thesis

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Submission date: 24-Jan-2024 04:23PM (UTC+0300)
Submission ID: 2265057585
File name: Mobile_Based_vLMIS_Thesis_Final_2023-Nigus.docx (439.44K)
Word count: 13918
Character count: 78436

COLLEGE OF HEALTH SCIENCES

SCHOOL OF PHARMACY

DEPARTMENT OF PHARMACEUTICS AND SOCIAL PHARMACY

Assessment of Mobile-Based Vaccine Logistics Management Information System (vLMIS) Implementation in Public Health Facilities of Gambella Region, Southwest Ethiopia

By

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September 2023

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Assessment of Mobile-Based Vaccine Logistics Management Information System Implementation in Public Health Facilities of Gambella Region, Southwest Ethiopia

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A thesis paper submitted to Addis Ababa University, College of Health Sciences, School of Pharmacy, Department of Pharmaceutics and Social Pharmacy in partial fulfillment of the requirements for the Degree of Master of Sciences in Health Supply Chain Management

September 2023

Addis Ababa, Ethiopia

Addis Ababa University

School of Graduate Studies

This is to certify that the thesis prepared by Nigus Abebaw, entitle "**Assessment of Mobile-Based Vaccine Logistics Management Information System (vLMIS) Implementation in Public Health Facilities of Gambella Region, Southwest Ethiopia"** and submitted in partial fulfillment of the requirements for the Degree of Master of Science in Health Supply Chain Management complies of the regulation of the university and meets accepted standards with respect to originality and quality.

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Abstract

Background*: Ethiopia uses a combination of an integrated and interoperable information system to manage vaccines within Ethiopian Pharmaceuticals Supply Service's (EPSS) supply chain system. Lack of access to reliable and timely data visibility for decision-making and poor vaccine management and efficiency are the challenges in Ethiopia. The mobile-based vaccine logistics management information system-(mBrana) implemented throughout Ethiopia for vaccine logistics information and inventory management.*

Objective*: The aim of this study is to assess mobile-based vaccine logistics management information system implementation in public health facilities of Gambella Regional State.*

Method*: Cross-sectional study design with sequential explanatory mixed data collection methods used in the study. Eighteen health facilities covered in the study and 44 respondents selected through random sampling technique. The quantitative data was analyzed by using descriptive and inferential statistics. Qualitative data analyzed thematically.*

Results: *the analysis and reporting of mBrana has statistical significant effect on perceived usefulness(r=0.315, p=0.037) and usability(r=0.441, p=0.003) for informed decision making at five percent level. The quality of data with timeliness, completeness, and accuracy were 89%, 97%, and 90% respectively. The stock availability as compared with the past six months to the day of data collection visit was reduced 11.7%.*

The identified challenges for mBrana were administrative (lack of support, poor internet connection, phone damage, staff turnover, lack of ownership, low data package, electric power interruption) and technical challenges (skill gap, communication gap, system configuration challenge, lack of commitment, lack of skill transfer).

Conclusion**:** *Data use in mBrana level of agreement is high and has direct relation with perceived usefulness and usability of mBrana. The overall average data quality was 92%. Identified challenges were administrative and technical challenges. It is all important to give attention on boosting the availability vaccines via effective use of digital logistics management system like mBrana in all public health facilities of the region.*

Key terms: mBrana, vaccine logistics management information system, implementation

Acknowledgments

First, I would like to express my deepest gratitude to my advisor, Mr. Zelalem Tilahun for his goodwill, valuable support, guidance, and mentorship for the preparation of this thesis. Second, I am grateful to Ethiopian Pharmaceuticals Supply Service for financial support for this course. Third, I am sincerely grateful to my lovely family for their great support to my dreams. Fourth, I would like to thank the Gambella Regional Health Bureau, Woreda Health Offices and health facilities cooperation during the study. Finally yet importantly, I extend my gratitude to my colleagues and friends for their support in providing information while I prepared this thesis.

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Abbreviations/ Acronyms

ART	Antiretroviral Therapy
BCG	Bacille Calmatte Guerin vaccine
CRDM	Collaborative Requirement Development Methodology
CSCMP	Council of Supply Chain Management Professionals
DHS	Demographic and Health Survey
DTP-HepB-Hib	Diphtheria, Tetanus, Pertussis-Hepatitis B- Haemophilus influenza type b
eHealth	Electronic Health
eLMIS	Electronic Logistics Management Information System
EPI	Expanded Program on Immunization
EPSA	Ethiopian Pharmaceuticals Supply Agency
EPSS	Ethiopian Pharmaceuticals Supply Service
eVIN	Electronic Vaccine Intelligent Network
FMoH	Federal Ministry of Health
GVAP	Global Vaccine Action Plan
HCMIS	Health Commodities Management Information System
ICT	Information and Communication Technology
IPLS	Integrated Pharmaceuticals Logistics System
IPV	Inactivated Poliovirus Vaccine
JSI	John Snow Incorporated
KPIs	Key Performance Indicators
LIAT	Logistics Indicator Assessment Tool
LMICs	Low and Middle Income Countries
LMIS	Logistics Management Information System
MCV	Measles Containing Vaccine
mHealth	Mobile Health
MoHFW	Ministry of Health and Family Welfare
ODK	Open Data Kit
OPV	Oral Poliovirus Vaccine
PATH	Program for Appropriate Technology in Health

PCV	Pneumococcal Conjugate Vaccine
Rx	Treatment
SCM	Supply Chain Management
SIAPS	Systems for Improved Access to Pharmaceuticals and Services
SMS	Short Message Service- Text message
SPSS	Statistical Package for Social Sciences
TAM	Technology Acceptance Model
Td	Adsorbed Tetanus and Diphtheria
USAID	United States Agency for International Development
VIMS	Vaccine Information Management System
vLMIS	Vaccine Logistics Management Information System
VRF	Vaccine Report Form
WHO	World Health Organization
WoHO	Woreda Health Office

1. Introduction

1.1. Background of the study

A well-functioning Logistics Management Information Systems (LMIS) provides decision-makers throughout a supply chain with accurate, timely, and appropriate data (DELIVER, 2006). Paper-based LMISs are being replaced by digital applications used on cell phones, tablets, and computers, often linked to central databases and online dashboards that provide supply chain managers easy access to data (John Snow, 2017).

World health organization (WHO) defines digital health is rooted in electronic health (eHealth): "the use of information and communication technology (ICT) in support of health and health-related fields". Mobile health (mHealth) is a subset of eHealth that indicates: "the use of mobile wireless technologies for health" (WHO, 2019).

Mobile health (mHealth) is increasingly been adopted in low- and middle-income countries (LMICs) to improve data visibility and informed decision-making. Consequently, it helps to ensure the availability of health commodities in health facilities (Iwu *et al*., 2020).

Immunization supply chain started in Ethiopia in 1980 with six antigens and currently twelve vaccines introduced for the aim of reducing mortality and morbidity of children and mothers from vaccine-preventable diseases(FMOH, 2015). Vaccine supply chain has poor data quality and visibility at lower levels. It has also poor vaccine stock management and no adherence to stock level policy especially at Woreda and health facility level (FMOH, 2021).

To tackle the weakness, the mBrana mobile system is a locally developed system by John Snow, Inc. (JSI) together with Ethiopian Pharmaceuticals Supply Agency (EPSA) now called Ethiopian Pharmaceuticals Supply Service (EPSS) for vaccine logistics information and inventory management system in 2016 starting with 52 Woredas receiving vaccine supplies. mBrana is appropriate for the district and last-mile deployment in areas with reliable 2G or better mobile coverage (Global Fund, 2019).

mBrana has interoperability with other upstream logistics tools, including EPSS's management information system, allowing automatic ordering and also the syncing of data to the national FANOS supply chain dashboard, enhancing data visibility of district stock and of what is used at facilities(Steele, 2020).

1.2. Statement of the problem

The comprehensive multi-year plan 2016-2020 of Ethiopia's national expanded program on immunization (EPI) and Global vaccine action plan (GVAP) set coverage goals of 90% at the national level and 80% at the district level by 2020. The major barriers related to low immunization coverage in Ethiopia are unreliable data at the Woreda and health facility level, shortage of recording and reporting materials, limited capacity of EPI managers to conduct equity-focused data analysis and inadequate budget allocation for immunization programs. (FMOH, 2015 and WHO, 2011).

In the report of Ethiopia's mini Demographic and Health Survey (mini DHS) 2019, the basic vaccination coverage was relatively higher in urban areas (57.3%) as compared to rural areas (36.9%). From mini DHS 2019, the reported dropout rate from penta1 to penta3 and penta1 to MCV1 (Measles containing vaccine) was for national 20.2% and 23.2% for Gambella 15% and 25% respectively. The average vaccine coverage for all types of vaccines in Gambella region was 38.3%. The possible reason for missed opportunities could be stock out of the vaccine at the time of visit and workload on the care providers (min-DHS, 2019).

In the electronic vaccine intelligent network (eVIN) report of the government of India, digitalizing vaccine stock management system, challenges are the availability of functional computers (mobile phone), internet access, electricity supply, theft, and availability of data entry operators. The expected benefits of eVIN are to improve stock availability, real-time data visibility, reports, and strengthened health system (MoHFW, 2018).

The study done in rural Zambia on incentivized mHealth technology to monitor the vaccine supply chain showed 93.8% of the dose and engage the health workers in timely stock reporting practice (Lamanna and Byrne, 2019). This shows a higher reporting rate by using the mobile application logistics system and it needs means of real-time reporting of data.

The use of mobile technology in supply chain system allows low-end mobile phones to capture transactional data, track inventory, place orders, forecast demand, optimize inventory and generate demand analytics which implies the enhancement of vaccine coverage, reduction in morbidity and mortality from vaccine-preventable diseases in children and improve the health status of the whole population beginning with children. The uninterrupted supply of immunization commodities improves the health of children and the availability of the antigen is vital during the visit of children's mothers (Nanteza, 2011).

Ethiopia uses a combination of an integrated and interoperable information system to manage vaccines within Ethiopian Pharmaceuticals Supply Service's (EPSS) supply chain system. The system has upgraded to manage vaccines and deployed to cold rooms. The different stakeholders can access the data by using the FANOS dashboard. mBrana allows smooth supply chain management including electronic ordering being interoperable with upstream logistics (- central and regional hubs) to provide real-time data visibility (mBrana, 2017).

Based on the Integrated Pharmaceuticals Logistics System (IPLS) survey of EPSA, blank VRF availability is less than 40%, vaccine forecasting is mainly done based on target and population data not by logistics or consumption data due to the non-availability of real-time data, and low completeness of VRF report (EPSA, 2018).

Gambella regional state is one of the emerging regions in Ethiopia. The immunization coverage status is low (38.3%) even if the mobile-based vaccine stock management was implemented in all Woredas since 2017(mini DHS, 2019).

There is no study conducted to determine the visibility, use, and success of mobile-based vaccine logistics management information system (vLMIS) implementation in a country setting. In addition, no studies done on the effectiveness of mBrana application system in country level. Since mBrana used for vaccine logistics management for, reducing stock out and improving availability related to immunization coverage and dropout rates. Thus, the aim of the study is to evaluate the effectiveness and challenges of the mobile-based (mBrana) vaccine logistics management information system implementation in government health facilities of Gambella regional state.

1.3. Objectives

1.3.1. General Objective

The general objective of this study is to evaluate the effectiveness and challenges of the mobile-based vaccine logistics management information system (vLMIS) implementation in public health facilities of the Gambella region, Southwest Ethiopia, and to identify opportunities for enhancing vaccine coverage and stock management.

1.3.2. Specific Objectives

The specific objectives were as follows:

- To assess the current implementation status of mobile-based vaccine logistics management information system
- To evaluate the data quality and reliability of mBrana related vaccine logistics management information system
- To explore challenges faced during the implementation of mobile-based vaccine logistics management information system and identify the potential opportunities for improvement

1.4. Research Questions

- How effectively has the mobile-based vaccine logistics management information system been implemented in public health facilities of Gambella region?
- What is the quality and reliability of the data generated by the mBrana related vaccine logistics management information system?
- What are the main challenges encountered during the implementation of the mobile-based vaccine logistics management information system, and what opportunities exist for enhancing its functionality and impact?

2. Related Literature Review

2.1. Theoretical Literature Review

As stated in the Council of Supply Chain Management Professionals (CSCMP)-"*Supply Chain Management (SCM) encompasses the planning and management of all activities involved in sourcing and procurement…and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers"*. Basically, supply chain management integrates supply and demand management within and across companies. (USAID | DELIVER PROJECT, Task Order 1, 2011).

Logistics management is the subset of supply chain management. The operational logistics activities are selection, forecasting and supply planning, sourcing, shipping, warehousing and inventory management, transport management, and information (John Snow, 2017). Thus SCM is the sum of logistics management and collaboration and coordination of stakeholders to satisfy the end users by balancing supply and demand. The main purpose of supply chain management is to fulfil the six rights. Availing products or services in the right quantity, with the right quality and condition, at the right place with the right time and cost (Gunasekaran and Ngai, 2004). Health sector supply chain is a network of interconnected actors to ensure essential medicine availability that the community needs (John Snow, 2017).

Logistics Management Information System (LMIS) is collects, organize and report health commodity data to make informed decision for logistics managers at all levels. The right combination of person, process and technology is vital for effective LMIS. Experts should collect, record, analyze, manage data and use the processed data for decision at all level of supply chain. The LMIS should enable efficient business workflows of the logistics functions and activities such as quantification, warehousing, distribution management, requesting and reporting, monitoring and data (John Snow, 2017). Recent developments in Information Communication and Technology (ICT) needs the emerging of different systems to get better flow of material and information in organizations. This application of ICT in supply chain management is referred to electronic logistics system (PATH, 2010).

The LMIS should use the appropriate application which is feasible to deploy and sustain, and embraced by users at all supply chain levels. In logistics management, LMIS is considered as the heart of the logistics cycle. Since the logistics workers and managers can collect information for each process and analyze that information to get informed decisions for logistics activities and coordinate future actions (USAID | DELIVER PROJECT, Task Order 4, 2015).

The use of various health technologies in supply chain workflow is designed and digitized to improve the quality of care and efficiency. Now a days it is expanding in all countries of the world. Some of the developed digital solutions are point of service system, electronic LMIS, warehouse management system, transport management system, distribution planning system, enterprise resource planning, barcode technology, and remote temperature monitoring system for last mile delivery of health commodities (John Snow, 2017).

The digitizing of the LMIS via electronic LMIS (eLMIS) solution is important to enhance the end to end visibility of the logistics data. And also improves the whole supply chain efficiency and reduces the total supply chain operation costs (Mwencha *et al*., 2017).

For the effectiveness of an eLMIS is influenced by different factors to ensure smooth design and implementation. The main factors are technical, administrative, customization and adaptation, implementation related factors. Technical factors are about the information system architecture and system interoperability. Administrative factors include the availability of skilled persons, the participation of key stakeholders, finances, ownership through user involvement, and staff motivation esteems in LMIS activities. The eLMIS implementation factors are adherence to guidelines and standard operating procedures, giving feedback to users, training, onsite supervision and monitoring of the system status to maintain reliability and validity to meet user's needs (Chindove and Mdege, 2012).

Some of the common eLMIS challenges in low-resource setting countries of health minister are lack of adequate knowledge and skills. These hinders the eLMIS is how designed and implemented that fits the requirements of supply chain and inadequate resources for structural, resource, and organizational support such as workforce and budget (SIAPS, 2018).

In an eLMIS, the digital device take the place of people in aggregating logistics data to perform calculations, producing reports and graphs for analysis and decision (Deliver, 2006).

2.1.1. mBrana vLMIS Functionality

mBrana is a dynamic solution to support all aspects of vaccine supply management. The WoHO EPI coordinators use the software to check stock levels, order and receive vaccines from EPSS hub as well as issue to health facilities. The other key features include:

- Electronic vaccine request form (eVRF) generation and submission to EPSS hubs
- Electronic Bin Card feature allows seeing stock status at anytime, anywhere to track batch numbers and expiry dates.
- Order management to track and trace the status of VRF
- Robust reporting for decision making, and
- Interoperability with Vitas and FANOS, allowing managers at any level of the supply chain in any facility to have full visibility to vaccine pipeline(FMoH, 2022)

2.1.2. mBrana Data Usage

mBrana is one of the supply chain system that shows end to end visibility of supply chain data to make informed decisions and take effective action. Logistics in each level starts with a basic set of LMIS forms and reports and evolve to digital tools to enter, record, report, analyze, and display supply chain data (John Snow, 2017).

An eLMIS has a comprehensive system to facilitate and optimize the selection and collection essential data used for end to end visibility and informed decision making (John Snow, 2017).

The end to end visibility is the flow of data from upstream and downstream of the supply chain for providing supply chain workforces at all levels to get the right information, of the right quality, at the right time. A paper system flows physical reports; a digital system flows electronic data that displayed on user interfaces and dashboards or other decision-support systems. Whether paper-based or digital, a reporting system must be in place to ensure that information flows correctly and consistently. However, eLMIS system can automatically capture report elements, if the eLMIS is also used for routine inventory control, and for opening balance, receipts, consumption, losses, or

adjustments that are recorded with every transaction (John Snow, 2017). The eLMIS is expected to improve data visibility by providing accurate, quality, and timely data (Mwencha *et al*., 2017).

2.1.3. vLMIS Data Quality

The purpose of vLMIS is to make informed decisions that will improve the health facility service by making effective monitoring and quality assurance. However, the quality of data is a challenge, there are specific procedures to improve the LMIS data quality. Such as designing and implementing simple standard tools, training the supply chain workforces, and motivational scheme to facilitate reporting and to triangulate reported data with other data sources, and digitalizing the information management processes (John Snow, 2017). Another important factor is data standards since issues such as different facility names in different systems; different reporting periods and different naming conventions for drugs have a significant impact on data quality. This could partly be solved with a more service-oriented approach to LMIS architecture (Bergum, 2017). Although both automated and manual tools can significantly improve the availability of logistics data, automated systems can result in more rapid availability of quality logistics data than manual systems due to real-time reporting and in-built system that can detect errors, missing data and simplify data checking (Fraser *et al*., 2005).

2.1.4. mBrana Information Flow

The vaccine distribution system in the country of Ethiopia from upper to downstream based on monthly targets, stock-outs, low stocks, and proximity to the district hub. Vaccines are pulled by recipient stores from central EPSS to hub quarterly and from hub to Woreda health offices, finally to service delivery points (hospitals, health centers, and health posts) on monthly basis (mBrana, 2017).

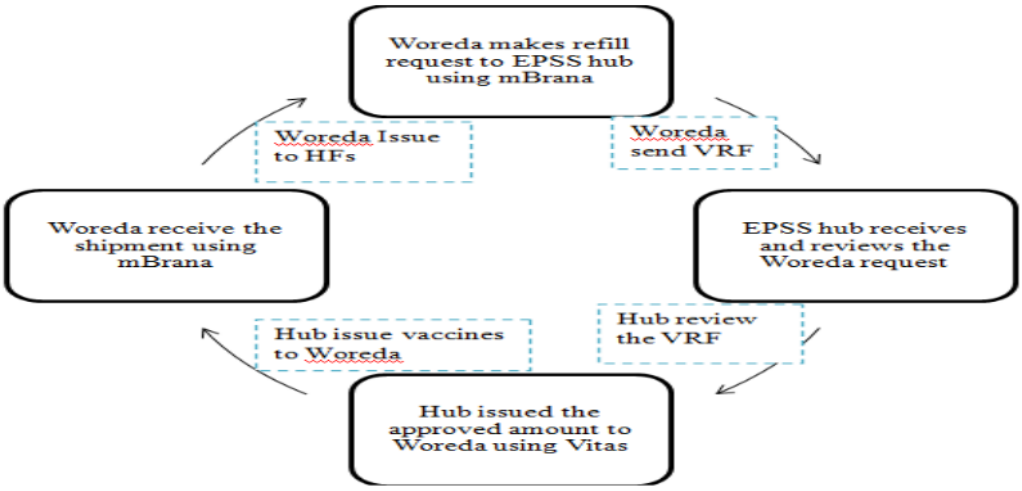

Figure2.1. mBrana information flow

2.2. Empirical Literature Review

The study conducted in Pakistan showed that the web-based vLMIS (vaccine LMIS) application has given managers, logisticians, and donors better visibility into the supply chain through a multilevel dashboard based on numerous key performance indicators (KPIs). It helps them make better decisions to ensure that vaccines are available for the population at all supply chain levels (the national, provincial, and district levels). The vLMIS enables authorized users at various locations to enter data and access vLMIS reports through a web browser (USAID | DELIVER PROJECT, 2016).

The other study conducted in Zambia and Tanzania, the central-level, web-based eLMIS interface with the ERP and WMS software used in each country, respectively. They help to process orders for delivery by the Medical Stores Department (MSD) in Tanzania and the Medical Stores Limited (MSL) in Zambia.

In Zambia, an offline eLMIS Facility Edition automates stock control cards and daily activity registers in public hospitals and health centers. The system automatically compiles and sends data via a web-based interface to the central eLMIS. The result is a reduced data collection burden on health facility workers and simplified end-of-the-month reporting and requisition process (USAID | DELIVER PROJECT, 2016).

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

Collection and reporting of logistics data tools be standard to get informed decision making on availability and quality of logistics data and availability of essential medicines including vaccines (Chindove and Mdege, 2012).

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

In Ethiopia, the eLMIS at facility (HCMIS Facility Edition-Dagu), the warehouse management system (HCMIS Warehouse-Vitas) and mBrana (vaccine logistics management) are helping health facilities to improve commodity management, data visibility, and overall performance. The system is user friendly users with various backgrounds, ranging from those with limited computing experience to advanced users and experts can use the system. The Vitas has given managers the ability to oversee and record deliveries and pickups, maintain inventory records, and track inventory location. They can use this detailed information to best manage their inventory at all times.

Web-based dashboards add the capability of visualizing the most updated data from all branch distribution locations to enhance decision-making. That is; forecasting, resupply, and inventory management decision are being made using data from stock status and demand reports to make decisions. The eLMIS (HCMIS Facility Edition-Dagu) gives facility manager visibility to every health commodity in their store. Users and managers can react quicker to changes in inventory and make more informed decisions about which products and how much of those products are needed to bring any facility up to adequate stock quantities, reducing the number and length of stock outs (USAID | DELIVER PROJECT, 2016).

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

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

The use of digital information systems to improve information and stock visibility, coupled with other interventions (such as training of health care workers on the use of innovative tools and redesign of the supply chain to tackle certain bottlenecks) have the potential to increase vaccine availability, reduce response times, and improve the quality of vaccine records (Iwu CJ et al, 2019).

2.3. Conceptual framework of the study

The study started by exploring many possible factors, which used by other researchers to assess the effectiveness of various information systems. Nshunju *et al* (2018) found five factors (perceived usefulness, system functionality, ease of learning, the usability of Vaccine Information Management System (VIMS), and analysis and reporting) and used them in assessing the model. Davis (2002) through the Technology Acceptance Model (TAM) measures of perceived usefulness and perceived ease of use were effective predictors for the success of an information system.

Mwencha et al (2017), constructed the conceptual framework for the management upgrade interventions for eLMIS interventions to bring about better supply chain outcomes through its

effect on improving reporting and data use (transparency, timeliness, visibility, and accessibility). Improved and streamlined supply chain management practices bring about better supply chain outcomes.

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

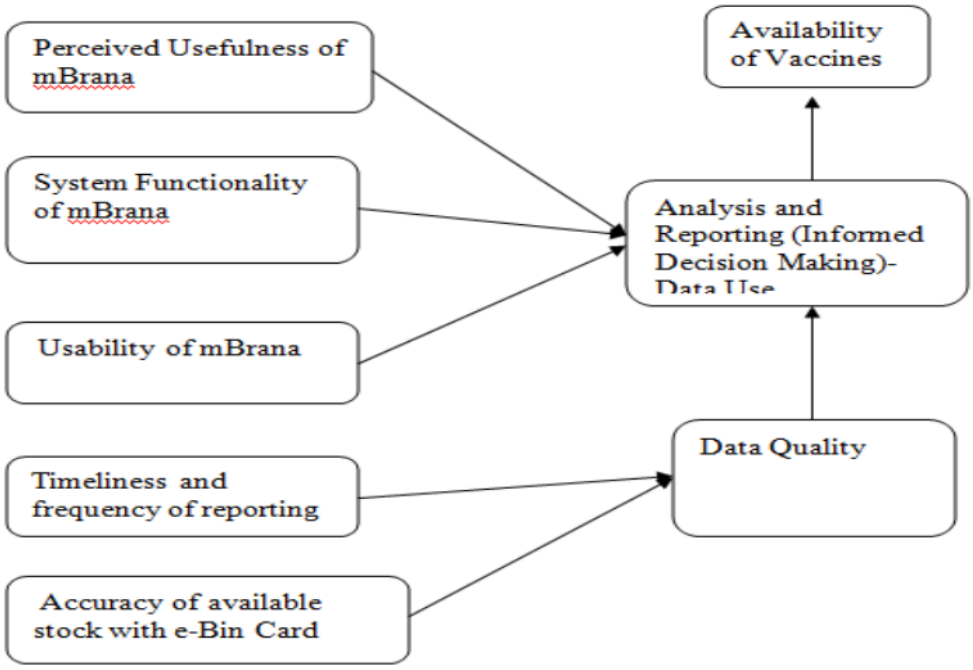

Figure2.2. a conceptual framework to measure the data use of mBrana vLMIS

Source: Nshunju *et al* (2018) and Mwencha et al (2017)

3. Methods and Materials

3.1. Description of the Study Area and Period

The study area was the public health administration and facilities found in the Gambella region which is located in Southwest Ethiopia. Gambella town is 766 kilometers far from Addis Ababa. Gambella is one of the eleventh regional states in Ethiopia with three zones and fourteen Woredas (one special Woreda, one town administration, and twelve Woredas) with a population of 514,330 according to the projection of the Central Statistics Agency (Ethiopia Central Statistical Agency, 2013). In the Gambella region, there are 14 Woredas, 5 hospitals, 29 health centers, and 142 health posts. The study conducted from January 01, 2022, to April 30, 2022.

3.2. Study design

A cross-sectional study design and mixed approach used in the study. According to Taherdoost (2022), sequential explanatory study design was used. Since the quantitative data were collected and analyzed in the first stage and then, the same processes are managed for qualitative data. The weighting on the quantitative data is more and the mixing process is based on the connection of both types of data within the separated forms. It occurs when the results of quantitative as the initial type informs the data collection of qualitative data. This method is employed when it is aimed to employ qualitative data as the follow-up for the initial quantitative results of method.

3.3. Source and Study Population

The health care workers in the health institutions of the region considered as the source population of the study. The study population of the study was Expanded Program on Immunization (EPI) coordinators, vaccine focal persons, and health care workers in study Woredas and health facilities who are involved in providing vaccinations and vaccination related services.

3.4. Eligibility Criteria

3.4.1. Inclusion Criteria

Since the mBrana system implemented in all Woreda health offices (WoHO) in the region, all Woredas were included in the study. Health facilities that receive vaccines and supplies from the nearest distributing EPSS hub directly include in the study because there is a direct exchange of logistics data. Thus, WoHO, hospitals, and health centers were included in the study.

Health care professionals and administrative units who manage vaccine commodities such as cold chain store manager, vaccine focal person, EPI coordinators, and vaccinators were included in the study since they are involved directly in the LMIS of the mBrana system.

3.4.2. Exclusion Criteria

Health facilities, which are not functional throughout the year due to seasonal condition, and those health facilities not directly delivered by EPSS hub (all health posts and seven health centers) excluded from the study.

3.5. Sampling Procedure and Sample size determination

For the quantitative study, the study covered all Woreda Health Offices (WoHO), hospitals, health centers, and the EPSS hub supplying the region.

The study was on mobile-based vLMIS implementation, and related to vaccine supply from EPSS to WoHO and health facilities. The data or information exchange is from supplier to receiver and vice versa.

By considering the eligibility criteria, the study (target) population was 14 WoHO, 5 hospitals, and 21 health centers totaled as 40.

In many situations, the margin of error and confidence level may be relaxed to allow for an attainable sample size. A more realistic margin of error and confidence level for a Logistics Indicators Assessment Tool (LIAT) showed that the 20% (+/- 10%) and 90% respectively. To get

representing sample size for the survey, it is the recommendation of the evaluators to set marginal error below 20% and confidence level above 90%. In addition to marginal error and level of confidence are selected, the other parameters are used to calculate the sample sizes (USAID /DELIVER PROJECT, Task Order1, 2011).

The general formula for calculating a sample size is:

$$n = \frac{t^2 \times p(1-p)}{m^2}$$

Where: n = required sample size

t = the value of the confidence level at 90% t= 1.64

p = Estimated prevalence of the indicator. (When p x (1-p) is maximum at p = 0.5. If the prevalence is not known, the 0.5 is used).

m = margin of error at 20%, m=0.2

$$n = \frac{t^2 \times p(1-p)}{m^2}$$

$$n = (1.64)^2 \times 0.5 \times (1-0.5) / (0.2)^2 = 16.81 = \mathbf{17}.$$

However, where there is a predetermined population (target population- N=40), since the target population was known, the finite population correction factor was used to calculate the new sample sizes. For this purpose, the new sample size is calculated as:

$$\text{New } n = \frac{n}{1 + [(n-1)/N]}$$

Where: New n = the adjusted new sample size N = the population size =40

n = the sample size obtained from the general formula=17

New n= 17/ (1+ ((17-1)/40) =**13**. With 10 percent error precision, 30 percent added for narrowing error. Add 30%: 13+13 x 0.3=16.9=**17**

Table3.1: Sample size determination of study health facilities

No.	**Study Facilities**	**Number of the facility**	**Sample Formula**	**Sample**	**%**
1	Woreda Health Office	14	14 x(17/40)	06	35.29%
2	Hospital	05	05 x(17/40)	02	11.76%
3	Health Center	21	21x(17/40)	09	52.94%
	Total	**40**		**17**	100%

The sampled health facilities were selected randomly first WoHO and the respective health facilities based on proportional allocation by the lottery method. In addition to 17 samples of WoHO and health facilities, the EPSS Gambella hub was also included in the study since the hub is the supplier of vaccine commodities. There is an exchange of vaccine logistics data among them. The participants expressed as follow:

Table3.2: Sampled Health Facilities

S.No	Study Facility	Sample	Number of Participant per facility	Total
1	Woreda Health Office	6	1	6
2	Hospital	2	3	6
3	Health Center	9	3	27
4	EPSS hub	1	5	5
Total				**44**

EPSS: Ethiopian Pharmaceuticals Supply Service

Therefore, the total sample size of respondents were the sum of all staff engaged in vaccine logistics data management implementation at the hub, WoHO, hospital, and health centers, which were **44**.

The vaccine logistics data and reports from selected health facility observed and evaluatedthe quality of data and reporting timelines and rates. The recording (Stock ledger) and reporting (VRF) tools selected from each sampled facility. One-year data, from January 01, 2021, to December 31, 2021 used for document review. Woreda health offices and health facilities are expected to submit their VRF to a higher level on monthly basis. Accordingly, the vaccine report forms of one year, that is, 12 VRFs and one ledger book from each facility was planned to review. The one-year VRF (17 x 12 = 204) and Stock ledger (17 x 1 =17) evaluated by using a data verification checklist (Annex 2).

For the qualitative study, purposively eight key informants selected from WoHO and EPSS hub for the complement of the quantitative study.

3.6. Data collection tools and techniques

Combinations of qualitative and quantitative tools used in the study. The data were collected by using a self-administrated questionnaire and an in-depth interview with key informants that will be designed after a preliminary observation on the practice of mBrana logistics data management. The questionnaire reviews the existence of all general functions and procedures that guarantee digital vLMIS implementation to be effective in achieving its goal (Annex 2).

For quantitative data collection, the structured questionnaires and data verification checklists adopted and modified from John Snow, Inc./USAID Deliver, WHO and literatures. For qualitative data collection, the semi-structured open-ended questions used for in-depth interviews of key informants from Woreda health offices and the supplier EPSS hub. Since mBrana vaccine, logistics management information system implementation intended to have an impact on immunization-related data at the Woreda and regional hub level. The mBrana applied in the Woreda health office. The Woreda served as the data verification checklist analysis center as compared to EPSS hub and selected health care facilities.

3.7. Study Variables

The study variables in this study are both dependent and independent.

3.7.1. Independent Variables

The independent variables are system functionality of mBrana, perceived usefulness of mBrana, usability of mBrana, timeliness and report frequency, accuracy and completeness of vLMIS, work experience, knowledge and skill on mBrana, administrative factors (network infrastructure, mobile device management, …) and technical factors .

3.7.2. Dependent Variable

The dependent variable is the effectiveness of mobile-based vaccine logistics management information system (analysis and reporting for informed decision), data quality and availability of vaccines.

3.8. Data Quality Assurance

3.8.1. Validity

Validity is the main extent to which a measurement is well founded and likely corresponds accurately to the real world. The research instrument was pre-tested before the final administration of questionnaires to 5% of the respondents. Pretest was conducted at randomly selected districts and health facilities, and that were not form part of the sample to establish if the respondents could answer the questions without difficulty. Peer review was done for qualitative data analysis. Appropriate modifications made accordingly to the findings of the pre-test. Continuous follow up was arranged to control the data collection procedures.

3.8.2. Reliability

Reliability is the consistency, stability, or dependability of the data. The internal consistency of reliability is measured by using Cronbach's alpha. Cronbach's alpha was calculated with application of Statistical Package for Social Sciences (SPSS) software for reliability analysis. It

qualifies the level of agreement on standardized 0 to 1 scale. Higher values indicate higher agreement between items. Taber, K. S. (2018) stated that common practice in science education to consider alpha reaching the somewhat arbitrary value of 0.70 as a sufficient measure of reliability or internal consistency of an instrument. The results on reliability presented in Table 2.1 below. All the study variables were found to have a Cronbach's alpha coefficient greater than 0.7 and thus they were all retained for further analysis.

Table3.3: Reliability test result, January, 2022 (n=44)

Variables	N of Items	Cronbach's Alpha
Perceived Usefulness	12	0.941
System Functionality	3	0.804
Usability of mBrana	14	0.906
Analysis and Reporting	6	0.850

3.9. Operational Definition of terms

Usability: The extent to which a product or system can be used by specified users to achieve specific goals with effectiveness, efficiency, and satisfaction in a specified context of use.

Data quality: it is the accuracy, completeness, and timeliness of logistics data.

Vitas: A platform designed to support logistics management information and warehouse management and inventory control. It starts functioning at the central warehouse and 19 regional hubs throughout Ethiopia.

Dagu: A platform designed to support logistics management information and inventory control at service delivery points by using systematic record keeping. This application provides service at more than 700 sites all over the country.

mBrana: A platform integrated with Vitas and other programs in EPSA that it uses to manage inventory from beginning to end. 'Brana' is the ancient Ethiopian system of record keeping.

eHealth: The use of information and communications technology (ICT) in support of health and health-related fields, including health care services, health surveillance, health literature, and health education, knowledge, and research. mHealth is a component of eHealth

Digital health: is the use of digital, mobile and wireless technologies to support the achievement of health objectives. Digital health describes the general use of information and communications technologies (ICT) for health and is inclusive of both mHealth and eHealth.

Mobile health (mHealth): is the use of mobile and wireless technologies to support the achievement of health objectives.

Effectiveness (Implementation status): The ability of a digital health intervention to achieve the intended results in real work (uncontrolled) setting (PATH, 2010).

3.10. Data Analysis, Interpretation and Dissemination

The data checked for completeness, clarity, and consistency by the principal investigator before entry into the statistical program and analysis. The data entered into Statistical Package for Social Sciences (SPSS) version 25 and analyzed using the same software.

The quantitative data were analyzed by using descriptive and inferential statistics. A descriptive statistics result presented in table with frequency, percentage, mean and standard deviation. Inferential statistics applied through correlation analysis based on the variable characteristics.

By using the five point Likert scale from strongly disagree (1) - strongly agree (5). Likert scale data can be analyzed as interval by using mean values. If the mean value is above or equal to 3.5, the level of agreement is high. If the mean value is between 2.5 and 3.49, then the level of agreement is medium. If the mean value is less than or equal to 2.49, then the level of agreement is low (Omary Z and Kalinga E, 2017).

The qualitative data by grouping responses analyzed thematically. The study findings will be disseminate to the Health Ministry of Ethiopia, Gambella regional health bureau, Woreda health offices, Partners, and EPSS. Moreover, it will be disseminate to the scientific community through conference presentation and publication.

3.11. Ethical Considerations

Ethical approval sought from the ethical review committee of School of Pharmacy, Addis Ababa University, and from the health facilities' Research Ethics Committee of Gambella Regional Health Bureau. Give a letter of permission obtained from the department of Pharmaceutics and Social pharmacy that was for all sampled health institutions. To ensure the confidentiality of the participant, informed consent was prepared and got acceptance before taking the study (Annex 1).

All the responses which were given by the participants and the results obtained was kept anonymous and confidential using a coding system whereby no one had access to their responses except principal investigator. The participants were informed verbally about how their confidentiality would keep and that they were free to withdraw from the interview at any time.

4. Results and Discussions

This chapter presents the findings, interpretations and discussions against results of literature reviews and study subjects.

4.1. General Information of the Study Participants

Out of the 44 respondents, 33(75%) were males and 11(25%) were females. The majority of the respondents hold a diploma levels at 31(70.5%), bachelor degree levels were 11(25%), postgraduate level was one (2.3%) and certificate level was one (2.3%) (Table4.1).

The result on work experiences of the study participants who have worked less than five years were 17(38.6%), between 5 to 10 years were 22(50%), between 11 to 15 years were 4(9.1%) and that who has worked 16 years and above was 1(2.3%). The study also sought to establish the positions held by the participants. The vaccine/EPI focal were 21(47.7%), EPI coordinators were 9(20.5%), store managers were 6(13.6%), vaccinators were 5(11.4%), WIM/DFM team leader was 1(2.3%), deliverer was 1(2.3%) and EPI officer was 1(2.3%) (Table4.1).

Table4.1: General information of the study participants in Gambella region, January, 2022 (n=44)

Characteristics	Frequency	Percent
Gender		
Male	33	75
Female	11	25
Educational level		
Certificate	1	2.3
Diploma	31	70.5
Degree	11	25.0
Post Graduate	1	2.3
Work experiences		
Less than five years	17	38.6

5-10 years	22	50.0
11-15 years	4	9.1
16 and above years	1	2.3
Position title or job role		
EPI Coordinator	9	20.5
Vaccine/EPI focal person	21	47.7
Store manager	6	13.6
Vaccinator	5	11.4
WIM/DFM team leader	1	2.3
Other Specify (Deliverer, EPI Officer)	2	4.5

Of the 44 participants, 27(61.4%) received mBrana training and 41% of the participants received both fresher and refresher trainings (Table4.2). The majority of the participants (56%) said they were somehow satisfied with the quality of training, but the 25(93%) of the participants said, they still needed additional training (Table4.2).

Among the respondents 11(42.3%) had an experience in mBrana system more than one year, 10(38.5%) had experience of between 6 months to one year and 5 (19.2%) had less than six months (Table4.2).

Table4.2: The training status of participants in mBrana, January, 2022

Characteristics	**Frequency**	**Percent**
Have you trained on the mBrana system?		
Yes	27	61.4
No	17	38.6
Which type of training did you receive?*		
Fresher training only	5	18.5
Refresher training only	11	40.7
Both fresher and refresher training	11	40.7

How would you rate the training you received?		
Unsatisfactory	4	14.8
Somehow satisfactory	15	55.6
Satisfactory	8	29.6
Do you think you need any additional training on mBrana?		
Yes	25	92.6
No	2	7.4
How long have you worked on this system?		
Less than six months	5	19.2
Six months to one year	10	38.5
Above one years	11	42.3

* Multiple responses was possible

4.2. Descriptive Analysis

Descriptive statistics provides the sample summary and measures of the study data. Percentages mean and standard deviations of the variables were extracted to describe all constructs in effectiveness of vaccine logistics data management implementation by using the mBrana system.

4.2.1. Perceived usefulness

Perceived usefulness is about the system's contribution in enhancing effectiveness, efficiency and stock management of vaccines by using the mobile application.

Means of variables extracted to enable exploration of the existence and importance of both the independent and dependent variables.

To assess the perceived usefulness of the mBrana system in health facilities, respondents were required to provide their opinions on 12 sets of questions. All the 12 statements have mean score of 3.84 and above that indicate the high level of agreement. The grand mean or the overall average score for the responses was compute as 4.081 with standard deviation of 0.958 (Table 4.3).

Table4.3: Level of agreement of participants on Perceived Usefulness of mBrana in Gambella region, January 2022 (N=44)

Item	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Mean	SD
Using mBrana saves time	2.3%	9.1%	13.6%	34.1%	40.9%	4.02	1.067
mBrana app meets my needs	4.5%	6.8%	4.5%	45.5%	38.6%	4.07	1.065
The mBrana can perform everything	0.0%	4.5%	9.1%	50.0%	36.4%	4.18	0.786
Stock out of vaccines easily predicts by it	0.0%	4.5%	11.4%	34.1%	50.0%	4.3	0.851
The system is easy to check data quality	2.3%	6.8%	9.1%	40.9%	40.9%	4.11	0.993
It allows auto-calculations	0.0%	6.8%	9.1%	47.7%	36.4%	4.14	0.852
The system takes less time to enter data	2.3%	4.5%	13.6%	38.6%	40.9%	4.11	0.97
mBrana links with a well performing supply chain	4.5%	6.8%	9.1%	43.2%	36.4%	4	1.078
mBrana helps to alleviate over and under stock	0.0%	4.5%	11.4%	36.4%	47.7%	4.27	0.845
The system used to produce stock status reports	2.3%	6.8%	11.4%	40.9%	38.6%	4.07	0.998
The data is protected and cannot be edited after approval	2.3%	6.8%	20.5%	45.5%	25.0%	3.84	0.963
mBrana prevents the non-complete report submission	2.3%	6.8%	25.0%	34.1%	31.8%	3.86	1.025
Average	**1.9%**	**6.2%**	**12.3%**	**40.9%**	**38.6%**	**4.081**	**0.958**

4.2.2. mBrana System Functionality

To assess the system functionality of the mBrana, vLMIS implementation in health facilities, respondents were required to provide their opinions on the three sets of questions. mBrana vLMIS is unstable and crashing many times had a mean score of 2.39 indicating low level of agreement. mBrana vLMIS allows offline data use and I do not aware of any data inconsistences as I use the mBrana, mean scores were 2.7 and 2.68 respectively indicating medium level of agreement (Table 4.4).

Table4.4: Level of agreement of participants on System Functionality of mBrana in Gambella region, January 2022

Item	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Mean	SD
mBrana vLMIS is unstable and crashing many times	31.8%	29.5%	15.9%	13.6%	9.1%	2.39	1.316
mBrana vLMIS allows offline data use	20.5%	34.1%	15.9%	13.6%	15.9%	2.7	1.374
I do not aware of any data inconsistences as I use the mBrana	18.2%	29.5%	25.0%	20.5%	6.8%	2.68	1.196
Average	**23.5%**	**31.0%**	**18.9%**	**15.9%**	**10.6%**	**2.590**	**1.295**

vLMIS:Vaccine logistics management information system

4.2.3. mBrana vLMIS Usability

To assess the usability of the mBrana system, respondents requested to give their opinions on the 14 sets of statements. Among the 14 statements, four of them using standard term, using the system frequently, user friendly and satisfying with it had a mean score of 3.5, 3.64, 3.59 and 3.66 indicating high level of agreement respectively. The remaining ten statements had mean scores of between 2.91 and 3.48 indicating medium level of agreements (Table 4.5).

Table4.5: Level of agreement of participants on Usability of mBrana vLMIS in Gambella region, January 2022 (N=44)

Item	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Mean	SD
I think that I would like to use this system frequently	9.1%	4.5%	25.0%	36.4%	25.0%	3.64	1.183
I found the system unnecessarily complex	9.1%	20.5%	29.5%	29.5%	11.4%	3.14	1.153
I found the various functions in this system were well-integrated	9.1%	6.8%	29.5%	36.4%	18.2%	3.48	1.151
I am fully assured in using the system	9.1%	9.1%	29.5%	36.4%	15.9%	3.41	1.148
I have faced difficulties using mBrana due to low connections	11.4%	11.4%	27.3%	25.0%	25.0%	3.41	1.3
mBrana vLMIS uses standard terminology throughout the system	2.3%	22.7%	20.5%	31.8%	22.7%	3.5	1.151
mBrana app is very reliable	4.5%	18.2%	22.7%	34.1%	20.5%	3.48	1.151
mBrana is user friendly	6.8%	11.4%	18.2%	43.2%	20.5%	3.59	1.148
mBrana vLMIS is easy to make correction	9.1%	20.5%	18.2%	29.5%	22.7%	3.36	1.296
I am pleased with mBrana system	4.5%	9.1%	29.5%	29.5%	27.3%	3.66	1.119
The staff member can easily locate the mBrana vLMIS portal	15.9%	25.0%	0.0%	36.4%	22.7%	3.25	1.465
The staff member can easily navigate of mBrana vLMIS	13.6%	29.5%	0.0%	34.1%	22.7%	3.23	1.445

The colleague can explain the data entry page	11.4%	40.9%	0.0%	25.0%	22.7%	3.07	1.437
They can generate report of the health facility by the time	22.7%	31.8%	0.0%	22.7%	22.7%	2.91	1.552
Average	**9.9%**	**18.7%**	**17.9%**	**32.1%**	**21.4%**	**3.37**	**1.26**

4.2.4. Analysis and Reporting (Informed Decision Making)

Respondents were asked on the analysis and reporting of the mBrana system for using in informed decision-making, among six set of statements, for making decision the dashboard is not very helpful had a mean score of 2.82 indicating medium level of agreement. The others five statements had a mean scores of between 3.61 and 3.93 indicating high level of agreement. The mean of mean or grand mean for reporting and analysis was 3.643 with the standard deviation of 1.103 (Table 4.6).

Table4.6: Level of agreement of respondents on Analysis and Reporting of mBrana in Gambella region, January 2022 (N=44)

Item	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Mean	SD
They can generate report of the health facility by the time	6.8%	6.8%	11.4%	43.2%	31.8%	3.86	1.153
mBrana vLMIS is easily generate and show trend reports	4.5%	4.5%	13.6%	47.7%	29.5%	3.93	1.021
It is easy to generate a report that shows data for multiple facilities	6.8%	4.5%	20.5%	43.2%	25.0%	3.75	1.102

For making decision the dashboard is not very helpful	18.2%	27.3%	15.9%	31.8%	6.8%	2.82	1.263
mBrana vLMIS shows quality reports to identify gaps	4.5%	6.8%	27.3%	45.5%	15.9%	3.61	0.993
mBrana vLMIS generated reports saves time	4.5%	6.8%	15.9%	40.9%	31.8%	3.89	1.083
Average	**7.6%**	**9.5%**	**17.4%**	**42.1%**	**23.5%**	**3.643**	**1.103**

4.2.5. Work experience and Data use

The relationship between work experience and data use was determined by cross tabulation. From Table4.7, one third of the participants have 5 to 10 years of experience with high level of data use.

Table4.7. the participant work experience with level of data use in Gambella region, January, 2022(N=44).

N=44		Analysis and reporting level of agreement			Total
		Low	Medium	High	
Work Experience	Less than five years	0%	9%	30%	39%
	5-10 years	7%	9%	**34%**	50%
	11-15 years	2%	0%	7%	9%
	16 years and above	0%	0%	2%	2%
Total		**9%**	**18%**	**73%**	**100%**

The relationship between work experience on mBrana and data use was determined by cross tabulation. From Table4.8, one third of the participants have more than one year of experience on

mBrana with high level of data use. Two third of the participants experience on mBrana was 67% with high level of data use increases.

Table4.8. the participant work experience on mBrana with level of data use in Gambella region, January, 2022(N=27).

N=27		Data use level of agreement			Total
		Low	Medium	High	
Work Experience on mBrana	Less than six months	0%	7%	**11%**	19%
	6 months to 1 year	11%	7%	**19%**	37%
	Above one years	4%	4%	**37%**	44%
Total		**15%**	**19%**	**67%**	**100%**

4.2.6. Availability of Vaccines

In this study, the availability of the routine vaccines on the day of visit and within six months prior to the study time measured. The overall availability of the eight vaccines is 99.2% (0.243) and 87.5 %(0.000) on the day of data collection and within six months prior to the study time respectively (Table4.10).

Average stock availability in the past six months is down by 11.7% when compared with that of the result on the day of data collection. The availability of the eight vaccines ranged from 87.5% to 100%. Only one vaccine stocked out in each assessed health facilities, BCG vaccine and PCV13 were the major once. Three facilities experienced BCG and PCV13 stocked out in three facilities.

Table4.9: Availability of the eight antigens in study facility of Gambella region (n=17), January 2022

S.No	Antigen (Vaccines)	Number of facility	Percent

1	BCG	16	94%
2	bOPV	17	100%
3	IPV	17	100%
4	Pentavalent	17	100%
5	PCV13	15	88%
6	Rota	17	100%
7	Measles	17	100%
8	Td	17	100%

Table4.10. Availability of the 8 vaccines on the day of data collection and within six months prior to the study time in health facilities of Gambella region, January 2022

Variables	Number	Percent
Availability of the 8 vaccines (antigens) on the day of data collection		
100%	16	94.1
85% to 99%	1	5.9
Mean (SD)		99.2 (0.243)
Minimum		87.5
Maximum		100
Availability of the 8 vaccines (antigens) within six months prior to the study		
85% to 99%	17	100
Mean (SD)		87.5(0.000)
Minimum		87.5
Maximum		87.5

4.3. Inferential Statistics

The dependent variables, analysis and reporting status of the system (AnRe) for decision-making and data quality compared with the independent variables of the study. The independent variables of the study include educational level, work experience, perceived usefulness (PU), system functionality (SF), usability of the system (US), and timeliness and accuracy of vLIMS. Spearman's correlation analysis undertook to explore relationships between the dependent and independent variables. Spearman correlation coefficient is a measure of linear association between two variables. Values of the correlation coefficient are always between -1 and +1. A correlation coefficient of (+1) indicates that the two variables are perfectly related in positive linear sense. A correlation coefficient of (-1) indicates that the two variables are perfectly related in a negative linear sense. A correlation coefficient of zero indicates that there is no linear relationship between the two variables.

Spearman's correlation analysis indicated that relationship exists between the analysis and reporting with that of perceived usefulness (r=0.315, p=0.037), system functionality (r=0.123, p=0.425) and usability of the system (r=0.441, p=0.003). The value of the Spearman's correlation coefficient for perceived usefulness and usability of the system are positive and their p values 0.037 and 0.003 are significant at 5 percent level.

Table4.11: The Spearman's correlation between dependent and independent variables, January 2022

Correlations (N=44)						
			PU	SF	US	AnRe
Spearman's rho	PU	Correlation Coefficient	1.000	0.190	.315*	.315*
		Sig. (2-tailed)		0.217	0.037	0.037
	SF	Correlation Coefficient	0.190	1.000	0.150	0.123
		Sig. (2-tailed)	0.217		0.330	0.425
	US	Correlation Coefficient	.315*	0.150	1.000	.441**
		Sig. (2-tailed)	0.037	0.330		0.003
	AnRe	Correlation Coefficient	.315*	0.123	.441**	1.000

	Sig. (2-tailed)	0.037	0.425	0.003

*. Correlation is significant at the 0.05 level (2-tailed). **. Correlation is significant at the 0.01 level (2-tailed). PU: Perceived Usefulness, SF: System Functionality, US: Usability, AnRe: Analysis and Reporting

4.4. Availability of vLMIS tools and Data Quality of mBrana

4.4.1. Availability of vLMIS tools

All study facilities maintained vaccine stock register, however 40% of them did not update it. Three facilities were not use VRF for vaccine requesting instead use letters (Table4.12).

Table4.12: Availability status of vLMIS tools at study facilities, January 2022.

S.No	vLMIS tools	Study Facilities (n=17)	
		Available (%)	Updated (%)
1	Vaccine Request Form /e-VRF	14 (82%)	14 (82%)
2	Vaccine stock register	17 (100%)	10 (59%)
3	Immunization monitoring chart	17 (100%)	8 (47%)
4	Temperature monitoring chart	10 (59%)	8 (47%)

4.4.2. Data Quality

Data quality in mBrana includes timeliness, completeness and accuracy of data generated from the system. Data quality calculated after cross checking the current balance of e-bin card or ledger book. The quality of data based on the timeliness, completeness and accuracy was 89%, 97% and 90% respectively. Woreda health office has better data quality as compared to hospital and health center. The overall data quality with the three parameters was 92% (Fig.4.1).

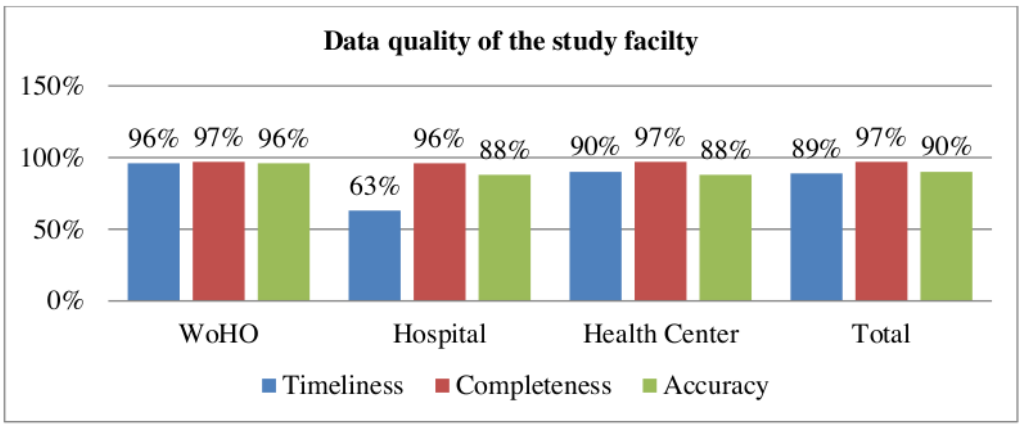

Figure4.1. Data quality status of the study facilities in Gambella region, 2022

4.5. Qualitative Analysis

A sequential explanatory mixed method approach applied in the study. The qualitative data collected by using interview guide for key informants (KI) from March to April 2022. Audio records of KIs interview was transcribed into the Amharic language verbatim and then translated to English. Themes identified and the data categorized and coded in those themes. Thematic analysis was applied to identify patterns and meaning in the data.

The study explored different aspects of vaccine logistics data management at public health facilities on the knowledge of mBrana, use to alleviate vaccine stock out, problems faced during using mBrana and how to alleviate the challenges(Annex 2). The findings are divided in to three main themes; the purpose and functioning of the mBrana system, the challenges of the mBrana system, and the recommendations to address identified challenges.

Theme1: The purpose and functioning of the mBrana system

The majority of the participants and Key Informants (KIs) have deep understanding about mBrana system with the purpose and functions of it. All the KIs explained the function of mBrana which used as a vaccine stock status reporting and requesting tool. One of the KIs expressed his feeling like this:

*"I took mBrana training and I have knowledge of the system how to use it. The system has receiving, issuing, VRF reporting pages and stock status pages. The receiving page shows the items that received and confirmed with physical invoice. The issuing page shows the issued vaccines to health centers and health posts. The VRF page shows the ordering and in process of antigens to supplying EPSS hub in monthly basis. The stock status page shows the current balance of the antigen with expiry and level of stocks." (*EPI focal, 33 year)

Another respondent also expressed his experience and knowledge with mBrana as follows:

"I took On the Job Training (OJT) for how to use the system by DHA field support. I use the application for vaccine stock management. Due to connection challenge sometimes the online VRF was not sent to EPSS hub instead I use telegram."(EPI focal of 32Year)

All of the KIs understand that mBrana system used for stock status monitoring of vaccines. One of the respondents expressed his feeling like this:

"...by using mBrana, the availability increases and stock out decreases. Using the system is better for the management of vaccine supplies. The system developer gives one GB internet package every month for sending order request to EPSS branch and to assess the stocks every time. " (EPI focal of 33 year)

*"It (mBrana) is the best application to increase antigen availability by reducing the lead time from ordering time to receiving time from EPSS. It is better for availability and stock management easily to know the stock status in daily basis. It is also better to request the antigen on time every month and issue to respective health centers." (*EPI focal of 36 year)

Theme2: The challenges of the mBrana system

The sub themes that emerged from the ineffectiveness of mBrana were administrative or organizational challenge (lack of support, poor internet connection, Phone damage, staff turnover, lack of ownership, low data package, electric power interruption) and technical challenges (skill gap, communication gap, system configuration challenge, lack of commitment, lack of skill transfer).

When participants asked if they have got basic training on how to use the mBrana application, some of them respond that they have not well trained. Knowledge was transfer to them from system developer and supporter of the government health system. One of the respondents expressed his feeling:

"I did not take mBrana training for how to use the system. I use the application for vaccine stock management."(EPI focal of 36 year)

There is trained staff turnover or staff rotation in the region. One of the respondents expressed his feeling:

"*Yes, the challenges are Connection problem, system configuration changed, damage of phone, No internet data package given, Communication gap due to staff turnover or rotation, and the system not retrieve historical data…"* (EPI focal of 38 year)

Poor connection strength is the major challenge that most of the respondents. One of the respondents expressed his feeling:

"*Yes, the connection problem-the system not use offline since it needs connection to do every transaction (stock status view, receiving and issuing to health center) and skill gap. Network connection is the most challenging."*(EPI focal of 32 year)

*"Yes, the challenge is connection problem due to this I send the e-VRF to EPSS hub in night time and by finding the place where wireless-fidelity (Wi-Fi) is available. Poor network connection is the most challenging."(*EPI focal of 36 year)

Theme3: Recommendations to address identified challenges

Suggestions to improve vaccine logistics management

One of the respondents expressed his feeling;

"*Continuous support and network upgrading to use the system perfectly and make informed decision."(*EPI focal of 33and 36 years)

"Strengthen the Network Connection and give refreshment training for the system". (EPI focal of 32and 38 years)

"Since mBrana apps always use internet data and if no connection, no transaction, so use offline tool like open data kit (ODK) to overcome the internet challenge" (EPI focal of 36 year)

4.6. Discussion

The effective use of mBrana system has a greater importance in the availability of communicable disease prevention vaccines in health facility. Over all to improve vLMIS data quality, the information collected and documented appropriately at the source. This study assessed mobile-based vaccine logistics management information system implementation in public health facilities at Woreda health office, hospitals and health centers. By asking self-administered questions, by reviewing some documents in vaccine data management, and using Key Informant deep interviews, vaccine logistics management information system implementation and challenges to data quality and system usage were explored.

Using VRF at service delivery points and administrative level is critical for the availability of vaccine, utilization and wastage status determination. Features of mBrana ordering by using VRF, receiving, issuing and stock status report and electronic Bin card are user friendly like eVIN in India. All health facilities have standard reporting format to compile reports from the registration book for service data. However, for logistics data reports, the Woredas use VRF both manual and electronic. Lack of proper guidelines for device management, loss and damage of mobile and replacement is challenging in this study and comply with other study reports in India (MoHWF, 2018).

A study done in Pakistan showed that 83.3% managers used data for decision making related to vaccine supplies, in this study showed high level of agreement of mean 3.643. 90% of the district store maintained vaccine stock register (Altaf *et al*., 2021) where as in this study 100% maintained and 59% were used.

The study done in Tanzania showed that 90% of respondents received the initial vaccine information management training and 63% of them were satisfied with the quality of training

received(Nshunju *et al*., 2018) where as in this study, 61% received the initial mBrana training and 56% of them were satisfied with the training.

The study done in South Africa, showed the novel alternative reporting portal by using 'Whatsapp'(Iwu *et al*., 2020)likewise in this study using 'ODK' as alternative reporting system.

The study done in Tanzania also showed that user responses on the use of VIMS were similar within this study in many aspects as mBrana vLMIS is easy and user friendly; allows auto calculations and can generate real time reports. It prevents submission of incomplete reports and makes it easy to detect reporting errors. It is important to make stock status management easier and provides dashboard displays of trends that help for informed decision-making.

The data quality in terms of timeliness, completeness and accuracy was 89%, 97% and 90% respectively. The overall data quality with the three parameters was 92% and it is above the national target-90%.

The availability of the eight vaccines ranged from 87.5% to 100%. This showed that non-availability of vaccines which increases non-vaccinated children in health facilities. The mBrana vLMIS has helped to trace the distribution of vaccines.

Poor internet connection was a challenge in this study like other system challenges in other studies(Nshunju *et al*., 2018) but it is a good system for data management including reporting, analysis and storage of data.

4.7. Limitation of the study

This study has certain limitations kept in mind before drawing any conclusions.

1. Only available descriptive results compared and comments on causality cannot based on this comparison.
2. Furthermore, it was not possible to control for confounders while selecting Woredas.
3. The data quality metrics only include the timeliness, completeness and accuracy of inventory data.
4. The mBrana application was not fully deploy in all health facilities only at Woreda level.

5. Conclusions and Recommendations

5.1. Conclusions

The perceived usefulness of mBrana had high level of agreement (mean=4.081 and SD=0.958). The mBrana application is user friendly. The system can easily show vaccine stock out, over stock and under stock. The functionality of the system is stable, consistent and it is not allow using the data offline. The staff members cannot access mBrana portals and cannot explain the features to generate reports.

Spearman's correlation analysis indicated that the analysis and reporting of mBrana has statistical significant effect on perceived usefulness(r=0.315, p=0.037) and usability(r=0.441, p=0.003) for informed decision making at five percent level. The quality of data with timeliness, completeness and accuracy was 89%, 97% and 90% respectively. The overall quality of data with the three parameters was 92%.

The possible factors that may have hinder mBrana effectiveness include unreliable internet connectivity, staff rotation, device damage, skill gap, negligence of the user, the use of both manual and electronic VRF leads duplicate data, lack of government ownership and lack of proper guidelines for device management and application usage.

Despite lack of evidence that mBrana usage resulted in data quality improvements, mBrana did integrate the existing tools and interoperable with VITAS and FANOS. It was well for users for easing the burden of data collection and management. With this mBrana brought fragmented vaccine logistics management information system in to one platform.

Users said mBrana is easy to use, streamline multiple functions, allows auto calculations and can generate real time reports, prevents submission of incomplete reports, makes it easy to detect reporting errors, is accessible anywhere with an internet connection, has the potential to make stock status monitoring easier, and helpful for decision making by using dashboard data.

One of the users expressed his feeling, as "*mBrana is the best system for vaccine logistics management compared to manual paper work. I have used since 2018, once data has been*

approved in mBrana, it cannot be changed and hence remains for as it is forever. So, mBrana is a very good application for data management including reporting, analysis and storage of data."

The overall availability of the eight vaccines is 99.2% (0.243) and 87.5 %(0.000) during the time visit and before six months to the study time respectively.

5.2. Recommendations

Based on the findings in this study, the following recommendations can be made for improving the mBrana system and implementation to maximize the benefit of future health outcome.

For Health Minister-Ethiopia

- Provide training for concerned body: Giving training for concerned body to get real time data that used for informed decision-making.
- Establishing accountability and ownership: The system have developed and deployed by JSI/ Digital Health Activity, health minister of Ethiopia should own the system and make guideline and direction for system and device management.
- Institutionalize the system for use at all levels and formalize clear tasks and responsibilities of mBrana users.

For Regional Health Bureau and EPSS hub

- Provide continuous and on the job training to mBrana users and focus on competency based training to build skills.
- End to end data visibility: It used to reduce stock out and wastage, and increase coverage by minimizing unvaccinated children and if all required data are availed, use consumption data based for forecasting rather target based forecasting.

For Health Facility and Woreda Health Office

- Using offline system: to overcome the connection challenge, make the system offline first and then synchronize the data wherever internet is available. Since vaccine availability is mandatory, the use of mBrana for requesting and receiving the vaccine is critical.

- All health facilities have standard reporting format to compile reports from the registration book for service data as well as for logistics data reports.
- Overall, availability of vaccines is improved by effective use of digital logistics management system like mBrana in all public health facilities of the region.

For Partners

- Support the system for end to end data visibility and use.
- Upgrade the connection strength and deploy the mBrana system for all health facility.

5.3. Area of Further research

This finding is a base for further research in vLMIS implementation in Ethiopia. The following are suggested potential areas for further studies.

- Since this is the first study, other research be done to know the effect of mBrana system with large coverage; similar studies can be expanded to explore related effectiveness of mBrana in public health facilities of Ethiopia.
- The study looked the logistics management information system implementation for vaccine in mobile based only. Similar study can be done to assess the effectiveness of mBrana with other system by cost effective analysis.

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Annexes

Annex 1: Information Sheet and Informed Consent Form (English)

Name of the Principal Investigator: Nigus Abebaw

Name of the organization: Addis Ababa University, College of Health Sciences, School of Pharmacy, Department of Pharmaceutics and Social Pharmacy, Health Supply Chain Management Program

Name of the Sponsor: Ethiopian Pharmaceuticals Supply Service (EPSS)

Introduction: the investigator whose main aim is to assess mobile-based vaccine logistics management information system (vLMIS) implementation in public health facilities of the Gambella region in Southwest Ethiopia prepares this information sheet and consent form. The investigator is a Master of Science (MSc) student in the Health Supply Chain Management Program.

Procedure: If you are willing to participate in the study, you need understand and give verbal consent or to give your agreement in words or to sign the consent form. Then, you will ask to give your response by the data collectors. All the responses which will be given by the participants and the results obtained will be kept anonymous and confidential using a coding system whereby no one will have access to your responses.

Risk and/or Discomfort: By participating in this research project, you may feel that it has some discomfort especially on wasting your time (**about 20-30 minutes**). There is no risk in participating in this research project.

Benefits: If you participate in this research project, you may not get the direct benefit but your participation is likely to help us in assessing the digital vLMIS outcome, challenges for the availability of vaccines, and immunization dropout.

Right to Refuse or Withdraw: You have the full right to refuse from participating in this research (you can choose not to respond to some or all the questions).

Persons to contact: Nigus Abebaw,

Phone: +251 917 10 60 17 or +251 921 28 87 52 **E-mail:** abebawnigus@gmail.com

You are asked if you are interested and willing to participate in the study. We would greatly appreciate your truthful and keen participation in responding to this questionnaire.

Yes I agree _____ No, I don't agree_____ Participants Signature_____

Thank you!

Annex 2: Questionnaires

Addis Ababa University

College of Health Sciences

School of Pharmacy

Department of Pharmaceutics and Social Pharmacy

MSc Program in Health Supply Chain Management

Dear Sir/ madam;

My name is Nigus Abebaw conducting a study "to assess mobile-based vaccine management information system implementation in public health facilities of Gambella region Southwest Ethiopia." The study believed to contribute to the understanding, monitoring, and evaluating the immunization implementation outcome, challenges for the availability of vaccines, and immunization dropout. Therefore, I am seeking your assistance to fill the questionnaires. The questionnaire will take about twenty to thirty minutes to complete. Participation in this study is voluntary, and all who participate will remain anonymous. Your name is not mandatory. All information offered is treated confidentially, and the results will be presented in such a way that no individuals may be recognized.

Thank you in advance for the available information you are sharing and the precious time you are going to spend on this purpose. If you have any inquiry, please do not hesitate to contact the researcher on:

•Email: abebawnigus@gmail.com

• Phone: +251 917 10 60 17 or +251 921 28 87 52 (Nigus Abebaw)

Section I: General Information

No.	Question	Coding categories	Codes	Skip to
1.1	Organization Name			
1.2	Sex of respondent	Male	1	
		Female	2	
1.3	Work experience in your current position?	Less than five years	1	
		5-10years	2	
		11-15years	3	

		Above 15 years	4	
1.4	What is your highest educational level?	Certificate	1	
		Diploma	2	
		Degree	3	
		Post Graduate	4	
		Others	5	
1.5	What is your job role/title position?	EPI Coordinator	1	
		Vaccine/EPI focal person	2	
		Store manager	3	
		Vaccinator	4	
		WIM/DFM team leader	5	
		Others Specify_____	6	

Section II: mBrana Training

No	Questions	Categories	Codes	Skip to
1	Have you trained on the mBrana system?	Yes	1	If 1-continue
		No	2	If 2-go to section III
2	If yes, which type of training did you receive?	Fresher training only	1	
		Refresher training only	2	
		Both	3	
3	How would you rate the training you received?	Unsatisfactory	1	
		Somehow satisfactory	2	
		Satisfactory	3	
4	Do you think you need any additional training on mBrana?	Yes	1	
		No	2	
5	How long have you worked on this system?	Less than six months	1	
		Six months to One year	2	
		Above one years	3	

Section III: Perceived Usefulness of mBrana in vLMIS

(Based on your experience of using the mBrana vaccine logistics management information system (vLMIS), please rate your agreement with the statements from strongly disagree to strongly agree). Please insert a mark in the appropriate box against each of the statements below.

No.	Questions	Strongly Disagree	Disagree	Neutral or Undecided	Agree	Strongly Agree
1	**Usefulness of mBrana**					
1.1	Using mBrana saves time					
1.2	The mBrana application meets my needs					
1.3	The mBrana can perform everything					
1.4	Stock out of vaccines easily predicts by it					
1.5	The system is easy to check data quality					
1.6	The system allows auto-calculations					
1.7	The system takes less time to enter data					
1.8	mBrana links with a well performing supply chain system					
1.9	mBrana helps to alleviate over and under stock					
1.10	The system used to produce stock status reports					
1.11	The data is protected and cannot be edited after approval					
1.12	mBran prevents the non-complete report submission					
2	**mBrana Functionality**					
2.1	mBrana vLMIS is unstable and crashing many times					
2.2	mBrana vLMIS allows offline data use					
2.3	I do not aware for any data inconsistences as I use the mBrana					

3	**mBrana vLMIS Usability**					
3.1	I think that I would like to use this system frequently					
3.2	I found the system unnecessarily complex					
3.3	I found the various functions in this system were well-integrated					
3.4	I am fully assured in using the system					
3.5	I have faced difficulties using mBrana due to low connections					
3.6	mBrana vLMIS uses standard terminology throughout the system					
3.7	The mBrana application is very reliable					
3.8	mBrana is user friendly					
3.9	mBrana vLMIS is easy to make correction					
3.10	I am pleased with mBrana system					
3.11	The staff member can easily locate the mBrana vLMIS portal					
3.12	The staff member can easily navigate of mBrana vLMIS					
3.13	The colleague can explain the data entry page					
3.14	They can generate report of the health facility by the time					
4	**mBrana Analysis and Reporting**					
4.1	The mBrana vLMIS generates automatic reports when the input data entered					
4.2	mBrana vLMIS is easily generate and show trend reports					
4.3	It is easy to generate a report that shows data for multiple facilities					
4.4	For making decision the dashboard is not very helpful					

4.5	mBrana vLMIS shows quality reports to identify gaps					
4.6	The mBrana vLMIS generated reports saves time					

Section IV: Challenge encounter in using mBrana vLMIS

No.	Questions	category	code	Skip to
1	Did you faced any challenges during using mBrana vLMIS?	Yes	1	Continue
		No	2	Go to Q3
2	Could you explain the challenges that you ever faced?			
3	What are the actions taken to alleviate the challenges?			
4	Which application is best concerning mBrana vLMIS immunization data quality as compared to the manual excel based?			
5	Additional comments to enhance the mBrana vLMIS?			

Health Facility Code: _____

Section V: Availability of Vaccines in the time of visit and the last six months

S.No	Vaccines	Stock availability on the day of visit (Yes=1, No=2)	Stock out experience in the previous six months (Yes=1, No=2)	Remark
1	BCG			
2	OPV			
3	Penta (DTP-HepB-Hib)			
4	PCV			
5	Rota			
6	IPV			
7	Measles			
8	Td			

Section VI: Data Quality

No.	Product	The balance on e-Bin Card	Physical count	Discrepancy reason
1	BCG			
2	OPV			
3	Penta (DTP-HepB-Hib)			
4	PCV			
5	Rota			
6	IPV			
7	Measles			
8	Td			

BCG: Bacille-Calmette-Guérin vaccine

DTP-HepB-Hib: Diphtheria, Tetanus, Pertussis, Hepatitis B and Haemophilus influenza type b

IPV: Inactivated Polio Vaccine, OPV: Oral Polio Vaccine

PCV: Pneumococcal Conjugate Vaccine

Td: Adsorbed Tetanus and Diphtheria vaccine

(Note: This tool is solely for the EPSS hub)

1. Regional hub _____

2. Number of Woredas that are expected to report data in the nearby hub? _____

3. The EPSS hub eVRF/VRF monthly report status in specified month of 2021.

Indication	Timely reported Woredas (i.e. up to on the 5th day of next month)	eVRF report submitting Woredas on specified period
Jan-21		
Feb-21		
Mar-21		
Apr-21		
May-21		
Jun-21		
Jul-21		
Aug-21		
Sep-21		
Oct-21		
Nov-21		
Dec-21		

Interview guide used for the Qualitative study

1. Participant introduction
2. mBrana application usage
3. The importance of mBrana to reduce stock out of antigens
4. Bottlenecks of the mBrana implementation are?
5. List the bottlenecks if exist?
6. The most challenging among them is?
7. Your comments or way forward to enhance the system

thesis

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