Implementing supply chain management information system in Liberia: How is logistics management information system data being used for decision-making to manage HIV, Tuberculosis and Malaria commodities in Liberia?

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Liberia

56th Master of Public Health/International Course in Health Development

KIT (Royal Tropical Institute)

Vrije Universiteit Amsterdam (VU)

Implementing supply chain management information system in Liberia: How is logistics management information system data being used for decision-making to manage HIV, Tuberculosis and Malaria commodities in Liberia?

A thesis submitted in partial fulfilment of the requirement for the degree of
Master of Science in Public Health

by

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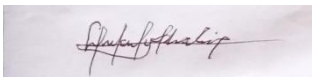
Signature: 

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List of abbreviations

AIDS	Acquired Immune Deficiency Syndrome
ART	Antiretroviral Therapy
BPHS	Basic Package of Health Services
CEmONC	Comprehensive Emergency Obstetric and Neonatal Care
CHAI	Clinton Health Access Initiative
CHS	Community Health Services
CHT	County Health Team
CHV	Community Health Volunteer
CHW	Community Health Worker
CMS	Central Medicine Store
COVID-19	Coronavirus Disease
DDIU	Data Demand and Information Use
DHS	District Health System
DQR	Data Quality Review
eLMIS	electronic Logistics Management Information System
EPHS	Essential Package of Health Services
ERP	Enterprise Resource Planning
EVD	Ebola Virus Disease
gCHV	general Community Health Volunteer
GDP	Gross Domestic Product
GF	Global Fund
HHP	Household Health Promoters
HIV	Human Immunodeficiency Virus
HMER	Health Management Information System, Monitoring and Evaluation, and Research
HMIS	Health Management Information System
HPHE	Health Products and Health Equipment

HRH	Human Resources for Health
IMF	International Monetary Fund
IRRF	Internal Reporting and Requisition Form
JFKMC	John F. Kennedy Medical Center
LGH	Liberia Government Hospital
LMIS	Logistics Management Information System
MDR/RR-TB	Multidrug Resistant/Rifampicin Resistant Tuberculosis
MOH	Ministry of Health
MPP	Medical and Pharmaceutical Products
NDS	National Drug Service
NHS	National Health Service
OIC	Officer-In-Charge
OIG	Office of the Inspector-General
PEPFAR	US President's Emergency Plan for AIDS Relief
PHC	Primary Health Clinic
PLHIV	People Living with HIV
PMI	US President’s Malaria Initiative
PSM	Procurement and Supply Management
KIT REC	Royal Tropical Institute Research Ethics Committee
RBM	RollBack Malaria
RDQA	Routine Data Quality Assessment
REC	Research Ethics Committee
SARA	Service Availability and Readiness Assessment
SCMU	Supply Chain Management Unit
SSRR	Stock Status Reporting and Requisition
TB	Tuberculosis
TOT	Trainer of Trainers
TTM	Trained Traditional Midwife

UL-PIRE IRB	University of Liberia Pacific Institute for Research and Evaluation Institutional Review Board
UN	United Nations
UNAIDS	Joint United Nations Program on HIV/AIDS
UNICEF	United Nations Children's Education Fund
USAID	United States Aid for International Development
WFP	World Food Programme
WHO	World Health Organization

Glossary

Logistics Management Information System (LMIS)— "is a system of records and reports – whether paper-based or electronic – used to aggregate, analyze, validate and display data (from all levels of the logistics system) that can be used to make logistics decisions and manage the supply chain"(1).

Electronic Logistics Management Information System (eLMIS)—is the electronic version of the LMIS. It is a "revolutionary and cost-effective system of health data management that ensures greater commodity security"(2). The eLMIS bears the benefit of an open access to timely, accurate and regular drug utilization or consumption data, instantaneous management resources to oversee all points of the supply chain from origin to consumption. It also provides the environment to enable forecasting of demands, planning and modeling of capability informed by consumption information.

OpenLMIS—"A collaboration of domain experts in logistics and supply chains, eHealth information systems, software development for low-resource settings, and process improvement"(3).

Otter.ai—is a web application which provides speech to text transcription. It can now be installed on mobile devices. Otter converts live speaking into a written transcription. Its terms and privacy policy has been updated. Otter was trained with machine learning on millions of hours of audio recordings(4).

Basic Package for Health Services (BPHS)—is a document that serves as the basis for the primary health care system and establishes its standards. For example, it shows the services that should be rendered by the various types of the primary healthcare service delivery point including health posts, basic health centers, comprehensive health centers and district hospitals. It also specifies the staff, equipment, diagnostic services, and medications required to provide those services(5).

Essential Package of Health Services (EPHS)— "is based on a Primary Health care (PHC) model with emphasis on high-impact, evidence based interventions; integration of services; standardization of protocols, guidelines and procedures; phased expansion of services towards a more comprehensive package; and consideration of urban and rural differences".(6)

Consumption recording tools--captures consumption or actual quantity of medicines or health product given to patients or health workers. For example: Daily Dispensing Register (DDR).

Stock keeping records--provide critical information about products in the store such as quantity of the stock available, shelf-life of products, batch number, quantity issued or received, date of transaction, losses/adjustments, and where products are received from, or issued to, including transaction references. Stock cards are used health facility level while Bin cards are used at medicines depot.

Transaction records--They capture and communicate information about products when they are received, issued, and when information about products are reported.

Stock Status Reporting and Requisition (SSRR) Form—captures information about each product to be communicated to the higher level of the supply chain every quarter.

Internal reporting and requisition form (IRRF)— is a transaction record that is used at health facilities between dispensaries and the store to report stock information and request resupply from the store in a regular interval. Besides communicating important stock information between the store and the dispensing unit, it also ensures transparency and accountability of stock movement within the facility.

Dedication

This thesis is dedicated to my family for being strong and supportive during my studies in the Netherlands. Your resilience in staying connected during my study leave and your singular best wishes spurred me on. Thank you for the teamwork.

To Mr. Sekou W. Konneh, Associate Professor and Dean of the College of Social Sciences and Humanities, University of Liberia, for being a father figure, always ready to provide support, no matter what. Thank you for your faith in my abilities; your constant assurances helped propel me to cement my career shift from Electrical Engineer to Public Health Practitioner.

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Abstract

Background: In Liberia, the health logistics management information system (LMIS) is gradually evolving to meet the Ministry of Health (MOH), County Health Team (CHT) and partner requirements of completeness, accuracy, timeliness, and reliability in providing routine supply chain data for decision making. The electronic LMIS, and enterprise resource planning (ERP) software, has been deplored and fully operationalized to accelerate data processes, and improve data quality, analysis, outlook, and production of reports for more rapid and improved data-informed supply chain decisions. However, while reports coming through the system shows high performing counties relative to submission of reports, others still struggling to fulfill reporting obligations. The objective of study is to explore the enablers and barriers to the use of LMIS data for decision making in Liberia.

Methods: The study design was a qualitative semi structured interview of purposively selected staff at health facility and county levels in three counties who use paper-based LMIS tools or have access to the electronic LMIS. The study centered on systemic capacity for the generation of supply chain logistics data and the demand for, and utilization of data for decision making. Eight out of 27 selected respondents from each tier of the system was interviewed via telephone.

Results: The main enabler highlighted through the study was the automation of the system and its useful data storage and display functions. The barriers include suboptimal collaboration between data producers and data users, rarity of data use culture, poor data quality, inadequate availability and access data, poor data use core competencies and low individual commitment and motivation.

Conclusion: To improve the use of LMIS data for decision making in Liberia, there is a need to train both data producers and decision makers on the importance of data use for decision making, provide equipment to users of the electronic system to facilitate easy access and promote the culture of data demand and information use for evidence-based decision making.

Key words: “logistics management information system”, “logistics data AND decision-making”, data utilization and supply chain”.

Word Count: 11,550

Chapter 1: Introduction

1.1 Demographics

Liberia has a land space of 96,319 square kilometers bounded in the south and southwest by the Atlantic Ocean, northwest by Sierra Leone, east by the Ivory Coast, and north by Guinea. It has an estimated population by July 2020 of 5.06 million, with about 52.6% dwelling in urban areas. The median age of its population is 19.4 years, while life expectancy is 65 years for both sexes(7) (8). In 2018 the infant mortality rate was 53.5 deaths per 1,000 live births while under 5 deaths is 70.9 deaths per 1,000 live births. In 2017 the maternal mortality ratio was 661 mothers per 100,000 live births(9).

1.2 Socioeconomic

Liberia is one of the world's poorest and underdeveloped countries. Its weak economy was further shattered by 15 years of civil conflict between 1990 and 2005. The primary exports are rubber, timber, and iron ore. Mining and donor support account for some of its national income. Its Gross Domestic Product (GDP) has been set at $3.264Bn with a per capita GDP of $677.3. The poverty headcount at national poverty lines (% of population) shifted from 54.1 in 2014 to 50.9 in 2016, while primary school enrollment dropped from 94.42% in 2014 to 85.11% in 2017(10). The out-of-pocket expenditure as a share of the current health expenditure was 47.3% in 2016(11).

1.3 Health and Other Resources

Liberia implements a three-tiered health system to deliver primary, secondary and tertiary health services. The Ministry of Health (MOH) delivered the Basic Package for health services (BPHS) during the post conflict period from 2007 to 2011, during which time it essentially devolved the management of health services to the subnational levels. By 2012 the MOH transitioned to the Essential Package of Health Services (EPHS), which engendered a flexible staffing pattern to commiserate with workload at the health facilities. The government owns and operates the tertiary health facilities while health facilities in the lower tiers are managed by the government, private entities, or faith-based organizations.

1.3.1 Primary Care

The Community Health System (CHS) is the first point of access to healthcare services. Community Health Volunteers (CHVs) including Household Health Promoters (HHPs), Trained Traditional Midwives (TTMs) and general Community Health Volunteers (gCHVs) provides outreach, health promotion and referral services for communities that are more than 5 kilometers from the nearest health facility. This can be a Primary Health Care (PHC) Clinic Level 1 or PHC Clinic Level 2. The PHC Clinic level 1 caters to isolated, clustered communities of 3,500 people while PHC Clinic Level 2 serves 3,500 to 12,000 people and provide outreach services for isolated communities outside of a 5km radius(12).

1.3.2 Secondary Care

This level has two healthcare systems: The District Health System (DHS) accommodates referrals from the CHS and caters to a population of 25,000 to 40,000 or more. The key facilities in this system are the health centers, which ideally has about 40 beds with a laboratory, and a district

hospital, which has higher clinical capacity, including emergency surgery and Comprehensive Emergency Obstetric and Neonatal Care (CEmONC). The County Health System renders general surgery, pediatrics, general medicine, obstetrics, and gynecologic services within the secondary level of care and receives referral from both the community and district health systems. A county hospital is ideally a facility with at least 100 beds including an intensive care unit, a laboratory and basic radiology services.

1.3.3 Tertiary care

The National Health System (NHS), which comprises the regional hospitals and the national hospital, the John F. Kennedy Medical Center (JFKMC), provides this level of care. The regional hospitals serve between 3-5 counties and receive referrals from the county hospitals. They have bed capacities of more than 100, complement the national referral hospital in providing additional specialized services, and serve as training sites for lower tier staff. The JFKMC is the specialized national referral facility and teaching hospital that trains physicians, sub-specialists and allied health professionals.

According to the Liberia Service Availability and Readiness Assessment (SARA) Report 2018, there are 831 health facilities in Liberia, 55% of which is government owned and 45% private. clinics account for 88% of this number while hospitals and health centers make up 5% and 7% respectively. There is a nearly even split in distribution of health facilities between rural and urban settings. It is important to mention that some rural communities are situated beyond 5km radius from the health facilities at which they access healthcare services.

1.4 Human Resource for Health (HRH) situation

There are approximately 12,601 health workers, 5802 civil servants (55%) paid by the government and contractors (45%) paid using donor fund to support Human Resources for Health (HRH), according to the HRH Transitional Plan which referenced the MOH payroll for December 2018. Females constitute 46% of the health workforce. There has been an increase in the density of core clinical workers from 6.3 to 11.8 per 10,000 population, however, it falls short of the global minimum standard of 23. Unfortunately, the rate of production of health workforce is not meeting the growing demand for HRH in the sector, despite current efforts to enhance the capacity of the faculty of training institutions, improve the quality of education and increase enrollment.

1.5 Supply chain system transformation since 2015.

The MOH has been transforming its supply chain system to facilitate the delivery of quality health services to the people of Liberia. In the previous design of the supply chain system, the National Drug Service (NDS) received and stored all procured Medical and Pharmaceutical Products (MPP) including laboratory supplies as well as Health Products and Health Equipment (HPHE). The NDS distributed supplies on a quarterly basis to 14 county depots, while the county pharmacist distributed to the health facilities. The Officers-In-Charge (OICs) of clinics provided medicines to Community Health Workers (CHWs) while retaining the health facility's share of the supplies. As for Montserrado County, NDS directly supplied health facilities. The Supply Chain Management

Unit (SCMU) collaborated with the Pharmacy Division of MOH and the national disease control programs to regulate the flow of commodities from NDS but had parallel communication mechanism for data and information flow with the County Health Teams (CHTs) and the NDS.

The envisioned design of the system by the year 2020 is an established Central Medicine Store (CMS), some regional hubs, and transit depots to ease access by health facilities to MPP and HPHE (*figure 1*). In this design, the CMS supplies regional hubs instead of the county depots, and health facilities in Montserrado County. The regional hubs distribute to the transit depots from where health facilities are supplied. The CHWs receive their supplies from the health facilities. There is a communication mechanism between CHWs and health facilities, health facilities and CHTs, and among CHTs, CMS and SCMU. The SCMU still coordinates with the national disease control programs and the Pharmacy Division.

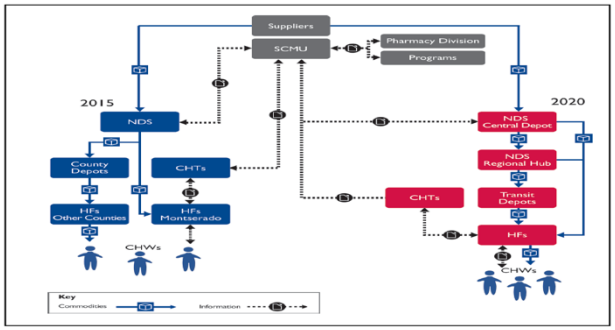

Figure 1: Design of supply chain system. Source: MOH

Chapter 2: Problem Statement

The post Ebola Virus Disease (EVD) investment plan for building a resilient health system was designed to address the profound issues of infrastructure, inadequate storage facilities, expiries, inadequate staff as well as capacity, logistics management information system (LMIS) and equipment for handling of materials at a storage facility. The key objective of the interventions made in resigning the supply chain system, the LMIS and the electronic logistics management information system (eLMIS) is to generate accurate, complete and timely supply chain data for decision-making at various levels of management.

But despite the gains made by the rollout of the LMIS and the adaptation of the eLMIS platform to digitize supply chain data, the suboptimal use of the data to inform decisions on the management of the supply chain system continues to undermine the returns on the investment. At different levels of the system, data generated are expected to inform decisions on requisition, resupply, forecasting, supply planning, stock status monitoring by product, procurement, consumption monitoring, stock-out monitoring, data quality monitoring and feedback.

I focused on supply chain management of Human Immunodeficiency Virus (HIV), Tuberculosis (TB) and malaria commodities for the reasons provided below:

Chapter 3: Justification

Due to the economic downturn in Liberia, the national response to other disease conditions is experiencing significant funding challenges unlike HIV, TB and malaria. There is incomparable potential for support, both technical and financial, to the national responses through the Global Fund (GF), US President's Emergency Plan for Acquired Immune Deficiency Syndrome (AIDS) Relief (PEPFAR), StopTB Partnership, Roll back Malaria (RBM), US President's Malaria

Initiative (PMI), United Nations International Children's Emergency Fund (UNICEF), World Food Programme (WFP) and Joint United Nations Program on HIV/AIDS (UNAIDS).

Additionally, the three diseases have claimed global, regional, and national attention as disease conditions of public health concern.

The UNAIDS reported in 2018 that there were about 1.7 million new HIV infections, 770,000 AIDS-related deaths and 37.9 million people living with HIV (PLHIV) worldwide. In Western and Central Africa, there were 280,000 new HIV infections, 160,000 AIDS-related deaths, and 5 million PLHIV. Liberia's share of the burden is 1900 new HIV infections, 1800 AIDS-related deaths and 39,000 PLHIV for the same year(13).

According to World Health Organization (WHO) Malaria Report 2019, there were about 228 malaria cases worldwide, 93% of which came from WHO African Region, compared with 251 million in 2010. Globally, the malaria incidence rate decreased from 71 to 57 cases per 1000 population. There were about 405,000 worldwide malaria deaths in 2018, with 94% contributed by WHO African Region, compared with 585,000 in 2010(14). Malaria incidence in Liberia increased from 1,345,523 to 1,742,079 while mortality declined from 2,583 to 2006 in 2010 and 2018 respectively(14). Still, this figure is high when considering the level of support, both internationally and domestically.

Globally, the total TB incidence in 2018 was about 10 million—5.7 million men, 3.2 million women and 1.1 million children. Multidrug Resistant/Rifampicin Resistant Tuberculosis (MDR/RR-TB) incidence stood at 484,000, while 1.5 million deaths were recorded(15). Based on the severity of the burden of TB disease incidence per capita, Liberia ranked 5th among 10 high burden countries. TB accounted for about 4.79% of all deaths, and according to the Global Tuberculosis Report 2019, 463 out of 6,730 PLHIV in Liberia who are newly placed on Antiretroviral Therapy (ART) were TB cases(16).

Some donors are now investigating issues relating to the management of medical and pharmaceutical products in Liberia's supply chain system to ascertain whether the stockouts and expiries recorded could be averted if recommended protocols were followed. Some are requesting restitution of funds based on outcome of some investigations. The GF Office of the Inspector General (OIG) recently concluded its audit of the Liberia grant portfolio and requested the restitution of some funds due to lack of accountability(17).

There is a knowledge gap as to whether staff at the various points of decision making in the supply chain system have core competencies for the use of data. What is their level of appreciation for data quality? Does the system design facilitate or inhibit the generation and use of data for decision-making? Are the users of the system taking advantage of the inherent coordination mechanism around data interpretation and use? What is the level of commitment and motivation of the users of the system?

A review of available literature on the results of data use assessments conducted in Uganda, Kenya, Nigeria, Tanzania and India indicated that poor data quality, insufficient skills to analyze, interpret and use data, insufficient institutional support for data collection and use, and insufficient access to data represent some constraints to the use of data for decision making(18). A study has not been

conducted in Liberia since the roll out of the LMIS and its automation in late 2018 on the enablers and barriers to the use of supply chain logistic data for decision-making. This study will provide an insight into the issues relative to data use and decision making.

3.1 General Objectives:

To explore the enablers and barriers to the use of logistics management information system data for decision making in supply chain management of in Liberia

3.1.1 Specific Objectives:

1. To assess the knowledge and practice of the use of logistics management information data by health facility, county and national level staff for decision making
2. To explore the suitability of the system design for the use of health supply chain logistics data by health facility, county, and national level staff for decision-making
3. To explore the coordination mechanism in place at different levels of decision making in the supply chain system
4. To recommend to decision makers in the supply chain system to increase the use of logistics management information system data for decision making

Chapter 4: Methodology

I used a two-pronged approach to conduct this study:

First, I undertook a literature review, searching PubMed using key words like "logistics management information system", "logistics data AND decision-making", data utilization and supply chain". Moreover, I used snowballing to access additional literature for the study. Also, I searched website for MEASURE Evaluation for additional resources on data demand and information use for decision making. This organization has done a lot of work in the areas of data and monitoring and evaluation, and therefore I was able to find some valuable resource to inform my review of literature on the use of data for decision making. I also searched for some frameworks to use to inform the design of the study and facilitate the analysis of the data that was collected.

In addition, I used a semi-structured interview method in a qualitative study to obtain information to answer the research questions.

4.1 Study type

I undertook an exploratory qualitative study involving eight respondents who work at the decision-making nodes of the supply chain system including health facility, county and national levels. I was unable to interview the technical supply chain leads from Clinton Health Access Initiative (CHAI), UNICEF, and USAID|CHEMONICS.

4.2 Selection of study areas

I searched the eLMIS database, where supply chain data is aggregated and analyzed, and purposively selected Bong, Grand Bassa and Margibi counties from among the 15 counties based on reporting rates in 2019 specifically for HIV, TB and malaria services for the study. I created

Rank	ARVs & Test Kits		Malaria		Tuberculosis	
1	Bong	91%	Bong	99%	Bong	86%
2	Grand Gedeh	87%	Grand Kru	92%	Bomi	80%
3	Bomi	85%	Lofa	90%	Grand Gedeh	76%
4	River Gee	58%	Bomi	90%	Lofa	49%
5	Grand Kru	58%	River Cesss	88%	River Gee	41%
6	Gbarpolu	57%	Grand Bassa	85%	Montserrado	32%
7	Grand Bassa	54%	Montserrado	78%	Grand Kru	30%
8	Lofa	53%	Gbarpolu	77%	River Cesss	26%
9	Sinoe	40%	Grand Cape Mount	76%	Grand Bassa	24%
10	Margibi	38%	Grand Gedeh	75%	Sinoe	22%
11	River Cesss	33%	River Gee	75%	Gbarpolu	15%
12	Nimba	26%	Nimba	74%	Grand Cape Mount	15%
13	Montserrado	25%	Sinoe	70%	Nimba	12%
14	Grand Cape Mount	22%	Maryland	63%	Margibi	11%
15	Maryland	19%	Margibi	44%	Maryland	6%
Bong	Appears 3 times in the first category as top reporter of logistics data and is accessible					
Grand Bas	Appears 2 times in the middle catgory and is accessible					
Margibi	Appears 2 times in the last category and is accessible. Although Marland appears 3 times it is not feasible due to inaccesibility, especially during the rainy season					

Table 1: Selection of study counties

three categories: highest reporting rate—ranks 1, 2 and 3; moderate reporting rate—ranks 7,8 and 9; and lowest reporting rate—ranks 13, 14 and 15. The selection was based on highest rank or frequency in each category for each of the commodity types (table 1).

Bong County, located in the central region of Liberia and the third most populous county with an estimated population of 406,071 in 2017(19), was at the top of each the rankings of reporting counties for TB, HIV and malaria commodities. It had 44 health facilities providing HIV and malaria services, 39 of which also provided TB services. I purposively selected three health facilities: Phebe Hospital, Charles B Dunbar Hospital and Salala Clinic because they are high burden integrated service delivery facilities and are easily accessible during the rainy season. The county depot, the other study area, is the storage facility for TB, HIV and malaria medical and pharmaceutical supplies in the county.

Grand Bassa, located in the south-central region of Liberia and bounded in the northeast by Nimba, north by Bong, northwest by Margibi and southwest by the Atlantic Ocean, is the fifth most populated county in Liberia with 278,635 people(20). It ranked top of the moderate reporting counties for HIV services, bottom for TB commodities and just above this category for malaria commodities. The county had 7 health districts, 3 hospitals, 1 health center and 26 clinics. I purposively selected two health facilities that are providing TB, HIV and malaria services: the Liberia Government Hospital (LGH) in Buchanan and the St. John Clinic. The county depot in Buchanan, headed and managed by the county pharmacist, is the third as it is the storage facility for medical and pharmaceutical supplies.

Maryland County fulfilled the criteria for frequency in the lowest reporting category but was deselected due to accessibility challenge during the rainy season. Instead, Margibi county was preferred as the second least performing county in terms of reporting. Located on the north to central coast of Liberia and bounded by Montserrado in the west, Bong in the north, Grand Bassa in the East and the Atlantic Ocean in the south, Margibi is the sixth most populous county in Liberia with 263,842 people(21). It ranked just below the moderate reporting counties for HIV commodities, lowest for malaria commodities and 14th for TB services. Margibi County has 4 health districts, 2 hospitals, 11 health centers and 24 clinics. I purposively selected the two high burden facilities that provide integrated TB and HIV services, along with malaria services. The county drug depot, located in Kakata, was the next area of study.

In addition, respondents were selected from the offices of the SCMU, CHAI at the Central MOH, UNICEF at the United Nations Building, and USAID|CHEMONICS, all in Monrovia.

4.3 Sampling and recruitment of respondents

All respondents to this study were purposively selected based on specific criteria. At the facility level in the selected counties, I selected the dispenser and OIC of the selected clinics; the head dispenser and the pharmacist of the hospitals were selected. They collect and manage data on stock, transaction and consumption of medicines and health products. They are the decision-makers at their assigned facilities. Further, they must have participated in the rollout training on the use of the LMIS data collection and reporting tools.

At the county level, I selected the County Supply Chain Coordinator who is responsible to coordinate the input of supply chain data collected from health facilities into the eLMIS. The inclusion criteria are that staff received the relevant training on use of LMIS tools and the eLMIS. They must have user rights to the eLMIS to perform their assigned functions.

At the national level, I selected the Procurement and Supply Management (PSM) Officers of the TB, HIV and Malaria control programs as they are responsible to review the consumption data and requisitions from the counties and make appropriate recommendations to the SCMU for approval of the resupply quantity. I selected the manager of the SCMU as the head approval agent at the national level. Also, he is the principal coordinator for the selection of medicines and health product for procurement, quantification, and preparation of requisition for national level procurement of medicines and health products. Also, I selected an LMIS Data Officer and the LMIS Officer at the SCMU. At the CMS I selected the Deputy Managing Director for Operations due his technical role in the planning and execution of requisitions for nationwide supply of medicines and and health products sanctioned by the SCMU.

I also selected the technical leads of the partners of the MOH who are involved with supply chain activities including quantification and procurement of HIV, TB and malaria commodities. They are USAID/CHEMONICS, CHAI, and UNICEF.

To recruit the respondents for the study, a formal communication was sent to the Head of the Department of Planning, Health Management Information System, Monitoring and Evaluation and Research (HMER), explaining the purpose and scope of the study and its intended benefits,

requesting permission to implement the study. Upon approval, the supervisors of all respondents were informed, and a copy of the communication was shared with me.

4.4 Data Collection Method

For this study, I adopted some frameworks to guide the development of my topic and interview guides for a semi-structured interview. This allowed me to grant the opportunity to respondents to elaborate on issues according to their understanding and professional views.

The Potter and Brough framework(22), a capacity building model on the hierarchy of system capacity needs was used to inform the topic guide for the first and second specific objectives .

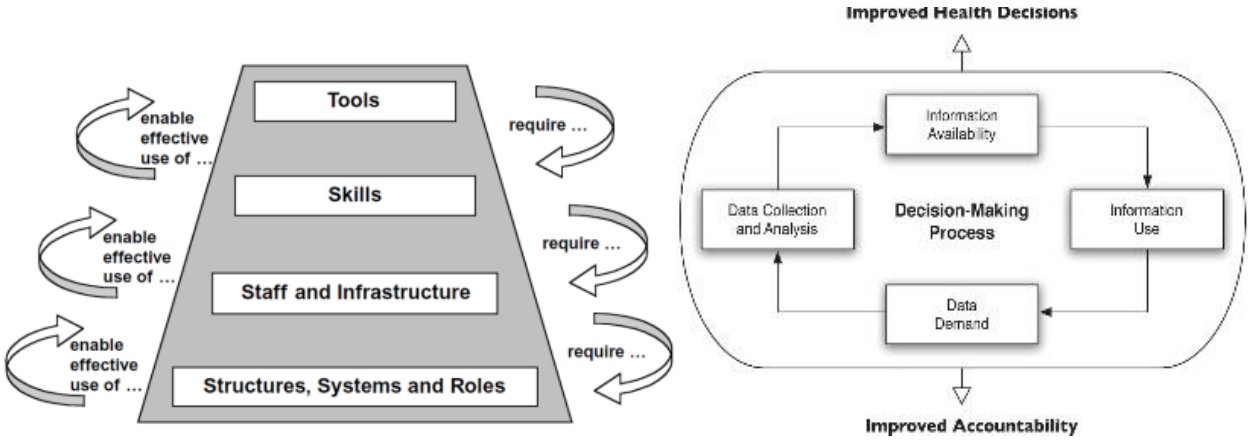

Figure 2: (L-R); Potter and Brough Hierarchy of System Capacity Needs (2004) and MEASURE EVALUATION's Data Demand and Information Use

Finally, the Data Demand and Information Use (DDIU) framework (23) of MEASURE EVALUATION was used to develop the topic guide for the third specific objective of this study. This framework focuses on the decision-making processes involving the demand for data and the use of information derived from the analyzed data. (*figure 2*)

4.4.1 Data collection

I worked with the research assistant I recruited to liaise with the Coordinator of the HMER Division to review the data collection tools including the topic and interview guides. I conducted a pre-test to ascertain the suitability of the tools for the study and made further adjustment in the tools following the pre-test based on feedback. I developed a full data collection plan including workplan and shared with the Coordinator. I used this plan to conduct the study. Other adjustments were made as the study went on.

Due to the prevailing Coronavirus Disease (COVID-19) pandemic which has precipitated significant restrictions on travel, I used telephone and other social media applications including Facebook messenger, Skype, WhatsApp and Zoom, depending on the most convenient means available to each of the respondents, to conduct the interview. The informed consent form was conveyed to the respondents by the research assistant ahead of the date of each interview. Before each interview, I read out the entire informed consent form including the purpose, objectives, and

scope of the study to the respondents, and reassured them of the effort that I exerted to ensure the confidentiality and anonymity of their contributions. For example, codes, instead of names, were used. The requested the respondents to ask questions if they needed further clarification. They respondents signed the informed consent form when no further clarification was needed. The signed forms were collected by the research assistant, scanned, and emailed to me.

To document the interviews, I installed an interview application called Otter on my laptop, phone, and tablet. This application has a functionality to audio record the interviews while simultaneously transcribing them. Both voice and transcriptions storage are password protected and can be accessed by me on my devices. I used my phone and tablet to record the interviews and followed the interview guide carefully so that nothing was inadvertently omitted. On the laptop, I listened to the audio recording and edited the automated transcript done by the application at the end of each interview. In this way, I simultaneously commenced the analysis with the interviews.

4.4.1.1 Description of methods for data processing and analysis

I developed the data processing and analysis plan before I started data collection. In this way, I adjusted the interview guide to ensure the completeness of the information I was seeking, and that no extraneous data was collected. To ease the sorting of data, I assigned a code to each of the participants. I carried out a final quality check to ensure completeness and consistency in the transcripts in comparison with the voice recording. Then, sing an analysis matrix, I categorized data based on responses, coded and summarized them. I organized the transcripts and grouped the responses according to the identified themes that were used to analyze the data. Finally, I developed a findings table in which I categorized the themes by health facility, county and national levels.

4.4.1.2 Ethical considerations

I obtained a waiver of ethical approval Research Ethics Committee (REC) of KIT Royal Tropical Institute as well as the University of Liberia Pacific Institute for Research and Evaluation Institutional Review Board of Liberia (UL-PIRE IRB**)** to conduct the study. Further, I took into consideration all potential risks to the respondents who contributed to the study in their professional capacity(24). I undertook measures to ensure that all ethical issues were addressed including providing a clear communication on the purpose, objective, risks, and benefits of the study. An informed consent form was signed by each of the respondents before the interview commenced.

4.4.1.3 Quality assurance

In addition to the pretest I conducted to ensure the suitability of the tools, the timing of the interview and interview guides, I continued adjusting ensure proper understanding as the study progressed. I simultaneously recorded the interviews using a tablet and a smartphone just in case technology failed. Afterwards, I compared the voice recording and the transcripts using the laptop after each interview and before I started sorting data.

4.4.1.4 Dissemination and use of results

The results are discussed in the thesis and submitted in partial fulfillment of the requirements for my degree program at KIT Royal Tropical Institute. Further, I planned to share the results at one

of the general meetings of the Liberia Coordinating Mechanism (LCM), where all the stakeholders of the national response to HIV, TB and malaria converge. Finally, I provided some recommendations on how program managers and stakeholders in the supply chain management system can increase the use of logistics management information system data for decision-making in the management of HIV, TB, and Malaria commodities in Liberia.

Chapter 5: Results

There are limitations to this mode of data collection, however. Only respondents who had internet enabled devices including smartphones and computers and consented to contribute to the study during the data collection period were interviewed. Therefore, out of a total of 27 purposively selected respondents, I interviewed eight representing health facility, county, national disease control programs and central ministry of health.

5.1 Analytical Frameworks

To help me analyze the data I collected, I used the Potter and Brough framework for systemic capacity building to assess the capacity developed by the administrators of the LMIS and the eLMIS to document medicines in stock, including the transaction and consumption of medicines at national, county and health facility levels. The key elements of this framework are tools, skills, staff and infrastructure, and structures, systems, and roles.

Tools with respect to the supply chain system considers the records on movement of drugs, funds to facilitate record keeping, and equipment and services required to perform specific roles. Skills describes the level of understanding, proficiency, and the confidence of the system user to undertake designated roles. Staff and infrastructure consider whether a system user has skills to cope with the workload, whether systems are in place to enhance monitoring, reporting and accountability, and whether there is available office space to support the workload. Finally, the framework considers the systems, structural and role capacities of the LMIS. It assesses the timeliness and effectiveness of the flow of information, money, and managerial determinations. It also considers whether there are accountability structures in place to address non-performance issues and ascertains if individuals, teams, and committees have the authority and responsibility to take decisions to improve performance with respect to staff appointment, funds and scheduling.

To assess the culture of evidence-based decision making within the system, I used the DDIU framework of Measure Evaluation to guide my analysis of the data collected. The data demand component of the framework explores the mechanism in place which specifies upfront, and actively seeks, the type of data required. The information use factor considers the analysis, interpretation and use of the data collected. It also considers the improved visualization of system data, early warning functions, and integration and interoperability with other relevant systems. In addition, DDIU framework puts into perspective the specific interventions to stimulate the demand for, and utilization of data to inform decision making. The framework depicts a sequence in which better data collection methods, evaluation, availability, explanation, and use unceasingly engender new necessity for, and continuous utilization of data. This results in better accountability and enhanced decision-making.

5.2 Findings

Using these analytical frameworks, I categorized my findings according to three levels: health facility, county and national. Each component of the frameworks is used to explain findings at the three levels mentioned (Table 2).

5.2.1 Tools

At the top of the capacity pyramid is tools, one of the component elements of systemic capacity building. The study explored whether there are tools, which includes funding, equipment, or some enablers to facilitate the performance of specific roles in the supply chain system.

At the health facility level, the paper-based LMIS tools are provided for use to document stock, transaction and consumption of medicines. There are, however, issues with timely resupply of the recording tools when some facilities exhaust its supply. Large hospitals receive paper-based tools and its supply chain staff have access to the eLMIS for direct data entry. However, some staff often lacks computers, internet modems and valid subscriptions to facilitate data entry. Sometimes, electric power is also a challenge at some facilities. Moreover, although the government provides direct budgetary support to large hospitals, and routes funding support to clinics through the CHT, it is often delayed.

For each county, the MOH provides the paper-based recording tools that are used to document stock information, transaction and consumption data at the county and health facility levels. The district data entry clerks collect and enter the consumption data monthly for each of the health facilities captured on the Stock Status Requisition and Reporting (SSRR) forms in the eLMIS. Occasionally, when new products are introduced or when tools get completely used up, reporting becomes a challenge. However, most data clerks do not have computers, internet modems and data subscription to access the eLMIS to enter data.

The national level is responsible for the overall management of the eLMIS, the basic interface at that level. The system automatically generates the resupply quantity for each health facility when data collected on the SSRR is uploaded. On this platform, the stock status of each health facility including the months of stock on hand for each medicine and other key information is provided by the system. The program supply chain staff review the data for each health facility and request for clarification if required prior to the approval of the requisitions.

In terms of the adequacy of the tools to accommodate the data collected, some respondents declared that some of the commodities are not listed on the printed LMIS tools and this occurs most especially when new antimalarials, antituberculosis, and antiretrovirals are introduced. In this case an improvised MS-EXCEL spreadsheet is deployed until new recording ledgers are produced and distributed.

The use of the MS-EXCEL spreadsheet is a good idea, but printed hard copies are unavailable for issuance of the commodity at the county level, and reception and dispensing of the medicine at the facility level. This confusion will most likely persist for a long time since printing of tools are not done frequently due to the limitation of resources. One of the respondents said,

"So in that case, that practitioner who is to input all the data on the hardcopy will have to find something extra. And look at the tools and copy that tools, to be able to input those extra commodities and report on them. That also makes the work to be very slow".

For users of the electronic system, participants reported challenges including lack of computers, modems for internet access and internet bundle subscription.

Also, PSM Officers at the national programs, as well as the data management staff at the SCMU have user rights to the eLMIS However, for some users of the electronic system, respondents reported key challenges including lack of computers, modems for internet access and funds for internet bundle subscription.

Some health facilities sometimes receive less medicines than what is needed and more of some medicines than required at other times. This situation leads to stock out of needed medicines and sometimes expiry of needed medicines resulting in waste of funds. A respondent explained,

"*Drugs come from the CMS at times when the expiry dates are very closer. They send huge (quantity) of product to the county. The counties cannot consume the product before they expire. So, you will observe that as they (central) push it (drugs) on us, we too, push it (drugs) to the health facilities. The health facilities at times cannot consume all those products. So, we have to go back to the health facilities and collect them and bring them back to the facility (depot) where they expire*."

5.2.2 Skills

The component element of systemic capacity building below tools is skills. Skills enable the effective use of the tools required to function at an optimal level in the supply chain system. This component describes whether staff knowledge is sufficient, skillset adequate and confidence high enough to carry out assigned functions, and whether they need to acquire more experience, get trained or be motivated.

In health facilities, respondents stated that training on the use of the LMIS reporting tools was conducted by the MOH with support from its partners. Dispensers, storekeepers, OICs, and hospital pharmacists participated in the training. Prior to the conduct of the LMIS training, pharmacists were also trained in the use of the tools during their academic coursework. These trainings, however, seem to be inadequate. Some of the respondents are in agreement that the technical skills required for data entry is low among system tool users, whether electronic or paper-based. Some of the participants stated that there is low level of technical skills for data entry. One of the respondents averred,

"*The tools, actually the tools are good. Okay. But the usage, the technical know-how, and those who use the tools, that is the challenge*".

Still, others highlighted low workforce capacity exacerbated by staff turnover as one of the key issues in the health supply chain. Essentially, more staff leave their assigned positions in search of better paid jobs than there are available resources to recruit and train their replacements. A new staff taking over a role which requires completing and submitting an SSRR for or entering data

	Tools (*performance capacity*)	**Skills** *(personal capacity)*	**Staff and infrastructure** (*workload, supervisory and facility capacity)*	**Structures, systems, and roles** *(structural, systems, and roles capacity)*	**Data Demand** *(Specify upfront, and actively seek, the type of data they require)*	**Information Use** (*Engage with the data collected by analysis, interpretation, and utilization* *Improved data visualization and early warnings* *Integration and Interoperability with other LMIS and HIS Systems)*
Health Facility Level	-The MOH provides the paper-based LMIS tools, but due to delayed resupply at times, facilities are stocked out. -Hospitals have access to the eLMIS platform but challenged by lack of computers, internet modems and subscription to facilitate data entry -Facilities sometimes receive more quantity of some commodities than required and often less of some commodities than needed -Allotment from the national budget for the management of health facilities is often delayed	-Users of the electronic platform have been trained but data entry challenges remain. -recording the opening balance on the SSRR form is a challenge	-The completion of the LMIS and HMIS reports in addition to the performance of clinical functions is a challenge for the Officer-in-Charge of clinics. The hospital pharmacist faces the same challenge. -The aggregation of consumption reports from all dispensaries at a hospital and entering of data is a challenge for the hospital pharmacist considering his clinical duties -Some facilities are supervised monthly by the district health team and quarterly by the county health team.	-The OIC and the hospital pharmacist have no authority to modify their roles required by the system, i.e. shifting some of their responsibilities to the dispenser or storekeeper. -	-The OIC and hospital pharmacist both require consumption of drugs report from the dispensers to complete their monthly consumption report	-Caseload of HIV or TB clients are used to make decisions on management of commodities. -Historical consumption report is used to determine malaria medicines need. Adjustments are made based on rainy or dry season.
County Level	-The paper-based tools used to track the reception of medicines from CMS and to document the movement of medicines from the county drug depot to the health facilities is in stock	-Users of the electronic platform have limited knowledge about the functions of the system. i.e. automatic calculation of resupply quantities, quantities approved	-There is inadequate support for supervision, mentoring and coaching activities to address needs of system users, both paper-based and electronic	-The CMS sometimes give drugs that are about to expire, and in huge quantities to counties	-Counties provide data on stock status, drug transaction and consumption report for each health facility quarterly. -Counties demand stock status, drug transaction	-To determine the resupply quantity, the counties compare consumption report from health facilities with previous supply received.

	Tools (*performance capacity*)	**Skills** *(personal capacity)*	**Staff and infrastructure** (*workload, supervisory and facility capacity)*	**Structures, systems, and roles** *(structural, systems, and roles capacity)*	**Data Demand** *(Specify upfront, and actively seek, the type of data they require)*	**Information Use** (*Engage with the data collected by analysis, interpretation, and utilization* *Improved data visualization and early warnings* *Integration and Interoperability with other LMIS and HIS Systems)*
	-Most data clerks do not have computer, internet modems and data subscriptions to access the online platform for data entry	by program PSM Officers, stock on hand, etc.	-Some counties do monthly supervision at all health facilities with partner support		and consumption report from each health facility monthly.	-The system generated resupply quantity is not what is supplied by CMS -quantity approved by program PSM Officers is often not available at CMS
National Level	-Central level staff from supply chain unit and national disease control programs have access to the electronic platform -Some staff do not have computer, internet modems and data subscriptions to access the online platform -Introduction of new drugs or shortage of recording paper-based tools poses problems at the county level -An EXCEL spreadsheet managed at the SCMU is used to record the movement of unlisted commodities until the issue is resolved	-pharmacists at the national level have skillsets to manage LMIS information via the electronic platform -Due to staff turnover, the training need for supply chain workforce is high -Partners are helping to provide online training on health logistics management for MOH staff -No follow up refresher training organized for users of the systems since the rollout training	-Support for supervision and monitoring is inadequate -LMIS staff do occasional mentoring during rare trips to the county level	-The program PSM Officers have the authority to review and approve the system generated resupply quantity -Supply chain technical working groups exist at national and county level to discuss critical supply chain issues -No structure to institute action against wrongdoers in the system. - Roles relative to the use of the system have been assigned to users at all levels	Data entered in the system is counterchecked before the system generated resupply quantity is endorsed (i.e. opening balance, what was received, days stocked out, and closing balance) -For HIV and TB medications, the number of clients and treatment regimen is also required from the HMIS to aid decision on resupply -There is infrequent stock out of HIV, TB and malaria commodities; donors have committed resources to procure.	The HMIS and eLMIS data are the sources for data to facilitate the quantification of drugs -The program PSM staff along with the HMIS and eLMIS stakeholders do the quantification -The systems (mSupply and eLMIS) both have product visualization functionalities including warning alerts for items at risk of expiry, but expiries and stock out still occur -The systems (eLMIS, HMIS and mSupply) are not interoperable

Table 2: Study findings

from an SSRR form into the eLMIS will be unable to perform satisfactorily without training. Consequently, reports from such facilities are mostly incomplete, delayed, and inaccurate.

Some of the users of the electronic platform at the county level have inadequate knowledge of the different functions of the eLMIS. For example, respondent explained that the system generated resupply quantity can only be viewed by the national level users,

"…*We said no, we cannot send requisition. We send consumption (report) for each facility. So, they asked why. We said because the spreadsheet for the last column is protected, it is under lock and key. We send it, they (eLMIS users at national level) look through it and open it up and it calculates automatically. So, they decide that one*"

On the contrary, another respondent confirmed that the resupply quantity generated by the system can be viewed. He additionally pointed out that there is another column called '*quantity approved*'. It is in this column that the quantity approved by the PSM Officers at the national programs is found for each of the medicines. However, even the approved quantity is not what is supplied by the CMS.

The PSM Officers at the national level have access to the electronic platform and have approving authority for drugs to be sent to the county or health facility. An advantage of this is that they have some proficiency in navigating the online system to effect approval of commodities to be sent to the counties or health facilities. The quantities approved, however, is contingent on what is available at the CMS. I could not get CMS's perspective on the determination of the quantity to resupply due to unavailability of a respondent from there.

The study revealed also that regular monitoring and supervision visit at the periphery is not happening, due to funding constraints. The eLMIS has a lot of functionalities including visualization of stock status as reported by the counties. A regular visit will enhance the connection between what is observed in the system and what is obtaining in the field.

The findings also indicate high training need for supply chain workforce. Some respondents attributed it to lack of refresher training after the rollout trainings for users of the paper-based as well as the eLMIS, while others say it is due to staff turnover. One respondent underscored training as a key intervention that is lacking,

"…*So I will say people (supply chain staff) should be really trained. They should know what they are doing because if you have people trained and they are up to the task, you won't have any challenge with anything related to the LMIS*".

Recognizing this gap in staff skills, the MOH has engaged it partners to help in providing online training on health logistics management for its supply chain staff. One of the respondents stated,

"The KIT Royal Tropical Institute in conjunction with i+solution, provided online training for a lot of Ministry of Health staff to be able to use the current LMIS tools to collect consumption data to inform the SCMU".

5.2.3 Staff and infrastructure

The staff and infrastructure of the system enables the effective use of skills. As a result, most of the data quality issues that should be routinely addressed are left to linger for longer periods.

At the health facility level, the respondents noted that one of the key issues affecting workload capacity is staff turnover. This is a situation where an employee decides to abandon his assigned post probably due to a better offer, perceived lack of professional development in present role, low remuneration or perhaps untenable work conditions. This poses a predicament for managers of the LMIS. The new staff to fill the position needs to be trained and brought up to speed in fulfilling data reporting obligations. Instant support for mentoring and coaching activities is not forthcoming in most instances due to funding constraints.

In addition, the key health facility staff responsible for the aggregating the reports from the dispensers are overburdened with reporting obligations. For example, the OIC is required to report on service delivery (HMIS report) and drug consumption (LMIS report), in addition to performing clinical functions at the health facility. Also, the hospital pharmacist sees patients in the hospital wards and is required to aggregate the drug consumption reports from the multiple dispensaries at the facility. The hospital pharmacist and the OIC have clinical services to perform and report on, in addition to preparing the LMIS report monthly. This might be challenging because reporting using the LMIS tools requires concentration and keen attention to details. Further, collecting data from handwritten forms might need sitting with the dispensers to understand some of the unreadable writings. Considering a hospital where there are many drug outlets to patients, the pharmacist aggregating the report from the different dispensers may be prone to data entry errors, delayed or incomplete reports.

Another staff to consider is the data clerk, who is responsible to collect data from all the health facilities within his assigned district. Depending on how large or densely populated a district is, the number of health facilities may be large and there is only one data clerk per district in most counties. The data clerk needs to find time to sit with the OIC to understand the reports since they are handwritten If you factor in many health facilities in a district, it could mean the reports could be delayed, incomplete or inaccurate. . Similarly, the hospital pharmacist will need to sit with the different dispensers to understand their reports. Since hospitals are usually high-volume service delivery facilities with many dispensaries, pharmacists who are often keen on submitting on time upload reports are sometimes incomplete and inaccurate.

Key to the successful implementation of an information management system is constant supervision including coaching and mentoring. Routinizing this intervention serves to improve the quality of the data collected at the service delivery points and entry at the electronic interface. The district health team should supervise monthly all the health facilities it manages. This is however governed by the availability of funds either from a Non-Governmental Organization (NGO) partner or the government. Some respondents described the different levels of the Joint Integrated Supportive Supervision (JISS) in a manner that shows how resource intensive the activity is,

"S*o, the joint integrated supportive supervision is done in two phases. The district should do the joint integrated supportive supervision monthly. And then the county should do it on a quarterly basis. So, for April May June, the county will do one supervision for that quarter while the district will do a monthly supervision. Every month they should visit the facility to do mentoring and coaching. So that's how the supervision goes. Then in case there is a need, other people will come to do solo supervision, and then the ministry (national level) should also do supervision after every six months, the central ministry"*.

At the county level, the county supply chain staff are required to conduct supportive supervision targeting 75% of the health facilities according to policy. However, due to inadequate support for supervision, mentoring and coaching, this is not happening as planned. These interventions are often not carried out due to funding and logistics challenges. One of the respondents stated,

"*And it is from the support from the county that you can go continuously into the field to do hands-on training, TOT, mentoring, or coaching. But at times it is also difficult to find the support to enable county supply chain coordinator to get in the field. There are issues of no vehicle, no fuel; there are so many challenges, when it comes to that*",

The central level supply chain staff is required to conduct supportive supervision semiannually. In each county, they target 25% of the health facilities. However, like the health facility and county level, there is inadequate support to national level staff for the regular implementation of this activity.

5.2.4 Structures, systems, and roles

In this section, the focus is the timeliness and effectiveness of the flow of information, money, and managerial determinations. Further, it assesses whether there are accountability structures established to address non-performance issues and if individuals, teams, and committees have the authority and responsibility to take decisions to improve performance with respect to staff appointment, funds, and scheduling.

At the health facility level, the study revealed that some of the key staff required to report for the health facility are overburdened with the obligation of reporting and service delivery. The OIC reports into two information systems: health management information system (HMIS) for service delivery and eLMIS for medicines consumption. The hospital pharmacist aggregates the medicine consumption reports from all the different dispensaries in the facility. When combined with full time clinical services, it becomes overwhelming. However, they do not have the authority to shift some of their responsibilities to the dispenser or storekeeper. One of the respondents suggested that the dispensers and storekeeper complete the SSRR form and submit to the hospital pharmacists and OIC for review and endorsement.

At the county level, there seem to be some irregularity in the flow of information from the CMS to the counties. The CMS supplies medicines to the counties quarterly based on approved request from SCMU, amounting to three months of stock and a buffer stock to last for one month. The county may also request emergency stock in the event supplies are depleted before the next resupply period. However, there are occasions when CMS supplies medicines that are not

requisitioned, a distribution system known as "push". Most often such supplies are in large quantities and are close to expiration. The county supply chain authorities distribute the medicines to the health facilities without prior notification or assessment to ascertain whether the quantity being supplied can be dispensed to patients be they expire.

Likewise, the county and national supply chain staff having access to the eLMIS should have greater medicines visibility through the system. However, system synthesized information is irregularly shared with the health facility staff who generate the data. This might be due to either challenge appreciating the full functionalities of the system or information asymmetry.

Moreover, supply chain technical working group functioning at the county have scheduled meetings to discuss issues relative to the supply and management of medicines. This group escalates issues beyond its scope to the national level for action. It is not, however, endowed with the authority to serve as an accountability structure to address issues of data quality and use, and non-performance of individuals, teams, and committees.

At the national level, the eLMIS displays the stock status when all facility SSRR reports are uploaded. A user of the electronic system declares,

"*For the county level, since they already have access to the eLMIS, they just do their inventory and upload on the eLMIS and we know exactly what they have at the county level".*

Similarly, the warehouse management software deployed at the CMS called mSupply has functions that display the stock status of the products that are uploaded. A respondent affirmed,

"*…mSupply has a way of tracking all items at risk. It means that these medications that are soon to expire, they are all being tracked by coloration*".

With this level of visibility of health products at all levels, it places in the hands of decision makers the information required to address issues of stock out or expiries. However, the occurrences of expiries and stock outs suggest a suboptimal use of the information provided by the systems for decision making. The delays in moving forward with the remedial actions may be attributed to inadequate appreciation of this function or limited resources to facilitate the redistribution of medicines to facilities or counties having less stock. When timely resupply or redistribution of medicines cannot happen, health facilities run the risk of stock outs or expiries.

Besides, the PSM Officers review the data entered by the counties for each health facility as well as the system generated resupply quantity for each of the medicines reported on. However, the quantity the PSM staff approves depends on what is available at the CMS. Speaking on the availability of stock information from CMS, a respondent explained,

"*…So the biggest issue is just the disconnect between the eLMIS and the mSupply. So that inventory (CMS) is done, and uploaded on a spreadsheet and sent to us* (*users of eLMIS)*…"

Clearly, this shows that the systems are not interoperable. So if the PSM Officers have this stock status update regularly from the CMS or at least prior to approving quantities for resupply, then the lower quantities approved than the system generated quantities should actually be available at CMS and be supplied to the counties and health facilities. On the contrary, the quantities supplied

by CMS are still lower in most instances than the approved quantity and sometimes some medicines are not supplied at all. A respondent recounted this after one of the regular quarterly distribution of medicines,

"…for malaria, adult (dosage) we never receive any, …six to thirteen (dosage for 6—13 yrs. old), none…).

Relative to the criteria used by CMS to determine the resupply quantity since what is supplied to the counties and facilities is not always the quantity approved by the PSM Officers, the respondent from the CMS was not interviewed due to limited internet connectivity.

Like the county level, the supply chain technical working group at the national level discusses critical procurement and supply management matters for the whole country and takes decisions to ensure that medicines are available and accessible to patients nationally, but there is no accountability structure in place to address issues of underperformance.

5.2.5 Data demand

The demand for data pervades the entire systems, paper-based as well as electronic. Paper-based tools exist to document all supply chain activities including stock keeping, transaction and consumption. The aggregate data for all such activities occurring at the health facility and county depot is what feeds into the eLMIS.

At the health facility, the paper-based tools tracks and documents the movement of medicines from the CMS to the dispensaries where patients receive it. The dispensers and storekeepers compile the daily consumption reports and submit to the OIC and hospital pharmacist respectively. The resulting aggregated data is what the OIC of a clinic or hospital pharmacist reports monthly.

The county supply chain authorities have reporting obligations too. They work to ensure that health facilities managed by the county health team present their quarterly SSRR, the data of which they enter in the eLMIS. The administrators of the system require this data to guide their decisions on the management of the medicines in the country.

To take decisions at the national level on the quantity of medicines to approve to replenish the supplies at the health facilities and counties, the program PSM Officers require the SSRR data. This report provides the information needed to facilitate the decision to resupply medicines.

5.2.6 Information use

To take decisions on the quantity of medicines to approve to replenish the supplies of the health facilities, counties and the entire country, the administrators of the system make use of the information resulting from the analysis of the data entered into the system.

The OIC and hospital pharmacist at the health facility keep record of the number of HIV clients and TB patients on routine treatment medicine. This information they use to determine the quantity of medicines to request. As for malaria medicine, the staff reviews the service delivery records to consider the number of cases treated for the various age categories and makes a projection. They also consider the season because the number of cases is usually higher during the rainy season than the dry season.

At county level, the eLMIS automatically generates the resupply quantity of each facility when the data presented on the SSRR form is entered into the system. However, the program supply chain staff do not always approve this quantity for resupply due to limitation of supplies at the CMS. Most often, less than the approve quantities are supplied by CMS. Moreover, the supply sent to the county is not disaggregated by health facility. It becomes the prerogative of the county level supply chain staff to determine the resupply quantity. In this case they use the consumption report from the previous supply received to determine the quantity.

At the central level, the supply chain staff determine resupply quantity for all the facilities in the country because the system generated quantity for resupply is most often not in stock at the CMS. They use previous consumption record against quantity supplied considering quantity of stock on hand before receiving the quarterly supply and quantity of stock on hand at the end of the past quarter.

Moreover, the quantification team comprising program PSM staff, stakeholders, and managers of the HMIS and eLMIS platforms determine on the quantity of medicines to forecast for a period of three years. This is the duration of the TB, HIV and malaria grants financed by the GF and PMI. The team compares information on the number of malaria cases treated as captured in the HMIS platform with the record of malaria medicines consumption over the same period to help them decide on what to forecast. Either the eLMIS information or HMIS data or a hybrid is used in case neither system is presenting a better set of information.

Further, the country's supply chain managers enjoy the benefit of three information systems to enable them to effectively manage the medicines and health products procured and stored for distribution to the last mile for patients to consume: the mSupply, the HMIS–the database for health facility service delivery data hosted by the DHIS2 server—and the eLMIS, are not interoperable. k. However, it is not possible to electronically share information among these three information systems because they are not linked. Manual downloads of selected data are shared among users of the three systems. This has an adverse impact on timeliness of decisions made in the management of medicines.

6.0 Discussion

The collection of health supply chain logistics data will be meaningless if the ultimate purpose is not to guide the decisions the users of the system make. Further, attempts to enhance the quality of data will be futile if interventions to stimulate local demand and expedite the use of data do not target all users of the system as well as stakeholders. To improve the efficiency of health systems in this context, it is critical to initiate undertakings to promote the demand and utilization of data. Since the interventions must also be informed by some evidence, let us consider what the enablers and barriers are to the use of logistics information for decision making.

6.1 Enabler to the use of LMIS data for decision making.

6.1.1 Implementation of the eLMIS

Prior to the use of the eLMIS, the paper-based system was the sole system in place. It was devised such that health facilities would send stock reports and requisition monthly to county level supply

chain managers for review, validation, and consolidation before communicating it to the SCMU. Upon verification of the reports and requisitions, the SCMU requests resupply of counties. Data analysis was subordinated in favor of verification of reports for the purpose of resupplying medicines.

The implementation of the eLMIS bears the benefit of real time analysis of logistics data and subsequent synthesis into useful information for decision-making. It facilitates data informed decision-making considering consumption data and historical requests, which the system provides in real time. Tanzania recorded similar experience when it launched the eLMIS. The health workers in charge of the facilities reported that the system eased their tasks owing to its improved precision in performing calculations when compared to the manual computations that often diminished the quality of the data (25). To take full advantage of its many functionalities, however, the challenges of irregular supply of electrical power, unavailability of functioning computers, limited access to internet connectivity and staff without basic computer knowledges needed to be addressed.

6.2 Barriers to the use LMIS data for decision making.

I identified six key barriers impacting the demand for and utilization of LMIS data for decision-making.

6.2.1 Inadequate core proficiencies in data use among most users of the system

To mainstream data demand and use in the management of medicines and health products, , some key skills in data evaluation, explanation, production, report, and the formulation of data-informed recommendations at all levels of a health system are an imperative(26). On the contrary, those skills are frequently subordinated to capacity enhancing schemes that lay emphasis on the management of data including verification and validation. This leads to inadequate skills and low technical capacities within the workforce.

The implementation of the eLMIS after the revision of the supply chain information system introduced benefits such as technologies and innovations to accelerate data processes, and improve data quality, data analysis, stock visibility, and the generation of reports for speedy and better quality decisions in the management of medicines. Consequently, the health facility staff simply collect and report consumption data and participate in the verification of the data submitted to get supplies replenished. Those at the county level who work at the electronic interface of the system are required to upload and publish consumption data and provide clarification on the data submitted when required. Those at the national level essentially carry on quarterly validation of the data to approve medicines for resupply. Though the system provides important information for decision making to manage the medicines, users at all levels have suboptimal core data use competencies to make full use of it. For example, staff could use the product visibility function of the system to manage issues of stock out and expiries. Essentially this could mean moving medicines from facilities of high stock level to other facilities that need them to address stock out situations, or distribute in a timely manner and in small quantities across many facilities some medicines in storage that are soon to expire.

Moreover, decision makers too require adequate skills in detecting information needs to be able to recognize opportunities for the use of data. They need advocacy and leadership skills to source and safeguard funding and support to advance recommendations emanating from the review of data. A study conducted in Nigeria(27) on the barriers and facilitators of evidence informed policy-making highlights the need to improve the skills of policymakers in information and communication technology, and the use and evaluation of data.

6.2.2 Poor quality of the data

Program managers cannot use poor quality data, which does not fulfill the criteria of timeliness, accuracy and completeness, to monitor program performance; it has an undesirable bearing on decision making and planning strategically (28).

There are some key reasons gathered from the study why data quality could be compromised. Health facility supply chain staff also have clinical duties in addition to the SSRR, as in the case of the OIC and the hospital pharmacist, who have tight reporting timeliness to submit SSRR and HMIS reports. A respondent commented,

"*So the work overwhelms the OIC... So at times, when the (reporting) time jams them or when the time elapses…, he sits around the table and half-bake the information*" (meaning prepare a table report).

This is not uncommon in reporting at health facility level. For example, there is evidence that data management was done hurriedly in Tanzania with fast approaching deadlines, leading to backlogs of data and less time available to aggregate data(29). This kind of practice erodes confidence in the data to be used for decision making.

6.2.3 Data available is Inadequate

One of the key barriers to the use of data for decision making is generally a limited access to data(30) to aid decision-making. People in positions of authority are not always aware of the availability of data or how that data might provide the basis for the making of sound decisions in the management of medicines. If the data analyzed by the system and transformed to useful information is available to decision makers at all levels, the quality of decisions will be impacted positively. For example, the eLMIS repository is updated every quarter on stock levels at all health facilities. If this information is synthesized and made available at health facility, county and national levels(31), the decision makers at those nodes will coordinate a mitigation plan to address stock out or expiry issues in a timely manner. When data does not emphasize important understandings or project a clear and concise set of recommendations, a study(32) found that people at the hem of decision making often deem it immaterial.

6.2.4 Weak interaction and connection between data producers and data users

Inadequate interaction and detachment between staff who produce data and users of data for decision making, especially through the processes of collecting data, synthesis, evaluation, explanation, and use, are a major barrier to the use of data. There is often a paucity of mutual respect and uncertainty about the skillsets of data producers and this intensifies negative perceptions about the quality of data and inhibits decision makers from requesting for and acting

on data. As one of the respondents explained the workload on data producers is overwhelming and so they sometimes prepare a table report just to fulfill their reportorial duties, for instance.

In addition, healthcare workers providing services at primary care level play the roles of producing and utilizing data, but they are not aware that they are accountable for both roles. Staff at lower ranks of the tiered reporting structures perceive themselves as playing the role of data producer only(33). In their singular focus on meeting the deadline for reporting, they completely downplay their duties of data analysis and interpretation. In this situation, opportunities to use data are missed because of inadequate knowledge about their responsibility to use them and how such data might be valuable in their work.

Further, due to poor coordination around priorities in decision making, data producers might be unmindful about the types of information each stakeholder craves, those decisions the information is likely to impact, and how such data should be sourced, analyzed, interpreted, and disseminated to meet decision-maker needs(34). As in the case of the data availability barriers discussed, it is critical to fully appreciate the technical skills of decision makers to clearly and concisely organize the information and share it in a timely manner(35). In the absence of proper methodologies to encourage constant commitment and mutual support between data producers and users, the efficiency of the demand and utilization modalities is impaired.

6.2.5 The weak culture of data use

Data use culture depicts the organizational norms, attitudes, and behaviors in supporting and promoting the utilization of evidence to guide decision making processes. When people at the decision-making hem of the health system underutilize data to support the management of performance, planning and service delivery, it undermines the effectiveness of health care service delivery and slows down gains in the health sector(36). A good data use culture promotes the collection of quality data and embraces all stakeholders on issues of the evaluation of data, including explanation and utilization. On the contrary, the role of data use for decision making is skewed toward the national level. For instance, the resupply of medicines to health facilities and counties is contingent on the submission of consumption information. There are established deadlines to meet and facilities run the risk of late supplies if reports are in late. Upon the fulfillment of their reportorial duties, subnational level supply chain staff only look forward to the resupply from the CMS.

There are no expectations of data analysis functions at the subnational level and any initiative to do so is entirely at the discretion of staff. Speaking on data analysis, a respondent made this point,

"Data analysis are done in such a way... that's why we call it like reconciliation".

This is more of the accountability context where health facility report should submit a fully reconcilable report. They perceive the quarterly data reports uploaded into the eLMIS is meant for central level use only. So synthetized information provided by the system, for instance, items at risk of expiring, stock status, and general visibility, is not being used for subnational level decision making.

Furthermore, health workers are motivated when their superiors give them regular performance feedbacks, including target achievement progress reports. The absence of this sort of engagement, a study revealed, influences a diminishing use of data at all levels for decision making(37).

6.2.6 Low Individual commitment and motivation

Health workers' low morale and diminished dedication to work can contribute to lessened drive to use data for decision making. Due to the economic crisis faced by Liberia, staff demotivation could be because of low pay, delayed salaries, unfavorable working conditions, limited or no comment from superiors on performance, and an imposing delegated responsibility. A study(35) done in Malawi concurs with the findings of this study that frontline health workers often subordinate reporting responsibilities to the challenging demands of healthcare service delivery. Moreover, other individual factors, including technology challenge as in the case of the eLMIS implementation, aversion to new work procedures, especially if it bears additional work responsibilities, have been identified as hindrances to the use of data for decision making(38).

7.0 Recommendations

I recommend the following actions to address the barriers to the use of LMIS data as discussed:

1. Build capacity at all levels on core competencies in data use. The consolidated intervention on data use should include trainings, workshops, coaching, mentoring, job specific training, on data use, evaluation and explanation (39).
2. Conduct routine data quality assessment (RDQA) and data quality review (DQR) to comprehend the strengths and vulnerabilities in data quality procedures and practices for standard health information, including the DQR and RDQA. This intervention should involve guidance on data collection highlighting the significance of public health information, response for performance of health information personnel and program managers, and monthly reviews of mundane data. Studies have shown that frequent audits on data quality (40) and data assessment discussions (41) have improved routine data on immunization

3. Make the three systems (eLMIS, mSupply and HMIS) interoperable. Program PSM Officers have the authority to review the system generated resupply quantity when data from SSRR forms are put in the system. If it is TB or HIV medicines which depends on the number of clients and the set of medication they use, for instance, the facility service delivery data reported through the HMIS is a good source for information to guide the verification of the consumption information in the eLMIS. Further, the quantity approved depends on what is available at CMS. Sometimes, CMS shares stock status on spreadsheet with the programs and SCMU. If this information is not forthcoming, quantities may be approved that the CMS does not have. This situation can be avoided if the systems are made interoperable as it will increase the availability of information needed to make decisions in real time. In the interim, however, program PSM Officers should be given access to, and be trained to navigate the HMIS and mSupply for information to guide their decisions.

4. Convene regular meetings with data users and producers to discuss data issues and the progress of programs against targets. Bringing these two groups together affords each the opportunity to articulate expectations as well as challenges relating to availability of data for decision making. The goal is to improve the coordination between the two groups.

5. Initiate a comprehensive method of enhancing data-informed decisions. This will include 1) evaluating and improving the data-use background; 2) Involving data users and data producers; 3) enhancing data quality; 4) expanding data availability; 5) categorizing information needs; 6) developing capacity in data use core competencies; 7) reinforcing the organization's data use substructure; and 8) monitoring and evaluating data use activities.

6. Train data producers and users on data demand and information use and follow up with mentoring and coaching activities to stimulate the demand for data for utilization in decision making.

8.0 Conclusion

Establishing an electronic repository for health logistics management data in Liberia is one key step forward in minimizing the risks of expiries which results in a waste of critically needed funds for health development, and avoiding stock outs which denies patients access to life saving medicines. The study revealed that the key thrust of implementation is to ensure the quality of the data put into the electronic repository. The administrators of the system envision that if data is reliable then the resulting decisions informed by that data will be on point. Therefore, the users of the system are required to fulfill reporting obligations in a timely manner and efforts are exerted at all levels to ensure validation is carried out. Currently, the data is being used to guide decisions on national quantification and replenishment of medicines and supplies nationally, in counties and at health facilities. However, there are other uses of the data that little emphasis is given to, for example, to avoid stock out of life saving medicines and to minimize loss due to expiration of medicines. A timely action to ensure that prominence is concurrently given to guaranteeing the collection of quality data and the use of the data for decision making is not only required but strongly recommended.

The eLMIS as a repository of LMIS data captured on paper-based tools has enormous advantages in terms of its many functions as an ERP software. It analyses data in real time and presents useful information indispensable to the management of medicines and health products at all three tiers of Liberia's health system. Like all databases, users need the required knowledge, skills, and tools to manage them. The study revealed, however, that there are fundamental knowledge, skills, and tools gaps among users of the system, including suboptimal appreciation of some key functions of the database, like stock visualization, items at risk of expiry and of stock out. This could be attributed to a lack of further training after the rollout training, lack of computers along with modems for internet connectivity and funds for internet data subscription, and loss of trained staff due to turnover. These factors contribute to the dire situation that supply chain managers must deal with, for instance, the current low performance regarding submission of reports from most of the

counties. Systems do not function in the absence of trained, equipped, and motivated human resources to manage them. The MOH is therefore on the right trajectory by linking up with donors and NGO partners to mitigate the gaps critical to the implementation of its systems.

On the issue of coordination around the use of data for decision making, two things stand out: the relationship between data producers and decision makers on one hand and the lack of interoperability of the systems in use. Except for the purposes of replenishment, and national quantification for the procurement, of medicines and health products at health facilities, counties, and the CMS, LMIS data is inadequately used. The current collaboration between data producers and decision makers is around the input of quality data in the eLMIS to ensure resupply of medicines at health facilities and county depots. Coordination between these groups should transcend those parameters to include the processes of data collection, its synthesis, evaluation, explanation and eventually, its use to guide management and evidence-informed decision making. Training for both groups on the relevance and use of data for decision making is key sustaining this collaboration. Making the three systems—eLMIS, HMIS and mSupply—interoperable gives decision makers the advantage of assessing data from different perspectives to formulate improved decisions to manage the health system.

The eLMIS presents a huge opportunity to all supply chain stakeholders including national program managers, data producers and information users to enhance the use of the data collected for decision making. If the recommendations are considered and implemented, the objectives of the implementation of the system will be realized.

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