strong governance and targeted capacity-building, can significantly enhance supply chain efficiency and improve health outcomes (Gilbert *et al.*, 2020; GUINEA, 2023). \

Finally, the conceptual model developed highlights the systemic, contextual, and operational challenges undermining LMIS performance in Ethiopia’s Amhara Region. Key issues include infrastructural gaps, limited human resource capacity, reliance on manual reporting, and weak data quality, challenges consistent with global evidence on fragmented and under-resourced supply chains in LMICs (WHO, 2010; Yadav and Yadav, 2015; Stevens and Huys, 2017). Contextual factors such as budget constraints, procurement delays, and increasing service demands (e.g., CBHI) further strain LMIS functionality (Ozawa *et al.*, 2019; Chemonics International, 2021). The grounded theory analysis revealed that effective LMIS performance depends on integrated digital systems, skilled personnel, and sustained investments in policy and infrastructure. This aligns with findings from other studies identifying digitalization challenges, including low digital literacy and poor system interoperability (USAID | DELIVER PROJECT, 2012; Gilbert *et al.*, 2020; Alemu *et al.*, 2021; FMOH, 2024b). The proposed conceptual model emphasizes that improving LMIS performance requires addressing interlinked systemic and contextual gaps through coordinated, technology-driven, and capacity-building interventions. It also underscores the urgent need for standardized, context-specific LMIS evaluation frameworks to guide sustainable improvements and evidence-based decision-making, an approach aligned with WHO recommendations (Abouzahr and Boerma, 2005; WHO, 2017a; MEASURE Evaluation, 2018a).

6.2 Strengths and Limitations of the Study

6.2.1. Strengths of the Study

This study presents a comprehensive and methodologically rigorous evaluation of the LMIS, and development of a conceptual model tailored to the performance of LMIS in health facilities. Employing a concurrent mixed-methods design, the study integrates both quantitative and qualitative approaches, enabling a holistic assessment that captures measurable performance indicators alongside rich contextual insights from key stakeholders. This dual approach enhances the validity, depth, and applicability of the findings. A notable strength of the study lies in its scale and representativeness, with data collected from 102 public health facilities across the Amhara Region, an early adopter of various LMIS initiatives, as well as from a diverse group of supply chain professionals, key informants, and system end-users. The use of standardized and well-validated tools such as the LIAT, LSAT and the Federal Ministry of Health Monitoring and Evaluation (M&E) framework, alongside grounded theory for qualitative analysis, ensures methodological rigor, reliability, and contextual relevance.

Importantly, this is the first study of its kind to conduct such a comprehensive assessment of LMIS in health facilities, evaluating manual systems and digital platforms such as Dagu LMIS, as well as the vaccine-specific LMIS. This inclusive assessment offers an in-depth understanding of current practices, systemic gaps, and infrastructural and human resource constraints, while also identifying future directions for improvement. The conceptual model developed through grounded theory provides a practical, evidence-based framework to inform future LMIS design, implementation, and performance evaluation. Its relevance extends beyond the Amhara Region, offering valuable policy and operational insights for national-level strategies and initiatives. Ultimately, this study makes a significant contribution to the global discourse on resilient, efficient, and data-driven health supply chains, particularly within resource-constrained settings.

6.2.2. Limitations of the study

The study is geographically limited to the Amhara Region, which may restrict the generalizability of its findings to other regions with differing infrastructure, socio-economic conditions, or health systems. Its cross-sectional design captures only a single point in time, limiting the ability to assess temporal trends, seasonal variations, or the impact of ongoing interventions on LMIS performance. External factors such as regional insecurity, political dynamics, and health emergencies (e.g., COVID-19) likely influenced system performance but were difficult to measure or control in this study. The exclusion of conflict-affected and inaccessible facilities may introduce bias toward better-performing sites. Self-reported data on system use and satisfaction could be affected by recall or social desirability biases. Additionally, the limited number of facilities using fully functional digital LMIS platforms constrains conclusions about digitalization impacts. While the conceptual model developed is promising, careful piloting is recommended before wider application to ensure context-specific relevance. Future research addressing these limitations will further deepen understanding and support more effective improvements in LMIS performance and implementation.

6.3 Implication of the Study

6.3.1 Practical Implication

This study highlighted the following findings with immediate practical implications:

- Identifies gaps in data accuracy, completeness, and timeliness; recommends regular training, supervision, and validation to improve data quality for better decision-making and resource allocation.
- Highlights the need to strengthen digital LMIS by addressing infrastructure challenges (electricity, internet) and expanding capacity-building for health workers and supply chain personnel.
- Emphasizes establishing clear policies, standard operating procedures, and accountability mechanisms to enhance LMIS performance.
- Stresses stakeholder engagement at all levels to foster ownership and promote adherence to best practices for LMIS performance

- Immediate need for effective integration of manual and digital LMIS tools to ensure seamless data flow, reduce duplication, and increase system efficiency.
- Recommends targeted support (mentorship, infrastructure upgrades, resources) for facilities with poor system performance to improve supply chain management.
- Suggests regular monitoring and evaluation of LMIS to detect issues early and drive continuous quality improvement.
- Suggests incorporating feedback from health workers, supply chain managers, and end users to tailor LMIS tools to user needs.
- Introduces the conceptual model as a framework for LMIS performance evaluation and KPI development.
- Encourages replication of successful practices across regions to promote a standardized, scalable approach to LMIS performance.

6.3.2 Policy Implication

This study highlighted the following findings with policy implication for LMIS Strengthening in the Health Sector:

- **LMIS Standardization:** The study highlights the urgent need to standardize LMIS across health facilities to ensure consistent data, reporting, and decision-making.
- **Ownership and Sustainability of Digital LMIS:** To ensure the sustainability of the digital LMIS, it is crucial to transition from a donor-driven initiative to a locally owned system by fostering homegrown software development, securing government funding, integrating the system into national health policies, and strengthening local technical and institutional capacities.
- **Investment in Digital Infrastructure and Technology Adoption:** The Government should prioritize investments in reliable internet connectivity, stable electricity, and necessary hardware such as computers to support effective digital LMIS implementation. The Ministry of Health and Regional Health Bureaus should implement phased digitalization strategies tailored to the capacity and readiness of individual health facilities to prevent setbacks and ensure sustainable system adoption.

- **Integration into Health System Strengthening:** LMIS improvements should be fully integrated into national health strategies, acknowledging their critical role in enhancing supply chain resilience and strengthening the overall health system.
- **Governance, Accountability, and Data Use:** There is a need for clear policies on governance, ownership, accountability, data access, and use to ensure data accuracy and foster sustainable data-driven decision-making at all levels of the health system.
- **Public-Private Partnerships and Stakeholder Engagement:** Policy frameworks should foster collaboration with private sector actors, donors, and other stakeholders to enhance resource mobilization, technical support, and innovation in LMIS.
- **Equity and Access:** Targeted policy measures are needed to support remote and underserved facilities, reducing disparities in LMIS implementation and ensuring equitable access to health commodities.
- **LMIS Performance Evaluation:** The Ministry of Health should develop an LMIS performance evaluation system supported by standardized KPIs to effectively monitor and evaluate the system for continuous improvement.

Chapter Seven: Conclusion and Recommendations

7.1. Conclusions

The evaluation of Logistics Management Information System performance in Amhara Region reveals a system in transition marked by progress in form availability, reporting practices, and digital uptake, but hindered by persistent systemic challenges. Key issues include unreliable infrastructure, inadequate internet and computer access, limited digital integration, data quality inconsistencies, insufficient staffing and training, and weak supervision. Manual and digital tools are both used, yet face integration, usability, and efficiency gaps. Inventory records show major discrepancies, undermining data reliability for decision-making and resupply. While tools like Dagu 2.0 and APTS have shown promise, underutilization of advanced metrics in data elements and low digital proficiency persist as a challenge. Vaccine LMIS faces similar challenges, particularly in standardization of LMIS tools and data quality.

The grounded theory-based conceptual model highlights critical performance determinants such as resource constraints, infrastructure gaps, public health emergencies, and implementation weaknesses. It suggested for systemic reforms including digital transformation, capacity building, improved governance, and stakeholder collaboration. Hence, optimization of LMIS in the region demands a holistic, integrated approach, investing in infrastructure, expanding digital systems, enhancing human resource capacity, standardizing tools, and fostering policy and stakeholder alignment. These steps are vital for improving data-driven decision-making, ensuring the availability of essential health commodities, and strengthening health system resilience. Future research should focus on validating the proposed model and developing context-appropriate digital solutions to sustainably enhance LMIS performance.

7.2. Recommendations

- The Federal Ministry of Health and Regional Health Bureaus should establish and enforce clear policies on LMIS standardization to guarantee high-quality data across all levels of the health system
- The health system should prioritize the development and implementation of locally developed, user-friendly and interoperable digital LMIS platform to enhance system ownership, real time end to end data visibility and sustainability.
- The health system should design flexible LMIS solutions tailored to the needs of low-performing, hard-to-reach, and lower-level health facilities, addressing infrastructural challenges, literacy levels, and security concerns to reduce disparities in digital access and service delivery.
- The health system should formulate and institutionalize national and regional LMIS implementation guidelines, SOPs, and data quality standards applicable to manual and digital LMIS.
- The health system should prioritize investments in robust LMIS infrastructure including electricity, internet connectivity, and cold chain capacity
- The health system should improve the consistent availability of both paper-based and digital reporting tools and ensure sustainable financing to support the effective functioning of the LMIS.

- The health system should integrate LMIS platforms with other digital health systems to enable seamless data flow and coordinated decision-making across all levels of the health system
- The health system has to strengthen cross-sectoral coordination platforms that engage the Federal Ministry of Health, Regional Health Bureaus, NGOs, and private sectors to align efforts and ensure cohesive implementation of LMIS initiatives
- The Federal Ministry of Health and Regional Health Bureau should design a continuous capacity-building program for health supply chain professionals, supported by ongoing supportive supervision and feedback system.
- The Federal Ministry of Health and Regional Health Bureau should develop a streamlined LMIS performance evaluation system with comprehensive indicators to enable continuous monitoring, evaluation, and sustainable improvement of the LMIS.

7.3. Directions for further research

- Conduct longitudinal studies to assess how the adoption of digital systems like Dagu impacts inventory accuracy, stockout rates, and overall supply chain efficiency over time
- Investigate socio-technical, infrastructural, and organizational factors that influence the successful implementation and scaling of digital LMIS to inform targeted intervention
- Conduct comparative studies on the economic implications and cost-effectiveness of digital versus manual logistics management systems to guide resource allocation and policy decisions.
- Examine disparities in LMIS implementation and support between urban versus rural and high-to reach versus low-resource facilities to design policies and strategies for equitable LMIS implementation
- Explore the integration and interoperability of LMIS with other health information systems to enhance comprehensive health planning and decision-making.
- Assess the potential of emerging technologies such as mobile health (mHealth), artificial intelligence (AI), and blockchain to improve data accuracy, security, and transparency within LMIS.

- Innovate low-cost, solar-powered, and offline-capable LMIS technologies and digital solutions to enhance system resilience, particularly in remote, underserved, or conflict-affected areas.
- Pilot the conceptual model developed in this study for evaluating LMIS performance across various public health facility contexts. This includes developing, testing, and standardizing comprehensive key performance indicators (KPIs) to systematically measure and improve LMIS effectiveness, responsiveness, and alignment with national health supply chain goals

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Health commodities logistics management information system performance at public health facilities of Amhara region, Ethiopia

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Introduction: Ensuring equitable access to essential medicines is a major global health challenge, particularly in low- and middle-income countries. Effective supply chain management and Logistics Management Information Systems (LMIS) are crucial for addressing these challenges. Despite substantial efforts, significant LMIS implementation issues continue, especially in Ethiopia.

Objectives: The study aimed to evaluate the performance of health commodities logistics management information systems at public health facilities in the Amhara Region, Ethiopia.

Methods: The study conducted in public health facilities of the Amhara region in Ethiopia used a quantitative methods approach. The region is supplied by four Ethiopian Pharmaceutical Supply Service hubs. A total of 102 facilities, selected through stratified random sampling, were included in the study. Data were collected through record review and and observation using data abstraction checklists to evaluate the LMIS forms availability, utilization, supply, and report timeliness.

Results: Infrastructure challenges were noted, including inconsistent power supply and limited internet access, with only 42.2% having internet connectivity. LMIS performance varied, with high availability and utilization of forms like the IFRR and RRF but lower rates for some forms and digital systems. Reporting and feedback mechanisms were generally adequate, though only 37.3% of facilities received periodic written feedback from higher levels of the healthcare system.

Conclusion and recommendation: The evaluation of the LMIS in Amhara Region's public health facilities shows notable achievements in the widespread use of LMIS forms and reporting systems. However, ongoing challenges such as unreliable infrastructure, poor internet connectivity, and insufficient human resources impede effective LMIS performance. Addressing these issues, digitalization of the LMIS, strengthening feedback mechanisms, and supervisory support will enhance LMIS performance and improve health outcomes.

KEYWORDS

LMIS, evaluation, performance, health commodities, health facilities

1 Introduction

Equitable access to health commodities, particularly essential medicines remains a critical global health challenge, particularly in low- and middle-income countries, where access issues persist despite the growing burden of diseases (1, 2). Affordable health commodities reduce mortality and morbidity (3–5). Governments must ensure access to health commodities including essential medicines, vaccines, and supplies as part of the right to health, which is essential for achieving Sustainable Development Goal 3 (6–9). Despite these objectives, a significant portion of the global population needs consistent access to essential health commodities, leading to substantial financial burdens on healthcare systems in developing countries (4, 10, 11).

Effective supply chain management is pivotal in global health systems to ensure the availability and accessibility of essential health commodities (2). In low-income countries, the supply chain for health commodities faces challenges rooted in structural and health system complexities, contributing to inefficiencies. These include multiple tiers of stock management and decision-making processes that exacerbate complexities and inefficiencies (12, 13). Robust logistics management information systems (LMIS) are essential for effective supply chain management, ensuring the availability of medicines, vaccines, and health technologies (14–16). The LMIS is an essential tool that enables the real-time flow of logistics information, providing vital support for strategic decision-making at every level of healthcare (5, 17). Challenges such as information distortions and lack of integration can lead to significant disruptions in the supply chain, known as the bullwhip effect (18, 19).

Programs like the Integrated Pharmaceutical Logistics System (IPLS) and digital LMIS initiatives have demonstrated potential impact in enhancing the effectiveness of LMIS in countries such as Ethiopia, although significant implementation challenges persist (20, 21).

Despite numerous efforts, various studies have indicated that the current health commodities' LMIS implemented in Ethiopia's healthcare system faces several challenges. These include partial implementation and a lack of sufficient LMIS forms in health facilities (Shewarega (22, 23)), poor infrastructure such as internet, electric power, and computers (24), challenges with LMIS interoperability with other systems (25), poor data quality (20, 26, 27), lack of end-to-end data visibility (14), gaps in training and staff commitment (28) and inadequate supportive supervision and timely feedback from higher levels (29).

Addressing these challenges necessitates comprehensively evaluating the current LMIS implementation (14, 30). The objective of this study is to conduct a comprehensive performance evaluation of the current health commodities LMIS implementation in public health facilities across the Amhara Region of Ethiopia.

2 Methods

2.1 Study area

The study was conducted in the Amhara National Regional State of Ethiopia, the second-most populous region in the country. It is administratively divided into 12 zones and three city administrations. As of 2021, the region had 5,775 functional health facilities, including 87 public hospitals, 873 public health centers, 3,565 health posts, six private hospitals, and 1,244 private clinics. Public health facilities in the region are primarily supplied through four hubs of the Ethiopian Pharmaceutical Supply Service (EPSS; Figure 1).

2.2 Study design

The study employed an institution-based quantitative design. This research is part of a larger project focused on assessing the performance of the health commodities LMIS, with its results mainly based on quantitative data analysis.

2.3 Source and study population

The study included all public health facilities managing health commodities for the provision of healthcare service. Specifically, the study population comprised selected public health facilities in the region.

2.4 Sampling procedure

Health centers and hospitals in all zonal administrations, except those with security problems, were eligible for sampling. Six zonal and two city administrations were chosen and grouped into three clusters based on EPSS hub locations. Ultimately, four zones and two city administrations were included. As per USAID's Logistics Indicators Assessment Tool (LIAT) recommendation, 15% of facilities were sampled, with a final adjusted sample size of 102. The sample size was allocated proportionally across Zones and *Woreda* (district level administration), using a multi-stage stratified random sampling method based on the number of facilities.

2.5 Inclusion and exclusion criteria

2.5.1 Inclusion criteria

- All Zonal Administrations
- All public health facilities that have been functional for more than 1 year

2.5.2 Exclusion criteria

- Health facilities damaged in conflict-affected areas or had security problems during the study.
- Health Posts

2.6 Data collection process

Data was collected through record review, after requesting the responsible persons to locate the appropriate document in each department and observations conducted by experienced and well-trained pharmacists using data abstraction checklists. These

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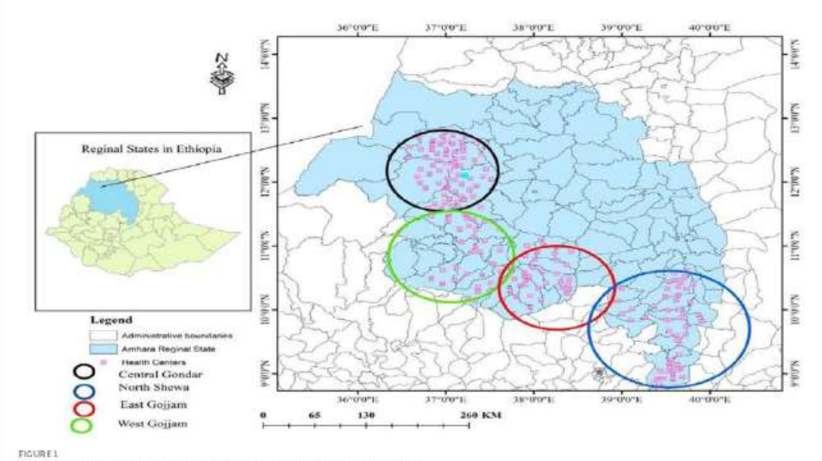

FIGURE 1
Map of selected health facilities for the study in Amhara Region, March 2022.

checklists were adapted from the Logistics Indicator Assessment Tool (LIAT), Logistics System Assessment Tool (LSAT), and the Ministry of Health's supply chain monitoring and evaluation tools (31, 32).

2.7 Data quality assurance

Ten experts in the field face-validated the data collection tools. Additionally, data collectors participated in a two-day training session. The tools were pre-tested, and adjustments were made based on the feedback received.

2.8 Operational definitions

- **RRF (Report and Requisition Form):** This LMIS tool allows health centers and hospitals to report consumption and request resupply of health commodities.
- **IFRR (Internal Facility Reporting and Requisition Form):** This tool facilitates the requisition and redistribution of health commodities within health facilities used by health centers and hospitals.
- **HPMMR (Health Post Monthly Report and Resupply Form):** This LMIS tool allows health posts to report consumption and request resupply of health commodities from health centers.
- **Model 19/Health:** An official financial transaction tool used in health facilities for receiving health commodities from suppliers, with a serial registration.
- **Model 22/Health:** An official financial transaction tool used in health facilities for issuing health commodities to other facilities and units, with a serial registration.
- **Health Commodities Management Information System (HCMIS):** It is a digital LMIS used to manage and track health commodities across the public healthcare system in Ethiopia.

2.9 Data analysis and interpretation

The data were reviewed for completeness and internal consistency before being entered into Epi Info Version 7 for initial processing. The data were then exported to SPSS Version 23.0 for detailed data management and analysis.

3 Results

3.1 General information

The study surveyed 102 public health facilities, of which 58.8% were located in rural areas. The majority of these facilities were health centers, 84.3% followed by primary hospitals 9.8% (Figure 2).

The health facilities were distributed across four zonal administrations: West Gojjam (29.4%), East Gojjam (25.5%), North Shewa (23.5%), and Central Gondar (21.6%; Figure 3).

The study involved 19 rural Woredas (woreda is the third-level administrative hierarchy in Ethiopia and a primary unit for local governance, equivalent to a district in other countries) and 9 City and Town administrations. On average, the distance of surveyed health facilities from the Woreda and zonal town was 11.98 km ± 9.56 and 63.13 km ± 60.7, respectively. The average distance from the regional city and the supplier EPSS hub was 149.58 km ± 146 km and 96.6 km ± 82.5 km, respectively. Additionally, the mean service duration of the health facilities was 19.4 years ±16.9 years, and each

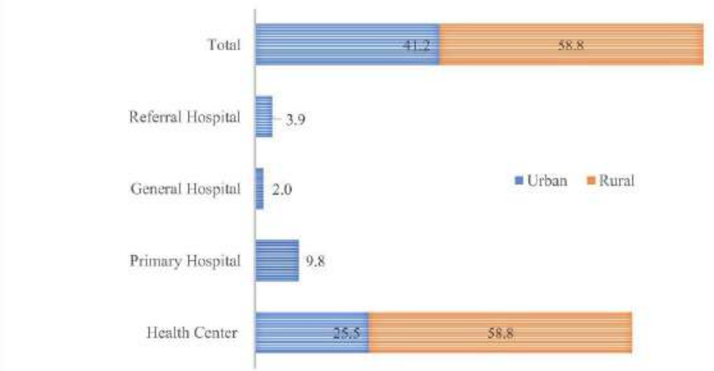

FIGURE 2
Percentage distribution of surveyed health facilities by level and location, March 2022.

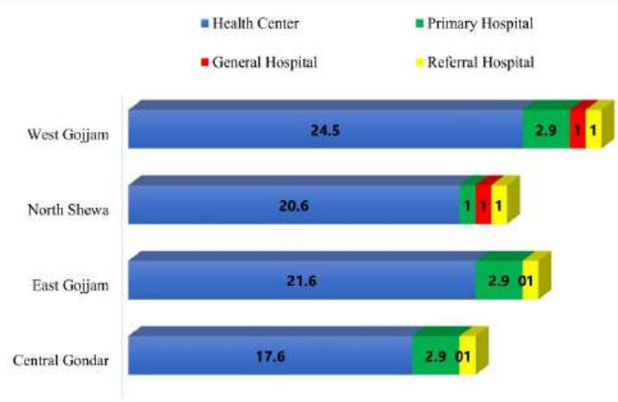

FIGURE 3
Percentage zonal distribution of surveyed public health facilities, March 2022.

facility was connected to an average of 4.9 ± 2.07 lower-level facilities through the referral system (Table 1).

3.2 LMIS-related infrastructure

Among the surveyed health facilities, 98 (96.1%) had an electric power supply on the day of the visit, but 28 (28.6%) experienced power interruptions during the study visit. Backup generators were available in 63 (61.8%) of the facilities. Internet connectivity was accessible in 43 facilities (42.2%), with only 25 (58.1%) having access specifically in the pharmacy department. The types of internet connectivity reported included wireless (55.8%), broadband (44.2%), and data (4.7%).

Half of the health facilities needed dedicated computers for the health supply chain and LMIS activities in key areas like dispensaries, stores, supply chain coordinator offices, and ART pharmacies. The other 50% had at least one computer for these activities, with a median of 0.5, a mean of 1.1 ± 2.1, and a range from 0 to 13 (95% CI [0.68, 1.5]). For the manual LMIS system, only 63 (61.8%) of the facilities

TABLE 1 Geographic location, year of service, and number of referral facilities for surveyed health facilities in Amhara Region, March 2022.

SN	Variable	Median	Mean ± SD	Min	Max
1.	Distance of HF from Woreda Town (KM)	9	11.98 ± 9.56	0	38
2.	Distance of HF from Zonal Town (KM)	42	63.13 ± 60.7	0	222
3.	Distance from Regional City (KM)	122.5	149.58 ± 146	4	690
4.	Distance from the supplier EPSS Hub (KM)	70	96.6 ± 82.5	1	265
5.	Service duration (years)	12	19.4 ± 16.9	1	85
6.	Number of referral health facilities	5	4.9 ± 2.07	1	11

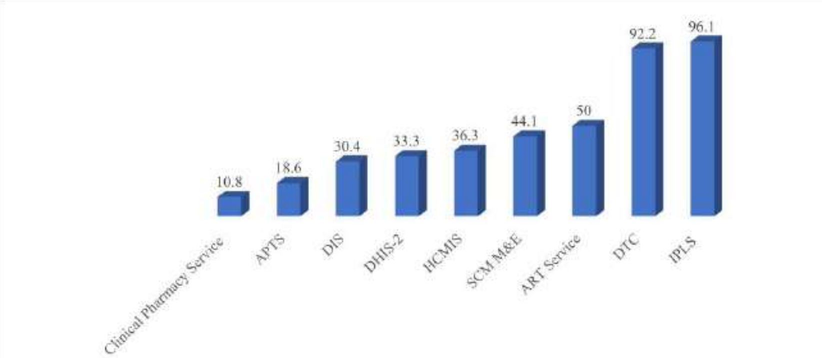

FIGURE 4
Implementation status of pharmacy services and supply chain management initiatives at public health facilities in the Amhara Region, March 2022.

reported having allocated budgets for printing and duplicating LMIS formats.

3.3 Performance of supply chain-related initiatives

Health facilities had an average of 7.05 ± 6.07 dispensaries (95% CI [5.86, 8.24]). The average number of pharmacy personnel present during the visit was 5.36 ± 8, ranging from 1 to 56 per facility. Only 62 (60.8%) facilities had a designated health commodities supply chain management coordinator. On average, 1.65 ± 1.34 professionals (95% CI [1.38, 1.91]) were assigned to supply chain activities, ranging from zero to eight. The average number of finance professionals assigned to supply chain tasks was 0.95 ± 2.44 (95% CI [0.43, 1.48]).

Of the healthcare facilities surveyed, 83 (81.4%) received program and RDF products directly from EPSS hubs within their respective clusters, while the remaining facilities received their supplies through the Woreda Health offices. Specifically, 56 (54.9%) facilities were supplied by the Bahir Dar EPSS hub, 24 (23.5%) by the Addis Ababa EPSS hub, and 22 (21.6%) by the Gondar EPSS hub.

During the visit, the three most widely practiced pharmacy service and supply chain management initiatives were the Integrated Pharmaceutical Logistics System (APTS), Drug and Therapeutics Committee (DTC), and ART Service, which were operational in 98 (96.1%), 94 (92.1%), and 51 (50%) of the facilities, respectively. In contrast, the least implemented initiatives were the Drug Information Service (DIS), APTS, and clinical pharmacy service, with frequencies of 31 (30.4%), 19 (18.6%), and 11 (10.8%), respectively (Figure 4).

3.4 Availability, utilization, and supply of LMIS forms

There is a notable variation in the availability and utilization of LMIS forms among healthcare facilities. The IFRR and RRF demonstrated the highest availability and utilization, were present in 99 and 98% of facilities, respectively, and were almost fully utilized in nearly all facilities. In contrast, the HCMIS Guide/Manual had the lowest availability, present in only 18.6% of health facilities, and was utilized in 84.2% of those cases. The Bin Card (BC) was widely available in 96.1% of health facilities, of which 89.8% actively used it, and 87.8% maintained a supply for three or more months. Although the Stock Record Card (SRC) was less available, present in only 27.5% of health facilities, it had a high utilization rate of 92.9% in the facilities where it was available. Other forms, such as the Job Aids for IPLS (laminated), Quantification Tool (Updated), and

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TABLE 2 Availability, utilization, and supply of LMIS forms in healthcare facilities in Amhara, March 2022.

SN	LMIS forms in HFs [N = 102]	Availability [N = 102]		Utilization status		Supply for 3+ months		Supply for < 3 months	
		N	%	N	%	N	%	N	%
1.	Bin Card (BC)	98	96.1	88	89.8	86	87.8	12	12.2
2.	Stock Record Card (SRC)	28	27.5	17	60.7	26	92.9	2	7.1
3.	HPMMR in HCs [N – 86]	72	83.7	65	90.3	63	87.5	9	12.5
4.	IFRR	101	99	100	99	86	85.2	14	14.9
5.	RRF	100	98	100	100	90	90	10	10
6.	Model 19/H	47	46.1	43	91.5	44	93.6	3	6.4
7.	Model 22/H	49	48	44	89.8	46	93.9	3	6.1
8.	IPLS SOP	63	61.8	57	90.5				
9.	Physical Inventory form	80	78.4	75	93.8				
10.	Job Aids for IPLS (laminated)	38	37.3	37	97.4				
11.	HCMIS Guide/Manual	19	18.6	16	84.2				
12.	Quantification tool (Updated)	63	61.8	61	96.8				
13.	M&E tool	54	52.9	48	88.9				

TABLE 3 Availability, utilization, and supply of LMIS forms in APTS sites in Amhara, March 2022.

SN	LMIS forms in APTS Sites [N = 19]	Availability		Utilization status		Supply for 3+ months		Supply for < 3 months	
		N	%	N	%	N	%	N	%
1.	Cash sales Ticket	19	100	19	100	18	94.7	1	5.3
2.	Free registration book	17	89.5	17	100	17	100	–	–
3.	Credit registration book	18	94.7	18	100	18	100	–	–
4.	Daily summary sheet	19	100	19	100	18	94.7	1	5.3
5.	Monthly sales summary sheet	18	94.7	18	100	18	100	–	–
6.	Model 19/H	18	94.7	17	94.4	18	100	–	–
7.	Model 22/H	18	94.7	17	94.4	18	100	–	–
8.	Sales ticket pad register	19	100	19	100	18	94.7	1	5.3
9.	Cash delivery note	18	94.7	18	100	18	100	–	–

Physical Inventory form, also exhibited high utilization rates (Table 2).

In the evaluation of LMIS forms at 19 APTS sites, it was found that Cash Sales Tickets, Daily Summary Sheets, and Sales Ticket Pad Registers were universally available at all sites, achieving 100% availability. The Free Registration Book, however, had the lowest availability, being present at only 89.5% of the sites. Utilization across these forms was notably high, with Cash Sales Tickets, Daily Summary Sheets, and Sales Ticket Pad Registers all being used at 100% of the sites. Most APTS-related LMIS forms had sufficient supplies of printed copies that lasted three or more months (Table 3).

In the assessment of LMIS forms at 51 ART sites, the ART monthly activity report format and the ART register were highlighted for their exceptional availability at 98% of the sites. In contrast, the EDT form had the lowest availability, found at only 17.6% of the sites. The utilization status of LMIS forms was greater than 80% across all ART sites. Furthermore, the ART register and the patient information sheet (PIS) had a better supply of print copies for managing supplies lasting three or more months at the ART sites (Table 4). Challenges related to the availability and utilization of LMIS forms directly impact LMIS performance, as these forms are critical for record-keeping, transactions, and reporting. A shortage of LMIS forms and gaps in their utilization lead to poor data quality and management, which in turn directly affects LMIS performance and subsequently impacts supply chain efficiency. Quality data and effective performance in LMIS are essential for informed decision-making. Therefore, gaps in this area directly impact inventory policies, order quantities, inventory costs, and ordering costs, ultimately affecting the availability of health commodities and service delivery.

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TABLE 4 Availability, utilization, and supply of LMIS forms in ART sites in Amhara, March 2022.

SN	LMIS forms in ART Sites (*N* = 51)	Availability		Utilization status		Supply for 3+ months		Supply for <3 months	
		N	%	N	%	N	%	N	%
1.	ART Monthly Activity report format	50	98.0	44	88.0	44	88.0	6	12.0
2.	EDIT	9	17.6	8	88.9	8	88.9	1	11.1
3.	Patient tracking chart	38	74.5	31	81.6	34	89.5	4	10.5
4.	ART Register	50	98.0	45	90.0	46	92.0	4	8.0
5.	Patient Information Sheet (PIS)	44	86.3	39	88.6	42	95.5	2	4.5

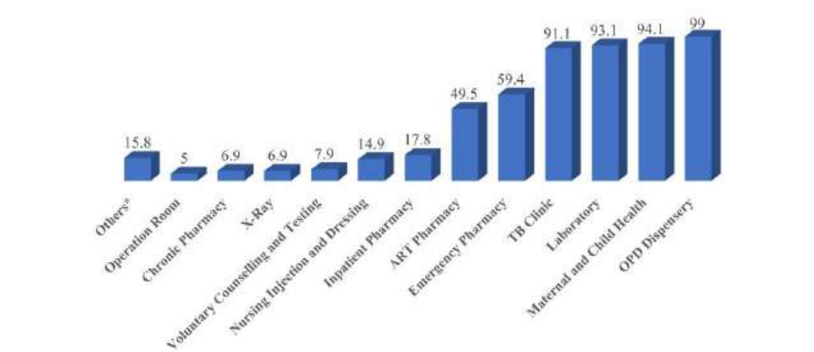

FIGURE 5
Utilization status of IFRR in public health facilities of Amhara Region, March 2022.

3.5 Health commodities LMIS performance

Among all surveyed facilities, only 37 (36.3%) had adopted the digital LMIS system known as the Health Commodities Management Information System (HCMIS), a facility version named Dagu. Of these, 21 (56.8%) utilized Dagu version 2.0, while 16 (43.2%) used the older version, Dagu 1.0. The average duration of HCMIS implementation preceding the visit was 4.63 ± 3.38 years (95% CI [3.5, 5.75]). Interestingly, the majority (73%) were in the mature implementation phases, with the remaining 27% evenly split between the pre-intensive and intensive phases.

Nearly all health facilities, except one, were found to utilize IFRR during the visit. The outpatient pharmacy, Maternal and Child Health pharmacy, and laboratory department were the primary units using IFRR to report consumption and request resupply from the health facility store, with frequencies of 100 (99%), 95 (94.1%), and 92 (93.1%), respectively. In contrast, the X-ray unit, Chronic diseases management pharmacy, and Operation room were the least frequent users of IFRR, with frequencies of 7 (6.9%), 7 (6.9%), and 5 (5%), respectively (Figure 5).

Among facilities utilizing IFRR, 96 (95%) adhered to a two-week schedule for reporting consumption and requesting resupply from the store. In contrast, 2 (2%) operated on a facility-specific one-month schedule, and 3 (3%) did not have a specified schedule. Among these facilities, 60 (61.2%) displayed their IFRR schedule at the store, while the remaining 38 (38.8%) did not.

Of the 719 dispensary units expected to report according to the IPLS 2-week schedule, 482 units (67.04%) submitted their latest IFRR on time. The median number of dispensaries submitting on time was 5, with a mean of 4.92 ± 3.3 and a range from 0 to 20 (95% CI [4.3, 5.6]). Conversely, 26.8% of dispensary units submitted their IFRR after the scheduled date, with a median of 1, a mean of 2.14 ± 5.8, and a range from 0 to 53 (95% CI [0.93, 3.4]).

Among the 719 dispensaries, 518 (72.1%) had their supply requests fulfilled within 2 days of making the request. Store managers mentioned workload, the complexity of requests needing additional processing time, and delays in IFRR reporting from units as factors contributing to delays in meeting the two-day supply request timeframe.

Of the 406 health posts connected via the referral system to the 86 surveyed health centers, 283 (69.7%) submitted the Health Post

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TABLE 5 Reporting status of IFRR and HPMRR at public health facilities in Amhara Region, March 2022.

SN	Variable	Frequency n(%)	Mean ± SD (Min, Max)	95% CI
1.	DUs sent IFRR as per the schedule ($N = 719$)	482(67.04%)	4.92 ± 3.3 (0,20)	[4.3,5.6]
2.	DUs sent IFRR after the schedule ($N = 719$)	193(26.8%)	2.14 ± 5.8(0,53)	[0.93,3.4]
3.	Stores resupply to DUs within 2 days of request? ($N = 719$)	518(72.1%)	5.34 ± 6.4(0,59)	[4.1,6.63]
4.	Health Posts submitted the latest HPMRR to the HC ($N = 406$)	283(69.7%)	3.29 ± 1.91(0,8)	[2.9, 3.7]
5.	Health Posts submitted the latest HPMRR as per the schedule ($N = 283$)	202 (71.4%)	2.69 ± 1.85(0,6)	[2.3,3.1]

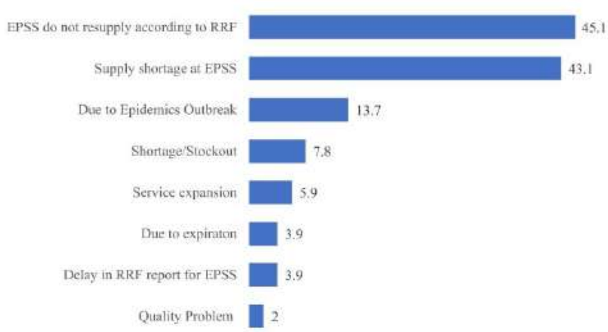

FIGURE 6
Reasons for emergency order placement in public health facilities of Amhara Region, March 2022.

Monthly Report and Resupply Form (HPMRR) to the health centers during the latest reporting period. The median number of health posts submitting the HPMRR on time was 3, with a mean of 3.29 ± 1.91 and a range from 0 to 8 (95% CI [2.9, 3.7]). Among these, 202 (71.4%) health posts submitted the HPMRR on schedule by the fifth day after the reporting period (Table 5).

Out of 102 health facilities, 100 (98%) used the Report and Requisition Form (RRF) for bi-monthly reporting of consumption and resupply requests to EPSS and Woreda Health Offices (WoHO). The remaining two facilities did not use the RRF due to difficulties in understanding its use and workload constraints. Among the RRF reports reviewed over the year, only 450 (75%) were approved and signed by either the health facility heads, Chief Executive Officers, or Chief Clinical Officers. The number of approvals per facility had a mean of 4.5 ± 2.2, ranging from 0 to 6 across the six reports reviewed during the year (95% CI [4.06, 4.94]).

Among the 100 facilities using the RRF, 51(51%) placed emergency orders at least once during the year. These orders had a mean of 2.32 ± 7.5, ranging from 0 to 72 (95% CI [0.83, 3.8]). The main reasons for these emergency orders were issues related to EPSS, including shortages and difficulties in fulfilling the requested quantities as specified in the RRF (Figure 6).

3.6 LMIS reporting and feedback

Regarding LMIS report submission channels, 77 health facilities (75.5%) submitted their reports to the Woreda Health Office (WoHO). Additionally, 62 facilities (60.8%) sent reports to EPSS, 16 facilities (15.7%) to the Zonal Health Department, and three facilities (2.9%) to the Regional Health Bureau. The most frequently mentioned transportation methods for sending LMIS reports to higher levels were public transportation, used by 49 facilities (48%); facility vehicles, used by 38 facilities (37.3%); and private vehicles, used by 21 facilities (20.6%; Figure 7).

Among the facilities surveyed, 38 (37.3%) received written periodic feedback on supply chain management and LMIS reports from higher levels. This feedback came from various sources, including 29 facilities (76.3%) received it from the Woreda Health Office (WoHO), four facilities (10.5%) from Zonal Health Departments, two facilities (5.3%) from partners, and three facilities

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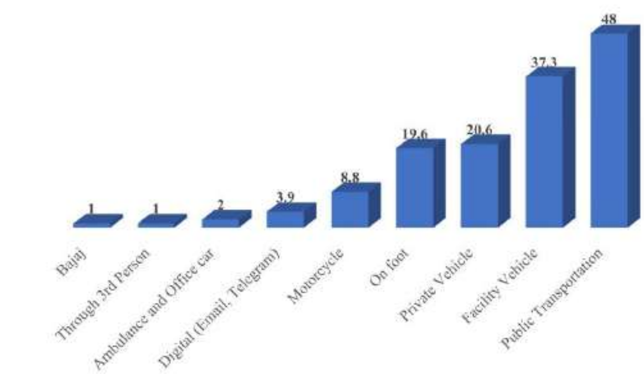

FIGURE 7
Frequently used transportation methods for sending LMIS reports to higher levels in public health facilities of Amhara Region, March 2022.

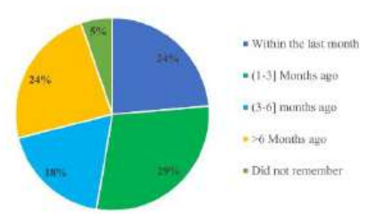

FIGURE 8
Timeliness of written feedback on LMIS reports in public health facilities of Amhara Region, March 2022.

(7.9%) from integrated teams. Of those receiving feedback, nine facilities (23.7%) received it within the month before the visit, while 11 facilities (28.9%) received it between 1 and 3 months prior to the visit (Figure 8).

3.7 LMIS supportive supervision

In the year leading up to the study, only 73 out of the surveyed health facilities (71.6%) received supportive supervision for supply chain activities and LMIS-related issues. Of these, 21 facilities (28.8%) received supportive supervision within the month prior to the visit, while 24 facilities (32.9%) received it between 1 and 3 months before the visit (Figure 9).

Recent supportive supervision was provided by the following institutions, including Woreda Health Office (WoHO) in 38 facilities (52.1%), Zonal Health Departments in 23 facilities (31.5%), Regional Health Bureaus in 15 facilities (20.5%), partners in 11 facilities (15.1%), and integrated teams in 4 facilities (5.5%). This supervision was reported to have improved supply chain management and LMIS practices, focusing on enhancing APTS, DAGU, DIS, DTC, and IFRR reporting. Additionally, it claimed to result in better bin card management, more effective RRF reporting systems, improved data quantification, and better management of expired products and stockouts.

4 Discussion

The evaluation of the Logistics Management Information System (LMIS) in Amhara Region's public health facilities reveals a complex landscape marked by significant achievements, persistent challenges, and opportunities for improvement. This discussion synthesizes key findings to highlight the system's strengths, weaknesses, and implications for improvement.

The study indicates that most health facilities (96.1%) had operational electric power systems during the survey. However, nearly a third of these facilities experienced power interruptions, underscoring vulnerabilities in infrastructure reliability. This finding aligns with the infrastructure challenges in low-income settings, where power instability disrupts LMIS operations. The presence of backup generators in 61.8% of facilities reflects a response to this challenge but indicates that reliance on backup power needs to be uniformly adequate. The unreliable power supply system can significantly impact the functioning of the LMIS, disrupt data transmission, and necessitate sending reports via transportation methods instead. This, in turn, poses another challenge, as the majority of health facilities lack dedicated transportation methods for sending LMIS reports to higher levels (20).

Similarly, internet connectivity is another critical infrastructure component, available in only 42.2% of the facilities, with limited access, particularly in pharmacy departments. This finding aligns with

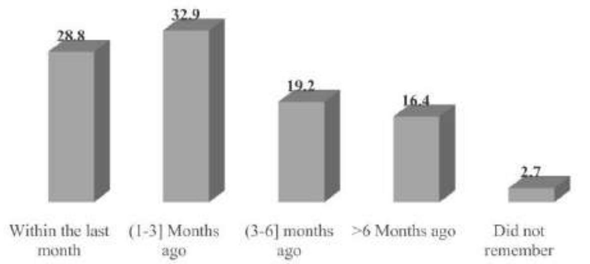

FIGURE 9
Supportive supervision of public health facilities on LMIS in Amhara Region, March 2022.

Endeshaw et al. (24), who identified poor internet infrastructure as a barrier to effective LMIS in health facilities. Additionally, the shortage of computers dedicated to LMIS activities in health facilities directly affects the system's functionality, which is consistent with the findings of Shewarega et al. (23) and Alemu et al. (22), who reported insufficient LMIS resources and technological gaps in healthcare facilities. This limitation restricts real-time data reporting and hampers the potential benefits of digital systems like HCMIS. Efforts to enhance connectivity infrastructure are essential to leveraging the full capabilities of digital LMIS, ensuring timely and accurate information flow across healthcare levels (5, 17).

Human resources dedicated to supply chain management are limited, with an average of 1.65 professionals per facility. Additionally, only 60.8% of facilities have designated supply chain coordinators, exposing gaps in leadership and oversight crucial for effective health supply chain practices and LMIS utilization. This is consistent with findings from a study in the Oromia Region, which identified a shortage of skilled human resources as a major bottleneck in LMIS performance, and with Fenta (33), which highlighted human resource challenges as key factors affecting supply chain performance in Ethiopia (33, 34).

The study reveals significant variability in the availability and utilization of LMIS forms. Essential forms such as the IFRR and RRF are widely available and used, whereas others, like the HCMIS Guide/Manual, are less accessible. This disparity underscores ongoing challenges in standardizing and integrating LMIS tools across facilities. The high utilization of Bin Cards and Stock Record Cards, despite their lower availability, indicates practical adaptations to resource limitations, aligning with findings from Bekele and Anbessa (26). The low availability and utilization of LMIS forms directly impact LMIS performance and decision-making, ultimately affecting the supply efficiency of health commodities.

The study indicates that 75.5% of facilities submit reports to the Woreda Health Office, with a significant portion reporting to EPSS. However, only 37.3% received written periodic feedback, and 71.6% received supportive supervision within the past year. These figures suggest that while reporting mechanisms are in place, feedback and supervisory support are insufficient, reflecting similar concerns raised in a study conducted in North West Ethiopia about the impact of inadequate feedback and supervision on LMIS performance (29). Strengthening communication channels and enhancing supervisory support are essential for continuous improvements in LMIS (34). Furthermore, the involvement of multiple stakeholders in supervision highlights the critical role of collaboration in sustaining LMIS performance improvements. Most importantly, digitizing the LMIS system and modernizing communication channels for reporting and feedback could significantly support the LMIS overall performance.

The discrepancy between the high utilization of reporting forms and the low percentage of facilities receiving timely feedback indicates a gap in effectively using information to improve practices. This issue mirrors the findings of other studies which highlighted difficulties in leveraging data for decision-making and is consistent with similar concerns noted regarding the underutilization of available data in enhancing health system performance (24, 27). Addressing this gap is crucial, as timely feedback can empower health facilities to improve LMIS performance and enhance overall health outcomes through improving availability of essential health commodities.

5 Conclusion and recommendation

The Logistics Management Information System performance evaluation in Amhara Region's public health facilities highlights a blend of successes and ongoing challenges. While essential forms like IFRR and RRF are widely available and power systems generally operational, critical issues persist, including frequent power interruptions, inadequate internet connectivity, insufficient computer resources, and inconsistent availability and utilization of LMIS forms. The IFRR reporting rate as per the IPLS 2 weeks schedule was found to be 67.04%. Of the facilities using the RRF, 51% placed emergency orders at least once per year. The need for more dedicated personnel for supply chain management and uneven supervisory support further compound these problems. To address these issues, investing in reliable power solutions and improving internet infrastructure is crucial; expanding computer access, standardizing LMIS tools, increasing staffing and training, and enhancing feedback and supervisory mechanisms are crucial. Collaborative efforts among stakeholders are vital to overcoming these barriers and enhancing the effectiveness of the LMIS. Digitizing the LMIS and increasing the utilization of its information for decision-making can significantly improve the health system's performance, ensuring better access to essential medicines and improved health outcomes.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

This study was approved by the Ethical Review Committee of the School of Pharmacy (Protocol No: ERB/SOP/399/14/2022) and the Institutional Review Board of College of Health Sciences, Addis Ababa University (Protocol number: 007/22/SoP). Written informed consent was obtained from all participants and institutions involved in the study.

Author contributions

ZM: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Software, Validation, Visualization, Writing – original draft. DC: Conceptualization, Funding acquisition, Resources, Supervision, Validation, Writing – review & editing. TF: Conceptualization, Funding acquisition, Investigation, Resources, Supervision, Validation, Writing – review & editing.

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Conflict of interest

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

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Paper II

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ORIGINAL RESEARCH

Logistics Management Information System (LMIS) for Health Commodities at Public Health Facilities in Amhara National Regional State of Ethiopia: A Data Quality Evaluation Survey

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Introduction: Access to essential medicines is limited in developing countries mainly due to inefficiencies in health supply chain management, such as the absence of standard monitoring frameworks and poorly designed Logistics Management Information Systems (LMIS). Health supply chain managers need accurate and timely data for decision-making. However, routine health information systems suffer from poor data quality, reliance on paper-based reports, insufficient logistic formats, inadequate infrastructure, and limited human resources.

Objective: This study evaluates the data quality of LMIS for health commodities in public health facilities in the Amhara National Regional State of Ethiopia.

Methods: The study was conducted in Ethiopia's Amhara National Regional State. The study employed an institution-based concurrent mixed-methods design. Data collection involved 102 facilities selected through multi-stage stratified random sampling, adhering to sampling criteria set by USAID's Logistics Indicators Assessment Tool (LIAT). Data abstraction checklists were used to collect data.

Results: Of the seven tracer medicines selected to evaluate data quality, there was substantial variability in inventory accuracy rates. Inventory discrepancies were significant, highlighting potential issues with manual and digital record-keeping systems, with overall mean physical and electronic inventory accuracy rates of 74.7% and 70.6%, respectively. Additionally, the Report and Requisition Form (RRF) showed trends of timely submission, with the overall mean percentage completeness for the seven tracer medicines at 90.2%. However, the data quality experienced fluctuations, with the overall average percentage of legality (authorization of LMIS reports) and the accuracy of the RRF at 77.2% and 76%, respectively.

Conclusion and Recommendation: The evaluation of data quality revealed significant discrepancies in physical and electronic records, with notable fluctuations in completeness, legality, legibility, and accuracy within the health LMIS. To rectify these issues, robust data quality verification processes, clear guidelines, targeted interventions, strengthened monitoring systems, regular audits, and comprehensive training for health supply chain staff are needed.

Keywords: LMIS, data quality, RRF, evaluation, performance, health facilities

Introduction

Access to essential medicines in developing countries is a dire global health crisis, with preventable diseases causing death and disability due to a lack of affordable treatments.[1–3] Structural and health system deficiencies, along with economic barriers, leave one-third of the global population and half of Sub-Saharan Africa without consistent access to lifesaving medicines.[1,4–6]

Robust supply chains for medicines, vaccines, and other health products are crucial for sustaining public health.[7,8] Inefficiencies in health supply chain management, including the absence of standard monitoring frameworks and poorly designed LMIS, impede the progress of health services.[9–12]

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Health supply chain managers rely on precise, timely data for strategic and operational decisions, and information distortions can severely disrupt supply chain efficiency.[13–15] Effective management of drug selection, forecasting, procurement, inventory, distribution, rational drug use, and reverse logistics centers on real-time logistics data.[9,11,16]

A well-designed LMIS that captures and reports routine data is vital for accurate forecasting, financial planning, procurement, and distribution of health commodities. Implementing integrated pharmaceutical logistic systems (IPLS) has enhanced supply chain efficiency in many developing countries, including Ethiopia.[12,17,18] Ethiopia's Health Sector Transformation Planning II (HSTP-II) agenda also emphasized improving data quality in accuracy, completeness, and timeliness.[19]

Despite the progress, routine health information systems in the health sector still need better data quality. Major challenges include reliance on paper-based reports, insufficient logistic formats, inadequate infrastructure, limited human resources, and weak inter-sectoral collaboration.[18,20] A study conducted in the public health facilities of the Harari Region revealed that only 51.35% of health facilities achieved good overall data quality for the health management information system (HMIS). This assessment was based on three quality dimensions, which required accuracy to be ≥80%, completeness to be ≥85%, and timeliness to be ≥85%. Consequently, the results fell significantly below the national target of 80%.[21] Digital LMIS in public health facilities and Ethiopian Pharmaceutical Supply Service (EPSS) hubs face issues related to poor internet connectivity, skill gaps, and poor data quality.[9,18,22–24] A study in Addis Ababa also showed 66.61% data quality, with only 39.17% utilization of regular reports for the digital LMIS in health facilities.[25]

This study evaluates LMIS data quality in public health facilities in the Amhara Region of Ethiopia, focusing on inventory accuracy and Report and Requisition Form (RRF) reports, including timeliness, completeness, legality, legibility, and accuracy.

Methods

Study Area

The research was conducted in the Amhara National Regional State of Ethiopia, the country's second most populous region. This area is administratively divided into 13 Zones and three city administrations. Health supplies for public health facilities in the region are distributed from four hubs operated by the EPSS. The area was selected for this study because it is one of the regions that has implemented new pharmacy service and supply chain initiatives, including clinical pharmacy services, auditable pharmaceutical transactions, and the Integrated Pharmaceutical Logistics System (IPLS), which are relatively at a mature phase for evaluation compared to other areas.[11]

Study Design

The study employed an institution-based concurrent explanatory mixed-methods design, combining quantitative and qualitative approaches to gather data. This research is part of a larger project assessing the performance of the health commodities Logistics Management Information System (LMIS), in which the findings presented here are predominantly drawn from quantitative data analysis.

Source and Study Population

The study encompassed all public health facilities in the Amhara Region. Specifically, the study population consisted of randomly selected public health facilities within the region.

Sampling Procedure

Health centers and hospitals in all administrative zones, except those with security challenges, were considered for sampling. Six zones and two city administrations were grouped into three clusters based on EPSS hub locations. Ultimately, the study included four zones and two city administrations. The public health facilities were stratified based on Zones and the level of the facility (Referral Hospital, General Hospital, Primary Hospital, Health Center). Since distance from the center is a key factor for supply chain management performance, distance from the EPSS hub, the Zonal Town, and the Woreda Town were also used for the stratification. Following USAID's Logistics Indicators Assessment Tool (LIAT), a 15% sample of facilities was selected; facilities were chosen using a multi-stage stratified random sampling method proportional to their size. Finally, a total of 102 health facilities were surveyed for the study.

Inclusion and Exclusion Criteria

Inclusion Criteria

- All Zonal Administrations.
- All public health facilities which have been operational for more than one year.

Exclusion Criteria

- Health facilities which were damaged in conflict-affected areas or had security issues during the study.
- Health Posts.

Data Collection Process

The data abstraction checklists were adapted from the Logistics Indicator Assessment Tool (LIAT), Logistics System Assessment Tool (LSAT), and the Ministry of Health's supply chain monitoring and evaluation tools.[26–28]

Data Quality Assurance

Ten experts validated the data collection tools, and data collectors underwent a two-day training session. The tools were pre-tested, and adjustments were made as needed.

Operational Definitions

Health Commodities Logistics Management Information System

It is a system designed to manage and oversee the flow of information along with the flow of health commodities across the healthcare system.

Data Quality

It is an assessment of LMIS data's fitness to serve its purpose in terms of health supply chain data completeness, timeliness, legality, legibility, and accuracy.

Data Analysis and Interpretation

The data underwent a thorough review for completeness and internal consistency before being entered into Epi Info Version 7 for initial processing. Afterward, the data were exported to SPSS Version 23.0 for comprehensive management and analysis.

Results

The study surveyed 102 public health facilities, with 58.8% located in rural areas. The majority were health centers (84.3%), followed by primary hospitals (9.8%), referral hospitals (3.9%), and general hospitals (2%). The evaluation focused on seven tracer medicines to assess the data quality of the LMIS in these facilities, explicitly targeting inventory and reporting. These medicines were selected from the basic health program categories, such as family planning, maternal and child health, malaria, tuberculosis, Human Immunodeficiency Virus/Acquired Immunodeficiency Syndrome (HIV/AIDS), and infectious diseases.

Inventory Accuracy Rate

Inventory accuracy was assessed in 88 health facilities utilizing bin cards. Accordingly, variability in bin card updates among these tracer medicines is substantial, ranging from 39.8% for Oxytocin Injection to 68.2% for RHZE/RH. This

Table 1 Tracer Medicines Inventory Accuracy Rate at Public Health Facilities in Amhara Region, March 2022

SN	List of Tracer Drugs (N=88)	Updated Bin card? (%)	Physical Inventory Discrepancy (%)	Electronic Inventory Discrepancy (%)
1	Medroxyprogesterone Injection	54.5	3.0±12.6 [0, 75]	6.7±25.8 [0, 100]
2	Oxytocin injection	39.8	26.3±98.9 [0, 575]	35.6±54.8 [0, 150]
3	Amoxicillin 250 mg dispersible tab	65.9	14.9±35[0, 140]	14.1±29.4 [0, 100]
4	ORS±Zinc sulphate*	50.0	10.7±28.5 [0, 120]	19.1±39.9 [0, 100]
5	RHZE/RH**	68.2	8±28.8 [0, 200]	55.6±145.7 [0, 566.7]
6	TDF/3TC/DTG (of 90)***	45.5	6.2±13.9 [0, 58.9]	64±15.4 [0, 367]
7	Artemether+Lumefantrine tab (6x4)	52.3	6.8±21.2 [0, 100]	57.2±128.5 [0, 471.4]

Notes: *Oral Rehydration Solution; **Rifampicin, Isoniazid, Pyrazinamide, Ethambutol/Rifampicin, Isoniazid; ***Tenofovir disoproxil fumarate/Lamivudine/Dolutegravir.

variability underscores inconsistencies in inventory record update frequencies, potentially impacting inventory accuracy and supply chain management. Oxytocin Injection notably exhibited high physical inventory discrepancies (26.3% ± 98.9), whereas medicines like TDF/3TC/DTG and Artemether + Lumefantrine tablet showed lower discrepancies, suggesting more effective inventory control. Electronic inventory discrepancies also varied widely. Tracer medicines, including RHZE/RH, TDF/3TC/DTG, and Artemether+Lumefantrine tablet, displayed exceptionally high electronic discrepancies. This indicates potential issues with the accuracy of manual and digital record-keeping systems in healthcare facilities. The overall mean physical inventory accuracy for tracer medicines was 74.7%, with a standard deviation 30.4 (0, 100). The mean electronic inventory accuracy was 70.6%, with a standard deviation of 31.9 (0, 100) (Table 1).

Timeliness of RRF Reporting Rate

Out of the 102 health facilities, 100 use the RRF for bi-monthly reporting of consumption and resupply requests to EPSS and the Woreda Health Office (WoHO). For these 100 facilities, six RRF reports submitted prior to this study were reviewed, resulting in a total of 600 reports. Among the reports reviewed, the reporting date was indicated in 82% of the RRFs for the most recent reporting period [Report Period 6] and in 94% for the second most recent period [Report Period 2].

Across these six reports, the proportion of health facilities submitting their RRF report within the first five days after the reporting period ranged from 67% in the fifth reporting period to 79% in the second. This trend of timely submissions within the first five days persists consistently across all reporting periods.

Additionally, the percentage of health facilities that submitted their RRF report until the 10th day after the reporting period ranged from 7% to 16% in the fourth and last reporting periods, respectively. Few health facilities submitted their RRF after the 10th day, which exceeds the recommended timeframe outlined in the IPLS for hospitals and health centers. The percentage of facilities that did not submit the RRF report during the reporting period ranged from 6% in the second reporting period to 18% in the sixth reporting period (Figure 1).

Completeness of RRF Reporting

The completeness of RRF data components is critical for suppliers when making resupply decisions. The analysis of RRF reports consistently showed more than 90% completeness for the six tracer medicines. However, the completeness of the RRF for the Antiretroviral (ART) medicine TDF/3TC/DTG was steadily less than 70%, with an average percentage completeness of 65.7%. The overall mean percentage completeness of RRF for the seven tracer medicines was 90.2% (Table 2).

Legality of RRF

The legality of the RRF report was evaluated using five data components. The data shows a general trend of increasing percentages across all metrics as the reporting periods advance. The highest frequency for the legality data component "who prepared the report" was seen in 97% in the second Reporting Period while the lowest was

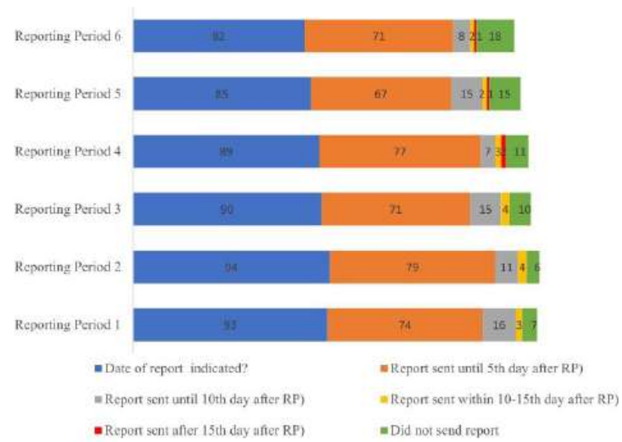

Figure 1 Timeliness of Report and Requisition Form (RRF) report at public health facilities in Amhara Region, March 2022.

in the sixth Reporting Period (81%). The legality data component "who approved report" ranged from 83% in the second Reporting Period to 74% in the sixth Reporting Period. Verification rates showed the most significant decline, from 66% in the second Reporting Period to 53% in the sixth Reporting Period. The presence of an official stamp and a cover letter followed similar trends, with the highest rates in the second and first Reporting Periods, respectively, and the lowest in the sixth Reporting Period. The overall average percentage legality of RRF was found to be 77.2% (Table 3).

Legibility of RRF

There were illegible items in the RRFs across all the reporting periods. Of the total 100 health facilities using RRFs, the percentage of health facilities with legible RRF ranges from 29% to 31% in the 2nd reporting period and the 6th reporting period, respectively. The average percentage of illegible items per the illegible RRF report ranged from 2.8% in the fifth Reporting Period to 6.4% in the first Reporting Period. The data highlights fluctuations in the quality of the RRFs, indicating periods with better and worse legibility (Table 4).

Pharmaceutical SCM M&E Reporting

Of the 102 health facilities studied, 45 were using the pharmaceutical monitoring and evaluation quarterly reporting system. The evaluation of the four reports from the year before the study showed a decline in the timely submission of reports over the four reporting periods. The highest percentage of on-time reports was in the first Reporting Period (53.3%), while the lowest was in the third Reporting Period (15.6%) (Figure 2).

Accuracy of RRF

The accuracy of the RRF report was evaluated using eight data components critical for resupply decisions. For the seven tracer medicines used to assess RRF accuracy, the highest average percentage accuracy was obtained for Amoxicillin 250 mg dispersible tablets, with a frequency of 81.1%, while the lowest was for Oxytocin injection, with a frequency of 68.5%. Among the eight data components, the highest score was for "Verified

Table 2 Completeness of Report and Requisition Form (RRF) Report at Public Health Facilities in Amhara Region, March 2022

SN	List of tracer medicines [N=100]	"Beginning Balance"	"Quantity Received"	"Ending Balance"	"Calculated Consumption"	"Maximum Quantity"	"Quantity to Reach Max"	"Average Percentage Completeness"
1	Medroxyprogesterone Injection	95	95	95	95	94	95	94.8
2	Oxytocin injection	95	94	95	95	94	94	94.5
3	Amoxicillin 250 mg tab	96	96	97	97	96	96	96.3
4	ORS± Zinc sulphate*	90	90	90	91	91	91	90.5
5	RHZE/RH**	94	94	94	95	95	95	94.5
6	TDF/3TC/DTG (of 90)***	66	65	65	64	67	67	65.7
7	Artemether+Lumefantrine tab	95	95	94	96	95	95	95
Average Percentage Completeness		90.1	89.9	90	90.4	90.3	90.4	90.2

Notes: *Oral Rehydration Solution; **Rifampicin, Isoniazid, Pyrazinamide, Ethambutol/Rifampicin, Isoniazid; ***Tenofovir disoproxil fumarate/Lamivudine/Dolutegravir.

Table 3 Legality of Report and Requisition Form (RRF) Reporting at Public Health Facilities in Amhara Region, March 2022

SN	Reporting Period [N=100]	No of Reports Which Indicated Who Prepared It	No of Reports Which Indicated Who Approved it	No of Reports Which Indicated Who Verified It	No of Reports with Official Stamp	No of Reports with Cover Letter	Average Percentage Legality
1	1st Report Period	92	79	63	84	79	79.4
2	2nd Report Period	97	83	66	87	81	82.8
3	3rd Report Period	92	79	62	82	78	78.6
4	4th Report Period	91	80	60	82	78	78.2
5	5th Report Period	86	75	59	79	72	74.2
6	6th Report Period	81	74	53	75	67	70
Average % Legality		89.8	78.3	60.5	81.5	75.8	77.2

Table 4 Legibility of Report and Requisition Form (RRF) Reporting at Public Health Facilities in Amhara Region, March 2022

SN	Reporting Period [N=100]	Percentage of Health Facilities with Legible RRF?	Average Percentage of Illegible Items
1	1st Report Period	80	6.4 [1, 47.3]
2	2nd Report Period	81	4.9 [1, 15]
3	3rd Report Period	75	3.5 [0.8, 15.5]
4	4th Report Period	76	4.7 [0.8, 15.8]
5	5th Report Period	74	2.8 [0.8, 18.2]
6	6th Report Period	69	3.8 [0.8, 46.9]

calculated consumption indicated on RRF", with a frequency of 88.9%, and the lowest was for "Ending balance of RRF vs Ending balance of bin card", with a frequency of 46.4%. The overall average percentage accuracy for RRF was 76% (Table 5).

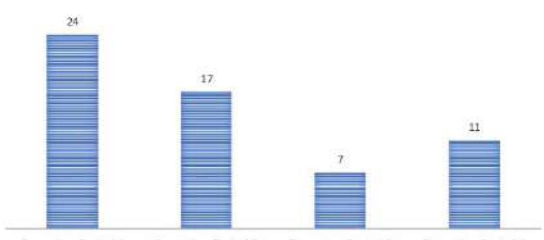

Figure 2 Pharmaceutical Supply Chain Management Monitoring and Evaluation quarterly reporting at public health facilities in Amhara Region, March 2022.

Table 5 Accuracy of Report and Requisition Form (RRF) Report at Public Health Facilities in Amhara Region, March 2022

SN	List of Tracer Medicines	Verified Calculated Consumption Indicated on RRF	Verified Maximum Stock Quantity Indicated on RRF	Verified Quantity Needed to Reach Max on RRF	Valid Beginning Balance of this RP of RRF vs Ending Balance of Previous RRF Report	Valid Quantity Received of RRF vs Quantity Received of STV/Model 19	Ending Balance of RRF vs Ending Balance of Bin Card	Loss/ Adjustment of RRF vs Bin Card	DOS of RRF vs DOS of Bin Card	Average Percentage Accuracy
1	Medroxyprogesterone injection	89.6	85.3	83.2	77.9	87.4	47.4	78.3	69.9	77.4
2	Oxytocin injection	86.3	83.0	77.7	73.7	78.7	35.8	56.6	56.0	68.5
3	Amoxicillin 250 mg dispersible tab	91.8	87.5	81.3	78.1	85.4	56.3	70.9	97.6	81.1
4	ORS± Zinc sulphate*	89.0	85.7	84.6	75.6	88.9	40	66.7	64.1	74.3
5	RHZE/RH**	89.5	84.2	83.9	76.6	89.4	48.9	76.2	75.3	78.0
6	TDF/3TC/DTG***	84.4	83.6	85.1	78.8	87.7	55.4	76.6	75.4	78.4
7	Arthmeter + Lumfanthrine tab	91.7	86.3	85.3	73.7	84.2	41.3	67.9	66.7	74.6
Average Percentage Accuracy		88.9	85.1	83	76.3	86	46.4	70.5	72.1	76

Notes: *Oral Rehydration Solution; **Rifampicin, Isoniazid, Pyrazinamide, Ethambutol/Rifampicin, Isoniazid; ***Tenofovir disoproxil fumarate/Lamivudine/Dolutegravir.

Discussion

Data quality evaluation within healthcare facilities' LMIS revealed substantial issues in inventory recording, critically impacting the supply chain's efficiency.[29] Timely and accurate data management is essential for generating quality information for decision-making.[15,30] This study indicated consistent inventory discrepancies among tracer medicines, particularly Oxytocin Injection, which showed the highest physical inventory discrepancies (26.3% ± 98.9), indicating severe challenges in maintaining accurate physical counts. This discrepancy will result in an unprecedented stockout, which will ultimately impact the health outcomes for mothers and new-born children, as this medicine is essential for inducing labor during delivery. The overall mean physical and electronic inventory accuracy were 74.7% and 70.6%, respectively, suggesting moderate reliability in stock management. The electronic inventory accuracy is lower than the physical inventory accuracy, which may be due to less frequent updates of the digital system after the manual recordings. Electronic discrepancies underscore potential issues with data integrity and system synchronization, necessitating consistent updates across all health commodities. This is likely a result of challenges related to workload, workforce shortages, and skill gaps in managing the digital system. The inventory accuracy in this study is comparable to the study report of 77% in the Southern Nations, Nationalities, and Peoples' Region (SNNPR),[31] lower than the report of 87% by[24] in South West Ethiopia and the report of 90.6% in Addis Ababa,[32] and surpasses the report of 52.45% in West Wollega.[33] This may be due to the lack of regular updates to the bin card, resulting from workload, workforce shortages, competency gaps, and the challenges of manual LMIS, which is tedious for frequent updating.[18,33] Addressing these discrepancies requires implementing improved inventory management practices, robust inventory control systems, and comprehensive staff training to ensure adherence to inventory protocols. These enhancements will ultimately boost supply chain efficiency, reduce wastage, and ensure adequate drug availability, thereby increasing access to essential medicines and improving health outcomes for patients.

The IPLS mandates hospitals and health centers to submit the RRF report within ten days after the reporting period. Analysis of six reports from the previous year showed variability in timely submissions, with non-submission rates ranging from 6% to 18%. The findings on timely RRF reporting performance are consistent with those from the Bahirdar EPSS branch study (75.6%)[34] and are higher compared to the studies conducted in SNNPR (56.7%), Gambela (64%), and West Wollega (62.9%).[31,33,35] However, the non-submission rates during each period were comparable to those in other studies. Delays and non-submissions can significantly impact the supplier's supply planning system and the availability of medicines. This can result in stockouts, where essential medicines are unavailable when needed, or overstock situations, which can lead to wasted resources and expired products. Ultimately, these disruptions can compromise patient care by limiting access to essential medicines, leading to potential health risks and poorer health outcomes.

The completeness of RRF data components is crucial for informed resupply decisions. Analysis of the reviewed RRF reports revealed over 90% completeness for six tracer medicines, whereas the ART medicine TDF/3TC/DTG consistently demonstrated lower completeness at 65.7%. This significant discrepancy in ART medicines may be attributed to the fact that this program is well-established, leading to less attention and follow-up for this donor-based program medicines. The overall mean completeness for the seven tracer medicines was 90.2%, indicating high completeness with notable exceptions for ART medicines. This finding is lower than the 97.8% completeness reported in East Wollega[36] but higher than the completeness rates reported in West Wollega (62.9%),[33] Gambella (71%),[35] and the EPSS Bahir Dar branch (68.5%).[34]

Legal approval of RRF is critical due to concurrent financial transactions within the reporting system. Verification rates significantly declined, from 66% in the 2nd Reporting Period to 53% in the 6th Reporting Period. The overall mean legality of RRF, evaluated across five data components, was 77.2%, indicating a need for improvement. The legibility of RRF reports is problematic, potentially affecting resupply decisions. The average percentage of illegible items per the illegible RRF varied from 2.8% to 6.4%, highlighting fluctuations in report quality. Digitization of the LMIS and the RRF reporting system is essential to address these issues.

Despite initiating a quarterly monitoring and evaluation system for pharmaceutical supply chain management, adherence to utilization and timely report submission still need to be revised. Out of 102 health facilities, only 45 utilized the quarterly reporting system. An analysis of four reports prior to this revealed a decline in timely submissions, with the highest on-time reporting rate of 53.3% in the nearest 1st report period and the lowest at 15.6% in the 3rd report period. This low performance in the monitoring and evaluation report may be attributed to the recent initiation of the framework within the healthcare system, as there may not yet be full implementation across all health facilities. Hence, these findings underscore the critical need for enhanced adherence to reporting timelines to ensure the effectiveness of the monitoring system.

The accuracy of RRF reports, evaluated using eight critical data components, is paramount for adequate report verification and informed resupply decisions. The analysis revealed that Amoxicillin 250 mg dispersible tablets had the highest accuracy at 81.1%, whereas Oxytocin Injection had the lowest at 68.5%. The overall average accuracy for the RRF was 76%, indicating a substantial need for improvement in data accuracy. This study's findings are higher compared to those reported in West Oromia (37.1%),[37] Gambella (49%),[35] North West Ethiopia (59.48%),[33] and East Wollega (64.6%).[36] However, the accuracy is lower than the 84.6% reported in South West Ethiopia.[38] This low accuracy rate can be improved by digitizing the LMIS system, replacing manual calculations with automated digital processes, increasing the supply chain workforce, enhancing capacity-building training, and providing adequate supportive supervision. These discrepancies in accuracy affect informed resupply decisions, which in turn impact facility stock levels, leading to either stockouts or overstock situations. This issue compromises patient care by limiting access to essential medicines.

Conclusion and Recommendation

Data quality evaluation within healthcare facilities' Logistics Management Information Systems showed significant variability in inventory accuracy rates. Severe discrepancies in both physical and electronic inventories highlight critical flaws in manual and digital record-keeping systems. Although the RRF report showed a trend of timely submissions, there were substantial inconsistencies in data completeness, legality, and legibility. The overall mean completeness, legality, and accuracy of the RRF were 90.2%, 77.2%, and 76%, respectively.

To address these issues, it is essential to strengthen the report verification system, improve record-keeping practices, and ensure timely submissions to enhance decision-making and the resupply of medicines. Digitalization of the inventory recording and reporting system may reduce workload, improve data quality, and enhance LMIS performance. Additionally, targeted interventions should focus on improving inventory accuracy for items with high discrepancies. Furthermore, strengthening monitoring systems through regular audits and feedback, along with comprehensive training for health supply chain staff, will continuously improve data quality in both manual and digital systems.

Institutional Review Board Statement

This study was approved by the Ethical Review Committee of the School of Pharmacy (Protocol No: ERB/SOP/399/14/2022) and the Institutional Review Board of College of Health Sciences, Addis Ababa University (Protocol number: 007/22/SoP).

Informed Consent Statement

Informed consent was obtained from all participants and institutions involved in the study.

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Author Contributions

All authors made a significant contribution to the work reported, whether in the conception, study design, execution, acquisition of data, analysis, and interpretation, or in all these areas; participated in drafting, revising, or critically reviewing the article; gave final approval of the version to be published; agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

All authors declared that there are no competing interests.

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Vaccine Logistics Management Information System at Public Health Facilities in Amhara Region, Ethiopia: A Performance Evaluation

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Objectives: This study aimed to evaluate the performance of vaccine logistics management information systems at public health facilities in Amhara Region, Ethiopia. **Methods:** An institution-based concurrent explanatory mixed design was used at public health facilities in Amhara Region, Ethiopia. In total, 102 health facilities were selected using the multi-stage, stratified, random-sampling proportionate-to-size method. Data were collected using a structured data abstraction checklist from vaccine logistics management information system records. Additionally, experiences of Expanded Program for Immunization focal persons were gathered through interviewer-administered questionnaires. **Results:** Among the 102 health facilities surveyed, 99 (97.1%) provided vaccination services during the study period. On the day of the visit, the average availability and utilization rates of 15 vaccine logistics management information system forms were 44.1% and 40.5%, respectively. The mean inventory accuracy for tracer vaccines stood at 58.3% ± 45.1%. The overall average accuracy percentages for urban and rural vaccine request form reports were 73.4% and 69.6%, respectively. **Conclusions:** The performance of vaccine logistics management information systems in these public health facilities was suboptimal. Key issues identified include inconsistent use of recording forms, shortages of reporting forms, lack of digitalization, poor data quality, and a shortage of qualified staff. These findings underscore the urgent need for standardization of the vaccine logistics management information system and enhancement of data quality.

Keywords: Vaccines, Health Facilities, Management Information Systems, Data Accuracy, Ethiopia

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I. Introduction

Access to essential medicines in developing countries is a critical global health issue [1]. Many communicable diseases, which lead to death and disability in these regions, can be prevented, treated, or mitigated with the availability of cost-effective essential medicines, including vaccines [2,3]. Immunization not only saves lives but also shields against serious illnesses and is acknowledged as one of the most cost-effective health interventions [4]. The World Health Organization (WHO) has identified equitable access to essential medicines, vaccines, and technologies as a fundamental component of any national health system [5].

However, one-third of the global population, including half of those in Sub-Saharan countries, lacks regular access to life-saving essential medicines and vaccines [1,6,7]. Although economic constraints in developing countries play a role, structural and health system-related factors are also significant bottlenecks in the supply chain for essential medicines and vaccines [8].

The primary purpose of the healthcare supply chain is to ensure that the right product is delivered to the right customer, in the correct quantity and condition, to the appropriate location, at the right time, and at an affordable cost [9]. Despite the complexity of the healthcare supply chain, meeting all these criteria is essential for the effective functioning of a healthcare system [8,9].

An efficient vaccine supply chain system is crucial for achieving the goals of the Expanded Program for Immunization (EPI), a key intervention in reducing mortality and morbidity among under-5 children [4,10]. The success of the EPI heavily relies on a specialized supply chain management system for vaccines, which includes proper storage, transportation, handling, and the involvement of qualified personnel [4,11]. Given that vaccines are temperature-sensitive biological substances, a robust end-to-end cold chain system is essential to maintain vaccine potency up to the point of delivery [11]. Without this, vaccines can rapidly lose their effectiveness or even become hazardous [12].

A robust vaccine logistics management information system (VLMIS) is essential for managing supplies, predicting demand, and strategic planning [13]. According to the WHO, an effective health information system that supports the production, analysis, and dissemination of data is crucial for the proper functioning of a healthcare system [5].

Likewise, an effective VLMIS, which provides real-time logistics data at every healthcare level, is crucial for a resilient and successful immunization program [9,11,14,15]. Its primary goal is to ensure an uninterrupted supply and optimal use of high-quality vaccines from manufacturers to service delivery points [9,16].

In Ethiopia, the EPI was launched in 1980, initially providing six antigens [10]. Starting in June 2014, the vaccine supply chain began transitioning to a phased approach, integrating with the Ethiopian Pharmaceutical Supply Service (EPSS) Integrated Pharmaceutical Logistics System (IPLS). Furthermore, the VLMIS has been incorporated into the IPLS using adapted logistics management information system (LMIS) tools [15,17].

Despite these efforts, studies in Ethiopia have identified numerous challenges at health facilities concerning immunization data quality. These issues encompass the use of non-standardized data recording and reporting tools, unreliable data, shortages of recording materials, poor data quality, and limited capacity among EPI officers [10,18–21]. Similar challenges have been documented in other low- and middle-income countries [22]. Although vaccine logistics management is a critical component of the EPI program, there has been a lack of in-depth research on the VLMIS and related data quality issues. Therefore, evaluating the performance of the existing VLMIS is crucial for enhancing the vaccine supply chain system in Ethiopia's public health facilities.

II. Methods

1. Study Design

An institution-based concurrent explanatory mixed study design was implemented in Amhara Region, the second-most populous region in Ethiopia. Data collection involved a combination of quantitative and qualitative methods.

2. Study Population

The study population comprised hospitals and health centers that provide EPI services, along with all EPI focal persons responsible for managing vaccines. Both manual and digital VLMIS implementations in the region were included in the evaluation.

3. Sampling Procedure

Six zonal and two city administrations were selected and stratified into three clusters according to the locations of EPSS hubs. Fifteen percent of the facilities were included following the recommendation from USAID's Logistics Indicators Assessment Tool [23]. A multi-stage stratified random sampling approach was used, with sample sizes for each zone and district allocated proportionally. In total, 102 facilities participated, comprising referral hospitals, general hospitals, primary hospitals, and health centers.

4. Inclusion and Exclusion Criteria

Inclusion criteria are all zonal administrations; public health facilities that had been functional for more than 1 year; EPI focal persons with >6 months of experience for the qualitative interview; and manual/digital VLMIS implemented in more than one zonal administration.

Exclusion criteria are health facilities that had been damaged in conflict-affected areas or had security problems during the study; manual and digital information management tools for other health services; and health posts.

5. Data Collection Process

The study utilized a structured data abstraction checklist and interviewer-administered questionnaires to collect quantitative data, while qualitative data were gathered using guiding questions. The tools for data collection were adapted from those developed by the WHO, the Ministry of Health, and the Amhara Regional Health Bureau. Data were extracted from vaccine ledger books, vaccine request form (VRF) reports, and VLMIS forms. The interviewer-administered questionnaires gathered information from EPI focal points about their experiences and the performance of the VLMIS at their facilities. Additionally, observations and physical counts of selected vaccines in refrigerators were conducted to verify inventory accuracy. Qualitative information was collected from the EPI focal points through guiding questions.

6. Data Quality Assurance

A triangulation technique was employed to ensure the validity of the data. Data collection tools, adapted from those developed by the WHO and the Federal Ministry of Health, were validated by 10 field experts. These tools were pretested, and necessary amendments were made prior to the commencement of data collection. Qualified health supply chain management postgraduate students, who had received two days of training, conducted the data collection. Field supervisors checked the completeness of the data on a daily basis.

7. Data Analysis and Interpretation

Quantitative data were thoroughly checked for completeness and consistency before being entered into Epi Info software. After validation, the data were exported to SPSS version 23.0 (IBM Corp., Armonk, NY, USA) for detailed descriptive statistical analysis. The results were subsequently presented through graphs and tables and interpreted in line with the study objectives. Qualitative data, which captured the experiences of EPI focal persons regarding VLMIS performance, were subjected to thematic analysis. This analysis involved translating audio recordings and manually coding the data. Key themes and patterns were then identified and interpreted to gain a comprehensive understanding of the VLMIS from the users' perspectives.

8. Ethics Statement

This study was approved by the Ethical Review Committee of the School of Pharmacy (Protocol No. ERB/SOP/399/14/2022) and the Institutional Review Board of College of Health Sciences, Addis Ababa University (Protocol No. 007/22/SoP). Informed consent was obtained from all participants involved in the study.

III. Results

1. General Information

VLMIS data were collected from 99 of the 102 public health facilities included in the study. Two facilities had not initiated EPI services, and one had its operations disrupted due to conversion into a COVID-19 treatment center. Of the facilities surveyed, 37 (37.4%) were located in urban areas, with the remainder in rural settings. The majority of the facilities (n = 84; 84.8%), were health centers. The remaining facilities were primary hospitals, general hospitals, and referral hospitals, which accounted for nine (9.1%), three (3%), and three (3%) respectively (Figure 1).

Among the facilities surveyed, 68 (68.7%) lacked a separate vaccine storage room and instead used shared spaces with immunization service areas. All but one facility had an assigned EPI focal person. Manual VLMIS was utilized in all facilities, with no instances of digital VLMIS adoption.

All surveyed facilities were equipped with at least one functional refrigerator. During the evaluation, the average availability of functional temperature monitoring devices within these refrigerators was 93.9% (standard deviation ±17.8). Of these devices, temperature recording charts were present in 89.5% of cases (standard deviation ±23.1). Over the course of a month, only 82 facilities (82.8%) consistently recorded refrigerator temperatures in accordance with WHO recommendations.

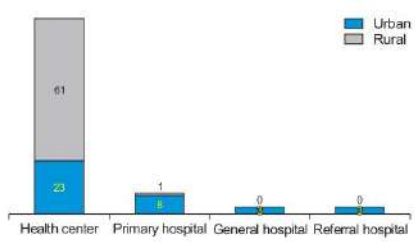

Figure 1. Levels and location of public health facilities surveyed, Amhara Region, Ethiopia on March 2022.

2. Availability and Utilization of VLMIS Forms

During the study, the average availability of 15 VLMIS forms was 44.1%, with a utilization rate of 40.5%. The VRF, which serves as a monthly consumption report and order request, was present in 96 (97%) of the surveyed facilities. In contrast, the bin card and stock card, both used for stock-keeping records, were found in only one or no facilities. The VRF maintained a better 3-month supply rate (93.9%), whereas the vaccine accuracy analysis tool form was in an exceptionally deficient supply (5.1%) (Table 1).

3. Data Quality

VLMIS data quality was evaluated across four dimensions: inventory accuracy rate, timeliness, completeness, and accuracy. The first dimension evaluated the accuracy of stock-keeping records, whereas the other three dimensions concentrated on VRF reports. For inventory accuracy, three key tracer vaccines used in child care and routine immunization were analyzed, while all eight tracer vaccines were examined for the remaining data quality dimensions.

1) Inventory accuracy rate for vaccines

Out of the 99 facilities providing vaccination services, only 84 (84.8%) utilized the vaccine stock management ledger book, and merely 42 (50%) of those updated it prior to the day of the visit. The mean inventory discrepancy rate for the three tracer vaccines—pentavalent, Bacillus Calmette-Guerin (BCG), and measles—was 15.9 ± 42.1 (range 0–255.2), 26.5 ± 59.6 (range 0–350), and 25 ± 66.3 (range 0–400), respectively. The overall mean inventory accuracy rate for these tracer vaccines stood at 58.3% ± 45.1%.

2) Timeliness of VRF reports

Public health facilities are required to submit monthly vaccine consumption and demand requests using the VRF. Woreda health offices or EPSS branches then distribute vaccines based on these reports. This study analyzed one year of monthly VRF reports to evaluate their timeliness. In the most recent reporting period, 85 facilities (85.9%) correctly indicated the reporting date, while 13 facilities (13.1%) failed to submit a report. Alarmingly, 44 facilities (44.4%) did not have a VRF report for the 12th reporting period. Approximately 65 facilities (65.7%) submitted VRF reports on time in the recent period, but this number dropped to 41 facilities (41.4%) in the latest period. The data indicate a declining trend in the timeliness of VRF report submissions over time (Figure 2).

Table 1. Availability and utilization of vaccine logistics management information system forms at public health facilities in Amhara Region, Ethiopia on March 2022

	Vaccine logistics management information system forms for vaccine management (n = 99)	Availability	Utilization status	Supply for ≥3 months	Supply for <3 months
1	Vaccine forecasting tool (Paper, Word, Excel)	59 (59.6)	58 (58.6)	56 (56.6)	2 (2)
2	Vaccine request form (VRF)	96 (97)	94 (94.9)	93 (93.9)	1 (1)
3	Model 19/H	27 (27.3)	26 (26.3)	24 (24.2)	2 (2)
4	Model 22/H	27 (27.3)	26 (26.3)	24 (24.2)	2 (2)
5	Bin card	1 (1)	0 (0)	-	-
6	Stock card	0 (0)	0 (0)	-	-
7	Vaccine stock management ledger book	94 (94.9)	75 (75.8)	82 (85.9)	3 (3)
8	Physical inventory form	32 (32.3)	30 (30.3)	30 (30.3)	0 (0)
9	Temperature monitoring chart	94 (94.9)	88 (88.9)	89 (89.9)	0 (0)
10	VRF accuracy analysis tool (Excel, Word)	5 (5.1)	5 (5.1)	5 (5.1)	0 (0)
11	Monthly vaccine wastage monitoring form	44 (44.4)	34 (34.3)	39 (39.4)	0 (0)
12	Damaged vaccine registration format (Excel, Word)	32 (32.3)	30 (30.3)	30 (30.3)	0 (0)
13	Immunization self-assessment tool	66 (66.7)	61 (61.6)	63 (63.6)	0 (0)
14	Temperature monitoring data summary sheet	44 (44.4)	41 (41.4)	40 (40.4)	1 (1)
15	Vaccine management key performance indicator monthly report template	34 (34.3)	33 (33.3)	32 (32.3)	1 (1)

Values are presented as number (%).

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Figure 2. Timeliness of monthly vaccine request form (VRF) reports among public health facilities in Amhara Region, Ethiopia on March 2022 (reporting schedule: until the 10th day after the end of the month).

3) Completeness of VRF reports

Public health facilities utilize distinct versions of the VRF for urban and rural settings; however, these forms must be used more clearly and consistently. Three rural facilities mistakenly used the urban VRF, while 12 urban facilities utilized the rural VRF. The completeness of the data for both urban and rural facilities was evaluated based on the VRF employed during the assessment.

4) Urban VRF report completeness

Of the 28 health facilities using the urban VRF, 26 submitted recent VRF reports, achieving an overall completeness rate of 88.4%. The data element "quantity of vaccines received" had the highest completeness score at 95.6%, whereas the "loss/adjustment" element recorded the lowest score at 76.1% (Table 2).

5) Rural VRF report completeness

Of the 71 health facilities utilizing the rural VRF, 60 provided recent reports, achieving an overall completeness rate of 87.8%. The data element "beginning balance" recorded the highest completeness at 98.3%. In contrast, the completeness scores for "doses discarded" and "vaccinations given in the last supply period" were the lowest, at 79.8% and 40.8%, respectively (Table 3).

6) Accuracy of VRF reports

The accuracy of both the urban and rural versions of the VRF was assessed.

7) Urban VRF report accuracy

The accuracy of VRF reports was assessed using only the most recent data available. The average accuracy across various facilities was 73.4%. The "quantity received" category achieved the highest accuracy, scoring 90.6%. In contrast, the "quantity needed (requested amount)" and "maximum stock" categories recorded the lowest accuracy scores, at 62.5% and 58.3%, respectively. The average accuracy rate for all eight vaccines across health facilities did not exceed 75% (Table 4).

8) Rural VRF report accuracy

The average accuracy rate of VRF reports for all eight vaccines in health facilities using rural VRF was 69.6%. The highest accuracy score (89.4%) was for "receiving during the last supply period," while the lowest score (31.3%) was for "vaccinations given in the last supply period" (Table 5).

4. EPI Focal Persons' Experiences and Reflections on VLMIS Performance

Out of the 99 facilities evaluated for VLMIS performance, 98 had EPI focal persons overseeing the vaccine supply chain. We interviewed 96 EPI focal persons, who had an average age of 28.97 ± 4.21 years. The majority, 51 (53.1%), were female nurses. In terms of academic qualifications, 36 (37.5%) held bachelor's degrees, while 60 (62.5%) possessed diplomas. On average, these individuals had 6.9±4.03 years of professional experience, including 2.1 ± 1.54 years as EPI focal persons. Their experience in other pharmaceutical supply chain-related activities averaged 0.3 ± 0.87 years.

1) Experiences of EPI focal persons related to VLMIS performance

(1) Vaccine logistics training

Of the EPI focal persons surveyed, 83 (86.5%) reported having participated in training related to vaccine and cold chain logistics management. The most frequently mentioned training topics were "Effective vaccine management," "EPI vac-

Table 2. Average percentage completeness of vaccine request forms (urban forms) at public health facilities in Amhara Region, Ethiopia on March 2022 (n = 26)

	List of vaccines	Beginning balance	Quantity received	Loss/ adjustment	Ending balance	Calculated consumption	Maximum stock	Quantity needed to (requested amount)	Average
1	Bacillus Calmette-Guerin vaccine	92.3	92.3	76.9	96.2	92.3	84.6	84.6	88.5
2	Measles vaccine	92.3	96.2	76.9	96.2	92.3	84.6	84.6	89.0
3	Pentavalent vaccine	92.3	96.2	76.9	96.2	92.3	84.6	84.6	89.0
4	Tetanus and Diphtheria vaccine	92.3	96.2	76.9	96.2	92.3	84.6	84.6	89.0
5	Pneumococcal Conjugate vaccine	92.3	96.2	73.1	92.3	88.5	80.8	80.8	86.3
6	Rotavirus vaccine	92.0	96.0	76.0	96.0	92.0	84.0	84.0	88.6
7	Inactivated Poliovirus vaccine	92.0	96.0	76.0	96.0	92.0	84.0	84.0	88.6
8	Bivalent Oral Polio vaccine	92.0	96.0	76.0	96.0	92.0	84.0	84.0	88.6
	Average	92.2	95.6	76.1	95.6	91.7	83.9	83.9	88.4

Table 3. Average percentage completeness of vaccine request forms (rural forms) at public health facilities in Amhara Region, Ethiopia on March 2022 (n = 60)

	List of vaccines	Beginning balance	Receiving during the last supply period	Used/ dispatched to a lower level	Doses discarded	Current balance	125% Requirement for the next supply period	Requested amount	Vaccinations are given in the last supply period	Average
1	Bacillus Calmette-Guerin vaccine	98.3	96.7	93.3	78.3	96.7	95.0	95.0	61.7	89.4
2	Measles vaccine	98.3	98.3	95.0	80.0	98.3	96.7	96.7	38.3	87.7
3	Pentavalent vaccine	98.3	98.3	95.0	80.0	98.3	96.7	96.7	38.3	87.7
4	Tetanus and Diphtheria vaccine	98.3	98.3	95.0	80.0	98.3	96.7	96.7	38.3	87.7
5	Pneumococcal Conjugate vaccine	98.3	98.3	95.0	80.0	98.3	96.7	96.7	38.3	87.7
6	Rotavirus vaccine	98.3	98.3	95.0	80.0	98.3	96.7	95.0	38.3	87.5
7	Inactivated Poliovirus vaccine	98.3	98.3	95.0	80.0	98.3	96.7	95.0	36.7	87.3
8	Bivalent Oral Polio vaccine	98.3	98.3	95.0	80.0	98.3	96.7	96.7	36.7	87.5
	Average	98.3	98.1	94.8	79.8	98.1	96.5	96.0	40.8	87.8

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Table 4. Average percentage accuracy of vaccine request form reports (urban forms) at public health facilities in Amhara Region, Ethiopia on March 2022 (n = 24)

	List of vaccines	Beginning balance	Quantity received	Loss/ adjustment	Ending balance	Calculated consumption	Maximum stock	Quantity needed to (requested amount)	Average
1	Bacillus Calmette-Guerin vaccine	83.3	87.5	75.0	70.8	70.8	58.3	62.5	72.6
2	Measles vaccine	83.3	91.7	75.0	70.8	75.0	58.3	62.5	73.8
3	Pentavalent vaccine	83.3	87.5	75.0	70.8	70.8	58.3	62.5	72.6
4	Tetanus and Diphtheria vaccine	83.3	91.7	75.0	70.8	75.0	58.3	62.5	73.8
5	Pneumococcal Conjugate vaccine	79.2	91.7	75.0	70.8	70.8	58.3	62.5	72.6
6	Rotavirus vaccine	83.3	91.7	75.0	70.8	75.0	58.3	62.5	73.8
7	Inactivated Poliovirus vaccine	83.3	91.7	75.0	70.8	75.0	58.3	62.5	73.8
8	Bivalent Oral Polio vaccine	83.3	91.7	75.0	70.8	75.0	58.3	62.5	73.8
	Average	82.8	90.6	75.0	70.8	73.4	58.3	62.5	73.4

Table 5. Average percentage accuracy of vaccine request form reports (rural forms) at public health facilities in Amhara Region, Ethiopia on March 2022 (n = 60)

	List of vaccines	Beginning Balance	Receiving during the last Supply Period	Used/ dispatched to the lower level	Doses discarded	Current balance	125% Requirement for the next supply period	Requested amount	Vaccinations are given in the last Supply Period	Average
1	Bacillus Calmette-Guerin vaccine	85.0	91.7	71.7	63.3	65.0	85.0	75.0	30.0	70.8
2	Measles vaccine	80.0	91.7	71.7	63.3	65.0	83.3	73.3	31.7	70.0
3	Pentavalent vaccine	83.3	85.0	71.7	63.3	65.0	85.0	73.3	31.7	69.8
4	Tetanus and Diphtheria vaccine	80.0	86.7	71.7	63.3	63.3	83.3	71.7	31.7	69.0
5	Pneumococcal Conjugate vaccine	81.7	91.7	71.7	63.3	63.3	83.3	71.7	31.7	69.8
6	Rotavirus vaccine	81.7	90.0	71.7	63.3	65.0	83.3	71.7	31.7	69.8
7	Inactivated Poliovirus vaccine	81.7	88.3	71.7	63.3	65.0	83.3	71.7	31.7	69.6
8	Bivalent Oral Polio vaccine	85.0	90.0	71.7	63.3	50.0	83.3	71.7	30.0	68.1
	Average	82.3	89.4	71.7	63.3	62.7	83.8	72.5	31.3	69.6

cine management," and "Vaccine cold chain management." These topics were cited by 37 (44.6%), 28 (33.7%), and 25 (30.1%) of the trained EPI focal persons, respectively (Figure 3).

(2) VLMIS supportive supervision

Among the EPI focal persons surveyed, 73 (76%) reported receiving supportive supervision for vaccine supply chain management and VLMIS-related issues. Of these, 25 (34.2%) received supervision within the last month, while 27 (37.0%) received it 1–3 months ago, 11 (15.1%) 3–6 months ago, and 10 (13.7%) more than 6 months ago. The primary organizations providing supportive supervision were the Woreda health office and the zonal health department, cited by 30 (41.1%) and 15 (20.5%) respondents, respectively. Additionally, joint teams from various organizations and NGOs were mentioned by 15 (20.5%) respondents, and another 11 (15.1%) cited other sources (Figure 4).

Supportive supervision primarily concentrated on various tasks including recording in vaccine ledger books, checking vaccine vial monitors, monitoring temperatures, managing cold storage, overseeing immunization, reporting through the VRF, preparing micro plans, ensuring data quality, recording vaccine wastage, forecasting, and maintaining the availability of LMIS forms. EPI focal persons reported improvements in these areas following supportive supervision.

(3) VLMIS feedback

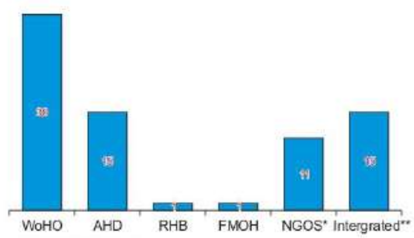
Of the 96 EPI focal persons interviewed, only 33 (34.4%) received written feedback from higher institutions last year. Among these, 24 (72.7%) received their feedback from the Woreda health office, while the remainder received feedback from the zonal health department and the regional health bureau. Of these individuals, only 19 (57.6%) received written feedback in the most recent quarter (3 months).

(4) Challenges and suggestions to improve the VLMIS

EPI focal persons shared challenges and recommendations for improving the VLMIS in health facilities, which are summarized thematically below (Table 6).

IV. Discussion

This survey evaluated the status of the VLMIS in Amhara Region, Ethiopia. A specialized, well-equipped infrastructure is essential for managing the vaccine supply chain [11]. In this study, only 68 (68.7%) of the surveyed health facilities had dedicated vaccine storage rooms. Additionally, only 93.9% (standard deviation ±17.8) of the functional refrigerators were equipped with functional temperature monitoring devices. The main infrastructural challenges identified in these facilities included poor road infrastructure, lack of power backup, and insufficient information and communication technology (ICT) materials. Responses from EPI focal persons and findings from other studies underscore these infrastructural issues as significant obstacles to efficient vaccine management and the operation of VLMIS [13,15].



* UNICEF (1) & WHO (9)
** RHB+WHO (1), UNICEF+WoHO+RHB (1), WHO+UNICEF (1), RHB+WHO (1), WoHO+ZHD (8), WoHO+ZHD+RHB (1), ZHD+RHB (1), ZHD+RHB+FMOH+WHO (1)

Figure 4. Organizations that provided supportive supervision on vaccine logistics for Expanded Program for Immunization focal persons at public health facilities in Amhara Region, Ethiopia on March 2022 (n = 73). UNICEF: United Nations Children's Fund, WHO: World Health Organization, RHB: regional health bureau, ZHD: zonal health department, WoHO: Woreda health office, FMOH: Federal Ministry of Health.

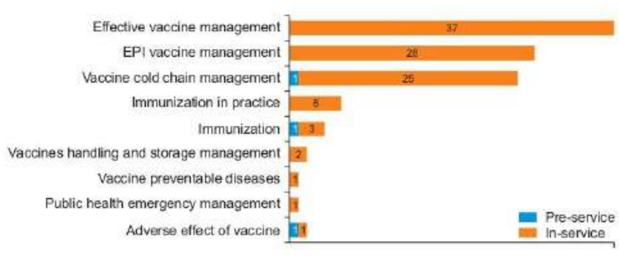


Figure 3. List of vaccine and cold chain logistics management-related training provided for Expanded Program for Immunization (EPI) focal persons at public health facilities in Amhara Region, Ethiopia on March 2022 (n = 83).

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Table 6. Challenges facing the vaccine logistics management information system and suggestions for improvement at public health facilities in Amhara Region, Ethiopia on March 2022 (reflections from Expanded Program for Immunization focal persons)

Challenges for vaccine logistics management information system	Recommendations
- Vaccine damage due to cold chain interruption over the weekend time	- Improve vaccine storage and cold chain management
- Electric power interruption due to lack of alternative power backup	- Provide regular integrated supportive supervision, evaluation, and feedback
- Demand fluctuation and high forecasting error	- Fix a consistent power supply system for vaccines
- Lack of commitment from health professionals	- Increase the number of fridges and spare parts
- High workload due to staff shortage	- Provide dedicated room for vaccine storage
- Lack of frequent maintenance for refrigerators	- Improve vaccine demand assumption and forecasting
- Absence of dedicated room for vaccine storage	- Increase Expanded Program for Immunization workforce
- Poor attitude and perception toward vaccines	- Hire biomedical technicians for fridge maintenance
- Shortage of refrigerators	- Avail computers and vaccine logistics management information system forms
- Delay in vaccine supply	
- Mix up different vaccines together (e.g., anti-rabies)	- Provide training on vaccine logistics & vaccine logistics management information system for focal persons and Health Extension Workers
- Lack of computer to print out different vaccine logistics management information system forms	
- Poor vaccine management skills of Health Extension Workers	- Increase staff commitment with motivation
- Lack of support and integration from higher government offices (Woreda Health Office, Zonal Health Department, Regional Health Bureau, Federal Ministry of Health)	- Establish strong collaboration and integration among different stakeholders
	- Improve the transportation system keeping the cold chain system
- The vaccines transportation problem in keeping the cold chain system	- Digitalize vaccine logistics management information system
- Shortage of vaccine reporting and recording forms	- Improve the road infrastructure to health facilities
- Lack of regular support and feedback from the respective higher offices	
- Absence of a digital system for vaccine logistics management information system	

These challenges could severely impact the supply chain, compromising vaccine potency to the last mile and the effectiveness of its information management system [11]. The study also revealed that nearly 17% of the facilities failed to record temperatures in the cold room regularly, as recommended by the WHO [11].

A well-designed supply chain system ensures the capture of reliable and timely information through standardized logistics recording forms [5]. Among the 15 VLMIS forms intended for use in surveyed health facilities, the average utilization rate was 40.5%. The VRF showed higher availability and utilization compared to the "bin card" and "stock card," which were almost entirely unused. This discrepancy highlights gaps in the design and implementation of VLMIS at public health facilities. Similar challenges with VLMIS have been reported in studies conducted in Northwest Ethiopia [20,21] and Uganda [22]. These issues with VLMIS forms can significantly impact data quality and, ultimately, the effectiveness of the immunization program [11,14,15].

This study evaluated the quality of VLMIS across four dimensions. Among the facilities surveyed, only 84 (84.8%) used the vaccine stock management ledger book, and merely 42 (50%) of those updated it prior to visits. The average inventory accuracy rate for the three tracer vaccines—pentavalent, BCG, and measles—was 58.3% ± 45.1%. Additional research identifies several challenges, including a shortage of recording formats, limited capacity of EPI managers, poor data visibility, and obstacles to digitalization, as significant contributors to the poor quality of inventory data [18,19,24]. The gap in vaccine stock management and the low inventory accuracy could lead to incorrect demand forecasting, procurement, and distribution, potentially affecting many lives and causing high vaccine wastage [25].

Health facilities are required to submit monthly consumption reports and demand requests to the Woreda health office or EPSS branches [26]. A 1-year review of monthly VRF reports revealed that 13 facilities (13.1%) failed to submit a report for the most recent reporting month, and 44 (44.4%) did not submit a report for the latest month. Furthermore, only 65 (65.7%) of the facilities submitted their VRF reports on time for the recent monthly report, and 41 (41.4%) did so for the latest report. This inconsistency in the timeliness of reports could lead to interruptions in vaccine supply, potentially impacting the goals of vaccination programs, as shown by multiple studies [9,11,14,15,24,27].

In low- and middle-income countries, data quality often suffers due to incomplete logistics data elements in reports [28]. This study found that VRFs were used inconsistently between urban and rural facilities. The average completeness of eight tracer medicines across seven data elements was 88.4% in facilities using the urban VRF, compared to 87.8% in those using the rural VRF. Such inconsistencies and gaps in report form completeness can adversely affect vaccine demand forecasting and supply planning, since each data element in the VRF is essential for informed decision-making [13].

The accuracy of both urban and rural VRF reports was evaluated. Facilities employing the urban VRF reported an overall accuracy of 73.4%, whereas those using the rural VRF reported an accuracy of 69.6%. Low accuracy in VRF reporting could compromise the efficiency of the supply chain and result in incorrect decision-making. Additionally, reports from the Ethiopian Ministry of Health and other studies have identified poor data quality as a major concern within the healthcare system [15,24,27].

Poor data quality in VLMIS can disrupt the supply chain and ultimately impact the lives of children. This issue may stem from the fact that all health facilities currently rely on manual VLMIS. Although implementing digital VLMIS necessitates additional infrastructure and ICT materials, it has been shown to enhance data quality and improve supply chain efficiency, as evidenced by experiences in Tanzania and other locations [29,30].

The vaccine supply chain, characterized by unpredictable demand and the need for specialized cold chain systems, must be managed by professionals with specific expertise [11]. However, this study revealed that the vaccine supply chains at health facilities were often managed by professionals lacking relevant pre-service training. EPI focal persons also identified deficiencies in regular supportive supervision and feedback from higher levels. The inconsistent use of VLMIS forms, coupled with insufficient training in vaccine management, has markedly affected the effectiveness of the immunization program. This underscores the urgent need for a standardized monitoring and evaluation framework for the VLMIS [15].

In conclusion, a robust health system necessitates a well-integrated supply chain and LMIS. Despite Ethiopia's endeavors to enhance its health commodities supply chain, this study highlights significant deficiencies in the VLMIS at public health facilities. The identified bottlenecks encompass inconsistencies and shortages of VLMIS forms, an absence of digitalization, substandard data quality, infrastructural deficiencies, inadequate supportive supervision, and staffing challenges. These findings emphasize the critical need to standardize the VLMIS and improve data quality.

The study's limitations are that the findings may not be

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generalizable to other regions due to differences in health infrastructure and local challenges specific to each context. Additionally, the lack of an electronic recording system for VLMIS could lead to errors in data abstraction from physical records, as it may be susceptible to human error.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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Paper IV

Original Research

End Users' Perspective of Digital Logistics Management Information System (eLMIS) Performance at Public Health Facilities of Amhara Region, Ethiopia

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Abstract

The healthcare supply chain relies on real-time logistics Management Information System (LMIS). Despite Ethiopia's adoption of a digital LMIS in 2009, ongoing evaluation of software, infrastructure, and sustainability remains essential for improving performance from users' and health system's perspectives. The study aimed to evaluate the performance of the facility version of digital LMIS at public health facilities in the Amhara Region, Ethiopia. An institution-based cross-sectional study was used. Out of 102 surveyed facilities, only 37 implemented the digital LMIS. Data was collected using interviewer-administered questionnaires. Out of 37 facilities using digital LMIS, 28 (75.7%) were functional. The average frequency of use across 27 sub-dashlets was 3.13 ± 0.67 out of 4. End users rated the digital LMIS performance as 3.21 ± 0.43 out of 5 (64.2%). Significant differences in LMIS performance related to organizational support were found due to varying end users' experience and internet access (P-value $< .05$). The digital LMIS performance from end users' perspective was 64.2%, with significant differences in agreement related to health system and organizational support, influenced by internet access and users' experience.

Keywords

end users, management information system, digital LMIS, performance, health facilities

Introduction

The supply chain system of health commodities, including medicines, vaccines, and health technologies, is a critical component of the healthcare system.[1] A well-functioning supply chain of medicines, vaccines, contraceptives, and other products is key for improving, maintaining, or protecting the health of the needy society.[2,3] The effectiveness of the major activities in the health supply chain management system is dependent on the availability of real-time logistics management information system (LMIS) across each level of the health care system.[4-6]

As countries continue to expand health programs, the supply chain of health commodities becomes more complex, and user-friendly tools and software packages are needed to support the timely accurate collection and reporting of LMIS data.[7] In the last few decades, the supply chain system has undergone several changes, replacing muscle power with brain power with the help of information and communication technologies.[8,9] However, the digital LMIS design and implementation needs demand-based project planning, identification of essential requirements, extensive piloting, deployment, continuous support, and system sustainability.[10,11]

Automation of LMIS can significantly facilitate supply chain activities by enabling faster data collection, transmission, aggregation, and analysis of data. In addition, it will help reduce human error and allow end-to-end data visibility up and down the supply chain stream.[2,8,11-14] Improved data visibility empowers key stakeholders to make informed decisions, thereby enhancing supply chain management

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performance and ensuring better commodity availability at public health facilities. It also significantly improves coordination across different program areas by streamlining the flow of information, reducing errors, and ensuring timely and accurate data sharing. Ultimately, this results in improved patient health outcomes.[15,16] Countries like Namibia and Malawi use different electronic LMIS tools for health commodities management.[16,17] Similarly, Tanzania's implementation of integrated electronic LMIS (eLMIS) enhanced vaccine availability in contrast to its previous paper and Excel-based system.[18]

In Ethiopia, the Integrated Pharmaceutical Logistics System (IPLS) implemented for the management of the health commodities supply chain in the public health system has 3 basic logistics functions: LMIS, inventory control system, and storage of pharmaceuticals. The purpose of LMIS, which is primarily a paper-based system, is to collect, organize, and report supply chain data to other levels in the system in order to make informed decisions Despite improvements in data utilization, the quality of data generated by the manual IPLS-based LMIS was very poor.[19-21]

Hence, as part of the Integrated Pharmaceutical Logistics System (IPLS) implementation process, a digital LMIS named Health Commodities Management Information System (HCMIS) was locally developed and implemented in 2009 by USAID/Deliver project and Ethiopian Pharmaceutical Supply Service (EPSS). The HCMIS is designed to manage health commodities, ensuring real-time data visibility, efficient distribution, and effective use of products such as medicines, vaccines, and medical supplies in EPSS and health facilities. Its goal is to improve availability, reduce wastage, enhance service delivery, and contribute to better health outcomes.[22,23] As per the Digital Health Activity report for 2021, the facility version of HCMIS (Dagu) is deployed in more than 1000 facilities in Ethiopia.[24]

Despite the efforts in the digitalization of LMIS, challenges related to software development project management, infrastructure, interoperability, and sustainability are usually observed in the healthcare system.[2,25-27] Likewise, the HCMIS digital tool used in Ethiopia faced challenges related to interoperability, integration, health system support, data quality, skill gap, and infrastructure.[4,21,23,27-31]

On top of that, automation of both the physical flow and the flow of information, as well as the level of automation aligning it with the physical and organizational needs of health facilities, is trouble for Digital LMIS developers.[32] The architectural domains of digital LMIS should consider the type of data needed, the type of records and reports, the responsible body for information recording, channels of reporting, governance, visibility, integration, interoperability, and level of automation.[5,33]

Evaluating the performance of the digital LMIS tool architecture and its user-friendliness within the context of healthcare system operations is essential for the ongoing improvement and functionality of the system.[31] Hence, this study focuses on evaluating the performance of the facility-version digital LMIS, including its interoperability, functionality, integration, and data quality, from the perspective of end users. The end users' evaluated the system using a set of Likert scale evaluation tools. This perspective is vital for identifying areas for improvement and ensuring the system's continued functionality, user-friendliness, and alignment with the needs of healthcare providers.

Methods

Study Area

This study was conducted in the Amhara Regional State of Ethiopia from March 01-31, 2022. Ethiopia, the second-most populous country in Africa and the 12th largest in the world is administratively divided into 12 regional states and two city administrations. Amhara, the second-most populous region in the country, is further subdivided into 12 Zones, three city administrations, and 166 Woredas (districts). As of 2020, the total number of functional health facilities in the region was 5775 including; 87 public hospitals, 873 public health centers, 3565 health posts, 6 private hospitals, and 1244 private clinics. Amhara was selected for this study because it was the first region to implement new pharmacy service and supply chain initiatives as well and eLMIS was implemented in the first phase of the implementation.[6]

Study Design

The study employed an institution-based cross-sectional study. This research is part of a larger project focused on assessing the performance of the health commodities LMIS, with its results mainly based on quantitative data analysis

Source and Study Population

The source population for this study was all public health facilities in the Amhara region and all health professionals involved in the health commodities supply chain system. The study population was public health facilities and store managers in selected health facilities. The lead of the digital LMIS database in health facilities was considered for the evaluation.

Sampling Procedure

Health centers and Hospitals in all Zonal administrations, except those with security problems, were considered for sampling. Accordingly, 6 zonal and two city administrations were selected and further stratified into 3 clusters based on the EPSS hubs' location. Fifteen percent of the facilities were included in the study per the recommendation of USAID's Logistics Indicators Assessment Tool (LIAT), in which 15% of the facilities were studied.[34] The sample size for each zone and district was allocated based on proportion to size. Accordingly, a total of 102 facilities, including 5 referral hospitals, 4 general hospitals, 10 primary hospitals, and 83 health centers, were included in the study. Finally, sample facilities were selected using a multi-stage stratified random sampling proportionate to the size method. All store managers managing the digital LMIS were considered for the interviewer-administered questionnaire.

Inclusion and Exclusion Criteria

Inclusion Criteria

- All Zonal Administrations
- All public health facilities that have been functional for more than 1 year
- All store managers with more than 6 months of experience
- Digital LMIS implemented in health facilities

Exclusion Criteria

- Health facilities were damaged in conflict-affected areas or had security problems during the study.
- Digital information management tools used for other health services

Data Collection Process

Both a data abstraction checklist and an interviewer-administered questionnaire (a Likert scale questionnaire with 2 sections containing 27 and 34 items) were used to collect data in health facilities (Supplemental Annexes 1 & 2). The data collection tool was developed based on literature, the Ministry of Health and EPSS monitoring and evaluation tools, and the standard operating manual of the HCMIS software.

Data Quality Assurance

The data triangulation technique was used to ensure the validity of the data. Ten experts in the area face-validated the data collection tools. Data was collected by Health Supply Chain Management MSc students, who received a 2-day training on the data collection tool. The data collection tools were pre-tested in 3 health facilities (1 hospital and 2 health centers). Revalidation was then conducted through a 1-day discussion with data collectors and coordinators, and necessary amendments were made to improve the clarity of the questions. In addition, the tools were changed from a self-administered version to an interviewer-administered version during the data collection process to enhance the validity of the data. Reliability and validity tests were conducted to check the internal consistency of the questionnaire. The study has adhered to the STROBE guideline provided by the EQUATOR Network.[35]

Operational Definitions

Health Commodity Management Information System (HCMIS): It is an automated inventory and LMIS having 4 versions including **Fanos** (an online real-time supply chain LMIS in EPSS), **Vitas** (open source software for warehouse, inventory and LMIS at EPSS central and hub warehouses), **mBrana** (open source mobile software platform designed to manage Vaccine LMIS), and **Dagu** (an open source software designed to manage health commodities' inventory and LMIS at health facilities).

Digital LMIS (eLMIS): The health facility version of HCMIS, comprising Dagu 1.0 as the latest version and Dagu 2.0 as the advanced version, is tailored for health commodities inventory management and LMIS within health facilities. Dagu 2.0 is connected to Vitas and Fanos and fully interoperable with the other supply chain systems in EPSS and facilities.

Model 19/Health: It is a serially registered official financial transaction tool used in health facilities to receive health commodities from suppliers

Model 22/Health: It is a serially registered official financial transaction tool used in health facilities for issuing health commodities for health facilities and different units

End Users' Perspective: Refers to the evaluation of the facility-version digital LMIS system by individuals who directly interact with and utilize the software. The evaluation captures users' experiences, satisfaction, and perceived effectiveness of the digital LMIS in various aspects of the system, including its interoperability, functionality, integration, and data quality.

Data Analysis and Interpretation

The quantitative data were checked for completeness and internal consistency. Then, the data were entered into Epi Info Version 7 statistical software. Finally, the data was exported to SPSS Version 23.0 for better data management and analysis. The data was cleaned by sorting the variables and cross-checking the hard copies for any missing data. The descriptive analysis was summarized using tables and graphs. Bivariate analysis was conducted to assess the performance of the Digital LMIS in relation to health system support, organizational support, and the technical skills of end users. The P-value $< .05$ shows a statistically significant association.

Ethical Consideration

The proposal was reviewed and approved by the Institutional Review Committee of the school and the Institutional Review Board of the college. The purpose of the study was clearly explained to all participants, and verbal informed consent was obtained after they comprehended the information. The verbal agreement was audio-recorded with the participant's

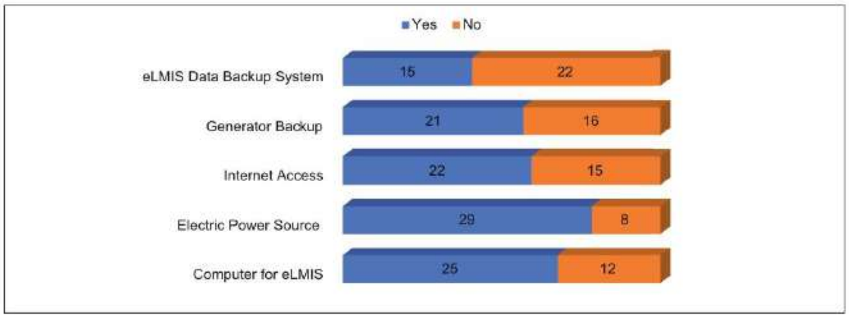

Figure 1. Infrastructural access in eLMIS implemented public health facilities of Amhara Region, Ethiopia; March 2022 (N = 37).

permission. No individual identifiers were included in the data collection to protect the privacy of the participants, and the data was analyzed in aggregate.

Results

General Information

Out of 102 public health facilities included in the study, only 37 health facilities implemented the digital LMIS. Except for 4 facilities, 33 (89.2%) of them are located in urban areas. Of the facilities that implemented eLMIS, the majority, 22 (59.5%), were Health centers and the rest were Primary Hospitals, General Hospitals, and Referral Hospitals, with a frequency of 9(24.3%), 2(2.0%), and 4(3.9%), respectively. Of these, 16 (43.2%) installed Dagu 1.0, and the rest 21 (56.8%) installed Dagu 2.0. Partners (USAID, JSI, and GHSC-PSM) installed the digital LMIS in 23 (82.1%) of the health facilities, 5 (17.9%) installed with government offices support and the rest 8 (21.6%) installed with joint support. Only 25 (67.6%) health facilities had dedicated computers for eLMIS (Mean = 2.4 ± 2.77). The digital LMIS is installed in all leading health facilities stores, whereas 2 facilities were installed at the offices of the supply chain case team leader and pharmacy head. Only 1 facility is installed at the dispensary and ART pharmacy; however, none are installed at the office of the facility's chief executive officer or medical director (CEO/MD). Concerning infrastructural support for digital LMIS, 29 (78.4%), 25 (67.6%), 22 (59.5%), 21 (56.8%), and (15 (40.5%) had access to electric power, computer, internet, generator backup, and data backup system, respectively (Figure 1).

At the time of the visit, the eLMIS was functional at 28 (75.7%) health facilities. Report and Requisition Form (RRF) is integrated with eLMIS in 27 (73%) health facilities, whereas Model 19/Health (Model19/H) and Model 22/Health (Model 22/H) transaction tools are integrated with eLMIS in 18 (48.6%) health facilities (Figure 2).

Sociodemographic Characteristics of Participants

Among the 37 health facilities that implemented eLMIS, only 27 eligible store managers were available and interviewed using an interviewer-administered questionnaire. Two-thirds of the participants were male, and all of them were pharmacy professionals (Table 1).

Utilization Status of Dagu Dashlets

The facility version of HCMIS (Dagu) has 4 main database features (Dashlet) for health commodities information management systems. These are activity log (have 5 sub-Dashlets), transaction (2 sub-Dashlets), reports (15 sub-Dahslets), and summary reports (have 5 sub-Dashlets; Figure 3).

A 27-item tool utilizing a 4-level Likert scale, with a Cronbach's Alpha value of .94 for internal consistency, was employed to assess end users' frequency of use of different Dashlets in the Dagu dashboard. Accordingly, the overall average mean rating for 27 items was 3.13 ± 0.67 (Supplemental Annex 1). The overall mean rating on the frequency of use of the *activity log* Dashlet was 3.43 ± 0.49. "Receive" and "Issue" dashlets were the most frequently used features among the *activity log* Dashlets, with a mean value of 3.93 ± 0.27 and 3.96 ± 0.19, respectively. The store managers claimed that the "Stock Transfer" sub-Dashlet was the least frequently used feature from the *activity log* Dashlet (mean, 2.78 ± 1.09; Figure 4)

The mean frequency of use of the 2 transaction Dashlets, model 19/H and model 22/H, was 3.08 ± 1.35 and 3.04 ± 1.40, respectively. The overall mean rating on the frequency of use of *report* Dashlet was 3.00 ± 0.78. The most frequently used report sub-dashlet was electronic bin card

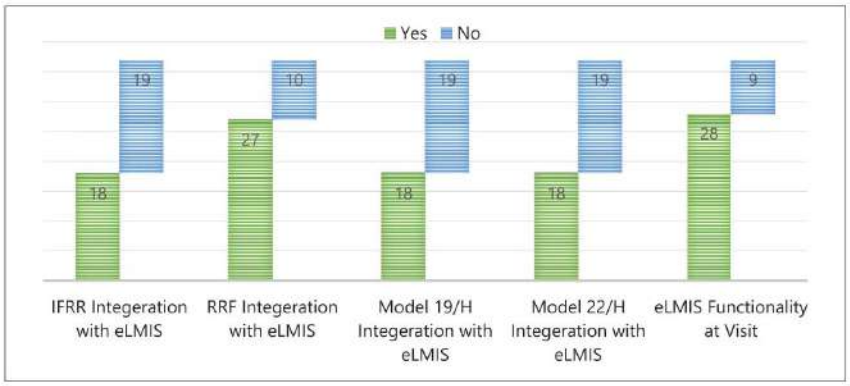

Figure 2. Functionality and integration of eLMIS with transaction and reporting tools in public health facilities of Amhara Region, Ethiopia; March 2022 (N=37).

Table 1. Sociodemographic and eLMIS Information of Participants in Public Health Facilities of Amhara Region, Ethiopia; March 2022.

Variable N=27	Description	Frequency	Percentage
Gender	Male	18	66.7
	Female	9	33.3
Age	20-30 years	19	70.4
	31-40 years	8	29.6
Profession	Pharmacy	27	100
Qualification	Diploma	9	33.3
	BPharm	18	66.7
Experience	≤5 years	11	40.7
	6-10 years	11	40.7
	≥11 years	5	18.5
Location of health facility	Urban	26	96.3
	Rural	1	3.7
Level of health facility	Health Center	14	51.9
	Primary Hospital	8	29.6
	General Hospital	3	11.1
	Referral Hospital	2	7.4
Zone	Central Gondar	9	33.3
	East Gojjam	5	18.5
	North Shewa	6	22.2
	West Gojjam	7	25.9
Version of Dagu	Dagu 1.0	10	37
	Dagu 2.0	17	63
Phase of implementation	Pre-HCMIS	1	3.7
	Intensive	2	7.4
	Mature	24	88.9

Figure 3. Dagu 1.0 Dashboard screenshot (EPSS &JSI, 2018).

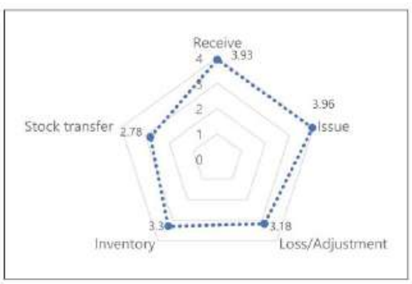

Figure 4. End users' rating on the frequency of use of *Activity Log* Dashlet of Digital LMIS in public health facilities of Amhara Region, Ethiopia; March 2022.

(mean = 3.63 ± 0.88), and the lowest frequently used sub-dashlet was HPMMR (mean = 2.04 ± 1.43; Figure 5).

The overall mean rating on the frequency of use of *the Summary* Report Dashlet was 3.25 ± 0.96. The most frequently used summary report sub-dashlet was stock expiry summary (mean = 3.41 ± 0.97), and the lowest frequently used sub-dashlet was cost summary (mean = 3.07 ± 1.14; Figure 6).

In addition to rating the frequency of use for the digital LMIS Dashlets, respondents suggested the addition of different data elements in the dashboard, including an *alarm for expired items, a database synchronization feature [Dagu 1.0), an Add & Delete feature for items, Unit of items, Model number, and Price markup.*

End Users' Perspective on the Performance of Dagu

End users who directly interact with and utilize the software evaluated the facility-version digital LMIS across various aspects of the system. The evaluation captures users' experiences, satisfaction, and perceived effectiveness of the digital LMIS by examining different dimensions of the software's performance.

A 34-item tool utilizing a 5-level Likert scale, with a Cronbach's Alpha value of .82 for internal consistency, was employed to assess end users' perspectives on the performance of Dagu. Among the 34 items, the highest mean score was obtained for the statement "*The Dagu benefits/improve the facility LMIS performance*" with a mean value of 4.60 ± 0.50. In contrast, the lowest mean value was obtained for "*The database is linked with higher levels with real-time end-to-end data visibility,*" with a score of 1.74 ± 0.98 (Supplemental Annex 2). The overall mean average score of the end user's rating for the performance of the digital LMIS was 3.21 ± 0.43. End users had a better agreement for digital LMIS performance metrics related to organizational support and the lowest agreement for items related to technical skills,

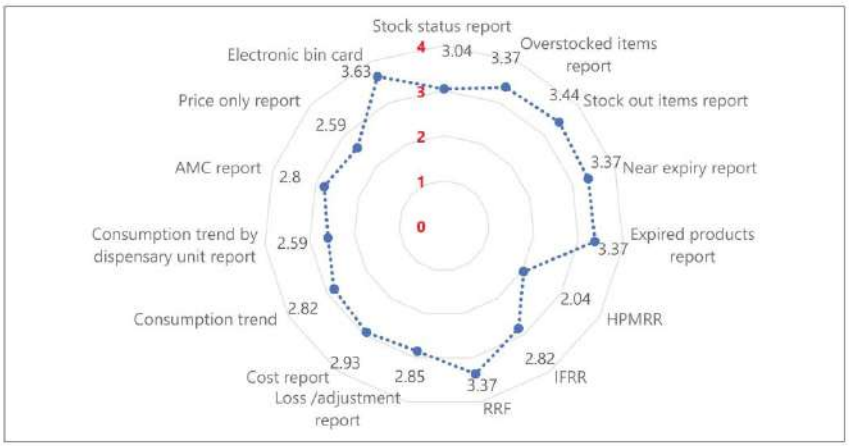

Figure 5. End users' rating on the frequency of use of *report* Dashlet of Digital LMIS in public health facilities of Amhara Region, Ethiopia; March 2022.

Figure 6. End users' rating on the frequency of use of *Summery report* Dashlet of Digital LMIS in public health facilities of Amhara Region, Ethiopia; March 2022.

with an average mean score of 3.42 ± 0.5 and 2.53 ± 0.96, respectively (Figure 7).

Bivariate and Multivariate Analysis

There is a significant mean difference in the frequency of use of *transaction* dashlets in Dagu 2.0 (Mean = 3.63) and Dagu 1.0 (Mean = 1.93) at a P-value of .02. In addition, there is a significant difference in the frequency of use of *transaction* dashlets in geographical locations. The mean frequency of use of *transaction* dashlets in North Shewa Zone (mean = 4.0) was significantly higher than in West Gojjam (Mean = 1.67) at a P-value of .009.

There is a significant mean difference in the end users' agreement on the performance of the digital LMIS in terms of health system support in different versions. There is also a significant mean difference in the end users' agreement on the performance of the digital LMIS in terms of organizational support due to differences in end users' experience and internet access. The end users claimed that the performance of technical skills was significantly better in facilities with internet access (Table 2).

Discussion

This survey has attempted to evaluate the digital LMIS performance from the end user's perspective. The study was conducted during the transition period of the digital LMIS from Dagu 1.0 to Dagu 2.0. However, the digital LMIS was functional at three-fourths of the facilities installed. This is due to the infrastructural challenges (computer, internet, power backup) and the partner-dependent governance and technical support system of the database. This is well reflected by the end users and different studies conducted in Ethiopia.[29,30,36] Due to challenges with electricity infrastructure, the number of facilities implementing eLMIS in rural areas is limited. Most health facilities implementing the digital LMIS needed to integrate the *transaction* Dashlets. A notable number of facilities also needed to integrate a critical *reporting* Dashlet used for periodic supply and re-supply of items. On top of the overload it creates due to manual recording might lead

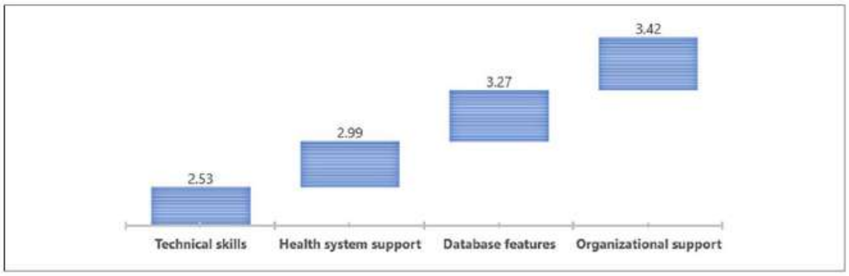

Figure 7. End users' perspective on the performance of Digital LMIS in public health facilities of Amhara Region, Ethiopia; March 2022.

Table 2. Bivariate and Multivariate Analysis Variables on the Performance of Digital LMIS in Public Health Facilities of Amhara Region, Ethiopia; March 2022.

Item group	Variable	Mean	Comparison group	P-value
Health system support	Dagu version	2.50	Dagu 1.0	.039
		3.28	Dagu 2.0	
Organizational support	Internet access	3.58	Yes	.01
		3.07	No	
Technical skill	Internet access	2.78	Yes	.021
		2.03	No	
Organizational support	Experience (≤5 years)	3.27	6-10 years	.995
			≥11 years	.012
	Experience (6-10 years)	3.29	≤5 years	.995
			≥11 years	.014
	Experience (≥11 years)	4.00	≤5 years	.012
			6-10 years	.014

to poor data quality due to loosening integration of all logistics records in the system.[3,36]

The average mean percentage frequency of use of dashlets in the Dagu dashboard was 78.3%. The *report* Dashlet has the lowest mean frequency of use. The mean frequency of use obtained from the Health Post Monthly Requisition and Report (HPMRR), a reporting and re-supply system between the health center and health post, was 2.04 ± 1.43. The findings indicated infrequent use of critical Dashlets for routine logistics management information systems. A study[30] in Addis Ababa Health facilities also indicated inconsistent use of the digital LMIS Dashlets. This might be due to multifaceted factors related to infrastructure, the skill of end users, location, and versions of the Dagu, as shown in different studies.[21,36-38]

The end users highly agreed on the benefit of the digital LMIS in improving supply chain performance. However, their agreement on integrating the digital LMIS across the healthcare system and its end-to-end data visibility could have been much higher. This aligns with the Federal Ministry of Health (FMOH) report, which boldly noted the integration and interoperability of digital tools as a primary challenge for the healthcare system.[27] This could pose practical challenges related to data integration, duplication of efforts, and data quality issues, which ultimately affect health system decision-making. Even though FMOH developed a national e-health architecture in its information revolution roadmap, which aimed to transform the integration, interoperability, and standardization of digitalization in the healthcare system,[39] it is not yet fully implemented due to multifaceted factors.[27] The information revolution and digitalization are some of the strategic initiatives stipulated in the health sector transformation plan II of the country,[40] and there are efforts by the Digital Health Activity to streamline digital health across the healthcare system.[24]

End users had a better agreement for digital LMIS performance metrics related to organizational support and the lowest agreement for items related to technical skills. This aligns with a recent technology acceptance model study of HCMIS in which the technology-task fit model showed skill gaps among end users.[36] This indicates the need for continuous capacity-building training and supportive supervision. There is a significant mean difference in the performance of digital LMIS across facilities due to internet access and the implementation of the Dagu version. It is crystal clear that internet access is a critical factor for data synchronization across the supply chain system, especially for Dagu version 2.0.[24,27] Overall, the performance of the digital LMIS in health facilities in the Amhara region requires improvement. Challenges related to infrastructure, skills, governance, integration, and interoperability need to be addressed through system revitalization and continuous enhancement. The low number of facilities using the eLMIS, compared to the total sample, may affect the inferential analysis and could be considered a limitation of this study.

Conclusion and Recommendation

The overall performance of the digital LMIS in terms of the frequency of use of dashlets was 78.3%. The highest mean score was obtained from the activity log Dashlet, and the lowest was from the reports Dashlet. There is a significant mean difference in the utilization status of transaction Dashlet in the different versions of Dagu and the facility's location. The overall mean average score of end users' agreement on the performance of the digital LMIS was 64.2%. The highest mean agreement score was obtained for organization support, and the lowest was for technical skills. In the end, there is a significant mean difference in users' agreement on the performance of the digital LMIS in terms of health system support in different versions and in terms of organizational support concerning internet access and end users' experience. The study's findings indicated the need to revitalize the digital LMIS performance, develop end users' technical skills, and scale up the system to Dagu version 2.0.

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Contribution

ZTM, TGF, and DJC conceived the idea and its study design. ZTM developed the proposal and conducted the data collection. TGF and DJC supervised the quality of the data collection. NC and KB mentored the data analysis and write-up. TGF, NC, and DJC did the final editing of the manuscript. All authors read and approved the final manuscript.

Data Availability Statement

The dataset associated with this article can be easily accessed via the following link: https://doi.org/10.6084/m9.figshare.25664289.v1

Declaration of Conflicting Interests

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Institutional Review Board Statement

This study was approved by the Ethical Review Committee of the School of Pharmacy on January 31, 2022 (Protocol No: ERB/SOP/399/14/2022) and the Institutional Review Board of College of Health Sciences, Addis Ababa University on February 23, 2022 (Protocol number: 007/22/SoP).

Informed Consent Statement

Verbal informed consent was obtained from all participants involved in the study. The verbal agreement was audio-recorded with the participant's permission.

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Supplemental Material

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Paper V

Evaluation of the Features and Requirements of LMIS Tools: Insights from Health Supply Chain Experts in Public Health Facilities of the Amhara Region

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Abstract

Introduction: Access to essential medicines and health commodities remains a significant challenge in many low- and middle-income countries, including Ethiopia, due to inefficiencies in health supply chains. The Logistics Management Information System (LMIS) is crucial for improving the availability of these commodities by enhancing data collection, reporting, and decision-making. However, issues such as poor interoperability, limited infrastructure, and dependence on manual tools continue to hinder LMIS performance.

Objective: This study aims to assess the features and requirements of LMIS tools based on insights from health supply chain experts in public health facilities in the Amhara Region, to guide future improvements in system design.

Methods: This study was conducted in the Amhara Region of Ethiopia in March 2022 using a quantitative cross-sectional design. A total of 102 public health facilities were selected through multistage stratified random sampling. Participants included pharmacy heads, supply chain coordinators and officers, outpatient pharmacy coordinators, and store managers with at least six months of experience. Data were collected using a validated, interviewer-administered questionnaire covering LMIS implementation, performance, usage, and tool convenience. Data were analyzed using SPSS Version 23 after entry into Epi Info.

Results: Of the 150 health supply chain professionals surveyed in the Amhara region, nearly all participants were involved in Logistics Management Information System (LMIS) activities, particularly in recording forms like RRF, IFRR, and Bin Cards. Experts generally viewed LMIS as user-friendly and useful for stock analysis, but identified significant challenges, including weak digitalization, limited interoperability, and inadequate infrastructure. The performance of LMIS tools was rated moderately, with low scores for system-wide integration and support. While essential LMIS data items were considered highly important, their actual usage, particularly for advanced metrics, was inconsistent. Among manual tools, Model 22/H and 19/H were considered the most convenient, while Stock Cards were found to be time-consuming and less user-friendly.

Conclusion and Recommendation: The study evaluates the effectiveness of LMIS tools in public health facilities, highlighting strengths in user-friendliness and stock analysis but identifying significant challenges in data backup, digitalization, and system integration. While certain initiatives like IPLS, APTS, and Dagu-2 received positive feedback, issues with manual and digital tools' efficiency and interoperability were noted. Despite recognition of the importance of LMIS data, the use of advanced metrics remained low. The findings underscore the need for improvements in infrastructure, training, and system integration to enhance LMIS effectiveness.

Key Words: Supply chain experts, Insights, Features, Requirements, LMIS tools, Performance, Health Facilities

1. Introduction

Access to essential medicines and health commodities is a fundamental right (Hogerzeil, 2006; Perehudoff, 2020). Despite ongoing efforts, disparities in access to these vital health commodities hinder health outcomes, especially in low- and middle-income countries (Stevens and Huys, 2017a; Ozawa *et al.*, 2019). The efficiency of health systems greatly relies on the ability to deliver health commodities such as medicines, vaccines, and medical supplies (WHO, 2010; Manyazewal, 2017). An effective and efficient health supply chain system is essential for ensuring that these health commodities are available at the right places and at the right times to the appropriate persons (Getele, Li and Arrive, 2020; Rowan and Laffey, 2020; Lugada *et al.*, 2022).

In many developing countries, including Ethiopia, the health supply chains system face entrenched challenges to ensure the uninterrupted availability of essential health commodities (Yadav and Yadav, 2015; Stevens and Huys, 2017b; Ozawa *et al.*, 2019). The major challenges are related with capacity, health system, workforce and budget which often lead to stockouts, wastage of resources, and inefficient service delivery (PATH, 2010; Yadav, 2017). To address these gaps, the Government of Ethiopia initiated the Integrated Pharmaceutical Logistics System (IPLS) in 2009, aiming to create a unified system for managing all public health commodities (PFSA, 2017).

The vital component of health supply chain management is the Logistics Management Information System (LMIS), which facilitates real-time monitoring and management of health commodities through recording, data collection, analysis, and reporting for informed decision-making (Khlie and Abouabdellah, 2016; Global Fund and GAVI, 2019). The successful implementation of a robust LMIS is essential for enhancing inventory management, demand forecasting, and maintaining effective communication across various stakeholders within the health supply chain (USAID Deliver, 2011; Bekele and Anbessa, 2021).

Despite the strides made through initiatives to improve the national health supply chain systema and LMIS, the implementation and performance of LMIS in Ethiopia, remain precarious. Challenges such as data integrity issues, inadequate infrastructure, insufficient user training, and a lack of interoperability among different health information systems continue to impede effective LMIS performance (Desale *et al.*, 2013; Taddesse, 2015a; FMOH, 2024).

This is compounded by the dynamic and often complex nature of health supply chains as countries expand their health programs and introduce new technologies, necessitating innovative and user-friendly LMIS tools to support timely data collection and reporting (PATH, 2010; García-Alcaraz *et al.*, 2017).

Despite ongoing efforts to digitize the LMIS in Ethiopia, most health facilities continue to rely on various manual LMIS tools that lack cross integration and interoperability, often resulting in redundant data items in different tools serving the same purpose (Dowling, 2017; EPSA, 2019; USAID, 2019; FMOH, 2020b). Assessing the specific features and requirements of LMIS tools from the perspective of health supply chain experts is essential for guiding future interventions and improving system design. Therefore, this study aims to evaluate the features and requirements of LMIS tools based on insights from supply chain professionals in public health facilities across the Amhara Region.

2. Methods

2.1. Study Area

This study was conducted in the Amhara Regional State of Ethiopia from March 01-31, 2022, the country's second-most populous region. The region is administratively classified into 12 Zones, three city administrations, and 166 Woredas (districts). Four EPSS hubs supply health commodities for public health facilities in the region.

2.2. Study design

An institution-based concurrent mixed study design employed a combination of quantitative and qualitative approaches used for the data collection. This study is part of the main project focusing on performance evaluation of health commodities LMIS and findings are based only on the quantitative data.

2.3. Source and Study Population

The source population for this study consisted of all public health facilities in the Amhara Region and all health professionals involved in the health commodities supply chain system. The study population specifically included selected public health facilities and key personnel directly engaged in supply chain management, namely Pharmacy Heads, Supply Chain Management (SCM) Coordinators, SCM Officers, Outpatient (OPD) Pharmacy Coordinators, and Store Managers.

2.4. Sampling Procedure

Health centers and Hospitals in all Zonal administrations, except those with security problems, were considered for sampling. Accordingly, six zonal and two city administrations were selected and further stratified into three clusters based on the EPSS hubs' location. Fifteen percent of the facilities were included in the study per the recommendation of USAID's Logistics Indicators Assessment Tool (LIAT) (USIAD Deliver Project, 2008). The sample size for each zone and district was allocated based on proportion to size. Accordingly, a total of 102 health facilities were included in the study, comprising five referral hospitals, four general hospitals, ten primary hospitals, and 83 health centers. The sample facilities were selected using a multi-stage stratified random sampling method, proportionate to size. Subsequently, all available pharmacy heads, supply chain coordinators, supply chain officers, outpatient pharmacy coordinators, and store managers in the selected facilities participated in the interviewer-administered questionnaire.

2.5. Inclusion and Exclusion Criteria

Inclusion Criteria

- All Zonal Administrations
- All public health facilities that have been functional for more than one year
- All pharmacy heads, supply chain coordinators, supply chain officers, outpatient pharmacy coordinators, and store managers with more than six months of experience

Exclusion Criteria

- Health facilities were damaged in conflict-affected areas or had security problems during the study.
- Digital information management tools used for other health services
- Health Posts

2.6. Data collection process

Data were collected using an interviewer-administered questionnaire consisting of seven sections: (1) socio-demographic characteristics of respondents, (2) level of participation in LMIS implementation for health commodities, (3) level of agreement on LMIS performance indicators, (4) rating of overall LMIS performance, (5) frequency of use and level of agreement on data items included in LMIS tools, (6) level of convenience of manual LMIS tools, and (7) level of convenience of digital LMIS tools.

2.7. Data quality assurance

Ten experts in the area validated data collection tools, and training was provided for data collectors for two days. The data collection tools underwent a pre-testing phase, during which necessary modifications were made. Reliability and validity tests were performed to assess the internal consistency of the questionnaire. The various sections contained 23 items, 15 items, 208 items, 48 items, and 60 items, yielding Cronbach's alpha values of 0.755, 0.861, 0.95, 0.987, and 0.963, respectively. All of these values demonstrate acceptable scores for the internal consistency of the items.

2.8. Operational Definitions

Bin Card: A bin card is a record-keeping tool used for inventory management and stock control of individual items in a store

Stock Card: A stock card is a record-keeping tool similar to a bin card, but it includes additional data elements such as price, which are used for inventory management in a store.

RRF (Report and Requisition Form): This LMIS tool allows health centers and hospitals to report consumption and request resupply of health commodities

IFRR (Internal Facility Reporting and Requisition Form): This tool facilitates the requisition and redistribution of health commodities within health facilities used by health centers and hospitals.

Model 19/Health: It is a serially registered official financial transaction tool used in health facilities to receive health commodities from suppliers

Model 22/Health: It is a serially registered official financial transaction tool used in health facilities for issuing health commodities for health facilities and different units

2.9. Data Analysis and Interpretation

The quantitative data were checked for completeness and internal consistency. Then, the data were entered into Epi Info Version 7 statistical software. Finally, the data was exported to SPSS Version 23.0 for better data management and analysis.

2.10. Ethical Consideration

The proposal was reviewed and approved by the Institutional Review Committee of the school and the Institutional Review Board of the college. The purpose of the study was clearly explained to all participants, and verbal informed consent was obtained after they comprehended the information. No individual identifiers were included in the data collection to protect the privacy of the participants, and the data was analysed in aggregate.

3. Results

3.1. Sociodemographic Characteristics of Participants

The survey of 150 healthcare professionals revealed a predominantly young and male workforce, with 74.7% under 30 years of age and 68.7% male. Most respondents were pharmacy professionals (99.3%), primarily working in health centers (68.7%) and urban areas (56%). The majority held diplomas (73.3%), with only a small percentage possessing bachelor's (25.3%) or master's degrees (1.3%). The majority of the participants were pharmacy heads (44.7%) and store managers (41.3%). A considerable number of participants indicated having less than five years of experience in healthcare supply chain management (70%), while 53.3% of the respondents reported an overall professional work experience of less than five years (Table 1).

Table 1: Sociodemographic Characteristics of Health Supply Chain Professionals in Public Health Facilities in the Amhara Region, March 2022

Variables (N=150)	Categories	N	Percentage
Zone	Central Gondar	34	22.7
	East Gojjam	38	25.3
	North Shewa	34	22.7
	West Gojjam	44	29.3
	Total	**150**	**100**
Level	Health Center	103	68.7
	Primary Hospital	26	17.3
	General Hospital	4	2.7
	Referral Hospital	17	11.3
	Total	**150**	**100**
Location	Urban	84	56
	Rural	66	44
	Total	**150**	**100**
Sex	Male	103	68.7

	Female	47	31.3
	Total	**150**	**100**
Age	≤ 30 Years	112	74.7
	>30 Years	38	25.3
	Total	**150**	**100**
Profession	Pharmacy	149	99.3
	Nurse	1	0.7
	Total	**150**	**100**
Working Department	Leadership/Coordination	67	44.7
	OPD Pharmacy	5	3.3
	SCM Case Team	16	10.7
	Store	62	41.3
	Total	**150**	**100**
Highest Qualification	Diploma	110	73.3
	Bachelor	38	25.3
	Masters	2	1.3
	Total	**150**	**100**
Current Position	Pharmacy Head	67	44.7
	SCM Coordinator	6	4.0
	SCM Officer	10	6.7
	OPD Pharmacy Coordinator	5	3.3
	Store Manager	62	41.3
	Total	**150**	**100**
Experience at the current position	≤1 Years	63	42.0
	1-2 Years	22	14.7
	2-3 Years	23	15.3
	3-4 Years	21	14.0
	4-5 Years	7	4.7
	>5 Years	14	9.3
	Total	**150**	**100**
Experience on HSCM	≤5 Years	105	70.0
	(5-10] Years	40	26.7
	>10 Years	5	3.3
	Total	**150**	**100**
Total Work Experience	≤5 Years	80	53.3
	(5-10] Years	51	34.0
	> 10 Years	19	12.7
	Total	**150**	**100**

3.2. *Experts' Experience with LMIS Implementation*

Of those 150 experts, 148 (98.7%) of them had experiences related with LMIS activities. The findings indicate that health supply chain professionals largely involved on essential activities such as report preparation 140 (94.6%), stock recording 132 (89.2%), in-service/on job LMIS training provision 44(29.7%) and LMIS formats development 8(5.4%). Supply chain experts are highly engaged in Logistics Management Information System (LMIS) recording activities. The majority are involved in the recording activities of RRF, IFRR, Bin Card, HPMRR, and Model 19&22/H, as claimed by 145 (98.0%), 144 (97.3%), 143 (96.6%), 106 (71.6%), and 94 (63.5%) of the participants, respectively. However, engagement of supply chain experts in the recording of Stock Cards, HCMIS/Dagu, SCM M&E, and DHIS-2 was minimal (Figure 1).

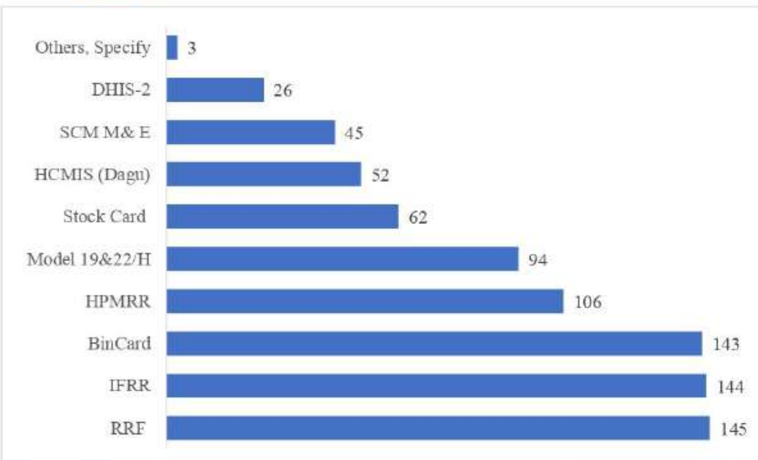
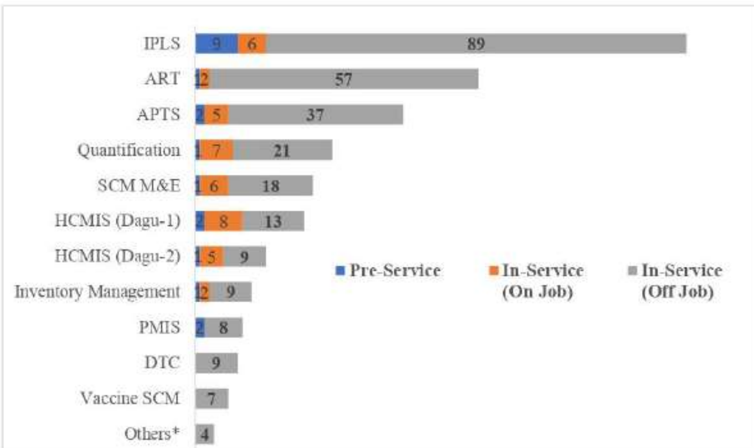


Figure 1: Health supply chain professionals' participation in LMIS recordings in public health facilities in the Amhara region, March 2022 (N=150)

Health supply chain professionals have reported participation in LMIS related capacity-building training programs, including pre-service, on-the-job in-service, and off-the-job in-service trainings. The most frequently attended trainings were IPLS, ART, and APTS claimed with 104 (69.3%), 60 (40%), and 44 (29.3%) participants, respectively (Figure 2).



IPLS - Integrated Pharmaceutical Logistics System; APTS - Auditable Pharmaceutical Transactions and Services; ART - Antiretroviral Therapy; SCM M&E - Supply Chain Management Monitoring and Evaluation; HCMIS - Health Commodities Management Information System; PMIS - Pharmaceutical Management Information System; DTC - Drug and Therapeutics Committee.

Figure 2: Participation of Health Supply Chain Professionals in LMIS related trainings in Public Health Facilities of Amhara Region, March 2022 (N=150)

3.3. Insights from Health SCM Experts on LMIS Implementation

The five-level Likert scale interviewer-administered 23-item tool used to assess the insights of health supply chain experts on LMIS implementation revealed mixed perspectives on various aspects of the system. A significant majority of experts indicated the user-friendliness of the LMIS, its appropriateness for stock analysis, and high staff commitment, with mean scores of 3.87, 3.8, and 3.77, respectively. However, challenges were highlighted, particularly concerning the LMIS data backup system, the need for improved digitalization, and efficient end-to-end data visibility, as evidenced by lower mean scores of 2.6, 2.37, and 2.01 for these items, respectively. While a lack of formats was not seen as a major issue, integration and interoperability with other health information systems were perceived as inadequate, scoring mean values of 3.09 and 2.93, respectively, both below the average threshold. Overall, while respondents acknowledged certain strengths in the LMIS, they also identified critical areas for enhancement, such as professional training on LMIS (2.35±1.13) and regular feedback from higher levels of the healthcare system (2.35±1.16) (Figure 3; Annex 1)

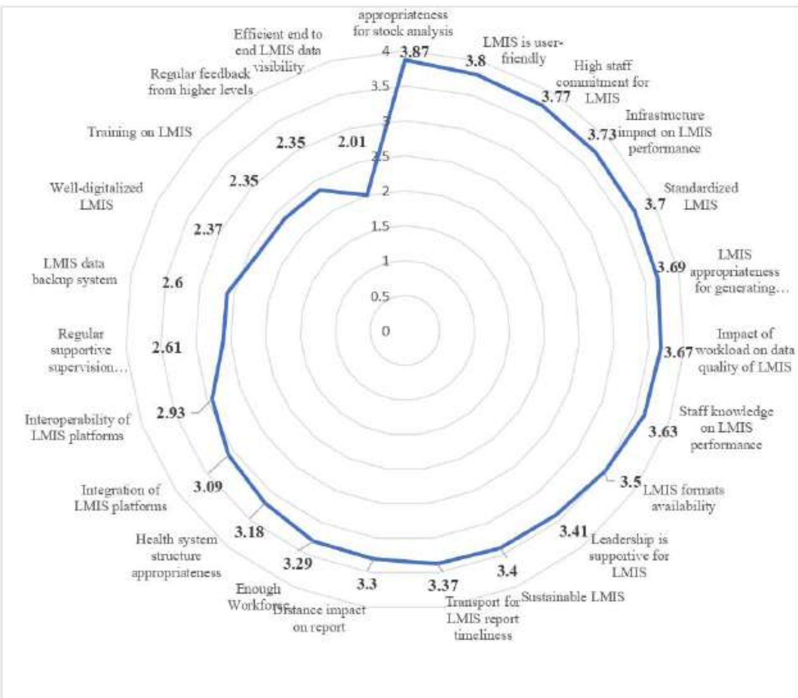


Figure 3: Insights of Health Supply Chain Professionals on LMIS implementation in Health Facilities of Amhara Region, March 2022 (N=150)

3.4. *LMIS Performance rating by HSCM Experts*

The five-level Likert scale interviewer-administered 15-item tool used to rate the performance of LMIS by health supply chain experts revealed generally mixed perceptions among respondents. While facility-specific supply chain performance was rated slightly better (3.04 ± 0.86) than the overall public health supply chain system performance (2.89 ± 0.92), the LMIS performance received a lower rating of 2.78 ± 0.94 in the public system, indicating concerns about data quality and digitalization. However, there were positive perceptions of initiatives such as IPLS (3.36 ± 0.79), APTS (3.42 ± 1.88), and Dagu-2 (3.43 ± 1.86), reflecting perceived improvements in LMIS performance. Staff commitment was rated positively at 3.41 ± 0.88, but management support (2.97 ± 0.96) and supportive supervision (2.38 ± 0.99) were seen as areas needing significant improvement. Additionally, concerns about the integration (2.83 ± 0.95) and interoperability of LMIS (2.43 ± 1.06) with other health information systems were highlighted, alongside inadequacies in infrastructure for LMIS activities (2.40 ± 1.00), indicating critical areas that require attention for overall enhancement (Table 2).

Table 2: Ratings of LMIS Performance by Health Supply Chain Professionals in Health Facilities of Amhara Region, March 2022 (N=150)

S N	Items related with LMIS Performance (N=150)	Very poor	Poor	Good	Very Good	Excellent	Mean ±SD
1	How do you rate the overall health commodities supply chain performance *(hint; data quality, availability, wastage rate, inventory accuracy, forecasting accuracy)* in the public health system in general?	5(3.3)	48(32)	64(42.7)	24(16)	9(6)	2.89±0.92
2	How do you rate the overall *health commodities supply chain performance* in your facility?	4(2.7)	34(22.7)	70(46.7)	36(24)	6(4)	3.04±0.86
3	How do you rate the overall *Health commodities' LMIS performance* (hint; *data quality, reporting, availability of LMIS formats, digitalization, etc*) in the public health system?	9(6)	52(34.7)	59(39.3)	23(15.3)	7(4.7)	2.78±0.94
4	How do you rate the overall *Health commodities' LMIS performance* in your facility?	5(3.3)	34(22.7)	71(47.3)	34(22.7)	6(4)	3.01±0.87
5	How do you rate the level of IPLS implementation?	3(2)	9(6)	80(53.3)	47(31.3)	11(7.3)	3.36±0.79
6	How do you rate the improvement of LMIS performance due to IPLS initiation?	2(1.3)	12(8)	78(52)	48(32)	10(6.7)	3.35±0.78
7	How do you rate the improvement of LMIS performance due to Quick-Win initiative? (*for Hospitals only*)	1(0.7)	7(4.7)	6(4)	10(6.7)	0	3.04±1.51
8	How do you rate the improvement of LMIS performance due to APTS initiative?	3(2)	5(3.3)	21(14)	15(10)	9(6)	3.42±1.88
9	How do you rate the improvement of LMIS performance due to Dagu-2 (HCMIS) implementation?	6(4)	3(2)	22(14.7)	25(16.7)	9(6)	3.43±1.86
10	How do you rate the staff commitment for LMIS activities	0	24(16)	57(38)	53(35.3)	16(10.7)	3.41±0.88
11	How do you rate the level of management support for LMIS activities	7(4.7)	42(28)	56(37.3)	38(25.3)	7(4.7)	2.97±0.96
12	How do you rate the level of supportive supervision from higher levels? (WoHo, ZHD, RHB, EPSA, FMOH)	28(18.7)	62(41.3)	37(24.7)	21(14)	2(1.3)	2.38±0.99
13	How do your rate the different LMIS integration with each other	8(5.3)	51(34)	56(37.3)	28(18.7)	7(4.7)	2.83±0.95
14	How do you rate the LMIS interoperability (data sharing) with other health information systems (eg. DHIS-2, Dagu, SCM M&E…)	17(11.3)	63(42)	42(28)	16(10.7)	1(0.7)	2.43±1.06
15	How is the infrastructure (Internet, Power, computer, stationary, transport….) to perform LMIS activities?	27(18)	58(38.7)	50(33.3)	8(5.3)	7(4.7)	2.40±1.0

3.5. LMIS Data Items: Frequency of Use and Importance

In the analysis, a four-level Likert scale for frequency of use and a five-level Likert scale for level of importance were employed to evaluate the six basic LMIS forms that are routinely used for stock keeping records, stock transaction, consumption reporting, and re-supply ordering. These forms include Bincard, Stockcard, RRF, IFRR, Model 19/H, and Model 22/H.

In the bin card, key data elements such as facility name, product name, strength, dosage form, and unit of issue were recorded consistently, with over 90% of professionals indicating a high level of utilization, rating them as "frequently" or "always." However, advanced metrics such as average monthly consumption (AMC) and emergency order points (EOP) had lower frequency of use, with mean scores of 2.52 and 3.29, respectively, despite high agreement on their importance. Overall, most data items received a strong level of agreement on their importance, with mean agreement scores above 4.6 (Annex 2).

In the context of stock cards, basic data items such as "Dosage Form," "Expiry Date," "Product Name," and "Strength" exhibit relatively high frequency of use, with mean scores of 2.54 ± 1.45, 2.54 ± 1.46, 2.53 ± 1.46, and 2.53 ± 1.46, respectively. These items also have high levels of agreement regarding their importance, with mean scores ranging between 4.35 and 4.4. Conversely, inventory management metrics like maximum stock level (MSL) (2.0 ± 1.17), emergency order point (EOP) (2.09 ± 1.24), and average monthly consumption (AMC) (2.0 ± 1.24) show lower utilization rates. Overall, while most data items are acknowledged for their significance with mean values between 4.1 and 4.4, their actual utilization levels are relatively low (Annex 3).

This may result from overlapping data items across bin cards and stock cards, potentially leading to redundant efforts among professionals, as all data items, except for the three mentioned, are similar (Figure 4)

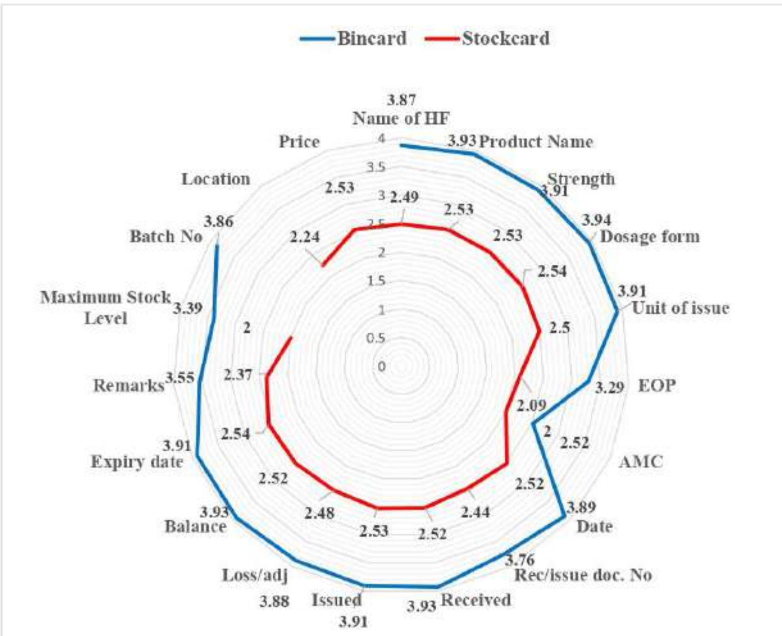


Figure 4: Comparison of Data Item Usage Frequencies for Bin Card and Stock Card by Health Supply Chain Professionals in Public Health Facilities of the Amhara Region, March 2022 (N=150)

The most consistently recorded data items in IFRR include *Item Name* (3.98±0.18), *Beginning Balance* (3.97±0.20), *Quantity Received* (3.97±0.21), and *Ending Balance* (3.97±0.21). However, *Remarks* (3.68±0.73) and *Maximum Stock Level* (3.72±0.74) were recorded less consistently, suggesting areas for improvement in documentation practices. The perceived importance of data items in RRF is consistently high, with mean scores ranging from 3.97 to 4.84 on a five-level scale. *Item Name, Beginning Balance, Quantity Received, Ending Balance*, and *Calculated Consumption* were among the most frequently recorded and highly rated in importance (≥4.83). Despite their lower recording frequency, items such as *Remarks* (4.74±0.52) and *Maximum Stock Level* (4.75±0.53) were still considered highly important, indicating a gap between perceived importance and actual usage (Annex 4).

The most essential data items in the RRF are frequently used in logistics recording, with mean scores ranging from 3.37 to 4.00 on a four-level scale. The most consistently recorded items include *Beginning Balance* (3.99±0.08), *Quantity Received* (3.99±0.08), and *Ending Balance in Store* (4.00±0.12. However, *Products with Less than Six Months Shelf Life* had the lowest recording frequency (3.37±1.05. Despite some variations in frequency of use, all data items were highly rated in importance, with mean scores between 4.69 and 4.86 (Annex 5).

The data items in Model 22/H are frequently used, with mean scores ranging from 3.1 to 3.99 on a four-level scale. Key items such as *Date* (3.99±1), *Receiver Name* (3.98±0.14), *Quantity Issued* (3.98±0.14), and *Unit Cost* (3.98±0.14) are among the most consistently recorded. However, items like *Drug Code* (3.1±1.25), *Retail Unit* (3.33±1.21), and *Total Selling Price* (3.38±1.15) showed lower recording frequency, indicating potential gaps in financial and retail tracking. Despite this variation in usage, all data items were highly rated in importance, with mean scores between 4.6 and 4.94 (Annex 6).

The findings on Model 19/H indicate that most essential data items are frequently used in logistics recordings, with mean scores ranging from 3.17 to 3.97. Items such as *Receiver Name* (3.96±0.2), *Quantity Received* (3.97±0.17), and *Total Cost* (3.94±0.28) are among the most consistently recorded data items. However, *Drug Code* (3.17±1.18) and *Serial Number* (3.54±0.94) showed lower usage, suggesting potential inconsistencies in tracking product identifiers. Despite varying usage frequencies, all data items received strong agreement for inclusion in the recording forms, with mean scores ranging from 4.5 to 4.88 (Annex 7).

3.6. Convenience of Manual LMIS Tools for Use

The convenience of manual LMIS tools was assessed using eight items on a five-level Likert scale. The findings revealed that Model 22/H and Model 19/H were the most user-friendly, scoring 4.48 and 4.44, respectively, while the Stock Card had the lowest score (3.63). The inclusion of essential data items was rated highest for RRF (4.61) and Model 22/H (4.59). In terms of ease of data aggregation and reporting, all tools performed relatively well. Uniformity across facilities was best maintained in RRF (4.37), while consistency with other records was highest for Model 22/H (4.36). However, recording errors were more frequent in IFRR (3.96) and RRF (3.91) compared to Model 22/H (4.11) and Model 19/H (4.09). Time consumption remained a concern across all tools, with the Stock Card being the most time-intensive (3.04) and Model 19/H being the least (3.83) (Figure 5; Annex 8)

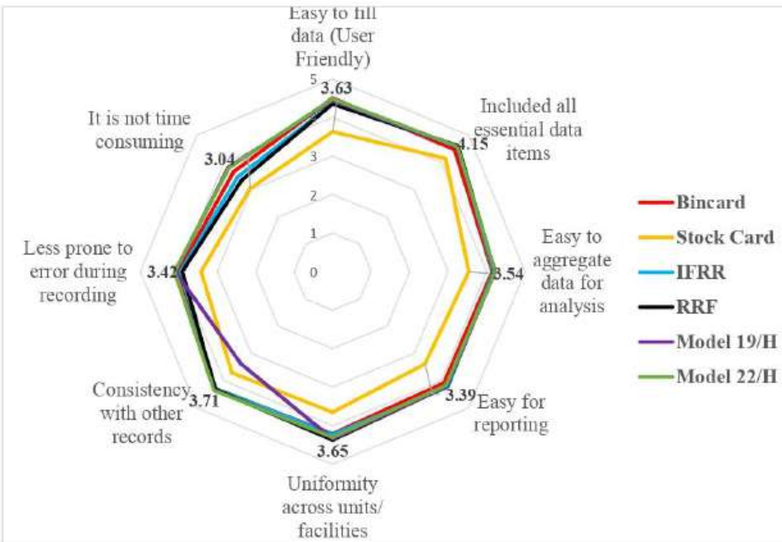


Figure 5: Comparison of Manual LMIS Tools Convenience for Use by Health Supply Chain Professionals in Public Health Facilities of Amhara Region, March 2022

3.7. Convenience of Digital LMIS Tools for Use

The convenience of digital LMIS tools was assessed using ten items on a five-level Likert scale. The findings revealed that Bin Card was the most user-friendly tool (4.81), followed by Stock Card (4.7), while Model 22/H had the lowest score (4.61). The inclusion of essential data items was rated highest for IFRR (4.75) and Model 19/H and Model 22/H (both 4.74). Ease of data aggregation and reporting was best in IFRR (4.87), while Model 22/H performed the best in reporting (4.88). Uniformity across facilities was highest for IFRR (4.68), and consistency with other records also rated best in IFRR (4.66). Digital tools were generally less prone to recording errors, with Bin Card and IFRR scoring the highest (4.7). However, integration and interoperability with other e-LMIS remained a challenge, with the lowest scores recorded in Model 19/H (3.67) and Model 22/H (3.67). Time consumption was rated better than manual tools, but variation existed across tools, with Bin Card (4.47) being the most time-efficient and Model 22/H (4.2) the least (Figure 6: Annex 9).

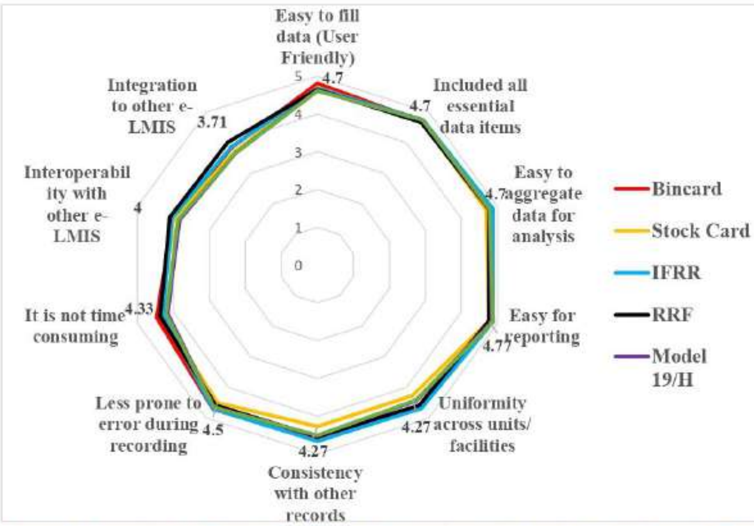


Figure 5: Comparison of Digital LMIS Tools Convenience for Use by Health Supply Chain Professionals in Public Health Facilities of Amhara Region, March 2022

4. Discussion

The current study shows that a vast majority of health supply chain professionals are actively engaged in LMIS activities. This is significant, as individuals with more extensive LMIS experience tend to participate more in critical logistics functions (EPSA, 2019; Samal, 2019). Despite this widespread involvement, there remains a considerable gap in the digitalization of LMIS systems. While many professionals are familiar with manual or paper-based tools, adoption of digital platforms such as HCMIS, Dagu, or DHIS-2 is still limited. For example, a study in Ethiopia revealed that paper-based tools continued to dominate despite digitization efforts, due to infrastructural limitations and low digital literacy among staff (Dowling, 2017). This highlights the need for continuous professional development and technological adaptation to improve LMIS efficiency (FMOH, 2020a; Alemu *et al.*, 2021)

Insights from supply chain experts point to both positive perceptions and key challenges in LMIS implementation. Experts gave relatively high ratings for system usability and staff commitment (3.87 and 3.77 out of 5, respectively), supporting findings that user experience is essential for successful LMIS adoption (Tummers *et al.*, 2021). On the other hand, digitalization, data backup, and end-to-end data visibility received low scores (2.37, 2.6, and 2.01), indicating broader issues such as inadequate infrastructure and poor system interoperability. Similar barriers have been reported in Ethiopia and other countries (Bekele and Anbessa, 2021; Shama *et al.*, 2021). Moreover, deficiencies in training and feedback mechanisms are major obstacles to LMIS performance. Targeted capacity-building initiatives are essential for strengthening system sustainability and enhancing supply chain outcomes (Kanyika *et al.*, 2022; Milulu, Mwita and Basinda, 2024).

Overall LMIS performance was rated at a moderate level, with an average score of 2.78 out of 5. However, initiatives like the IPLS, APTS and digital platforms such as Dagu-2 have shown measurable improvements in performance (Gedif *et al.*, 2016; Gudeta *et al.*, 2025).

The handling of critical LMIS data items reveals a disconnect between their recognized importance and actual use. While manual tools like Bin Cards and Stock Cards are commonly used, essential data items such as Average Monthly Consumption (AMC) and Emergency Order Points (EOP) are often rarely used, leading to inefficiencies in the supply chain (Raj *et al.*, 2024). Manual LMIS tools are generally perceived as less convenient due to their error-proneness and time-consuming nature. In contrast, digital tools like electronic bin cards and IFRR platforms are rated more highly for user-friendliness and efficiency (Gilbert *et al.*, 2020; Fritz, Herrick and Gilbert, 2021).

Nonetheless, implementation barriers such as unreliable internet, limited staff training, and weak system integration continue to hinder their full potential (Desale *et al.*, 2013; Mabirizi *et al.*, 2018). Digital systems such as HCMIS have demonstrated benefits in reducing errors and enhancing data aggregation, yet still face challenges in infrastructure and interoperability (USAID Deliver Project, 2014; Taddesse, 2015b; Bekele and Anbessa, 2021).

A well-designed LMIS requires a multidisciplinary approach that prioritizes both technical robustness and user-centered usability. According to the WHO, a resilient LMIS should be comprehensive, adaptable, scalable, and interoperable particularly in low-resource settings (WHO, 2017, 2021). Effective system architecture should include stakeholder engagement, data validation protocols, and alignment with local workflows (Richardson, 2006; Tummers *et al.*, 2021). Digital integration enhances real-time data visibility, reduces errors, and strengthens decision-making (USAID, 2011; Global Fund, 2019). Success stories from countries like Namibia, Tanzania, and Ethiopia show that digitization can significantly improve supply chain efficiency, though infrastructural and workforce limitations still pose major challenges (Dowling, 2017; Mabirizi *et al.*, 2018; Gilbert *et al.*, 2020).

5. Conclusion and Recommendation

The LMIS tools were generally considered user-friendly and suitable for stock analysis, although several challenges were identified, including inadequate data backup systems, limited digitalization, and poor integration with other health information systems. The performance of LMIS was rated relatively low, especially in terms of data quality, digitalization, and integration with other systems. Despite these issues, certain LMIS initiatives like IPLS, APTS, and Dagu-2 received more favorable reviews, and staff commitment to LMIS was viewed positively. Manual tools such as Model 22/H and Model 19/H were seen as more user-friendly but also more time-consuming, whereas digital tools like Bin Card and IFRR were considered more efficient and user-friendly, though still faced challenges with integration and interoperability. Although most professionals recognized the importance of LMIS data items, the use of advanced metrics, such as average monthly consumption and emergency order points, remained low. Overall, the findings highlight the strengths of LMIS tools in use but emphasize the need to address gaps in infrastructure, training, and system integration to improve the effectiveness of LMIS in the region's public health facilities.

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Data Availability Statement

The raw data supporting the conclusions of this article will be made available by the authors upon request without undue reservation.

Conflicts of Interests

All authors declared that there are no competing interests.

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Annexes: Supplimentary Documents

Annex 1: Insights of Health Supply Chain Professionals on LMIS implementation in Health Facilities of Amhara Region, March 2022 (N=150)

SN	Items related with LMIS implementation (N=150)	Level of Agreement					
		Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**	**Mean±SD**
1.	We have a well standardized logistics management information (LMIS) system in our facility	5(3.3)	26(17.3)	10(6.7)	85(56.7)	24(16)	3.7±1.05
2.	There is no LMIS formats availability problem	10(6.7)	38(25.3)	4(2.7)	62(41.3)	36(24)	3.5±1.3
3.	The number of professionals is enough to manage LMIS activities	10(6.7)	51(34)	6(4)	52(34.7)	31(20.7)	3.29±1.3
4.	There is high staff commitment for LMIS activities	1(0.7)	28(18.7)	11(7.3)	75(50)	35(23.3)	3.77±1.03
5.	The health system structure is appropriate for LMIS activities	10(6.7)	46(30.7)	14(9.3)	67(44.7)	13(8.7)	3.18±1.16
6.	Lack of infrastructure (*warehouse space, internet, power, computer, furniture, etc)* highly affects the LMIS performance in our facility	14(9.3)	19(12.7)	9(6)	60(40)	47(31.3)	3.73±1.3
7.	Our LMIS is user-friendly (easily understandable to perform)	4(2.7)	19(12.7)	9(6)	88(58.7)	30(20)	3.8±0.99
8.	Our LMIS is appropriate for stock analysis	4(2.7)	16(10.7)	6(4)	94(62.7)	30(20)	3.87±0.95
9.	Our LMIS is appropriate for generating reports	6(4)	26(17.3)	6(4)	82(54.7)	30(20)	3.69±1.1
10.	We have a good LMIS data backup system in our facility	29(19.3)	57(38)	21(14)	31(20.7)	12(8)	2.6±1.24
11.	We have a sustainable LMIS system in our facility	3(2)	46(30.7)	13(8.7)	64(42.7)	24(16)	3.4±1.14
12.	The LMIS in our facility is well digitalized	57(38)	37(24.7)	12(8)	31(20.7)	13(8.7)	2.37±1.4
13.	There is efficient end to end LMIS data visibility in the health system (*From lower-level heath facility up to MOH and EPSA*)	68(45.3)	46(30.7)	9(6)	20(13.3)	7(4.7)	2.01±1.2
14.	Distance highly attributes to delay in reporting	12(8)	45(30)	7(4.7)	57(38)	29(19.3)	3.3±1.3
15.	Transport problem highly attributes to the LMIS report timeliness (delay)	12(8)	40(26.7)	7(4.7)	63(42)	28(18.7)	3.37±1.28

16.	Work load highly attributes to data quality of the LMIS in our facility	7(4.7)	25(16.7)	11(7.3)	75(50)	32(21.3)	3.67±1.13
17.	SCM officer's knowledge affects LMIS performance	5(3.3)	25(16.7)	18(12)	75(50)	27(18)	3.63±1.06
18.	The different LMIS platforms are integrated with each other	11(7.3)	49(32.7)	18(12)	60(40)	12(8)	3.09±1.16
19.	The different LMIS platforms are interoperable (able to exchange infomation) with other Health information systems	15(10)	58(38.7)	10(6.7)	56(37.3)	11(7.3)	2.93±1.21
20.	The facility's leadership is supportive for LMIS activities	7(4.7)	36(24)	13(8.7)	76(50.7)	18(12)	3.41±1.12
21.	Professionals working on health commodities SCM got enough LMIS training to effectively discharge their duties	35(23.3)	67(44.7)	11(7.3)	34(22.7)	3(2)	2.35±1.13
22.	The facility is getting regular supportive supervision from the respective higher levels (WoHo/ZHD/RHB/EPSS/MOH)	33(22)	53(35.3)	14(9.3)	39(26)	11(7.3)	2.61±1.28
23.	The facility is getting regular feedback from the respective higher levels (WoHo/ZHD/RHB/EPSS/MOH)	39(26)	59(39.3)	16(21.3)	32(21.3)	4(2.7)	2.35±1.16

Annex 2: Frequency of Use and Level of Agreement on Data Items of Bin Card by Health Supply Chain Professionals in Health Facilities of Amhara Region, March 2022

Proposed Additional Data Items for Inclusion: *Price (37); Cost (3); Location (3); Manfacturer (1); Transer to (1)*

Essential data items (N=150)	How often these data items are used in logistics recordings in your facility					Level of agreement for the importance of these data item in the LMIS forms					
	Never	Sometimes	Often	Always	Mean±SD	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Mean±SD
Name of HF	2(1.3)	5(3.3)	3(2.0)	140(93.3)	3.87±0.51	0	3(2)	2(1.3)	24(16)	121(80.7)	4.75±0.58
Product Name	2(1.3)	1(0.7)	2(1.3)	145(96.7)	3.93±0.40	0	0	3(2)	19(12.7)	128(85.3)	4,83±0.42
Strength	2(1.3)	1(0.7)	5(3.3)	142(94.7)	3.91±0.42	0	0	2(1.3)	20(13.3)	128(85.3)	4.84±0.40
Dosage form	2(1.3)	0	3(2)	145(96.7)	3.94±0.37	0	0	1(0.7)	22(14.7)	127(84.7)	4.84±0.39
Unit of issue	2(1.3)	1(0.7)	5(3.3)	142(94.7)	3.91±0.42	0	0	2(1.3)	24(16)	124(82.7)	4.81±0.42
Maximum Stock Level	11(7.3)	24(16)	11(7.3)	104(69.3)	3.39±1.00	0	5(3.3)	10(6.7)	33(22)	102(68)	4.6±0.77
EOP	10(6.7)	29(19.3)	18(12)	92(61.3)	3.29±1.00	0	4(2.7)	6(4)	41(27.3)	99(66)	4.57±0.70
AMC	50(33.3)	30(20)	12(8)	58(38.7)	2.52±1.30	4(2.7)	5(3.3)	7(4.7)	37(24.7)	97(64.7)	4.45±0.93
Date	3(2)	2(1.3)	4(2.7)	141(94)	3.89±0.50	0	1(0.7)	2(1.3)	26(17.3)	121(80.7)	4.78±0.49
Rec/issue doc. No	4(2.7)	10(6.7)	4(2.7)	132(88)	3.76±0.69	0	2(1.3)	3(2)	27(18)	118(78.7)	4.74±0.56
Received	2(1.3)	1(0.7)	2(1.3)	145(96.7)	3.93±0.40	0	0	1(0.7)	23(15.3)	126(84)	4.83±0.39
Issued	2(1.3)	2(1.3)	3(2)	143(95.3)	3.91±0.43	0	0	3(2)	22(14.7)	125(83.3)	4.81±0.44
Loss/adj	2(1.3)	4(2.7)	4(2.7)	140(93.3)	3.88±0.49	0	0	3(2)	23(15.3)	124(82.7)	4.81±0.44
Balance	2(1.3)	1(0.7)	3(2)	144(96)	3.93±0.40	0	0	2(1.3)	24(16)	124(82.7)	4.81±0.42
Batch No	2(1.3)	4(2.7)	7(4.7)	137(91.3)	3.86±0.51	0	2(1.3)	4(2.7)	26(17.3)	118(78.7)	4.73±0.58
Expiry date	2(1.3)	2(1.3)	3(2)	143(95.3)	3.91±0.43	0	1(0.7)	3(2)	22(14.7)	124(82.7)	4.79±0.50
Remarks	3(2)	27(18)	6(4)	113(75.3)	3.55±0.86	0	7(4.7)	4(2.7)	30(20)	109(72.7)	4.61±0.76

Annex 3: Frequency of Use and Level of Agreement on Data Items of Stock Card by Health Supply Chain Professionals in Health Facilities of Amhara Region, March 2022

Essential data items	How often these data items are used in logistics recordings in your facility					Level of agreement for the importance of these data item in the LMIS forms					
	Never	Sometimes	Often	Always	Mean±SD	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Mean±SD
Name of HF	33(22)	6(4)	2(1.3)	34(22.7)	2.49±1.44	5(3.3)	3(2)	0	20(13.3)	47(31.3)	4.35±1.33
Product Name	33(22)	5(3.3)	1(0.7)	36(24)	2.53±1.46	5(3.3)	3(2)	0	16(10.7)	51(34)	4.4±1.34
Strength	33(22)	5(3.3)	1(0.7)	36(24)	2.53±1.46	5(3.3)	3(2)	0	17(11.3)	50(33.3)	4.39±1.14
Dosage form	33(22)	5(3.3)	2(1.3)	36(24)	2.54±1.45	5(3.3)	3(2)	0	16(10.7)	51(34)	4.4±1.4
Unit of issue	33(22)	6(4)	2(1.3)	34(22.7)	2.5±1.44	5(3.3)	3(2)	0	16(10.7)	51(34)	4.4±1.14
Location	36(24)	11(7.3)	2(1.3)	26(17.3)	2.24±1.36	5(3.3)	5(3.3)	4(2.7)	19(12.7)	42(28)	4.17±1.21
MSL	35(23.3)	19(12.7)	5(3.3)	15(10)	2.0±1.17	5(3.3)	6(4)	3(2)	21(14)	39(26)	4.1±1.23
EOP	35(23.3)	17(11.3)	4(2.7)	19(12.7)	2.09±1.24	5(3.3)	7(4.7)	2(1.3)	22(14.7)	39(26)	4.11±1.24
AMC	39(26)	15(10)	3(2)	18(12)	2.0±1.24	5(3.3)	5(3.3)	2(1.3)	21(14)	42(28)	4.2±120
Date	33(22)	6(4)	0	26(24)	2.52±1.46	5(3.3)	3(2)	0	20(13.3)	47(31.3)	4.35±1.13
Rec/issue doc. No	34(22.7)	7(4.7)	1(0.7)	33(22)	2.44±1.44	5(3.3)	4(2.7)	0	17(11.3)	49(32.7)	4.35±1.17
Received	33(22)	6(4)	0	26(24)	2.52±1.46	5(3.3)	3(2)	1(0.7)	18(12)	48(32)	4.35±1.15
Issued	33(22)	6(4)	35(23.3)	1(0.7)	2.53±1.47	5(3.3)	3(2)	0	19(12.7)	48(32)	4.36±1.14
Loss/adj	33(22)	7(4.7)	1(0.7)	34(22.7)	2.48±1.44	5(3.3)	3(2)	0	19(12.7)	48(32)	4.36±1.14
Balance	33(22)	6(4)	0	36(24)	2.52±1.46	5(3.3)	3(2)	1(0.7)	18(12)	48(32)	4.35±1.45
Price	33(22)	6(4)	1(0.7)	36(24)	2.53±1.45	5(3.3)	3(2)	0	18(12)	50(33.3)	4.38±1.13
Expiry date	33(22)	6(4)	0	37(24.7)	2.54±1.46	5(3.3)	3(2)	0	18(12)	49(32.7)	4.37±1.14
Remarks	33(22)	10(6.7)	3(2)	29(19.3)	2.37±1.38	5(3.3)	4(2.7)	2(1.3)	22(14.7)	42(28)	4.23±1.17

Annex 4: Frequency of Use and Level of Agreementt on Data Items in the IFRR by Health Supply Chain Professionals in Health Facilities of Amhara Region, March 2022

Essential data items	**How often these data items are used in logistics recordings in your facility**					**Level of agreement for the importance of these data item in the LMIS forms**					
	Never	**Sometimes**	**Often**	**Always**	**Mean±SD**	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**	**Mean±SD**
Name of dispensing unit	2(1.3)	5(3.3)	6(4)	137(91.3)	3.85±0.52	0	0	0	31(20.7)	119(79.3)	4.79±0.41
Reporting period	190.7	1(0.7)	5(3.3)	143(95.3)	3.93±0.34	0	1(0.7)	0	28(18.7)	121(80.7)	4.79±0.45
From/To___	1(0.7)	1(0.7)	6(4)	142(94.7)	3.93±0.35	0	0	0	29(19.3)	121(80.7)	4.81±0.40
Max.stock Level	6(4)	8(5.3)	8(5.3)	128(85.3)	3.72±0.74	0	1(0.7)	4(2.7)	26(17.3)	119(79.3)	4.75±0.53
Item Name	0	1(0.7)	1(0.7)	148(98.7)	3.98±0.18	0	0	0	25(16.7)	125(83.3)	4.83±0.37
Beg. Balance	0	1(0.7)	2(1.3)	147(98)	3.97±0.20	0	0	0	24(16)	126(84)	4.84±0.37
Qty. Received	0	1(0.7)	3(2)	146(97.3)	3.97±0.21	0	0	0	24(16)	126(84)	4.84±0.37
Loss/Adj.	1(0.7)	8(5.3)	4(2.7)	137(91.3)	3.85±0.53	0	0	0	26(17.3)	124(82.7)	3.97±0.21
Ending Balance	0	1(0.7)	3(2)	146(97.3)	3.97±0.21	0	0	0	24(16)	126(84)	4.84±0.37
Calculated Consumption	1(0.7)	2(1.3)	3(2)	144(96)	3.93±0.36	0	0	0	25(16.7)	125(83.3)	4.83±0.37
Max. Qty	2(1.3)	2(1.3)	3(2)	143(95.3)	3.91±0.43	0	0	0	26(17.3)	124(82.7)	4.83±0.38
Qty to reach Max	1(0.7)	2(1.3)	5(3.3)	142(94.7)	3.93±0.38	0	0	2(1.3)	23(15.3)	125(83.3)	4.82±0.42
Quantity ordered	1(0.7)	1(0.7)	5(3.3)	143(95.3)	3.93±0.34	0	1(0.7)	0	25(16.7)	124(82.7)	4.81±0.44
Qty to be supplied	2(1.3)	8(5.3)	4(2.7)	136(90.7)	3.83±0.58	0	0	1(0.7)	29(19.3)	120(80)	4.79±0.42
Remarks	1(0.7)	20(13.3)	5(3.3)	124(82.7)	3.68±0.73	0	1(0.7)	3(2)	30(20)	116(77.3)	4.74±0.52
Completed by	0	3(2)	5(3.3)	142(94.7)	3.93±0.33	0	1(0.7)	1(0.7)	25(16.7)	123(82)	4.8±0.46
Approved by	2(0.7)	4(2.7)	3(2)	141(94)	3.89±0.49	0	2(1.3)	0	25(16.7)	123(82)	4.79±0.50

Proposed Additional Data Items for Inclusion*; Date at the end of the IFRR, Requested by, Issued by*

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Annex 5: Frequency of Use and Level of Agreementt on Data Items in the RRF by Health Supply Chain Professionals in Health Facilities of Amhara Region, March 2022

Essential data items	How often these data items are used in logistics recordings in your facility					Level of agreement for the importance of these data item in the LMIS forms					
	Never	Sometimes	Often	Always	Mean±SD	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Mean±SD
Name of HF	1(0.7)	1(0.7)	2(1.3)	146(97.3)	3.95±0.31	0	0	0	21(14)	129(86)	4.86±0.35
Region/Zone/Woreda	1(0.7)	4(2.7)	3(2)	142(94.7)	3.91±0.42	0	4(2.7)	1(0.7)	25(16.7)	120(80)	4.74±0.61
Suppling Branch	3(2)	10(6.7)	5(3.3)	132(88)	3.77±0.66	0	1(0.7)	3(2)	15(16.7)	121(80.7)	4.77±0.50
From/to____	2(1.3)	3(2)	3(2)	142(94.7)	3.9±0.46	0	0	0	23(15.3)	127(84.7)	4.85±0.36
Maximum stock level	1(0.7)	4(2.7)	7(4.7)	138(92)	3.88±0.45	0	0	1(0.7)	26(17.3)	123(82)	4.81±0.41
EOP	2(1.3)	17(11.3)	13(8.7)	118(78.7)	3.65±0.73	0	2(1.3)	7(4.7)	26(17.3)	115(76.7)	4.69±0.62
Product Description	0	3(2)	0	147(98)	3.96±0.28	0	0	0	24(16)	126(86)	4.84±0.37
Unit of Issue	1(0.7)	0	2(1.3)	147(98)	3.97±0.27	0	0	0	24(16)	126(84)	4.84±0.37
Beg. Balance	0	0	1(0.7)	149(99.3)	3.99±0.08	0	0	0	22(14.7)	128(85.3)	4.85±0.36
Qty. Received	0	0	1(0.7)	149(99.3)	3.99±0.08	0	0	0	22(14.7)	128(85.3)	4.85±0.36
Los/adj	1(0.7)	4(2.7)	2(1.3)	143(95.3)	3.91±0.42	1(0.7)	0	0	21(14)	128(85.3)	4.83±0.47
Ending Balance-DU	0	3(2)	2(1.3)	145(96.7)	3.95±0.30	1(0.7)	0	0	21(14)	128(85.3)	4.83±0.47
Ending Balance-store	0	0	1(0.7)	149(99.3)	4.0±0.12	0	0	0	21(14)	129(86)	4.86±0.35
Calculated Consumption	0	1(0.7)	2(1.3)	147(98)	3.97±0.20	0	0	1(0.7)	20(13.3)	129(86)	4.85±0.37
Days out of stock	2(1.3)	12(8)	6(4)	130(86.7)	3.76±0.65	0	3(2)	0	24(16)	123(82)	4.78±0.54
Max. stock quantity	0	3(2)	2(1.3)	145(96.7)	3.95±0.30	0	2(1.3)	0	20(13.3)	128(85.3)	4.83±0.47
Qty to reach max	0	3(2)	2(1.3)	145(96.7)	3.95±0.30	0	0	2(1.3)	21(14)	127(84.7)	4.83±0.41
Qty ordered	0	1(0.7)	3(2)	146(97.3)	3.97±0.21	0	1(0.7)	1(0.7)	21(14)	127(84.7)	4.83±0.45
Completed/verified/approved	1(0.7)	3(2)	9(6)	137(91.3)	3.88±0.43	0	1(0.7)	2(1.3)	23(15.3)	124(82.7)	4.80±0.48
Products < 6 Month shelf life	15(10)	19(12.7)	11(7.3)	105(70)	3.37±1.05	0	2(1.3)	3(2)	27(18)	118(78.7)	4.74±0.56

Proposed Additional Data Items for Inclusion; *Requested by, separate ending balance dispensery unit and store on Dagu-2*

Annex 6: Frequency of Use and Level of Agreementt on Data Items in the Model 22/H by Health Supply Chain Professionals in Health Facilities of Amhara Region, March 2022

Essential data items (N=100)	How often these data items are used in logistics recordings in your facility					Level of agreement for inclusion of these data item in the recording forms					
	Never	Sometimes	Often	Always	Mean±SD	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Mean±SD
Ser. No	1(1)	6(6)	5(5)	88(88)	3.8±0.59	1(1)	0	0	11(11)	88(88)	4.85±0.5
Receiver name…for…	0	0	2(2)	98(98)	3.98±0.14	0	0	0	7(7)	93(93)	4.93±0.26
Date	0	0	1(1)	99(99)	3.99±1	0	0	0	6(6)	94(94)	4.94±0.24
SN	6(6)	8(8)	5(5)	81(81)	3.61±0.88	2(2)	1(1)	1(1)	11(11)	85(85)	4.76±0.71
Drug code	21(21)	12(12)	7(7)	60(60)	3.1±1.25	3(3)	2(2)	4(4)	11(11)	80(80)	4.63±0.9
Description of drugs,…	0	0	2(2)	98(98)	3.98±0.14	0	0	0	6(6)	94(94)	4.94±0.24
Unit	0	1(1)	2(2)	97(97)	3.96±0.25	0	0	0	7(7)	93(93)	4.93±0.26
Quantity issued	0	0	2(2)	98(98)	3.98±0.14	0	0	0	7(7)	93(93)	4.93±0.26
Unit Cost	0	0	2(2)	98(98)	3.98±0.14	0	0	0	7(7)	93(93)	4.93±0.26
Total cost	0	0	5(5)	95(95)	3.95±0.22	0	0	0	10(10)	90(90)	4.9±0.3
Total selling price	16(16)	6(6)	2(2)	76(76)	3.38±1.15	1(1)	1(1)	3(3)	10(10)	85(85	4.77±0.65
Retail Unit	19(19)	4(4)	2(2)	75(75)	3.33±1.21	3(3)	2(2)	5(5)	12(12)	78(78)	4.6±0.91
Retail unit price	16(16)	4(4)	1(1)	79(79)	3.43±1.14	1(1)	3(3)	2(2)	11(11)	83(83)	4.72±0.74
Sum Total	12(12)	3(3)	2(2)	83(83)	3.56±1.02	0	1(1)	1(1)	9(9)	89(89)	4.86±0.45
Delivered by	0	1(1)	2(2)	97(97)	3.96±0.24	0	2(1)	0	8(8)	91(91)	4.89±0.4
Received by	0	0	3(3)	97(97)	3.97±0.17	0	0	1(1)	10(10)	89(89)	4.88±0.36

Proposed Additional Data Items for Inclusion; *Expire Date (4), Batch number (3), Dispensing Price (1), remarks (1)*

Annex 7: Frequency of Use and Level of Agreement on Data Items in the Model 19/H by Health Supply Chain Professionals in Health Facilities of Amhara Region, March 2022

Essential data items	**How often these data items are used in logistics recordings in your facility**					**Level of agreement for inclusion of these data item in the recording forms**					
	Never	**Sometimes**	**Often**	**Always**	**Mean±SD**	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**	**Mean±SD**
Ser. No	2(2)	5(5)	6(5.9)	88(87.1)	3.78±0.63	0	0	3(3)	13(12.9)	85(84.2)	4.8±0.46
Receiver name…from	0	0	4(4)	97(96)	3.96±0.2	0	0	0	13(12.9)	88(87.1)	4.87±0.34
Invoice No	2(2)	2(2)	8(7.9)	89(88.1)	3.82±0.56	0	0	4(4)	12(11.9)	85(84.2)	4.8±0.49
SN	9(8.9)	5(5)	10(9.9)	77(76.2)	3.54±0.94	0	2(2)	7(6.9)	10(9.9)	82(81.2)	4.7±0..69
Drug code	17(16.8)	11(10.9)	11(10.9)	62(61.4)	3.17±1.18	3(3)	5(5)	5(5)	12(11.9)	76(75.2)	4.5±1.01
Description of drugs,…	0	1(1)	3(3)	97(96)	3.95±0.26	0	1	2(2)	9(8.9)	89(88.1)	4.84±0.48
Unit	0	0	3(3)	98(97)	3.97±0.17	0	0	2(2)	8(7.9)	91(90.1)	4.88±03.8
Quantity received	0	0	3(3)	98(97)	3.97±0.17	0	0	2(2)	10(9.9)	89(88.1)	4.86±0.4
Unit Cost	0	2(2)	3(3)	96(95)	3.93±0.32	0	0	2(2)	9(8.9)	90(89.1)	4.87±0.39
Total cost	0	1(1)	4(4)	96(95)	3.94±0.28	0	0	3(3)	8(7.9)	90(89.1)	4.86±0.43
Batch No	6(5.9)	3(3)	8(7.9)	84(83.2)	3.68±0.8	0	4(4)	1(1)	5(5)	91(90.1)	4.8±0.64
Expiry Date	6(6)	1(1)	5(5)	88(87.1)	3.75±0.76	0	3(3)	2(2)	7(6.9)	89(88.1)	4.8±0.62
Sum Total	2(2)	0	2(2)	97(96)	3.92±0.44	1(1)	0	1(1)	11(10.9)	88(87.1)	4.83±0.53
Delivered by	0	1(1)	3(3)	97(96)	3.95±0.26	0	0	4(4)	7(6.9)	90(89.1)	4.85±0.46
Received by	0	0	4(4)	97(96)	3.96±0.2	0	0	1(1)	10(9.9)	90(89.1)	4.88±0.36
Remarks	0	11(10.9)	8(7.9)	82(81.2)	3.7±0.66	0	0	5(5)	15(14.9)	81(80.2)	4.75±0.54

Annex 8: Level of Convenience of Manual LMIS tools by Health Supply Chain Professionals in Health Facilities of Amhara Region, March 2022

Data Items	Criteria for Level of Convenience	Very Less Convenient (1)	Less Convenient (2)	Medium (3)	Convenient (4)	Very Convenient (5)	Mean±SD
Bin Card	Easy to fill data (User Friendly)	2(1.3)	8(5.3)	9(6)	25(16.7)	106(70.7)	4.5±0.93
	Included all essential data items	1(0.7)	3(2)	9(6)	47(31.3)	90(60)	4.48±0.76
	Easy to aggregate data for analysis	10(6.7)	14(9.3)	9(6)	27(18)	90(60)	4.15±0.13
	Easy for reporting	13(8.7)	12(8)	13(8.7)	22(14.7)	90(60)	4.09±1.34
	Uniformity across units/ facilities	5(3.3)	15(10)	8(5.3)	38(25.3)	84(56)	4.21±1.13
	Consistency with other records	4(2.7)	8(5.3)	13(8.7)	39(26)	86(57.3)	4.3±1.01
	Less prone to error during recording	8(5.3)	15(10)	18(12)	36(24)	73(48.7)	4.01±1.22
	It is not time consuming	19(12.7)	16(10.7)	17(11.3)	45(30)	53(35.3)	3.65±1.39
Stock Card	Easy to fill data (User Friendly)	8(11.1)	16(22.2)	4(5.6)	11(15.3)	33(45.8)	3.63±1.52
	Included all essential data items	6(8.3)	4(5.6)	5(6.9)	15(20.8)	28(58.3)	4.15±1.27
	Easy to aggregate data for analysis	13(18.1)	8(11.1)	7(9.7)	15(20.8)	29(40.3)	3.54±1.55
	Easy for reporting	15(20.8)	9(12.5)	11(15.3)	7(9.7)	30(41.7)	3.39±1.62
	Uniformity across units/ facilities	10(13.9)	12(16.7)	4(5.6)	13(18.1)	33(45.8)	3.65±1.53
	Consistency with other records	9(12.5)	8(11.1)	9(12.5)	15(20.8)	31(43.1)	3.71±1.44
	Less prone to error during recording	13(18.1)	11(15.3)	8(11.1)	13(18.1)	27(37.5)	3.42±1.55
	It is not time consuming	20(27.8)	10(13.9)	9(12.5)	13(27.8)	20(27.8)	3.04±1.61
IFRR	Easy to fill data (User Friendly)	4(2.7)	10(6.7)	14(9.3)	23(15.3)	99(66)	4.35±1.07
	Included all essential data items	1(0.7)	4(2.7)	10(6.7)	24(16)	111(74)	4.6±0.79
	Easy to aggregate data for analysis	10(6.7)	9(6)	15(10)	26(17.3)	90(60)	4.18±1.23
	Easy for reporting	14(9.3)	7(4.7)	11(7.3)	16(10.7)	102(68)	4.23±1.32
	Uniformity across units/ facilities	2(1.3)	17(11.3)	17(11.3)	22(14.7)	92(61.3)	4.23±1.12
	Consistency with other records	3(2)	10(6.7)	15(10)	33(22)	89(59.3)	4.3±1.03
	Less prone to error during recording	8(5.3)	15(10)	23(15.3)	33(22)	71(47.3)	3.96±1.23

	It is not time consuming	20(13.3)	20(13.3)	27(18)	34(22.7)	49(32.7)	3.48±1.41
RRF	Easy to fill data (User Friendly)	2(1.3)	12(8)	11(7.3)	31(20.7)	94(62.7)	4.35±1.01
	Included all essential data items	1(0.7)	5(3.3)	5(3.3)	29(19.3)	110(73.3)	4.61±0.77
	Easy to aggregate data for analysis	9(6)	14(9.3)	6(4)	28(18.7)	93(62)	4.21±1.24
	Easy for reporting	13(8.7)	8(5.3)	8(5.3)	28(18.7)	93(62)	4.2±1.28
	Uniformity across units/ facilities	1(0.7)	16(10.7)	9(6)	24(16)	100(66.7)	4.37±1.04
	Consistency with other records	3(2)	10(6.7)	13(8.7)	34(22.7)	90(60)	4.32±1.02
	Less prone to error during recording	8(5.3)	17(11.3)	22(14.7)	37(24.7)	66(44)	3.91±1.23
	It is not time consuming	21(14)	23(15.3)	28(18.7)	39(26)	39(26)	3.35±1.38
Model 19/H	Easy to fill data (User Friendly)	4(4.2)	5(5.2)	4(15.6)	15(15.6)	68(70.8)	4.44±1.07
	Included all essential data items	3(3.1)	2(2.1)	5(5.2)	13(13.5)	73(76)	4.57±0.93
	Easy to aggregate data for analysis	10(10.4)	5(5.2)	6(6.3)	8(8.3)	67(69.8)	4.22±1.37
	Easy for reporting	10(10.4)	5(5.2)	5(5.2)	12(12.5)	64(66.7)	4.2±1.36
	Uniformity across units/ facilities	1(1)	11(11.5)	6(6.3)	14(14.6)	64(66.7)	4.34±1.08
	Consistency with other records	2(2.1)	6(6.3)	9(9.4)	16(16.7)	63(65.6)	3.38±1.03
	Less prone to error during recording	6(6.3)	9(9.4)	11(11.5)	14(14.6)	56(58.3)	4.09±1.28
	It is not time consuming	14(14.6)	6(6.3)	12(12.5)	14(14.6)	50(52.1)	3.83±1.48
Model 22/H	Easy to fill data (User Friendly)	3(3.1)	6(6.1)	4(4.1)	13(13.3)	72(73.5)	4.48±1.04
	Included all essential data items	2(2)	3(3.1)	6(6.1)	11(11.2)	76(77.6)	4.59±0.9
	Easy to aggregate data for analysis	9(9.2)	6(6.1)	5(5.1)	12(12.2)	66(67.3)	4.22±1.33
	Easy for reporting	9(9.2)	6(6.1)	7(7.1)	13(13.3)	63(64.3)	4.17±1.33
	Uniformity across units/ facilities	2(2)	11(11.2)	7(7.1)	14(14.3)	64(65.3)	4.3±1.13
	Consistency with other records	1(2)	6(6.1)	9(9.2)	19(19.4)	62(63.3)	4.36±1.02
	Less prone to error during recording	6(6.1)	9(9.2)	10(10.2)	16(16.3)	57(58.2)	4.11±1.27
	It is not time consuming	13(13.3)	7(7.1)	15(15.3)	14(14.3)	49(50)	3.81±1.46

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Annex 9: Level of Convenience of Digital LMIS tools by Health Supply Chain Professionals in Health Facilities of Amhara Region, March 2022

Data Items	Criteria for Level of Convenience	Very Less Convenient (1)	Less Convenient (2)	Medium (3)	Convenient (4)	Very Convenient (5)	Mean±SD
BinCard	Easy to fill data (User Friendly)	0	0	1(1.9)	8(15.1)	44(83)	4.81±0.44
	Included all essential data items	0	0	0	16(30.2)	37(69.8)	4.7±0.46
	Easy to aggregate data for analysis	0	0	1(1.9)	6(11.3)	46(86.8)	4.85±0.41
	Easy for reporting	0	1(1.9)	0	5(9.4)	47(88.7)	4.85±0.50
	Uniformity across units/ facilities	0	1(1.9)	3(5.7)	12(22.6)	37(69.8)	4.60±0.69
	Consistency with other records	0	0	6(11.5)	8(15.4)	38(73.1)	4.61±0.69
	Less prone to error during recording	0	0	2(3.8)	12(22.6)	39(73.6)	4.70±0.54
	It is not time consuming	1(1.9)	3(5.7)	3(5.7)	9(17)	37(69.8)	4.47±0.97
	Interoperability with other e-LMIS	4(7.5)	4(7.5)	7(13.2)	11(20.8)	27(50.9)	4.00±1.29
	Integration to other e-LMIS	7(13.2)	4(7.5)	6(11.3)	9(17)	27(50.9)	3.85±1.46
Stockcard	Easy to fill data (User Friendly)	0	0	0	9(30)	21(70)	4.70±0.47
	Included all essential data items	0	0	0	10(33.3)	20(66.7)	4.70±0.48
	Easy to aggregate data for analysis	0	0	3(10)	3(10)	24(80)	4.70±0.65
	Easy for reporting	0	1(3.3)	1(3.3)	2(6.7)	26(86.7)	4.77±0.68
	Uniformity across units/ facilities	1(3.3)	2(6.7)	1(3.3)	10(33.3)	16(53.3)	4.27±1.05
	Consistency with other records	1(3.3)	0	5(16.7)	8(26.7)	16(53.3)	4.270.98±
	Less prone to error during recording	0	0	3(10)	9(30)	18(60)	4.50±0.68
	It is not time consuming	1(3.3)	1(3.3)	2(6.7)	9(30)	17(56.7)	4.33±0.99
	Interoperability with other e-LMIS	2(6.7)	3(10)	3(10)	7(23.3)	15(50)	4.00±1.29

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	Integration to other e-LMIS	5(16.1)	4(12.9)	1(3.2)	6(19.4)	15(48.4)	3.71±1.58
IFRR	Easy to fill data (User Friendly)	0	2(4.3)	1(2.1)	7(14.9)	37(78.7)	4.68±0.73
	Included all essential data items	0	0	1(2.1)	10(21.3)	36(76.6)	4.75±0.49
	Easy to aggregate data for analysis	0	0	1(2.1)	4(8.5)	42(89.4)	4.87±0.40
	Easy for reporting	0	1(2.1)	0	3(6.4)	43(91.5)	4.87±0.49
	Uniformity across units/ facilities	0	1(2.1)	2(4.3)	8(17)	36(76.6)	4.68±0.66
	Consistency with other records	0	0	4(8.5)	8(17)	35(74.5)	4.66±0.64
	Less prone to error during recording	0	0	1(2.1)	12(25.5)	34(72.3)	4.70±0.51
	It is not time consuming	1(4.3)	3(6.4)	3(6.4)	10(21.3)	29(61.7)	4.30±1.12
	Interoperability with other e-LMIS	3(6.4)	5(10.6)	5(10.6)	8(17)	26(55.3)	4.04±1.30
	Integration to other e-LMIS	5(10.6)	4(8.5)	6(12.8)	9(19.1)	23(48.9)	3.87±1.39
RRF	Easy to fill data (User Friendly)	1(1.9)	1(1.9)	1(1.9)	9(17.3)	40(76.9)	4.65±0.79
	Included all essential data items	1(1.9)	0	1(1.9)	11(21.2)	39(75)	4.67±0.71
	Easy to aggregate data for analysis	1(1.9)	0	1(1.9)	6(11.5)	44(84.6)	4.77±0.68
	Easy for reporting	1(1.9)	0	2(3.8)	4(7.7)	45(86.5)	4.77±0.70
	Uniformity across units/ facilities	1(1.9)	1(1.9)	3(5.8)	9(17.3)	38(73.1)	4.58±0.85
	Consistency with other records	1(1.9)	0	5(9.6)	10(19.2)	36(69.2)	4.54±0.83
	Less prone to error during recording	1(1.9)	0	2(3.8)	14(26.9)	35(67.3)	4.58±0.75
	It is not time consuming	2(3.8)	2(3.8)	5(9.6)	9(17.3)	34(65.4)	4.37±1.07
	Interoperability with other e-LMIS	4(7.7)	4(7.7)	4(7.7)	11(21.2)	29(55.8)	4.10±1.29
	Integration to other e-LMIS	4(7.7)	4(7.7)	4(7.7)	9(13.5)	28(53.8)	4.02±1.31
Model 19/H	Easy to fill data (User Friendly)	1(2.3)	0	2(4.7)	8(18.6)	32(74.4)	4.63±0.79
	Included all essential data items	0	0	2(4.7)	7(16.3)	34(79.1)	4.74±0.54

	Easy to aggregate data for analysis	0	1(2.3)	0	7(16.3)	35(81.4)	4.77±0.57
	Easy for reporting	0	0	1(2.3)	5(11.6)	37(86)	4.84±0.43
	Uniformity across units/ facilities	2(4.7)	1(2.3)	2(4.7)	9(20.9)	29(67.4)	4.44±1.03
	Consistency with other records	0	1(2.3)	5(11.6)	8(18.6)	29(67.4)	4.51±0.80
	Less prone to error during recording	0	0	1(2.3)	13(30.2)	29(67.4)	4.65±0.53
	It is not time consuming	3(7)	3(7)	2(4.7)	11(25.6)	24(55.8)	4.16±1.23
	Interoperability with other e-LMIS	4(9.3)	4(9.3)	8(18.6)	6(14)	21(48.8)	3.84±1.38
	Integration to other e-LMIS	5(11.6)	6(14)	6(14)	7(16.3)	19(44.2)	3.67±1.46
Model 22/H	Easy to fill data (User Friendly)	1(2.3)	0	2(4.7)	9(20.9)	31(72.1)	4.61±0.79
	Included all essential data items	0	0	2(4.7)	7(16.3)	34(79.1)	4.74±0.54
	Easy to aggregate data for analysis	0	1(2.3)	0	6(14)	36(83.7)	4.79±0.56
	Easy for reporting	0	0	0	5(11.6)	38(88.4)	4.88±0.32
	Uniformity across units/ facilities	2(4.7)	1(2.3)	3(7)	8(18.6)	29(67.4)	4.42±1.05
	Consistency with other records	0	1(2.3)	5(11.6)	8(18.6)	29(67.4)	4.51±0.80
	Less prone to error during recording	0	0	1(2.3)	13(30.2)	29(67.4)	4.65±0.53
	It is not time consuming	3(7)	3(7)	2(4.7)	10(23.3)	25(58.1)	4.20±1.24
	Interoperability with other e-LMIS	4(9.3)	4(9.3)	7(16.3)	6(14)	22(51.2)	3.88±1.38
	Integration to other e-LMIS	5(11.6)	6(14)	6(14)	7(16.3)	19(44.2)	3.67±1.46

Paper VI

Developing a Conceptual Model for the Performance of Health Commodities LMIS in Public Health Facilities of the Amhara Region, Ethiopia: A Grounded Theory-Based Qualitative Study

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Introduction: Access to essential medicines is a pressing global health issue, particularly in developing countries where ineffective supply chains impede access to lifesaving treatments (WHO, 2010; Stevens and Huys, 2017). Over one-third of the world's population lacks regular access to essential medicines, significantly impacting public health, especially in Sub-Saharan Africa (Evans and Boerma, 2009). The complexities arising from supply chain structures and inadequate Logistics Management Information Systems (LMIS) and absence of performance evaluation farmwork exacerbate these challenges (Yadav, 2015).

Objectives: This study aimed on developing a conceptual model for LMIS performance evaluation based on the grounded theory approach, specifically targeting health commodities LMIS in Ethiopia's healthcare facilities.

Methods: This study was conducted in the Amhara Region of Ethiopia, utilizing an institution-based concurrent mixed-methods design with a focus on qualitative data. The source population consisted of health professionals in leadership roles related to health commodities supply chain management across public healthcare facilities, including health facility heads, medical directors, pharmacy heads, supply chain coordinators, district supply chain coordinators, and chief executive officers. A stratified random sampling method led to the selection of 102 facilities, with 83 key informants purposefully chosen based on their relevant experience. In-depth interviews were conducted using open-ended questions, and audio recordings were made with participant consent. To ensure data quality, expert validation, training, and iterative feedback were employed throughout the data collection process. The qualitative data analyzed using grounded theory methodology, including open,

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axial, and selective coding, with findings categorized according to the coding paradigm model established by (Corbin J and Strauss A, 2015). MAXQDA (version 24.4.1) was utilized for comprehensive coding and analysis through grounded theory method (Rädiker, 2023). Ethical considerations were strictly followed, with review and approval from the Ethical Review Committee of the School of Pharmacy and the Institutional Review Board of the College of Health Sciences at Addis Ababa University. Participant confidentiality was maintained throughout the research process.

Results: A total of 1,427 coding segments, 187 first-level concepts, 64 second-level categories, and 21 high-level categories were identified through the open coding, axial coding, and selective coding processes of grounded theory. Then, the conceptual crafted using coding paradigm approach of the grounded theory, pinpoints critical factors that influence the performance of the health commodities LMIS and its impact on the efficiency of the health commodities supply chain. It emphasizes causal factors such as budget constraints, data quality issues, workforce training deficiencies, and LMIS implementation challenges that lead to system inefficiencies. Additionally, it highlights contextual factors, including government commitment, infrastructure, public health emergencies, and security concerns, that shape system performance. To mitigate these challenges, the model recommends strategies such as digital innovation, LMIS integration, workforce development, and enhanced implementation support. Importantly, the model illustrates that a well-functioning LMIS improves healthcare delivery by providing real-time, reliable, and high-quality data for informed decision-making.

Conclusion and Recommendations: This conceptual model is highly recommended as a framework for assessing LMIS performance in Ethiopian healthcare facilities, with a cautious piloting phase before full-scale implementation. Furthermore, a quantitative study is proposed to validate the model by assessing the impact of each factor and paradigm dimension on LMIS performance, which would then inform the development of measurable key performance indicators (KPI) for routine monitoring and evaluation of LMIS in healthcare facilities.

Key Words: Conceptual Model, LMIS Performance, Health Facilities, Grounded Theory, Coding Paradigm

1. Introduction

Access to essential medicines is critical for any nation's healthcare system, providing vital medical products, vaccines, and technologies necessary for public health (WHO, 2010; Khlie and Abouabdellah, 2016; Global Fund, 2019). However, the effectiveness of these systems hinges on the availability of timely and accurate health data essential for informed decision-making (WHO, 2010). Many low-and middle-income countries (LMICs) struggle with incomplete, untimely, and inaccurate data from health facilities, undermining the effectiveness of health information systems (Chaulagai *et al.*, 2005; Rowe, 2009). A well-functioning LMIS is vital for managing health commodities efficiently, aiding in forecasting, procurement, and distribution, thus enhancing health outcomes (Choudrie *et al.*, 2017).

The Ethiopian government has launched several Health Sector Transformations to enhance healthcare services across the country. However, persistent challenges related to the health commodities LMIS hinder access to essential medicines (Roadmap, 2016; FMOH, 2021, 2024b). The major challenges include inadequate data quality, poor infrastructure, staff shortages, lack of training, and limited system integration (Fenta, 2017; Alemu *et al.*, 2021; Shama *et al.*, 2021).

Tackling these systemic challenges is essential for improving healthcare delivery in Ethiopia and similar LMICs. Furthermore, to enhance LMIS performance, it is crucial to develop and implement a structured evaluation framework. Grounded Theory (GT), developed by Glaser and Strauss, offers a systematic and iterative approach to developing theories through qualitative data collection and analysis. Studies demonstrate that in-depth analyses of qualitative information using GT is invaluable in developing formal theories and conceptual models that can inform practice and improve health systems (Glaser, B. G., Strauss, 1967; Qureshi and Ünlü, 2020). The model is intended to serve as a forward-looking framework for evaluating and improving LMIS performance, and integrate effective data management practices that improve supply chain efficiency and ultimately increase access to essential medicines and overall healthcare delivery (PATH, 2010; Hailu, Ahmed and Yimer, 2020).

2. Objectives

This study focuses on developing a conceptual model for LMIS performance in public health facilities of Amhara region, Ethiopia

3. Methods

3.1. Study Area

The study was conducted in Amhara National Regional State of Ethiopia, the country's second-most populous region. The region is administratively classified into 12 Zones and three city administrations. Four EPSS hubs supply health commodities for public health facilities in the region.

3.2. Study Design

An institution-based concurrent mixed study design employed a combination of quantitative and qualitative approaches used for the data collection. This study is part of the main project focusing on performance evaluation of health commodities LMIS and the findings in this article are based only on the qualitative data.

3.3. Theoretical Foundation

In qualitative data analysis, the core objective is to identify key categories, concepts, and dimensions, as well as to uncover relationships among these elements. The Grounded Theory Method (GTM), originally developed in sociology during the 1960s by Glaser and Strauss (1967), has since been widely adopted across diverse disciplines, including information systems (IS) (Glaser, B. G., Strauss, 1967; Birks *et al.*, 2013; Urquhart and Fernández, 2016). Its primary aim is to derive theory inductively from data rather than applying pre-existing frameworks. This methodology enables the discovery and articulation of core concepts, providing theoretical insights that extend beyond current knowledge. The strength of the Grounded Theory Method (GTM) lies in its empirical relevance, methodological rigor, and ability to generate grounded, substantive theories. GTM is particularly well-suited for contexts where theoretical foundations are limited or incomplete, making it ideal for emerging domains and concepts. In the context of LMIS performance evaluation, where the underlying constructs and relationships are not fully understood, GTM offers a structured yet exploratory approach for conceptual model development. The literature reveals the absence of a comprehensive framework for evaluating LMIS performance and identifying its influencing variables, highlighting the need for further investigation (USAID Deliver Project, 2011; FMOH, 2019). Accordingly, this research adopts GTM to develop a mid-range conceptual model that explains the factors and interdependencies influencing LMIS performance.

3.4.Source and Study Population

The source population included health professionals employed in public healthcare facilities across the Amhara region. The study population was purposefully selected to include individuals in leadership roles within health commodity supply chain management, such as health facility heads, medical directors, chief executive officers, pharmacy heads, and supply chain management coordinators from woreda (district) health offices. This focus aimed to gather insights into the challenges and best practices affecting the supply chain's effectiveness, particularly regarding the performance of the Logistics Management Information System. Understanding their insights, perceptions, and experiences is vital for developing a conceptual model to enhance LMIS performance.

3.5.Sampling Procedure

Health centers and hospitals in all Zonal administrations, except those with security problems, were considered for sampling. Accordingly, six zonal and two city administrations were selected and further stratified into three clusters based on the EPSS hubs' location. Fifteen percent of the facilities were included in the study per the recommendation of USAID's Logistics Indicators Assessment Tool (LIAT) (USIAD Deliver Project, 2008). Sample sizes for each zone and district were allocated proportionately to their size. In total, 102 facilities were included in the study, comprising five referral hospitals, four general hospitals, ten primary hospitals, and 83 health centers. The facilities were selected using a multi-stage stratified random sampling method, also proportionate to their size. Subsequently, medical directors, chief executive officers, heads of health centers, pharmacy heads, and health supply chain coordinators from the woreda health office were purposively chosen from the selected facilities, taking into account their relevant experience with the performance of the LMIS system within their respective institutions.

3.6.Inclusion and Exclusion Criteria

Inclusion Criteria

- All Zonal Administrations
- All public health facilities that have been functional for more than one year

- All health facility heads, medical directors, chief executive officers, pharmacy heads, and supply chain management coordinators from woreda health offices.

Exclusion Criteria

- Health facilities were damaged in conflict-affected areas or had security problems during the study.
- Health Posts
- Non accessible participants and those having < 6 months of experience at the time of the survey

3.7. Data collection process

Open-ended guiding questions were utilized in in-depth interviews with key informants, as interviews serve as an effective tool for theoretical sampling in grounded theory, facilitating the generation of highly conceptualized data (Foley *et al.*, 2021). Additionally, probing questions were included to further explore specific issues related to the performance of LMIS. The guiding questions began with a broad inquiry into the performance of supply chain management, subsequently narrowing down to examine the performance of the Logistics Management Information System, including its strengths, weaknesses, challenges, and insights for potential improvements. The data was audio recorded based on the participants' consent.

3.8. Data quality assurance

Ten experts in the area validated data collection tools, and training was provided for data collectors for two days. The data collection tools were pre-tested, and necessary amendments were made. During the first two days of data collection, the data collection coordinators carefully reviewed the audio recordings of the interviews. They provided constructive feedback to the interviewers, focusing on their question-asking techniques and how effectively they probed for additional issues or clarified responses. This feedback aimed to improve the consistency and depth of the data gathered throughout the study.

3.9. Reflexivity

The principal investigator of this study is a pharmacist by profession and having experience at both the federal and facility levels of the healthcare system. The additional interviewers were all pharmacists with significant experience within the health system. They hold at least a master's qualification in health supply chain management or related fields, and possess in-depth knowledge of health supply chain systems and the challenges related to the implementation of LMIS in healthcare facilities. Given the nature of qualitative research, the interviewers were aware of their positionality and potential biases in the interview. The interviewers took steps to actively engage in self-reflection and critically examine their personal experiences, assumptions, and professional backgrounds, which could influence the interview process. This reflexive approach was aimed at minimizing the impact of any unconscious bias and ensuring that the responses of the key informants were not unintentionally shaped by the interviewers' views. Before data collection, the interviewers discussed and clarified their roles in the research process to establish a shared understanding and ensure transparency. These discussions allowed the team to be mindful of their influence on the interview process and the interpretation of responses. The transcription, coding and analysis was done by the principal investigator. In recognition of the reflexive process, the principal investigator strived to approach the data with openness, ensuring that the findings were grounded in the lived experiences of the key informants rather than shaped by his personal preconceptions and experiences.

3.10. Data Analysis and Interpretation

The qualitative data were carefully reviewed, and the audio recordings of the interviews were systematically coded. Following this, the recordings were transcribed into English to ensure accuracy and consistency. The resulting transcripts were then imported into MAXQDA (version 24.4.1), a tool for computer-assisted qualitative and mixed methods data analysis software for comprehensive coding and analysis (Rädiker, 2023).

The coding and analysis of the transcripts adhered to the grounded theory analysis framework. The first step in this grounded theory analysis was open coding, where relevant segments were identified and coded. The transcripts were reviewed line by line to highlight important segments related to LMIS performance. In this step, there is a need of continuous interplay between analysis and data collection until the saturation of ideas. In this study, data was collected at a single time point, with no back-and-forth data collection. To ensure theoretical saturation, the sample size was maximized and the coding process was closely monitored for the emergence of new concepts. In line with the 'all is data' principle of grounded theory, any information encountered by the researcher during the study was treated as potentially relevant data. In this study, 83 participants were interviewed, aligning with

Creswell's (2007) recommendation of 20-30 individuals for a primary interview and Khan's (2014) guideline of 20-60 participants (Creswell, 2007; Khan, 2014). However, theoretical saturation was reached after analysing transcripts from 50 participants, as no new insights emerged beyond that point. Nevertheless, the larger sample size contributed significantly to the identification of key concepts that were consistently emphasized and articulated from multiple perspectives. In contexts where iterative interviews are not feasible, obtaining rich and comprehensive data in a single interaction becomes essential to capturing the depth and diversity of participant experiences (Birks and Mills, 2011; Corbin and Strauss, 2015).

The second step, axial coding, was used to explore similarities and differences among the generated codes. During this step, coded segments were continuously compared to shift from mere description to analytical and conceptual thinking. This process aimed to identify consistencies and differences, allowing for the refinement of concepts and the development of theoretically relevant categories, which were then organized into higher-order categories (Tie, Birks and Francis, 2019).

Finally, selective coding was applied to systematically relate these high-level categories to one another and to further refine existing categories, ultimately leading to the development of the conceptual model (Corbin and Strauss, 2012; Rädiker, 2023). The identified concepts presented in a data structure indicating different level of categories which helps for better visualization adapted from Goia and his colleagues (Gioia, Corley and Hamilton, 2013). The data structure provides a visual representation of how raw data is transformed into themes, enhancing transparency and demonstrating analytical rigor in qualitative research (Figure 1).

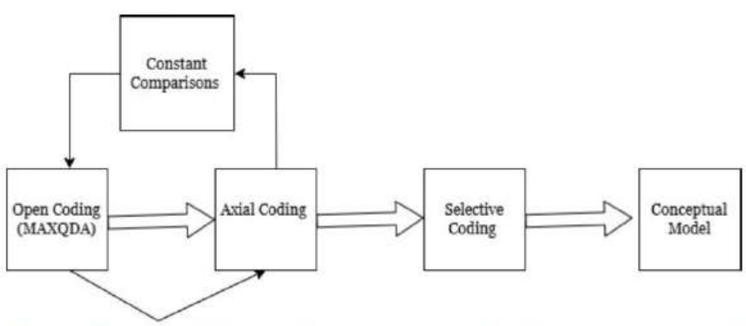

Figure 1: Illustration of the grounded theory process to develop the conceptual model.

Strauss and Corbin (1990) introduce the "coding paradigm" as a fundamental framework in grounded theory to analyse relationships between categories and concepts. This coding paradigm structures theory development by examining key elements; *causal conditions, context, intervening conditions, action/interaction strategies,* and *consequences* in which all interacting with the *central category or phenomenon.* It helps establish connections between categories and subcategories developed during open coding, enhancing depth and precision in grounded theory by systematically linking concepts on a meta level (Corbin J and Strauss A, 2015; Vollstedt and Rezat, 2019) (Figure 2)

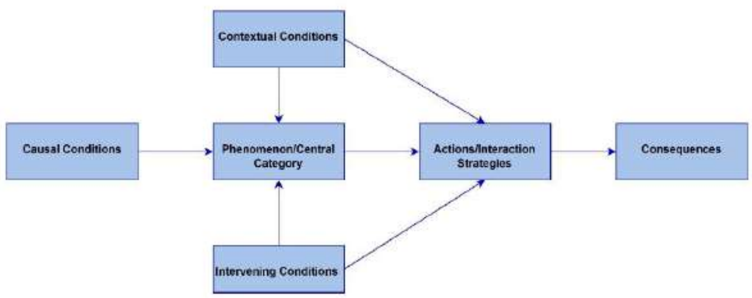

Figure 2: Coding paradigm for Grounded Theory Method, adopted from (Corbin J and Strauss A, 2015)

3.11. Ethical Consideration

The proposal was reviewed and approved by the Ethical Review Committee of the school of Pharmacy and the Institutional Review Board of the college of health sciences of Addis Ababa University. The purpose of the study was clearly explained to all key informants, and verbal informed consent was obtained after they comprehended the information. The interview was audio-recorded with the participant's permission. There were no individual identifiers included in the data collection to protect the privacy of the participants, and the data was analysed in aggregate.

4. Results

4.1. Participants' Information

In this qualitative exploration, a total of 83 participants were interviewed. The study participants enrolled from four zones of Amhara Region: Central Gondar (25.30%), East Gojjam (21.69%), North Shewa (18.07%), and West Gojjam (34.94%). Most participants (80.72%) were working in Health Centers, while others were from Primary Hospitals (10.84%) and Woreda Health Offices (8.43%). The average age of the participants was 31.35 years, ranging from 25 to 39 years, with the vast majority being male (96.39%).

In terms of profession, Health Officers made up the largest group (43.37%), followed by Nurses (25.30%), Pharmacists (20.48%), Midwives (6.02%), and Medical Doctors (4.82%). Regarding educational background, most participants (80.72%) held a Bachelor's degree, with smaller proportions having Diplomas (10.84%), MSc degrees (7.23%), and Medical Speciality (1.20%). The majority (69.88%) held Health Center Head positions, while others served as Pharmacy Head (10.84%), Woreda Supply Chain Management Coordinator (9.64%), Chief Executive Officer (7.23%) and Medical Director (2.41%). On average, participants had 7.87 years of experience in their field, ranging from 3 to 15 years. They had an average of 2.61 years of experience in their current position, with a range from 0.5 to 9 years (Table 1).

Variables (N=83)	Categories	N	Percentage
Zone	Central Gondar	21	25.3
	East Gojjam	18	21.69
	North Shewa	15	18.07
	West Gojjam	29	34.94
	Total	**83**	**100**
Level	Health Center	67	80.72
	Primary Hospital	9	10.84
	Woreda Health Office	7	8.43
	Total	**83**	**100**
Age	Mean ±SD (Min, Max)*	31.35±2.95 [25, 39]	
Sex	M	80	96.39
	F	3	3.61

	Total	**83**	**100**
Profession	Health Officer	36	43.37
	Nurse	21	25.3
	Pharmacy	17	20.48
	Midwifery	5	6.02
	Medical Doctor	4	4.82
	Total	**83**	**100**
Highest Qualification	Bachelor Degree	67	80.72
	Diploma	9	10.84
	Masters	6	7.23
	Medical Speciality	1	1.20
	Total	**83**	**100**
Current Position	Health Center Head	58	69.88
	Pharmacy Head	9	10.84
	WOHO SCM coordinator**	8	9.64
	Chief Executive Officer	6	7.23
	Medical Director	2	2.41
	Total	**83**	**100**
Total Professional Experience (Mean ±SD (Min, Max)		7.87+±293 [3,15]	
Experience at Current Position (Mean ±SD (Min, Max)		2.61±1.77 [0.5,9]	

*SD-Standard Deviation **WOHO SCM-Woreda Health Office supply chain management

4.2. Health Commodities Supply Chain Performance

The performance of the health commodities supply chain (HCSC) in public health facilities of the Amhara Region is shaped by a complex interplay of systemic, contextual, and operational factors. A grounded theory analysis, conducted using MAXQDA and structured within the Corbin and Strauss (2015) paradigm framework, identified various codes, subcodes, and segments that elucidate these interrelations (Annex 1). The resulting coding model visually maps these interconnected factors, highlighting their collective impact on health commodities access, wastage reduction, and overall health service delivery outcomes (Figure 3).

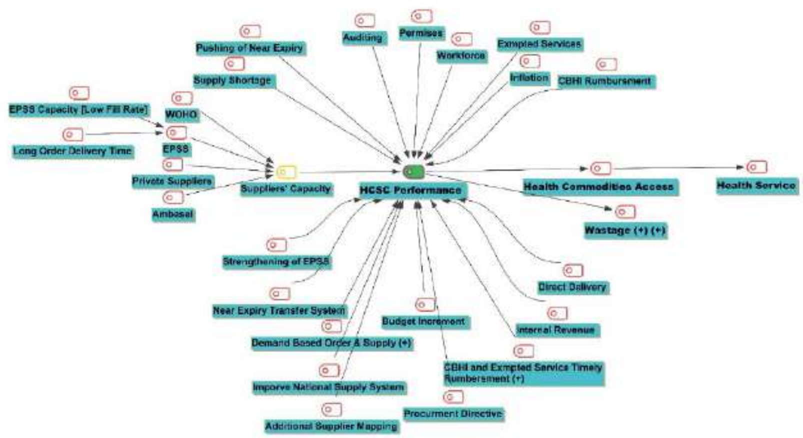

Figure 3: Code, Subcode and segments model for health commodities supply chain performance using MAXQDA (MAXMAP) based on grounded theory method

The conceptual model developed for health commodities supply chain performance highlights the central phenomenon of systemic challenges. These challenges stem from interconnected causal, contextual, and intervening conditions, necessitating strategic actions to drive meaningful improvements and enhance healthcare delivery (Figure 4).

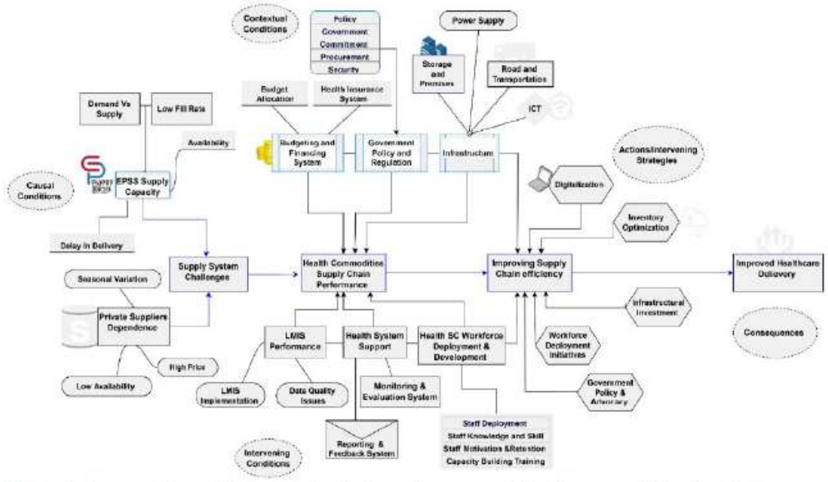

Figure 4: Conceptual model for supply chain performance of health commodities based on grounded theory method

Causal Conditions: The limited supply capacity of EPSS is primarily attributed to persistent low fill rates (10–50%), delayed deliveries, the distribution of near-expiry stock, and misalignment between supply and actual demand. These issues have led to frequent stockouts of essential and program medicines, compelling reliance on private suppliers who often charge higher prices and provide inconsistent availability due to capacity constraints and seasonal fluctuations. Compounding these challenges are inefficiencies in the LMIS, characterized by inaccurate reporting, manual data entry, and poor data visibility, which hinder effective inventory management, timely decision-making, and accurate demand forecasting.

Contextual Conditions: Several contextual factors exacerbate supply system challenges. Structural issues such as limited budget allocations, complex and bureaucratic procurement policies, and weak governmental commitment to reform impede progress. The Community-Based Health Insurance (CBHI) scheme, while increasing healthcare access, has introduced additional demand without corresponding improvements in timely financial reimbursements. National macroeconomic factors like inflation elevate medicine costs, while infrastructural deficits including inadequate storage facilities, poor road access, inconsistent power supply, and limited ICT capacity further challenge the system. Security threats, including conflict and large numbers of internally displaced persons (IDPs), directly disrupt distribution networks and medicine access.

Intervening Conditions: The success of supply chain interventions is influenced by intervening conditions such as the performance of the LMIS, which suffers from data quality issues and a lack of full digital integration. Fragmented or delayed reporting, coupled with weak monitoring and feedback systems, hampers real-time decision-making. Human resource constraints including workforce shortages, high turnover, resistance to new technologies, and insufficient training limit the system's adaptive capacity. Additionally, the absence of institutionalized policy advocacy and cross-sector coordination creates barriers to implementing sustainable improvements.

Action/Intervention Strategies: To address these interconnected challenges, the model proposes several strategies. Digitalization is critical for enhancing LMIS performance, enabling better data visibility, demand forecasting, and inventory control. Inventory optimization strategies aim to align supply with actual needs, reducing stockouts and wastage. Infrastructural investments including upgrades to storage, transport, and ICT systems are essential for boosting supply chain resilience. Workforce-focused interventions, such as continuous capacity-building programs, strategic staff deployment, and retention mechanisms, are recommended to strengthen the health supply chain at critical points. Furthermore, policy advocacy and reform particularly concerning procurement, budget utilization, and public-private partnerships are necessary to create an enabling environment for long-term success.

Consequences: If effectively implemented within favorable contextual and intervening conditions, these strategies are expected to yield a more resilient and efficient supply chain, ensuring the timely, reliable, and equitable availability of essential health commodities. Improved supply chain performance will directly enhance healthcare service delivery, reduce resource wastage, and increase operational efficiency. This, in turn, will contribute to greater staff satisfaction and professional engagement, creating a reinforcing cycle of performance improvement. Ultimately, the model underscores that achieving sustainable improvements in the health commodities supply chain requires integrated reforms across digital systems, infrastructure, policy, financing, and human resources, all aimed at supporting better public health outcomes in the health system.

4.3.Health Commodities' LMIS Performance

A grounded theory analysis, conducted using MAXQDA and structured within the Corbin and Strauss (2015) paradigm framework, identified various codes, subcodes, and segments that reveal the relationships between these factors (Annex 2). The resulting coding model visually maps these interconnections, emphasizing their collective impact on LMIS performance, including health commodity access, wastage reduction, and overall health service delivery outcomes (Figure 5).

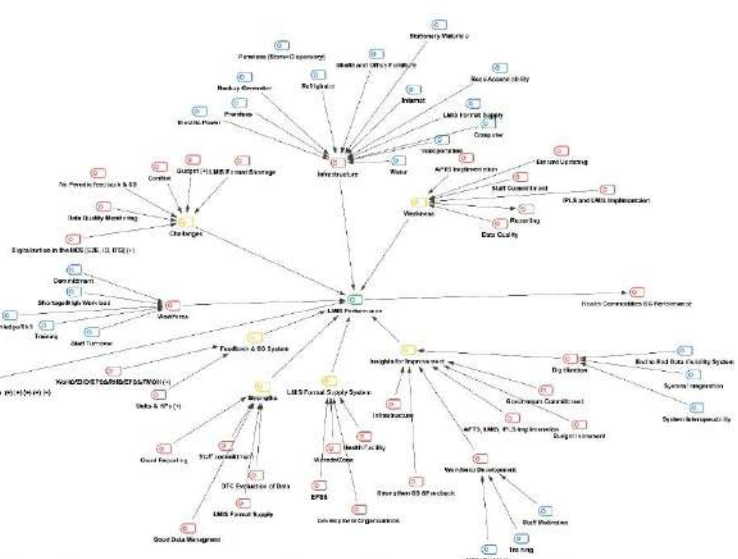

Figure 5: Code, Subcode and segments model for health commodities LMIS performance using MAXQDA (MAXMAP) based on grounded theory method

The code cloud highlights key factors influencing Health Commodities LMIS performance, based on grounded theory analysis. Central challenges include supply shortages, delivery delays, high costs, poor data quality, and heavy workloads, compounded by infrastructure issues like unreliable power and limited road and internet access. Improvement areas involve workforce development, better supervision and feedback, stronger data systems, integration, and timely CBHI reimbursements. Strengths include effective reporting, system visibility, EPSS support, and government commitment. Strategic priorities focus on increased funding, digitization, private sector involvement, and inventory optimization. Overall, enhancing LMIS performance requires robust supply systems, infrastructure upgrades, skilled personnel, and digital tools (Figure 6).

Figure 6: Code Cloud of Health Commodities LMIS Performance using MAXQDA MAXMAP) based on grounded theory method

4.4. Conceptual Model for Health Commodities' LMIS

The conceptual model developed through grounded theory analysis, using the coding paradigm framework of Corbin and Strauss (2015), reveals key insights into the implementation and performance of the LMIS. The model developed through this framework positions LMIS performance as the central phenomenon, revealing a complex interplay of causal, contextual, and intervening factors that influence it, and proposes strategies for improvement and the achievement of desired outcomes (Figure 7)

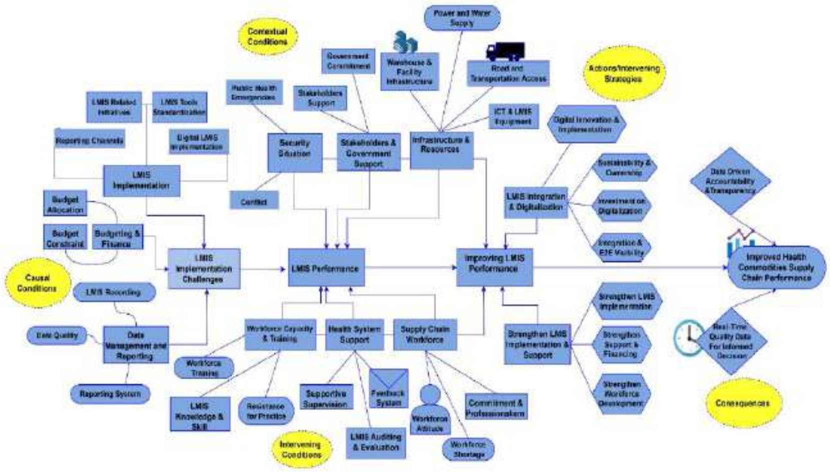

Figure 7: Conceptual model for LMIS performance of health commodities based on grounded theory method

Causal Conditions: The conceptual model developed in this study elucidates the multifaceted challenges that undermine the performance of LMIS, which stem from a complex interplay of systemic inadequacies. Central among these are suboptimal data recording practices and the disjointed use of both manual and digital systems, which collectively compromise the accuracy, completeness, and timeliness of supply chain data. The lack of standardized LMIS tools and the inconsistent implementation of reporting formats such as the RRF, HPMMR), and IFRR further contribute to data fragmentation and reporting inefficiencies. These technical deficits are exacerbated by weak data governance structures and underdeveloped data management frameworks. Moreover, significant human resource constraints persist, characterized by limited capacity and insufficient training in both general supply chain management and LMIS-specific competencies. Financial limitations, particularly inadequate budgetary allocations for the procurement of LMIS tools, workforce development, and digital infrastructure, further impede LMIS functionality. The fragmented implementation of critical interventions including APTS, DTC and integrated digital platforms reflects a broader lack of coherence in LMIS performance. Collectively, these interrelated challenges create a structural fragility that severely limits the LMIS's ability to generate reliable and actionable data to support effective health supply chain management.

Contextual Conditions: The model emphasizes that the performance of Logistics Management Information Systems (LMIS) is influenced by a variety of contextual factors. Infrastructural challenges, such as unreliable power supply, limited information and communication technology (ICT) capacity, inadequate transportation networks, and insufficient storage facilities, significantly impede the efficiency of LMIS. Geographic inaccessibility and the seasonal unavailability of roads further intensify these logistical difficulties, especially in remote areas. In addition, broader security issues, including armed conflict and public health emergencies such as epidemics and population displacement, disrupt routine operations and divert essential resources. The level of government commitment and the extent of stakeholder engagement are also critical in determining the prioritization, funding, and long-term sustainability of LMIS initiatives. While support from development partners contributes to system improvements, its inconsistency poses challenges to maintaining steady progress.

Intervening Conditions: Several mediating factors influence how causal and contextual challenges affect the outcomes of Logistics Management Information Systems (LMIS). Workforce capacity, including the availability, competence, and retention of LMIS-trained personnel, has a direct impact on system functionality. Ongoing knowledge gaps and resistance to adopting new technologies hinder effective system use. Institutional support often stemming from deeply rooted organizational cultures, limits the adoption of digital tools. Inadequate supervision and the lack of regular performance feedback reduce opportunities for continuous improvement and accountability. On the other hand, supportive measures such as structured capacity-building programs, professional development initiatives, and regular LMIS audits help improve adaptability, enhance data quality, and strengthen overall system resilience.

Action/Interaction Strategies: To address these multifaceted challenges, a series of strategic interventions has been highlighted by the model. A primary focus is the digitization and integration of LMIS platforms (e.g., Dagu-2), which aim to standardize data collection and reporting while providing real-time visibility into inventory levels. Investments in digital infrastructure, including internet connectivity, hardware provision, and ICT training, are essential for effectively operationalizing these systems. The model also emphasizes the importance of strengthening institutional support through increased budget allocations, robust supervision frameworks, and enhanced stakeholder coordination. Workforce development strategies, including ongoing in-service training and professional mentorship, are essential for bridging skills gaps and fostering a sense of ownership over LMIS processes. Additionally, the model stresses the significance of embedding a culture of performance monitoring through routine evaluations and feedback mechanisms, which are crucial for sustaining reforms and institutionalizing best practices.

Consequences: If these strategic interventions are effectively implemented within supportive contextual and intervening conditions, significant improvements in LMIS performance can be expected. These improvements include enhanced data quality, increased transparency, and better accountability throughout all levels of the health supply chain. Real-time, accurate data will enable evidence-based decision-making, optimize resource allocation, and strengthen service delivery. Ultimately, these outcomes are expected to improve the availability and accessibility of essential health commodities, thereby contributing to improved public health outcomes and greater system resilience.

5. Discussion

This study presents a comprehensive exploration of the multifaceted challenges and strategic pathways influencing the performance of the health commodities supply chain and its embedded LMIS within the Ethiopian context, particularly in the Amhara Region. The grounded theory approach, supported by MAXQDA analysis and framed within Corbin and Strauss's coding paradigm (2015), revealed interconnected systemic, contextual, and operational factors that collectively hinder or facilitate effective health commodities' LMIS performance. The findings underscore systemic challenges as the central phenomenon affecting supply chain performance, aligning with global insights that health supply chains are inherently complex and vulnerable to fragmentation, inefficiencies, and resource constraints (WHO, 2010; USAID, 2011; Khlie and Abouabdellah, 2016).

In Ethiopia, these systemic issues are exacerbated by low EPSS supply capacities, frequent stockouts, and demand-supply misalignments, which are compounded by inefficiencies in LMIS such as inaccurate reporting, manual data entry, and poor data visibility. These challenges resonate with broader observations in low-income countries where weak integration and unreliable data systems undermine supply chain resilience (Annan and Amagon, 2013; Yadav, 2015).

Contextual factors, including limited budget allocations, bureaucratic procurement processes, infrastructural deficits, and security threats, further deepen these systemic problems. Similar structural issues have been documented across LMICs, where inadequate infrastructure and governance hinder the deployment of digital solutions and effective supply chain management (WHO, 2017; Chemonics International, 2021). Notably, the rising demand from initiatives such as Community-Based Health Insurance (CBHI), without adequate and timely financial reimbursements, places additional strain on the health system. This underscores the urgent need for integrated policy reforms and sustainable resource mobilization (Ozawa *et al.*, 2019).

The study highlights several intervening factors such as underperforming LMIS performance, shortages in skilled human resources, resistance to digital transformation, and fragmented reporting systems that collectively undermine the effectiveness of supply chain interventions. These insights are consistent with existing research, which emphasizes the importance of capacity building, digitalization, and strong institutional support in reinforcing health system performance (PATH, 2010; Alemu *et al.*, 2021).

The model's strategic recommendations including LMIS digitalization, infrastructure development, workforce capacity building, and policy reform align with global best practices that promote integrated, technology-driven supply chains as a means to enhance health system performance and improve health outcomes (García-Alcaraz *et al.*, 2017; WHO, 2017; Gilbert *et al.*, 2020). Effective implementation of these strategies can lead to improved data visibility, reduced wastage, fewer stockouts, and enhanced service delivery—outcomes that are essential for advancing Universal Health Coverage (UHC) and achieving the Sustainable Development Goals (SDGs) (WHO, 2017; Lugada *et al.*, 2022).

The findings reinforce the notion that health supply chain resilience depends on a holistic approach that addresses infrastructural, human, and governance factors simultaneously. In the realm of LMIS performance, the analysis reveals that poor data quality, infrastructure deficits, and limited digital literacy significantly impair system functionality. These issues are well-documented across LMICs, where manual and semi-automated systems often coexist with digital platforms, leading to fragmentation and data inconsistencies (USAID Deliver, 2011; Taddesse, 2015; Alemu *et al.*, 2021). The importance of digitization is emphasized by successful examples in Namibia and Tanzania, where integrated eLMIS platforms have improved stock management and reduced stock-outs (Mabirizi *et al.*, 2018; Gilbert *et al.*, 2020). However, Ethiopia's ongoing efforts to implement and integrate digital LMIS tools face persistent challenges related to infrastructure, user capacity, and interoperability, underscoring the need for a phased, context-sensitive digital transformation strategy (USAID | DELIVER PROJECT, 2012; FMOH, 2016, 2024a).

The proposed conceptual models highlight that LMIS performance and supply chain efficiency are contingent upon addressing systemic deficits through strategic interventions digitization, capacity building, infrastructure development, and policy reforms. These models resonate with the WHO's health system framework, which advocates for strengthening health information systems as a core component of resilient health systems (WHO, 2010; MEASURE Evaluation, 2018b). Moreover, the emphasis on integrating LMIS within broader health information ecosystems aligns with global calls for interoperability, data quality, and governance to support evidence-based decision-making (Abouzahr and Boerma, 2005; Richardson, 2006).

The evaluation of LMIS performance remains a critical gap identified in this study, echoing broader concerns about the lack of standardized assessment frameworks in LMIC settings (WHO, 2008; Greenwell and Salentine, 2018). Developing robust, context-specific evaluation tools will be essential for benchmarking progress, guiding improvements, and ensuring sustainability. Such frameworks should incorporate key performance indicators including data quality, system availability, user satisfaction, and data use practices, as recommended by global standards (USAID Deliver Project, 2008; MEASURE Evaluation, 2018a)

6. Conclusion and Recommendation

The conceptual model, developed through the grounded theory coding paradigm approach, identifies key factors that influence the performance of the health commodities Logistics Management Information System (LMIS) and its impact on the efficiency of the health supply chain. It highlights both causal factors such as budget limitations, poor data quality, inadequate workforce training, and challenges in LMIS implementation, as well as contextual elements including government commitment, infrastructure constraints, public health emergencies, and security issues. These interrelated challenges contribute to inefficiencies within the LMIS, which subsequently affect the overall performance of the healthcare supply chain.

To address these barriers, the model recommends strategic interventions such as adopting digital innovations, integrating LMIS platforms, strengthening workforce capacity, and providing enhanced implementation support. Therefore, the model serves as a valuable framework for assessing LMIS performance in Ethiopian healthcare facilities.

In conclusion, improving the functionality of LMIS and the performance of the health commodity supply chain in healthcare facilities requires a holistic and integrated approach. This includes combining technological advancements, infrastructure development, human resource strengthening, and policy reforms. Strong governance, sustained funding, and active stakeholder engagement are critical to achieving long-term success. Future research should focus on validating the proposed model, developing standardized tools to assess LMIS performance, and exploring context-appropriate digital solutions that can enhance system responsiveness and service delivery outcomes.

Authors' Contribution

ZTM, TGF, and DJC conceived the idea and study design. ZTM developed the proposal and conducted the data collection. TGF and DJC supervised the quality of the data collection. TGF and DJC edited the manuscript finally. All authors read and approved the final manuscript.

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Institutional Review Board Statement: This study was approved by the Ethical Review

Committee of the School of Pharmacy (Protocol No: ERB/SOP/399/14/2022) and the Institutional Review Board of College of Health Sciences, Addis Ababa University (Protocol number: 007/22/SoP).

Informed Consent Statement: Informed consent was obtained from all participants and institutions involved in the study.

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Conflicts of Interests

All authors declared that there are no competing interests.

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Annex 1: Coding Paradigm for health commodities supply chain performance in public health facilities of Amhara Region, March 2022 (Based on Corbin and Strauss, 2015).

1ST Level Concepts	2nd Level Categories	High Level Categories	Paradigm model Dimensions
Low supply fill rate from EPSS (10-50%)	EPSS supply Capacity	Supply System Challenges	Causal Conditions
Delayed delivery			
Pushing of near expiry items			
Frequent stockouts of essential and program medicines in EPSS			
Inconsistent supply versus demand			
Poor availability of essential items	Private Supplier Dependence		
Reliance on private suppliers			
Higher costs from private suppliers			
Capacity of private suppliers			
Seasonal fluctuations in availability in private supplier			
Limited budget for procurement	Budget allocation	Medicnes budgeting and financing system	Contextual Conditions
CBHI leading to increased demand for essential medicines	Health Insurance System		
Timely CBHI reimbursement			
Exempted services reimbursement system			
Challenges in meeting the medication needs of a growing population			
Continuous inflation of medicines price	Macroeconomic issues	Government Policy and Regulation	Contextual Conditions
Government policies to support and strengthen the supply chain	Government policy		
Bureaucratic procurement processes hindering timely supply of medicines	Procurement law		
Political or bureaucratic barriers for budget allocation	Government commitment		
Lack of coordination between different levels of health authorities	Coordination		
Conflict and high number of IDPs	Security		
Absence of standardized infrastructures (storage, facilities)	Storage and Premises	Infrastructure	Contextual Conditions
Insufficient space for dispensing of medicines			
Poor organization of storage areas			
Equipment shortages (computers, refrigerator, internet)	Equipment		

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Challenges with electric power supply system	Power supply		
Challenges with transportation and road access	Road and transportation		
The impact of terrain and seasonal conditions			
Completeness and accuracy of reports (e.g., RRF, IFRR, HPMMR)	Data quality issues	LMIS Performance	Intervening Conditions
Inconsistency in data recording from different health facility units			
Issues with accurately forecasting demand			
Inaccurate reports			
Availability and usability of LMIS formats	LMIS implementation		
Manual versus digital LMIS tools integration			
Lack of digitalization leading to inefficiencies			
Inconsistencies in timely reporting	Reporting and feedback system	Health System support	Intervening Conditions
Feedback issues between different levels of the health system			
Periodic assessments and written feedback systems to ensure accountability			
Monitoring and evaluation of the supply chain	Monitoring and Evaluation		
Regular discussions and evaluations among stakeholders			
Regular discussions within DTC			
Health SC workforce shortage	Staff deployment	Heath SC Workforce deployment and development	Intervening Conditions
Staff Knowledge and skill gaps	Knowledge and skill gaps		
Resistance to adopting new systems			
Commitment and engagement of health SC professionals	Staff motivation and retention		
Hight staff turnover rate			
Inadequate motivation and retention strategies			
Need for continuous training and capacity building	Capacity building training		
Limited training opportunities			
Enhancing Data Management of the supply chain system	Digitalization	Improving Supply Chain efficiency	Actions/Intervening Strategies
Minimize stockouts and Reduce Wastage	Implementing inventory optimization		
Implement continuous training programs for staff	Workforce Development		

Implementing staff retention strategies	Initiatives		
Upgrading storage facilities	Infrastructural Investments		
Improving transportation logistics			
Increase budget allocation and utilization	Government policy and Advocacy		
Strengthen public-private partnerships with suppliers			
Increased availability of essential medicines leading to better patient outcomes	Resilient supply chain	Improved Healthcare Delivery	Consequence
Establishment of resilient supply chain system			
Waste reduction and optimized resource usage	Operational efficiency		
Improved staff satisfaction and professional commitment			

Annex 2: Coding Paradigm for LMIS performance in public health facilities of Amhara Region, March 2022 (Based on Corbin and Strauss, 2015).

1ST Level Concepts	2nd Level Categories	High Level Categories	Paradigm Model Dimensions
Gaps in full implementation of IPLS	LMIS related initiatives	LMIS Implementation	Causal Conditions
APTS implementation			
DTC functionality			
Gaps in HCMIS (Digital LMIS) implementation	Digital LMIS Implementation		
Frequent interruption of digital LMIS			
Absence of up-to-date data on availability and near-expiry			
Utilization of both manual and digital LMIS tools			
LMIS reporting channels	Reporting Channel		
Reporting to EPSS using RRF			
Reproting to HFs using HPMMR			
Reporting of units using IFRR			
Stadardization of LMIS tools	LMIS tools Standardization		
LMIS Formats supply system			
LMIS format suppliers (WOHO, EPSS, NGOs)			
Dependence on manual systems			
Inconsistency in manual LMIS Recording	LMIS Recording	Data Management and Reporting	Causal Conditions
Irregular updating of digital record-keeping			
Irregular use and updating of stock card			
Utilization of LMIS forms (Model 19, Model 22, RRF, HPMMR, and IFRR)			
Inefficient management of LMIS forms			
Negligence in updating logistics records			
Challenges in data accuracy and legibility	Data Quality		
Data quality issues for IFFR and RRF			
Issues with data completeness			
Variances in data quality across health facilities			
Errors in calculation of manual LMIS			

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Poor data management practices			
Occasional reporting delays leading to bullwhip effects	Reporting System		
Regular reporting system of IPLS			
Issues with completeness and timeliness of reports			
Inconsistent availability of reporting formats (e.g., HPMMR, IFRR, RRF)			
Receiving of reports with poor data quality			
Interruptions in receiving reports			
Regular reporting system from dispensaries and health posts			
Manual and digital reporting system			
Absence of dedicated budget for LMIS	Budget Allocation	Budgeting and Finance	Causal Conditions
Delay in budget allocation			
High costs for LMIS tools printing	Budget Constraint		
Limitations in funds from different sources			
Low internal revenue of health facilities			
Financial constraint for LMIS training			
High cost of investment for digitalization			
Insufficient warehouse and shelving	Warehouse and Facility Infrastructure	Infrastructure and Resources	Contextual Conditions
Inadequate furniture, pallets and equipment			
Absence of well-standardized store and dispensaries			
Inconvenient location of store and dispensary			
Shortage of rooms and space for LMIS activities			
Absence of enough refrigerators			
Lack of clean water supply system	Power and Water Supply		
Power supply (backup generators, electricity access)			
Frequent power interruption			
Road access for transportation	Road and Transportation Access		
Road inaccessibility during the rainy season			
Transportation of donkeys and mules			
Shortage of vehicles for transportation			

ICT equipment for digitalization	ICT and LMIS Equipment		
Internet connectivity			
Shortage of computers and printers			
LMIS Formats supply system			
LMIS recording tools supply			
Conflicts in the northern part of the country	Conflicts	Security Situation	Contextual Conditions
National security threats due to conflicts			
Increasing number of public health emergencies	Public Health Emergencies		
High number of IDPs in the country			
Repurposing of the supply chain activities to emergencies			
Partners support for LMIS implementation	Stakeholders Support	Stakeholders and Government Support	Contextual Conditions
Government commitment for LMIS digitalization (policy and funding)	Government Commitment		
Health facilities, Woredas and Zones involvement			
Governments offices involvement in LMIS activity (EPSS, RHB, NGOs)			
Staff commitment and performance	Commitment and Professionalism	Supply Chain Workforce	Intervening Conditions
Negligence in accurate record-keeping			
Gaps in professional responsibility			
Shortage of skilled supply chain personnel	Workforce Shortage		
High turnover of trained professionals			
High Workload due to staff shortage			
Attitude and resistant to change of the workforce	Workforce Attitude		
Poor attention for digitization			
Skill gaps on data management	Knowledge and Skill	Workforce Capacity and Training	Intervening Conditions
Knowledge and skill gaps for initiating the digitized system			
Insufficient engagement in data management	Resistance for Practice		
Resistance to change among staff			
Low engagement in professional development	Training		
Continuous training gaps on IPLS, LMIS and APTS			
Ongoing training in LMIS utilization			

Training gap on digitalization of LMIS			
Marginalized capacity-building training in the country			
Periodic supportive supervision system	Supportive Supervision	Health System Support	Intervening Conditions
Lack of continuous supportive supervision and support			
Regular discussions with supply chain professionals			
Quarterly integrated supportive supervision for HFs and units			
Systems for feedback mechanism	Feedback System		
Inconsistent feedback and communication from higher levels			
Absence of written feedback system from higher levels			
Feedback system to dispensary units			
Feedback system through telegram channel			
Feedback system via phone calls			
Auditing system for LMIS	LMIS Auditing & Evaluation		
Quarterly evaluation system for supply chain and LMIS performance			
Regular evaluation supply chain and LMIS data quality by DTC			
Monitoring system for LMIS data quality and performance			
Implementation of digital LMIS	Digital Innovation and Implementation	LMIS Integration & Digitization	Actions/Interaction Strategies
Innovation and implementation of LMIS Technologies			
Implementation of new LMIS digital tools			
Full implementation of Dagu-2			
Digitalization of IPLS and APTS			
Investment on digital infrastructure	Investment on Digitalization		
Increase access to computers and internet			
Invest on digital literacy of supply chain experts			
Standardization of digital system across health system	Integration & End to End Visibility		
LMIS end-to-end data visibility			
Integration of LMIS across the health system			
Sustainability of digital system	Sustainability and Ownership		
Ownership of the digital LMIS			

Strengthening LMIS Implementation	Strengthen LMIS Implementation	Strengthen LMIS Implementation & Support	Actions/Interaction Strategies
Strengthen the digital systems in the healthcare system			
Improve LMIS interoperability in the healthcare system			
Strengthening Supportive Supervision & Feedback	Strengthen Support and Financing		
Improving budget allocation			
Enhancing Government & stakeholders Support			
Investment on physical infrastructure			
Strengthen workforce deployment	Strengthen Workforce Development		
Strengthen workforce capacity building			
Data driven accountability and transparency in the supply chain system	Data Driven Accountability and Transparency	Improved Healthcare Supply Chain Performance	Consequences (Outcomes)
Improved efficiency in data management and reporting			
Access to real-time end to end data visibility in supply chain	Realtime Quality data for decision making		
Access to quality data for informed decision-making in supply chain			

Annexes

Annex 1:Data Abstraction Checklist for Health Facilities

ADDIS ABABA UNIVERSITY

COLLEGE OF HEALTH SCIENCE

SCHOOL OF PHRMACY

DEPARTMENT OF PHARMCEUTICS AND SOCIAL PHARMACY

Instruction*:* *Fill the following information through asking the respective persons (CEO/head, pharmacy coordinator, SCM coordinator and store manager), with observation and reviewing the relevant documents. Write in the provided space or tick the answer in the box or circle it (☑)*

Section I: General Information		
SN	**Items**	**Response**
1.	Code of Health Facility	
2.	Name of health facility	
3.	GPS location (10 Meters Accuracy)	
4.	Level of Health Facility	**1)** Health Center **2)** Primary Hospital **3)** General Hospital **4)** Referral Hospital
5.	Location of health facility (*for Health centers)*	**1)** Urban **2)** Rural
6.	Address	**1)** Zone ____________ **2)** Woreda/Town admin.____________ **3)** Kebele____________
7.	Estimated distance (KM)	**1)** From Woreda Town______________________KM **2)** From Zonal Town________________________KM **3)** From Regional City_______________________KM **4)** From EPSA Branch________________________KM
8.	When was the facility started providing the service?	Month _____/________E.C
9.	Number of lower level HFs in the health tier system?	___________________________
Section II: Health Commodities' SCM and LMIS related information		

10.	Number of Dispensary Units (DUs) or pharmacies in the facility? (all DUs using IFRR)	______________________
11.	Number of pharmacy personnel in the facility?	__________________
12.	Is there assigned coordinator for Pharmaceutical supply chain management (SCM) activities? (check letter)	**1)** Yes **2)** No
13.	Number of pharmacy professionals assigned for SCM activities? (including store manager)	__________________
14.	Number of finance officers dedicated for pharmaceutical transaction? (accountants, cashiers)	__________________
15.	How does EPSA deliver pharmaceuticals to your facility?	**1)** Direct delivery by EPSA **2)** Through the WoHO
16.	Which EPSA hub responsible for suppling to your facility?	**1)** Bahirdar **2)** Gondar **3)** Addis Ababa
17.	Which *pharmacy service* and *SCM initiatives* are implemented in the facility? *(Observation of units for service initiation, check the relevant documents (minutes, reports, charts) and eLMIS database in the respective units)*	**1)** IPLS paper-based **2)** HCMIS (DAGU-1&DAGU-2) **3)** DHIS-2 **4)** APTS **5)** ART Service **6)** Clinical Pharmacy **7)** DIS **8)** DTC **9)** SCM M&E **10)** Others, Specify__________________
18.	If HCMIS is initiated, when did the facility start using HCMIS?	Month ______/________E.C
19.	If HCMIS is initiated in the facility, which version is implemented?	**1)** DAGU-1 **2)** DAGU-2
20.	If HCMIS is initiated in the facility, what is the phase of implementation?	**1)** Pre-HCMIS **2)** Intensive

		3) Matured
21.	Is the facility using IFRR? (check reports in store)	**1)** Yes **2)** No
22.	If No for Q21, Why? (Ask store manager) (Skip to Q30)	____ ____ ____
23.	If yes for Q21, which DUs use the IFRR form for reporting and requesting? (Multiple reponses are possible, check sample reports from the main store)	**1)** OPD dispensary **2)** ART Pharmacy **3)** MCH **4)** Laboratory **5)** TB clinic **6)** In Patient Pharmacy **7)** Chronic Pharmacy **8)** Emergency Pharmacy **9)** X-ray **10)** Others, Specify______________________
24.	Which IFRR schedule is used by the facility?	**1)** IPLS (2 Weeks) **2)** Facility Specific Schedule
25.	If the answer for Q24 is No-2, write the IFRR schedule period in days?	__________________Days
26.	Is the IFRR schedule posted? (check in store)	**1)** Yes **2)** No
27.	How many of the DUs sent IFRR as per the schedule? (Check the recent IFRR reports for all DUs in the store)	_________________________
28.	How many of the DUs sent IFRR after the schedule? (Check the recent IFRR reports for all DUs in the store)	_____________________
29.	For how many DUs did the store manager resupply within two days of request? *(check Model 22 and recent IFRR)*	________________________

30.	If they did not supply within two days for any DU, why? (*Ask store manager*)	____________________ ____________________ ____________________
31.	How many health posts submitted HPMRR to the HC in recent report period of the visit? (check recent reports in the store)	____________
32.	How many health posts submitted HPMRR to HCs as before the deadline? (Count reports submitted until 5^{th} day after RP)	____________
33.	For whom you are sending Health Commodities LMIS reports? (e.g. RRF, VRF) (Multiple reponses are possible)	**1)** WoHo **2)** ZHD **3)** RHB **4)** FMOH **5)** EPSA **6)** Others, Specify__________
34.	Is the facility using RRF? (check reports in store)	**1)** Yes **2)** No
35.	If No for Q 34, Why? (Ask store manager/SCM Coordinator)	____________________ ____________________
36.	In how many RRFs did the Facility Head/CEO/CCO sign/approve on the report before sent to EPSA or WoHO)? (*Check the signature of CEO/CCO/Head from six recent RRF reports)*	____________
37.	How many emergency orders were placed in the last one year?	______________
38.	What were the possible reasons for placing emergency orders?	____________________ ____________________
39.	What type of transportation is most often used to send reports to higher levels? (Multiple Responses possible)	***1)*** Facility vehicle ***2)*** Public transportation **3)** Private vehicle ***4)*** Motorcycle

		5) Bicycle ***6)*** On foot **7)** Postal Service **8)** Digital (Email, Telegram) **9)** Other (specify) ______________________________
40.	Is there electric power supply system for the facility?	**1)** Yes **2)** No
41.	Is there electric power interruption at the day of visit?	**1)** Yes **2)** No
42.	Does the facility have backup generator?	***1)*** Yes **2)** No
43.	How many functional desktop/laptop computers are available for health commodities supply chain management? (DUs, Store, SCM coordinator, ART, etc)	______________________
44.	Does the facility allocate budget for renovation, printing, and duplication of LMIS formats (*BC, IFRR, RRF, patient profile form, cash and credit sales tickets, registration books*)?	**1)** Yes ***2)*** No
45.	Does the facility have internet connectivity?	***1)*** Yes **2)** No
46.	If yes for Q45, which form of internet connectivity is available?	***1)*** Fixed (Broad band) ***2)*** Wireless (CDMA, etc) ***3)*** Data
47.	If yes for Q45, does the pharmacy department have internet connectivity?	**1)** Yes **2)** No
48.	Did you get supportive supervision for SCM/LMIS related issues in the last one year?	**1)** Yes **2)** No
49.	If yes for Q 48, when did you get the recent supportive supervision?	**1)** Within the last month **2)** [1-3] Months ago **3)** (3-6] months ago **4)** >6 Months ago **5)** Did not remember
50.	If yes for 48, who provided the	**1)** WoHo

	most recent supportive supervision? (Multiple responses possible)	**2)** ZHD **3)** RHB **4)** FMOH **5)** Partners, Specify____________________ **6)** Integrated, specify____________________
51.	What has improved as a result of the most recent supportive supervision?	____ ____ ____
52.	Did you get periodic written feedback about SCM/LMIS reports from higher levels? (check recent feedback)	**1)** Yes **2)** No
53.	If yes for Q52, who provided the most recent periodic feedback?	**1)** WoHo **2)** ZHD **3)** RHB **4)** FMOH **5)** Partners, Specify____________________ **6)** Integrated, Specify____________________
54.	When did you receive the recent feedback about LMIS report?	**1)** within the last month **2)** (1-3] Months ago **3)** (3-6] months ago **4)** >6 Months ago **5)** Did not remember

<u>Section III: Availability and Utilization status of LMIS formats</u>

<u>Instruction</u>*:* *Check the following LMIS formats from the respective units and estimate supply of each form as per their consumption rate. Tick in the box (☑)*

Facilities Category	LMIS forms	Available	Not Available	Utilization Status	Supply for 3+months	Supply for < 3 months
All Facilities	Bin Card (BC)					
	Stock Record Card (SRC)					
	HPMRR					
	Internal Facility Report and Requisition (IFRR)					
	Facility Report and Re-supply (RRF)					
	Model 19/H					
	Model 22/H					
	IPLS SOP					
	Physical Inventory form					
	Job Aids for IPLS (laminated)					
	HCMIS Guide/Manual					
	Quantification tool (Updated)					
	M&E tool					
APTS Sites	Cash sales Ticket					
	Free registration book					
	Credit registration book					
	Daily summery sheet					
	Monthly sales summery sheet					
	Model 19/H					
	Model 22/H					
	Sales ticket pad register					
	Cash delivery note					
ART Sites	ART Monthly Activity report format					
	EDT					
	Patient tracking chart					
	ART Register					
	Patient Information Sheet (PIS)					

Section IV: Data Quality

1. **Inventory Accuracy Rate (only for available items in the stock)**

Instruction: The data will be filled in the main store. *Bin card Update; Check the last transaction for the respective items from Model 19 and Model 22). Consider only those items managed by the facility* Inventory Discrepancy Rate/Item = Balance on bin card record-Stock on hand X 100% / stock on hand Inventory Accuracy Rate/Facility = Number of items with stock record count equals physical count X 100 / Total number of items counted						
SN	**List of Tracer Drugs**	**Is the bin Card Updated? (Yes=1; No=0)**	**Bin Card Balance (Manual)**	**Electronic Record Balance (HCMIS)**	**Physical Count**	**Remark**
1.	Medroxyprogesterone Injection					
2.	Oxytocine injection					
3.	Amoxicillin 250 mg dispersible tab					
4.	ORS+/- Zinc sulphate					
5.	RHZE/RH					
6.	TDF/3TC/DTG (of 90)					
7.	Arthmeter + Lumfanthrine tablet (6x4)					

2. **Timeliness of RRF reporting rate**

Instruction; *Take six recent RRF for programs items supplied to Health Centers. RRF sent date is the date mentioned on the cover letter. Write the date in Ethiopian Calendar.* ***(February 1, 2021, January 30, 2022)***						
SN	**Reporting Period**	Is the date of report clearly indicated? (Yes=1; No=0)	Does the facility sent the report on the schedule (until 5th day after RP) (Yes=1; No=0)	Does the facility sent the report on the schedule (until 10th day after RP) (Yes=1; No=0)	Does the facility sent the report on the schedule (After 10-15th day after RP) (Yes=1; No=0)	Does the facility sent the report on the schedule (After 15th day after RP) (Yes=1; No=0)
1.	Reporting Period 1					
2.	Reporting Period 2					
3.	Reporting Period 3					
4.	Reporting Period 4					
5.	Reporting Period 5					
6.	Reporting Period 6					

3. **Completeness of RRF**

Instruction: *Take* ***one recent RRF report*** *sent by Health center/Hospital and check whether the cells are properly filled or not (If Yes=1; N0=0)*							
SN	List of tracer medicines	Beginning balance	Quantity received	Ending Balance	Calculated consumption	Maximum quantity	Quantity to reach max
1.	Medroxyprogesterone Injection						
2.	Oxytocine injection						
3.	Amoxicillin 250 mg dispersible tab						
4.	ORS+/- Zinc sulphate						
5.	RHZE/RH						
6.	TDF/3TC/DTG (of 90)						
7.	Arthmeter + Lumfanthrine tablet (6x4)						

4. **Legality of RRF**

Instruction: *Take six recent RRF for programs items supplied by Health centers/Hospitals. Check whether the legal information is completed or not.* ***(February 1, 2021, January 30, 2022)***						
SN	**Reporting Period**	Report indicate completed by (Yes=1; No=0)	Report indicate approved by (Yes=1; No=0)	Report indicate verified by (Yes=1; No=0)	Report has official stamp (Yes=1; No=0)	Cover Letter (Yes=1;No=0)
1.	Report 1					
2.	Report 2					
3.	Report 3					
4.	Report 4					
5.	Report 5					
6.	Report 6					

5. **Legibility of RRF**

Instruction: *Take six recent RRF for program items supplied to Health centers/Hospitals. Review the legibility of all program RRFs. RRF is legible if the handwritings or prints on the RRF are clear enough to read.* ***(February 1, 2021, January 30, 2022)***					
SN	**Reporting Period**	RRF is legible (Yes=1; No=0)	Number of legible items	Number of illegible items	Total number of items
1.	Report 1				
2.	Report 2				
3.	Report 3				
4.	Report 4				
5.	Report 5				
6.	Report 6				

6. **Pharmaceutical SCM M& E Reporting for HC, and Hospitals**

Instruction; *Take all Pharmaceutical M& E quarterly report in the last one-year. HC should send to WoHO from 21-23; Hospitals to RHB from 21-23. Write the date in Ethiopian Calendar.* ***(February 1, 2021, January 30, 2022)***			
S.N.	**Reporting Period**	**Date sent to Higher Level (E.C)**	**Send report on time (Check period in the instruction) (If Yes, put 1, if not, put 0)**
1.	Reporting Period 1		
2.	Reporting Period 2		
3.	Reporting Period 3		
4.	Reporting Period 4		

7. Accuracy of RRF

Instruction:

- If "Calculated Consumption" indicated on the RRF is correctly matched with to the verified CC (recalculating the CC as "SOH at the start of the period + Quantity Received – SOH at the end of the period +/- Loss/Adj.
- If "Maximum Stock Quantity" indicated on the RRF is the same with the verified "Maximum Stock Quantity" (recalculating the "Maximum Stock Quantity" as CC X 2).
- If "Quantity Ordered" indicated on the RRF is same as the verified "Quantity Ordered" (recalculating the "Quantity Ordered" as "Maximum Stock Quantity" – "Ending Balance in the Store").

(if it is accurate use '' ☑ ", If not " X")

SN	List of tracer medicines	Verified calculated consumption indicated on RRF	Verified maximum stock quantity indicated on RRF	Verified quantity needed to reach max on RRF	Valid beginning balance of this RP of RRF Vs Ending balance of pervious RRF report	Valid quantity received of RRF Vs quantity received of STV/model 19	Ending balance of RRF Vs Ending balance of bin card	Loss /adjustment of RRF Vs bin card	DOS of RRF Vs DOS of bin card
1.	Medroxyprogesterone inj.								
2.	Oxytocine inj								
3.	Amoxicillin 250 mg dispersible tab								
4.	ORS+/- Zinc sulphate								
5.	RHZE/RH								
6.	TDF/3TC/DTG								
7.	Arthmeter + Lumfanthrine tablet (6x4)								

Section V: Digital LMIS Tools Evaluation Checklist (HCMIS)

Instruction: *Fill the following questions with observing the HCMIS/DAGU and asking the responsible professional managing the database in the store.*

SN	Question Items	Responses
1.	Which version of the HCMIS installed in the facility?	**1)** DAGU-1 **2)** DAGU-2
2.	Who installed the HCMIS?	**1)** Government (WoHO/RHB/EPSS) **2)** In-house by the facility **3)** Partners, Specify_________________
3.	Number of computers dedicated for LMIS?	_______________________
4.	What is the power source for digital LMIS? (Multiple responses possible)	**1)** Electric Power **2)** Solar Power **3)** Generator
5.	Is there power backup in case of power interruption? (check the generator)	**1)** Yes **2)** No
6.	Type of internet service?	**1)** Broadband **2)** Wifi **3)** Data
7.	Where is the HCMIS installed? (Multiple response possible)	**1)** Dispensary **2)** Main Store **3)** SCM Case team **4)** Pharmacy Head **5)** CEO/CCO **6)** Others, Specify______________
8.	Is it functional at the time of visit? (check in each unit, Multiple response possible)	**1)** Dispensary **2)** Main Store **3)** SCM Case team **4)** Pharmacy Head **5)** CEO/CCO **6)** Others, Specify______________
9.	Do you have data back up system for HCMIS?	**1)** Yes **2)** No
10.	Is IFRR integrated with HCMIS?	**1)** Yes **2)** No
11.	Is RRF integrated with HCMIS?	**1)** Yes **2)** No
12.	Is Model 19/H integrated with HCMIS?	**1)** Yes **2)** No
13.	Is Model 22/H integrated with HCMIS?	**1)** Yes **2)** No

Annex 2:Data Abstraction and Observation Checklist for Vaccine LMIS (Rural Facilities Version)

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COLLEGE OF HEALTH SCIENCE

SCHOOL OF PHRMACY

DEPARTMENT OF PHARMCEUTICS AND SOCIAL PHARMACY

Instruction: *Visit the vaccine room and discuss with the cold chain officer for respective documents review*

Section I: General Information		
SN	Questions	Responses
1.	Code of Health Facility	
2.	Level of Health Facility	**1)** HC **2)** Primary Hospital **3)** General Hospital **4)** Referral Hospital
3.	Location of Health Facility	**1)** Urban **2)** Rural
4.	Is the facility has dedicated vaccine store?	**1)** Yes **2)** No
5.	Does the facility have dedicated EPI focal?	**2)** Yes **2)** No
6.	Type of LMIS tool using for vaccine management?	**1)** Manual **2)** Digital HCMIS (DAGU, mBirna) **3)** Others, Specify_________________
7.	Is /DAGU/mBirana functional at the time of visit? (*check it from mobile or computer dashboard)*	**1)** Yes **2)** No
8.	How many of the functional refrigerators have functional temperature monitoring device?	________ **o**ut of ____________
9.	For every functional refrigerator with functional temperature monitoring device, how many have a temperature recording chart?	________out of ____________
10.	Did they regularly record temperature in the	**1)** Yes

	temperature monitoring sheet? (*Check at least a one-month record, twice in a day)*	**2)** No

Section II: Availability and Utilization Status of Vaccines LMIS formats

Instruction: Check availability of forms either in hard copy or soft copy (*word, Excel, database*)

SN	LMIS forms for Vaccine management	Available	Not Available	Utilization status	Have supply for 3+months	Supply for < 3 months
1.	Vaccine forecasting tool (Paper, Word, Excel)					
2.	Vaccine Request Form (VRF)					
3.	Model 19/H					
4.	Model 22/H					
5.	Bin Card					
6.	Stock Card					
7.	Vaccine stock management ledger book					
8.	Physical Inventory form					
9.	Temperature Monitoring chart					
10.	VRF accuracy analysis tool (Excel, word)					
11.	Monthly Vaccine wastage monitoring form					
12.	Damaged vaccines registration format (excel, word)					
13.	Immunization self-assessment tool					
14.	Temperature monitoring data summery sheet					
15.	Vaccine Management KPI Monthly Report Template					

Section III: Data Quality

1. Inventory Accuracy Rate for Vaccines

Instruction: *The data will be filled in the vaccine room/cold room. Check the last transaction for the respective items from Model 19 and Model 22 to fill the updating status. Then, check the last* ***ledger balance*** *with the physical count and electronic balance)*

Inventory Discrepancy Rate/Item = $\frac{\text{Balance on ledger record-Stock on hand}}{\text{stock on hand}} \times 100\%$

Inventory Accuracy Rate/Facility = $\frac{\text{Number of items with stock record count equals physical count}}{\text{Total number of items counted}} \times 100$

NB: ***Check the Ledger book update status one day in advance before the day of visit. Then, the physical count=Count in the stock+ Quantity in the tally sheet at the day of visit.***

SN	**List of Vaccines**	**Is ledger book available? (Yes=1; No=0)**	**Is the ledger book Updated? (Yes=1; No=0)**	**Ledger book Balance (Manual)**	**Electronic Record Balance (HCMIS)**	**Physical Count**
1	**Penta**					
2	**BCG**					
3	Measles					

2. Timeliness of VRF reports

Instruction; *First ask the VRF report schedule agreement from the cold chain officer. Then, take twelve recent VRF for vaccines sent by Health center/Hospital to WHO/ZHD/EPSA. VRF sent date is the reporting date written on VRF. Write the date in Ethiopian Calendar.*

S.N.	**Reporting Period**	Is the date of report clearly indicated? (Yes=1; No=0)	If Yes, write the Approval/ Verified date?	Does the facility sent the report as per the WHO/ZHD/EPSS Schedule? (Yes=1; No=0)	Does the facility sent the report after the report schedule of WHO/ZHD/EPSS? (Yes=1; No=0)
7.	Reporting Period 1				
8.	Reporting Period 2				
9.	Reporting Period 3				
10.	Reporting Period 4				
11.	Reporting Period 5				
12.	Reporting Period 6				
13.	Reporting Period 7				
14.	Reporting Period 8				
15.	Reporting Period 9				
16.	Reporting Period 10				
17.	Reporting Period 11				
18.	Reporting Period 12				

3. Completeness of VRF reports

Instruction; *First ask the VRF report schedule agreement from the cold chain officer. Then, take one recent VRF report sent by Health center/Hospital to WHO/ZHD/EPSS. Check whether the cells are properly filled or not (If Yes=1; N0=0)*									
SN	**List of vaccines**	Beginning balance	Quantity received	Used/ dispatched to lower level	Doses discarded	Current balance	(125%) Requirement for next supply period	Requested amount	Vaccinations given in the last supply period
1.	BCG								
2.	Measles								
3.	Penta								
4.	Td								
5.	PCV 13								
6.	Rota								
7.	IPV								
8.	BOPV								

4. **Accuracy of VRF reports**

Instruction; *First ask the VRF report schedule agreement from the cold chain officer. Then, take* ***one recent*** *VRF report sent by Health center/Hospital to WHO/ZHD/EPSS. Check whether the calculation is right or not (refer the beginning balance, ending balance, consumption data from Bin card, STV, Model 19 and Model 22) (If Yes=1; N0=0)*									
SN	**List of Vaccines**	Balance at the beginning	Receiving during the last SP	Used/dispatched to lower level	Doses discarded	Current balance	125% Requirement for next supply period	Requested amount	Vaccinations given in the last supply period
1.	BCG								
2.	Measles								
3.	Penta								
4.	Td								
5.	PCV 13								
6.	Rota								
7.	IPV								
8.	BOPV								

Annex 3:Data Abstraction and Observation Checklist for Vaccine LMIS (Urban Facilities Version)

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SCHOOL OF PHRMACY

DEPARTMENT OF PHARMCEUTICS AND SOCIAL PHARMACY

Instruction: *Visit the vaccine room and discuss with the cold chain officer for respective documents review*

Section I: General Information		
SN	Questions	Responses
1.	Code of Health Facility	
2.	Level of Health Facility	**5)** HC **6)** Primary Hospital **7)** General Hospital **8)** Referral Hospital
3.	Location of Health Facility	**3)** Urban **4)** Rural
4.	Is the facility has dedicated vaccine store?	**3)** Yes **2)** No
5.	Does the facility have dedicated EPI focal?	**4)** Yes **2)** No
6.	Type of LMIS tool using for vaccine management?	**4)** Manual **5)** Digital HCMIS (DAGU, mBirna) **6)** Others, Specify________________
7.	Is /DAGU/mBirana functional at the time of visit? (*check it from mobile or computer dashboard)*	**3)** Yes **4)** No
8.	How many of the functional refrigerators have functional temperature monitoring device?	________ **o**ut of ___________
9.	For every functional refrigerator with functional temperature monitoring device, how many have a temperature recording chart?	________out of ___________
10.	Did they regularly record temperature in the temperature monitoring sheet? (*Check at least a one-month record, twice in a day)*	**3)** Yes **4)** No

Section II: Availability and Utilization Status of Vaccines LMIS formats

Instruction: Check availability of forms either in hard copy or soft copy (*word, Excel, database*)

SN	LMIS forms for Vaccine management	Available	Not Available	Utilization status	Have supply for 3+months	Supply for < 3 months
1.	Vaccine forecasting tool (Paper, Word, Excel)					
2.	Vaccine Request Form (VRF)					
3.	Model 19/H					
4.	Model 22/H					
5.	Bin Card					
6.	Stock Card					
7.	Vaccine stock management ledger book					
8.	Physical Inventory form					
9.	Temperature Monitoring chart					
10.	VRF accuracy analysis tool (Excel, word)					
11.	Monthly Vaccine wastage monitoring form					
12.	Damaged vaccines registration format (excel, word)					
13.	Immunization self-assessment tool					
14.	Temperature monitoring data summery sheet					
15.	Vaccine Management KPI Monthly Report Template					

Section III: Data Quality

1. Inventory Accuracy Rate for Vaccines

Instruction: *The data will be filled in the vaccine room/cold room. Check the last transaction for the respective items from Model 19 and Model 22 to fill the updating status. Then, check the last* ***ledger balance*** *with the physical count and electronic balance)*

Inventory Discrepancy Rate/Item = Balance on ledger record-Stock on hand X 100% / stock on hand

Inventory Accuracy Rate/Facility = Number of items with stock record count equals physical count X 100 / Total number of items counted

NB: ***Check the Ledger book update status one day in advance before the day of visit. Then, the physical count=Count in the stock+ Quantity in the tally sheet at the day of visit.***

SN	List of Vaccines	Is ledger book available? (Yes=1; No=0)	Is the ledger book Updated? (Yes=1; No=0)	Ledger book Balance (Manual)	Electronic Record Balance (HCMIS)	Physical Count
1.	**Penta**					
2.	**BCG**					
3.	**Measles**					

2. Timeliness of VRF reports

Instruction; *First ask the VRF report schedule agreement from the cold chain officer. Then, take twelve recent VRF for vaccines sent by Health center/Hospital to WHO/ZHD/EPSA. VRF sent date is the reporting date written on VRF. Write the date in Ethiopian Calendar.*

S.N.	Reporting Period	Is the date of report clearly indicated? (Yes=1; No=0)	If Yes, write the Approval/ Verified date?	Does the facility sent the report as per the WHO/ZHD/EPSS Schedule? (Yes=1; No=0)	Does the facility sent the report after the report schedule of WHO/ZHD/EPSS? (Yes=1; No=0)
1.	Reporting Period 1				
2.	Reporting Period 2				
3.	Reporting Period 3				
4.	Reporting Period 4				
5.	Reporting Period 5				
6.	Reporting Period 6				
7.	Reporting Period 7				
8.	Reporting Period 8				
9.	Reporting Period 9				
10.	Reporting Period 10				
11.	Reporting Period 11				
12.	Reporting Period 12				

3. **Completeness of VRF reports**

Instruction; *First ask the VRF report schedule agreement from the cold chain officer. Then, take one recent VRF report sent by Health center/Hospital to WHO/ZHD/EPSS. Check whether the cells are properly filled or not (If Yes=1; N0=0)*								
SN	**List of vaccines**	Beginning balance	Quantity received	Los/Adj ustment	Ending Balance	Calculated consumption	Maximum stock	Quantity needed to (Requested amount)
1.	BCG							
2.	Measles							
3.	Penta							
4.	Td							
5.	PCV 13							
6.	Rota							
7.	IPV							
8.	BOPV							

4. **Accuracy of VRF reports**

Instruction; *First ask the VRF report schedule agreement from the cold chain officer. Then, take* ***one recent*** *VRF report sent by Health center/Hospital to WHO/ZHD/EPSS. Check whether the calculation is right or not (refer the beginning balance, ending balance, consumption data from Bin card, STV, Model 19 and Model 22) (If Yes=1; N0=0)*								
SN	**List of vaccines**	Beginning balance	Quantity received	Los/Adj ustment	Ending Balance	Calculated consumption	Maximum stock	Quantity needed to (Requested amount)
1.	BCG							
2.	Measles							
3.	Penta							
4.	Td							
5.	PCV 13							
6.	Rota							
7.	IPV							
8.	BOPV							

Annex 4: Interviewer-Administered Questionnaire

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SCHOOL OF PHRMACY

DEPARTMENT OF PHARMCEUTICS AND SOCIAL PHARMACY

Section I: Information Sheet and Informed Consent

Purpose: This is a PhD study project designed to *evaluate and develop hypothetical model for the health commodities' logistics management information system (LMIS) in the public health system of Amhara region*. Your answers are very important and valuable to the successful completion of this study project. ***Please*** be honest in filling this questionnaire, as it will be used for improving the pharmaceutical supply chain system in the public sector. This survey will be confidential, anonymous, and data will be analyzed in aggregates. You are free to withdraw from the study at any time and if you are not comfortable in any one of the questions, you are not obliged to answer it.

If you have any question, please do not hesitate to ask the data collectors or research coordinators at any time. If you need any further clarification, you can contact the following persons;

1) Zelalem Tilahun Mekonen (Principal Investigator); +251923109539
2) Prof. Teferi Gedif Fenta (Primary Project Supervisor): +251911684854
3) IRB, CHS-AAU: chs.irb@aau.edu.et or +251913001278

Are you clear with all the information stated above? (If no, discuss with the study coordinators/ data collectors)

If yes, would you please be willing to take part in this research project?

1) If yes, please proceed to the next section
2) If no, please kindly return the questionnaire for data collectors

Thank you

Participants;

- Pharmacy heads
- SCM coordinators (assigned)
- SCM officers (assigned)
- OPD pharmacy coordinator (assigned)

- Store Manager (Pharmaceutical Store)

Section II: Socio-demographic Characteristics of Respondents

Instruction: Write your responses the provided space or circle the choice/tick in the box (☑)

SN	Questions	Responses
1.	Code of the Health Facility	
2.	Name of the Health facility	
3.	Level of the Health Facility	**1)** Health Center **2)** Primary **3)** General Hospital **4)** Referral Hospital
4.	Location of the HF (*for Health centers only*)	**1)** Urban **2)** Rural
5.	Gender of the respondent	**1)** Male **2)** Female
6.	Age	____________________ Years
7.	Profession	**1)** Pharmacy **2)** Nurse **3)** Other, Specify________________
8.	Highest level of education	**1)** PhD **2)** MSc **3)** Bachelor Degree **4)** Diploma **5)** Certificate **6)** Others, Specify____
9.	Current working department/unit	_____________________________________
10.	Current position/ responsibility in the facility?	**1)** Pharmacy head **2)** SCM coordinator **3)** SCM officer **4)** OPD pharmacy coordinator **5)** Store Manager **6)** Others, Specify__________________
11.	Total work experience in the current position?	______________________Years

12.	Total experience in *health commodities supply chain* related activities?	____________________Years
13.	Total work experience?	___________________Years
	Section III: Implementation of Health Commodities LMIS	
14.	Have you ever participated in LMIS activities?	**1)** Yes **2)** No
15.	If yes for Q14, in what activity did you participate? *(Multiple answers possible)*	**1)** LMIS formats development **2)** Stock recording **3)** Report Preparation **4)** Providing LMIS training (In-service/on job) **5)** Others, Specify______________________
16.	Have you ever participated in the following LMIS recordings? *(Multiple answers possible)*	**1)** HPMRR **2)** IFRR **3)** RRF **4)** Bin card **5)** Stock Card **6)** Model 19&22/H **7)** HCMIS (Dagu) **8)** DHIS-2 **9)** SCM M& E **10)** Others, Specify______________________________________
17.	Have ever participated in any of the following trainings? (*Fill modality of the training on the space provided, Multiple response possible)* *Pre-Service=1* *In-service (On-job training) =2* *In-service (Off-job training) =3* *RMNCH=Reproductive, Maternal, Neonatal, and Child Health* *PMIS=Pharmaceutical Management Information system*	**Type of Training** — **Modality of Training** **1)** IPLS ____________ **2)** HCMIS (Dagu-1) ____________ **3)** HCMIS (Dagu-2) ____________ **4)** APTS ____________ **5)** Quantification ____________ **6)** SCM M&E ____________ **7)** PMIS ____________ **8)** Inventory Management ____________ **9)** ART ______________ **10)** RMNCH ______________ **11)** Vaccine SCM ______________ **12)** Others, Specify _________________ _______________

Section IV: Level of agreement of SCM Personnel on LMIS performance items

SDA=*Strongly Disagree;* ***DA***=*Disagree;* ***N***=*Neutral;* ***SA***=*Strongly Agree;* ***IK***=*I don't Know*

SN	Items related with LMIS implementation	Level of Agreement					
		SDA (1)	DA (2)	N (3)	A (4)	SA (5)	IK (0)
1.	We have a well standardized logistics management information (LMIS) system in our facility						
2.	There is no LMIS formats availability problem						
3.	The number of professionals is enough to manage LMIS activities						
4.	There is high staff commitment for LMIS activities						
5.	The health system structure is appropriate for LMIS activities						
6.	Lack of infrastructure (*warehouse space, internet, power, computer, furniture, etc)* highly affects the LMIS performance in our facility						
7.	Our LMIS is user-friendly (easily understandable to perform)						
8.	Our LMIS is appropriate for stock analysis						
9.	Our LMIS is appropriate for generating reports						
10.	We have a good LMIS data backup system in our facility						
11.	We have a sustainable LMIS system in our facility						
12.	The LMIS in our facility is well digitalized						
13.	There is efficient end to end LMIS data visibility in the health system (*From lower level heath facility up to MOH and EPSA*)						
14.	Distance highly attributes to delay in reporting						
15.	Transport problem highly attributes to the LMIS report timeliness (delay)						
16.	Work load highly attributes to data quality of the LMIS in our facility						
17.	SCM officer's knowledge affects LMIS performance						

18.	The different LMIS platforms are integrated with each other						
19.	The different LMIS platforms are interoperable (able to exchange information) with other Health information systems						
20.	The facility's leadership is supportive for LMIS activities						
21.	Professionals working on health commodities SCM got enough LMIS training to effectively discharge their duties						
22.	The facility is getting regular supportive supervision from the respective higher levels (WoHo/ZHD/RHB/EPSS/MOH)						
23.	The facility is getting regular feedback from the respective higher levels (WoHo/ZHD/RHB/EPSS/MOH)						
Section V: SCM Professionals rating on LMIS performance							
	Items	**Very poor (1)**	**Poor (2)**	**Good (3)**	**Very good (4)**	**Exce llent (5)**	**IK (0)**
1.	How do you rate the overall health commodities supply chain performance *(hint; data quality, availability, wastage rate, inventory accuracy, forecasting accuracy)* in the public health system in general?						
2.	How do you rate the overall *health commodities supply chain performance* in your facility?						
3.	How do you rate the overall *Health commodities' LMIS performance* (hint; *data quality, reporting, availability of LMIS formats, digitalization, etc*) in the public health system?						
4.	How do you rate the overall *Health commodities' LMIS performance* in your facility?						
5.	How do you rate the level of IPLS implementation?						
6.	How do you rate the improvement of LMIS performance due to IPLS initiation?						
7.	How do you rate the improvement of LMIS performance due to Quick-Win initiative? (*for Hospitals only*)						

8.	How do you rate the improvement of LMIS performance due to APTS initiative?						
9.	How do you rate the improvement of LMIS performance due to Dagu-2 (HCMIS) implementation?						
10.	How do you rate the staff commitment for LMIS activities						
11.	How do you rate the level of management support for LMIS activities						
12.	How do you rate the level of supportive supervision from higher levels? (WoHo, ZHD, RHB, EPSA, FMOH)						
13.	How do your rate the different LMIS integration with each other						
14.	How do you rate the LMIS interoperability (data sharing) with other health information systems (*eg. DHIS-2, Dagu, SCM M&E…)*						
15.	How is the infrastructure (*Internet, Power, computer, stationary, transport….)* to perform LMIS activities?						

1. How is the current pharmaceutical supply chain and LMIS performance in the public health system?

____
____
____
____

2. How is the performance of logistics management information system (LMIS) in your institution? (*Availability of LMIS tools, Data Quality, Reporting and Feedback, Digitalization, Infrastructure, etc*)

____
____
____
____

3. What are the main challenges related with the logistics management information system (LMIS) in your facility?

____

____

____

____

4. What do you suggest to improve health commodities' logistics management information system (LMIS) of the public health system?

____

____

____

____

____

Additional points you want to add;

____

____

____

____

Section VI: Frequency of use and Level of agreement to data items used in the LMIS

Instruction: *The following table is about the different essential logistics data items used in LMIS of IPLS. Please provide your judgment based on your experience. The table has three parts; 1) Frequency of use; 2) Level of importance of included data items; 3) Additional data items to be included.*

Logistics Records	**Essential data items**	**How often these data items are used in logistics recordings in your facility**				**Level of agreement for the importance of these data item in the LMIS forms**				
		Never	**Sometimes**	**Often**	**Always**	**SDA**	**DA**	**N**	**A**	**SA**
1. Bin Card	Name of HF									
	Product Name									
Data Items already included in the Bin card	Strength									
	Dosage form									
	Unit of issue									
	Maximum Stock Level									
	EOP									
	AMC									
	Date									
	Rec/issue doc. No									
	Received									
	Issued									
	Loss/adj									
	Balance									
	Batch No									
	Expiry date									
	Remarks									
Suggest data items to be included in the Bin Card										

Logistics Records	Essential data items	How often these data items are used in logistics recordings in your facility				Level of agreement for inclusion of these data item in the recording forms				
		Never	Sometimes	Mostly	Always	SDA	DA	N	A	SA
2. Stock Record Card *Data Items already included in the Stock Record card*	Name of HF									
	Product Name									
	Strength									
	Dosage form									
	Unit of issue									
	Location									
	MSL									
	EOP									
	AMC									
	Date									
	Rec/issue doc. No									
	Received									
	Issued									
	Loss/adj									
	Balance									
	Price									
	Expiry date									
	Remarks									
Suggest data items to be included in the Stock Record card										

Logistics Records	Essential data items	How often these data items are used in logistics recordings in your facility				Level of agreement for inclusion of these data item in the recording forms				
		Never	**Sometimes**	**Often**	**Always**	**SDA**	**DA**	**N**	**A**	**SA**
3. IFRR	Name dispensing unit									
	Reporting period									
Data Items already included in the IFRR	From/To___									
	Max. stock Level									
	Item name									
	Beg. Balance									
	Qty. Received									
	Loss/adj									
	Ending Balance									
	Calculated consumption									
	Max. Qty									
	Qty to reach Max									
	Quantity ordered									
	Qty to be supplied									
	Remarks									
	Completed by									
	Approved by									
Suggest data items to be included in the IFRR										

Logistics Records	Essential data items	How often these data items are used in logistics recordings in your facility				Level of agreement for inclusion of these data item in the recording forms				
		Never	Sometimes	Often	Always	SDA	DA	N	A	SA
4. RRF	Name of HF									
	Region/Zone/Woreda									
Data Items already included in the RRF	Suppling Branch									
	From/to____									
	Maximum stock level									
	EOP									
	Product description									
	Unit of Issue									
	Beg. Balance									
	Qty. received									
	Los/adj									
	Ending Balance-DU									
	Ending Balance-Store									
	Calculated Consumption									
	Days out of stock									
	Max. stock quantity									
	Qty to reach Max									
	Qty ordered									
	Completed/verified/approved									
	Products < 6 month shelf life									
Suggest data items to be included in the RRF										

Logistics Records	Essential data items	How often these data items are used in logistics recordings in your facility				Level of agreement for inclusion of these data item in the recording forms				
		Never	Sometimes	Often	Always	SDA	DA	N	A	SA
5. Model 22/H	Ser. No									
	Receiver name…for…									
	Date									
	SN									
Data Items	Drug code									

already	Description of									

Logistics Records	Essential data items	How often these data items are used in logistics recordings in your facility				Level of agreement for inclusion of these data item in the recording forms				
		Never	Sometimes	Often	Always	SDA	DA	N	A	SA
6. Model 19/H	Total selling price Ser. No									
	Retail Unit Receiver name…from									
	Retail unit price Invoice No									
	Sum Total SN									
Data Items	Delivered by Drug code									
	Received by									
Suggest data items to be included in the Model 22/H										

already included in the Model 19/H	Description of drugs,…									
	Unit									
	Quantity received									
	Unit Cost									
	Total cost									
	Batch No									
	Expiry Date									
	Sum Total									
	Delivered by									
	Received by									
	Remarks									
Suggest data items to be included in the Model 19/H										

<u>Section VII: Level of convenience of Manual LMIS tools;</u> *Please rate each of LMIS tool based on their convivence as the per the listed criteria in each column (1=Very less convenient; 2=Less Convenient 3= Medium; 4=convenient 5= Very convenient)*

SN	LMIS Tools	Easy to fill data (User Friendly) (1-5)	Included all essential data items (1-5)	Easy to aggregate data for analysis (1-5)	Easy for reporting (1-5)	Uniformity across units/ facilities (1-5)	Consistency with other records (1-5)	Less prone to error during recording (1-5)	It is not time consuming (1-5)
1.	Bin Card								

2.	Stock Card								
3.	IFRR								
4.	RRF								
5.	Model 19/H								
6.	Model 22/H								

Section VIII: Level of convenience of Digital LMIS tools (only for digitalized tools); *Please rate each of LMIS tool based on their convivence as the per the listed criteria in each column (1=Very less convenient; 2=Less Convenient 3= Medium; 4=convenient 5= Very convenient)*

SN	LMIS Tools	Easy to fill data (User Friendly) (1-5)	Included all essential data items (1-5)	Easy to aggregate data for analysis (1-5)	Easy for reporting (1-5)	Uniformity across units/ facilities (1-5)	Consistency with other records (1-5)	Less prone to error during recording (1-5)	It is not time consuming (1-5)	Interoperability with other e-LMIS (1-5)	Integration to other e-LMIS (1-5)
1.	Bin Card										
2.	Stock Card										
3.	IFRR										
4.	RRF										
5.	Model 19/H										
6.	Model 22/H										

Annex 5: Interviewer-Administered Questionnaire for EPI Focal Persons

ADDIS ABABA UNIVERSITY

COLLEGE OF HEALTH SCIENCE

SCHOOL OF PHRMACY

DEPARTMENT OF PHARMCEUTICS AND SOCIAL PHARMACY

Section I: Information Sheet and Informed Consent

Purpose: This a PhD study project designed to *evaluate and develop hypothetical model for the health commodities' logistics management information system (LMIS) in the public health system of Amhara region*. Your answers are very important and valuable to the successful completion of this study project. ***Please*** be honest in filling this questionnaire, as it will be used for improving the pharmaceutical supply chain system in the public sector. This survey will be confidential, anonymous, and data will be analyzed in aggregates. Even you are free to withdraw from the study at any time and there will not be any undue influence on you.

If you have any question, please do not hesitate to ask the data collectors or research coordinators at any time. If you need any further clarification, you can contact the following persons;

4) Zelalem Tilahun (Principal Investigator); +251923109539
5) Prof. Teferi Gedif (Primary Project Supervisor): +251911684854
6) IRB, CHS-AAU: chs.irb@aau.edu.et or +251913001278

Are you clear with all the information stated in the informed const section? (If no, discuss with the study coordinators/ data collectors)

If yes, would you please be willing to take part in this research project?

3) If yes, please proceed to the next section
4) If No, please kindly return the questionnaire for data collectors

Thank you

Section II: Socio-demographic Characteristics of Respondents

<u>**Instruction**</u>**:** Please encircle your answer or write on the provided space or tick in the box (☑)

SN	Question Items	Answers
1.	Code of Health Facility	
2.	Name of Health facility	

3.	Level of Health Facility	**1)** HC **2)** Primary Hospital **3)** General Hospital **4)** Referral Hospital
4.	Location of Health Facility	**1)** Urban **2)** Rural
5.	Gender	**1)** Male **2)** Female
6.	Age	__________________ Years
7.	Profession	**1)** Pharmacy **2)** Health Officer **3)** Nurse **4)** Midwifery **5)** Other, Specify_______________
8.	Highest level of education	**1)** MSc **2)** Bachelor Degree **3)** Diploma **4)** Certificate **5)** Others, Specify____________________
9.	Experience as EPI focal?	___________________Years

10. Did you get periodic written feedback about vaccines SCM/LMIS reports from higher levels?	**1)** Yes **2)** No
11. If yes for Q28, who provided the most recent periodic feedback?	**1)** WoHo **2)** ZHD **3)** RHB **4)** FMOH **5)** Partners, Specify____________________ **6)** Integrated, specify____________________

12. When did you receive the recent feedback about vaccines LMIS report?	**1)** within the last month **2)** (1-3] Months ago **3)** (3-6] months ago **4)** >6 Months ago **5)** Did not remember

1) What are the major challenges you faced related to Vaccine LMIS?

____

____

____

2) What are your recommendations to improve the Vaccine LMIS?

____

____

____

Additional points you want to add;

____

____

____

Thank you for the participation

Annex 6:Interviewer-Administered Questionnaire for Digital LMIS End Users

ADDIS ABABA UNIVERSITY

COLLEGE OF HEALTH SCIENCES

SCHOOL OF PHRMACY

DEPARTMENT OF PHARMCEUTICS AND SOCIAL PHARMACY

Section I: Information Sheet and Informed Consent

Purpose: This is a PhD study project designed to *evaluate and develop hypothetical model for the health commodities' logistics management information system (LMIS) in the public health system of Amhara region*. Your answers are very important and valuable to the successful completion of this study project. ***Please*** be honest in filling this questionnaire, as it will be used for improving the pharmaceutical supply chain system in the public sector. This survey will be confidential, anonymous, and data will be analyzed in aggregates. You are free to withdraw from the study at any time and if you are not comfortable in any one of the questions, you are not obliged to answer it.

If you have any question, please do not hesitate to ask the data collectors or research coordinators at any time. If you need any further clarification, you can contact the following persons;

1) Zelalem Tilahun Mekonen (Principal Investigator); +251923109539
2) Prof. Teferi Gedif Fenta (Primary Project Supervisor): +251911684854
3) IRB, CHS-AAU: chs.irb@aau.edu.et or +251913001278

Are you clear with all the information stated above? (If no, discuss with the study coordinators/ data collectors)

If yes, would you please be willing to take part in this research project?

1) If yes, please proceed to the next section
2) If no, please kindly return the questionnaire for data collectors

Thank you

Participants;

- Store Managers managing HCMIS (Dagu)

Section II: Frequency of use for HCMIS features

Instruction: *First, request the store managers to open the HCMIS database. Then, ask the store manager who is frequently managing the database. (If it is managed by more than one person, allow them to fill independently)*

SN	HCMIS Functions		Frequency of use		
		Never used	**Sometimes**	**Mostly**	**Always**
	Activity Log				
1.	Receive				
2.	Issue				
3.	Loss/Adjustment				
4.	Inventory				
5.	Stock transfer				
	Transactions				
6.	Model 19/H				
7.	Model 22/H				
	Reports				
8.	Stock status report				
9.	Overstocked items report				
10.	Stock out items report				
11.	Near expiry report				
12.	Expired products report				
13.	HPMRR				
14.	IFRR				
15.	RRF				
16.	Loss /adjustment report				
17.	Cost report				
18.	Consumption trend				
19.	Consumption trend by dispensary unit report				
20.	AMC report				
21.	Price only report				
22.	Electronic bin card				
	Summary reports				
23.	Stock status summary				
24.	Receive summary				
25.	Issue summary				
26.	Stock expiry summary				
27.	Cost summary				
	What functions do you recommend for addition?				

Section III: Level of agreement for HCMIS related items

Instruction: *Ask the store manager who is frequently managing the HCMIS database to fill this section (If it is managed by more than one person, allow them to fill independently)*
*(**SDA**=Strongly Disagree; **DA**=Disagree; **N**=Neutral; **SA**=Strongly Agree; **NA**=Not applicable)*

SN	*Items*	*Level of Agreement*				
		SDA (1)	***DA (2)***	***N (3)***	***A (4)***	***SA (5)***
	Database features					
1.	The software is adaptable to the working environment					
2.	The HCMIS contains all the features necessary for health commodities LMIS					
3.	The HCMIS benefit/improve the facility LMIS performance					
4.	The HCMIS allows to add/delete new/outdated items					
5.	It is important to add other features helping for facilitating the transaction and reporting process					
6.	The system set up can prevent, detect and mitigate the effects of viruses, malware, and other harmful software?					
7.	The system access is limited to only authorized individuals?					
8.	There is no risk of the data being corrupted					
9.	Error in transaction carried out by the system doesn't result performance problem					
10.	The database has data back-up system that ensures easier retrieval of data					
11.	HCMIS can work offline					
12.	HCMIS is compatible with the available computers and Windows operating systems					
13.	The system able to provide the information in an electronic format (e.g. Excel file, .csv, pdf, xml or similar data extract)?					
14.	The system able to produce an accurate and complete copy of the records on paper					
15.	The data base is linked with higher levels (*WoHO, ZHD, RHB, EPSA, FMOH*) (real time end to end data visibility)					
16.	The database system is easily interoperable (share data) to other health information systems (eg. DHIS-2) and other logistics information systems					
17.	The database has approval system for pharmaceutical transactions					
	Health system support					
18.	There is regular support from higher government offices (*FMOH, EPSA, RHB, ZHD, WOHO)*					
19.	There is regular technical support from partners					
20.	There is regular monitoring and evaluation system					

21.	The reported data is interpreted and used by suppliers for logistics activates like forecasting, distribution, procurement					
	Organizational support					
22.	The information system fits well with the working practices					
23.	Management involvement and support is in place					
24.	Computer is always accessible for operating the HCMIS					
25.	The capacity of the computer is enough to export reports from the HCMIS					
26.	Access to electricity supply doesn't interrupt the ongoing job by the HCMIS					
27.	The computer has access to reliable internet connectivity					
28.	The data presented is always used by decision makers					
29.	There is enough qualified staff who can manage the operation of the system					
30.	The data is useful for activities and reporting					
31.	The cost of maintaining and upgrading the system is low					
	Technical skills					
32.	Staffs are efficient to use the HCMIS					
33.	Staffs have good computer skill to use HCMIS					
34.	Staffs are well trained and have enough knowledge to operate the HCMIS					
35.	The computer has access to reliable internet connectivity					
36.	The data presented is always used by decision makers					
37.	There is enough qualified staff who can manage the operation of the system					
38.	The data is useful for activities and reporting					
39.	The cost of maintaining and upgrading the system is low					
	Technical skills					
40.	Staffs are efficient to use the HCMIS					
41.	Staffs have good computer skill to use HCMIS					
42.	Staffs are well trained and have enough knowledge to operate the HCMIS					

1. What are the major challenges you faced related with HCMIS (DAGU Version)?
____
____

2. What are your recommendations to improve the HCMIS?

____

____

Thank you very much!

Annex 7:Guiding Questions for Key Informant Interview

ADDIS ABABA UNIVERSITY

COLLEGE OF HEALTH SCIENCE

SCHOOL OF PHRMACY

DEPARTMENT OF PHARMCEUTICS AND SOCIAL PHARMACY

Section I: Information Sheet

I want to thank you for being volunteer for the interview. My name is ……………………… I am working with the research team of the Department of Pharmaceutics and Social Pharmacy, School of Pharmacy, Addis Ababa University. First of all, let me introduce about the study and its purpose;

Introduction: Access to essential medicines is part of the human right and it is one of the most pressing global health issues. Hence, the supply chain system of health commodities is a critical component of the health care system. The effectiveness of the major activities in the health supply chain management system are highly dependent on the availability of real-time information. A well-designed logistics management information system (LMIS) is a critical backbone for the healthcare system.

Purpose: This is a PhD study project designed to *evaluate and develop hypothetical model for the health commodities' logistics management information system (LMIS) in the public health system of Amhara region*. Assessing the strengths and weaknesses of the current health commodities' logistics management information systems implemented in Amhara Region, and identifying the common requirements/features for LMIS and developing a hypothetical model will have a paramount importance for Amhara Regional Health Bureau, Federal Ministry of Health, EPSS and other stakeholders working in the area. The findings from this study will be used as an input to improve the LMIS system in public health facilities.

Section II: Informed Consent form

Dear participant, in this specific interview, we will focus on logistics management information system related issues. The discussion may take half an hour. All responses will be kept confidential. This means we will ensure that any information we include in our report does not identify you as the respondent. The data will be analyzed in aggregate. Remember, you don’t have to talk about anything you don’t want to and you may withdraw from the interview at any time. Are you willing to participate in this interview? Yes □ No □

Can I get your consent to audio record the interview? Yes □ No □

If yes, the interview will be continued

List of Key informants;

- Hospital CEO/CCO/ HC Head
- Pharmacy Head
- Woreda SCM Coordinator

አዲስ አበባ ዩኒቨርሲቲ

የጤና ሳይንስ ኮሌጅ

የፋርማሲ ትምህርት ቤት

የፋርማሲዩቲክስና የሶሻል ፋርማሲ ዲፓርትመንት

ክፍል I: ስለ ጥናቱ የሚሰጥ ቅፅ

በቅድሚያ በቃለመጠይቁ ለመሳተፍ ፍቃደኛ ስለሆናችሁ አመሰግናለሁ፡፡ ስሜ………………..ይባላል፡፡

በአሁኑ ሰዓት ከአዲስ አበባ ዩኒቨርሲቲ የፋርማሲ ትምህርት ቤት ውስጥ ካለው የፋርማሲዩቲክስና የሶሻል ፋርማሲ ዲፓርትመንት የጥናት ቡድን ጋር አብሬ እየሰራሁ ነው፡ በቅድሚያ ስለጥናቱና ምንነትና ዓላማ ገለፃ ላድርግላችሁ፤

መግቢያ፡ ህይወት አድን የሆኑ መድሃኒቶች ተደራሽነት የሰብዓዊ መብቶች አንድ አካል ሲሆን በአለምአቀፍ ደረጃም በጣም አስፈላጊ ከሆኑ የጤና ጉዳዮች አንዱ ነው፡ በመሆኑም የጤና ግባቶች አቅርቦት ሰንሰለት አስተዳደር በጣም ወሳኝ ከሆኑ የጤና ስርዓት መዋቅሮች ውስጥ አንዱነው፡ የጤና ግባቶች አቅርቦት ሰንሰለት አስተዳደር ውጤታማነት በወቅታዊና ታማኝነት ባለው የሚረጃ ስርዓት ላይ በእጅጉ የተወሰነ ነው፡ በአግባቡ የተዋቀረ የሎጅስቲክስ የሚረጃ አስተዳደር ስርዓት ለጤና አገልግሎት ስርዓቱ ዋና የጀርባ አጥንት ነው፡

የጥናቱ ዓላማ ይህ የጥናት ፕሮጀክት የሶስተኛ ዲግሪ መመረቂያ ፅሁፍ ሲሆን የጥናቱ ዋና ዓላማበአማራ ክልል የመንግስት ጤና ተቋማት ላይ ያለውን የሎጅስቲክስ የሚረጃ አስተዳደር ስርዓት ማምገም ከጥናቱ በመነሳት አዲስ የሎጅስቲክስ የሚረጃ አስተዳደር ስርዓት መንደፍ ነው፡ አሁን በአማራ ጤና ስርዓት ያለውን የሎጅስቲክስ የሚረጃ አስተዳደር ስርዓት ጥንካሬና ድክመት ማጥናት፤ የሎጅስቲክስ የሚረጃ አስተዳደር ስርዓት ማነፈርቶችን ማየትና አዲስ የሎጅስቲክስ የሚረጃ አስተዳደር ስርዓት መንደፍ ለክልሉ ጤና ቢሮ፣ ለጤና ሚኒስቴር፣ ለኢትዮጵያ መድሃኒት አቅርቦት አግልግሎትና በዘርፉ ለሚሰሩ ባለድርሻ አካላት ከፍተኛ ጠቀሜታ ይኖረዋል፡፡ የዚህ ጥናት ውጤቶች በመንግስት ተቋማት ያለውን የሎጅስቲክስ የሚረጃ አስተዳደር ስርዓት ለማሻሻል አንደ ግባት ይጠቅማሉ፡፡

ክፍል II፡ ፈቃደኝነት የማጠየቂያ ቅፅ

የተከበሩ ተሳታፊያችን፤ በዚህ ጥናት በሚኖረን ቃለ-መጠይቅ የምናተኩረው የሎጅስቲክስ የሚረጃ አስተዳደር ስርዓትን በተመለከተ የሚያተኩሩ ጉዳዮች ላይ ነው፡ ቃለ-መጠይቁ ግማሽ ሠዓት ሊጨርስብን ይችላል፡፡ ለሁሉምተሳታፊዎች ሚስጢራዊነቱ የተጠበቀ ነው፡ ይህምማለት ማንኛውም በጥናቱ ሪፖርት የሚካተት ሚረጃ የግለሰቦችን ማንነት አያሳይም ማለት ነው፡ ጥናቱ የሚካነተነውበጥቅል ነው፡ መናገር የማይፈልጉትን ነገር መናገር አይጠበቅበዎትም፤

እንዲሁም ከጥናቱ ውይይት በማንኛውም ሠዓት አቋርጠው መውጣት እንደሚችሉ ማሳሰብ እንወዳለን፡ ፡

በጥናቱ ለማሳተፍ ፈቃደኛ ነዎት? ሀ) አዎ ለ) አይደለሁም

ቃለ-ማጠይቁን በድምፅ ለመቅረፅ ፈቃድ ማግኘት እችላለሁ? ሀ) አዎ ለ) አይደለሁም

ተሳታፊውፈቃደኛ ከሆኑ ውይይቱምመቅረፀ-ድምፁምይቀጥላል፡ ፡

Section III: Background information of the key informants

2. Working Institution____________________

   Location: Zone________________ City/Town______________Woreda______________

3. Age in years ______________________
4. Sex Male ☐ Female ☐
5. Profession ________________________
6. Highest level of education _______________________
7. Total Work experience __________________________
8. Current position in the institution _______________
9. Work experience in the current position ___________

Section IV: Guiding questions for interview

1. How is the current pharmaceutical supply chain performance in your institution /Woreda?
2. How is the performance of logistics management information system (LMIS) in your institution/Woreda?
    - Availability of LMIS tools
    - Data Quality
    - Reporting and Feedback
    - Digitalization
    - Infrastructure
3. What are the strengths and weaknesses of health commodities' logistics management information systems implemented in your facility/Woreda?
4. What are the main challenges related with the logistics management information system of the public health system?

5. What do you suggest to improve health commodities' logistics management information system of the public health system?
6. Is there anything you would like to add?

____

____

Thank you for your time and cooperation

Ethical Approval Letters

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አዲስ አበባ ዩኒቨርሲቲ
Addis Ababa University

School of Pharmacy
Ethical Review Committee

ቀን
Date January 31, 2022

ቁጥር
Ref. No. ERB/SOP/399/14/2022

To: **Zelalem Tilahun Mekonen**
School of Pharmacy

Re: Ethical Clearance

It is to be recalled that you submitted a research proposal entitled "**Performance Evaluation and Hypothetical Model Development for Health Commodities' Logistics Management Information System (LMIS): The Case of Amhara Region, Ethiopia**". The committee thoroughly reviewed the proposal based on its operational guidelines and found that it fulfills all the ethical requirements stipulated in the guidelines. This is, therefore, to inform you that the proposal is ethically approved for implementation.

With best regards,

Shemsu Umer (PhD)
Chairperson, ERC
School of Pharmacy
College of Health Sciences
Addis Ababa University

አዲስ አበባ ዩኒቨርሲቲ
የፋርማሲ ት/ቤት
School of Pharmacy
Addis Ababa University

00251156 02 12 1176 ቴሌክስ Telex: 21205 ፋክስ Fax: 00251(11)1558566 ቴሌግራም Cable: AAUNIV

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Institutional Review Board

ANNEX 3
Form AAUMF 03-008

IRB's Decision

Meeting No: 02/2022 Meeting Date: February 23,2022
Protocol number: 007/22/SoP

Protocol Title: Performance Evaluation and Hypothetical Model Development for Health Commodities' Logistics Management Information System (LMIS): The Case of Amhara Region, Ethiopia	
Principal Investigator:	Zelalem Tilahun
Institute:	College of Health Sciences, AAU
Elements Reviewed (AAUMF 01-008)	☑ Attached ☐ Not attached
Review of Revised Application ☐ Yes ☐ No	Date of Previous review:
Decision of the meeting:	☑ Approved ☐ Approved with Recommendation ☐ Resubmission ☐ Disapproved

I. Elements approved-
1. Protocol Version No: 2
2. Protocol Version Date:
3. Informed consent Version No. 2
4. Informed Consent Version Date:

II. Obligations of the PI-
1. Should comply with the standard international & national scientific and ethical guidelines
2. All amendments and changes made in protocol and consent form needs IRB approval
3. The PI should report SAE within 10 days of the event
4. End of the study, including manuscripts and thesis works should be reported to the IRB
5. The PI should report non-compliance and unanticipated events

III. TO NERC ☐

Institution Review Board (IRB) Approval: Period from: March 07, 2022 to March 06, 2023
Follow up report expected in 3 Months ___ 6 months ___ 9 months ✔ one year ___

Chairperson, IRB
Dr. Adamu Addissie

Signature
Date: March 07/2022

Institutional Review Board Office (IRB)
ADDIS ABABA UNIVERSITY

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Institutional Review Board

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Form AAUMF 03-008

IRB's Decision

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Principal Investigator:	Zelalem Tilahun	
Institute:	College of Health Sciences, AAU	
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Review of Revised Application ☐ Yes ☐ No	Date of Previous review:	
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Dr. Adamu Addissie
Signature
Date: March 07, 2022

Institutional Review Board Office (IRB)
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Addis Ababa University
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በፋርማሲ ት/ቤት
የፋርማሲዩቲክስና ሶሻል ፋርማሲ
ትምህርት ክፍል

School of Pharmacy
Department of Pharmaceutics
and Social Pharmacy

ቀን : የካቲት 29 ቀን 2014 ዓ.ም
Date
ቁጥር: ፋር/ሲ.ዩ.ቲ.ክስ/276/14/2022
Ref.No

ለአማራ ህብረተሰብ ጤና ኢንስቲትዩት

ጉዳዩ፡ ትብብርን ይመለከታል

በአዲስ አበባ ዩኒቨርሲቲ ጤና ሳይንስ ኮሌጅ በፋርማሲ ትምህርት ቤት የ3ኛ ዓመት የሶሻል እና አድሚንስትሬቲቭ ፋርማሲ ፕሮግራም የሶስተኛ ዲግሪ (ፒ.ኤች.ዲ) ተማሪ የሆኑት አቶ ዘላለም ጥላሁን መኮንን "Performance Evaluation and Hypothetical Model Development for Health Commodities' Logistics Management Information System(LMIS): the Case of Amhara Region,Ethiopia" በሚል ርዕስ በአማራ ክልል በሚገኙ የመንግስት ጤና ተቋማት ላይ ጥናት ለመስራት ዝግጅታቸውን ስለጨረሱ፣በእናንተ በኩል አስፈላጊውን ትብብር ይደረግላቸው ዘንድ በትህትና እንጠይቃለን። ለመማር ማስተማር ስራችን ለምታደርጉት በጎአስተዋጽኦ ከልብ እናመሰግናለን። (የአዲስ አባባ ዩኒቨርሲቲ ጤና ሳይንስ ኮሌጅ ፣የስነ-ምግባር መርማሪ ቦርድ (Institutional Review Board) የጥናቱን ፕሮፖዛል ያፀደቀበት ደብዳቤ (Protocol No: 007/22/SoP) ኮፒ ተያይዟል)

ከሰላምታ ጋር

ገብረማርያም ብርሃኑ (ዶ/ር)
የፋርማሲዩቲክስና ሶሻል ፋርማሲ
ትምህርት ክፍል ኃላፊ

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