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Evaluating the OpenLMIS ecosystem and understanding the key factors influencing its effective use to improve immunisation outcomes in Nigeria

Evaluation Report

Gavi The Vaccine Alliance

Johns Hopkins Bloomberg School of Public Health
Center for Global Digital Health Innovation

BroadImpact Development & Business Consulting

NPHCDA National Primary Health Care Development Agency

health enabled

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Abbreviations and Acronyms

2PL	Second Party Logistics
BI	BroadImpact
CCE	Cold Chain Equipment
CCO	Cold Chain Officer
CHAI	Clinton Health Access Initiative
DALYs	Disability-Adjusted Life Years
DHIS	District Health Information System
DHPRS	Department of Health Planning Research and Statistics
eLMIS	Electronic Logistics Management Information System
EMID	Electronic Management of Immunization Data
FMOH	Federal Ministry of Health
ISCL	Immunization Supply Chain and Logistics
ISP	Immunization Service Point
LGA	Local Government Area
LIO	LGA Immunization Officer
LMIC	Low-and Middle-Income Country
NAV	Microsoft's Navision
NHMIS	National Health Management Information System
NiSCMIS	Nigeria Immunization Supply Chain Management Information System
NLWG	National Logistics Working Group
NPHCDA	National Primary Health Care Development Agency
NSCS	National Strategic Cold Store
ODK	Open Data Kit
OpenLMIS	Open Logistics Management Information System
PHC	Primary Healthcare Center
PO	Purchase Order
SCCO	State Cold Chain Officers
SIA	Supplementary Immunization Activities
SIO	State Immunization Officer
SLWG	State Logistics Working Group
SPHCB	State Primary Health Care Board
SRV	Stock Receipt Vouchers
TEC	Technical Evaluation Committee
ToC	Theory of Change
TSS	Target Software Standards
VSM	Vaccine Supply Management
VVM	Vaccine Vial Monitor
ZCCO	Zonal Cold Chain Officers

Executive Summary

Effective electronic Logistics Management Information Systems (eLMIS) can improve health outcomes by maintaining accurate and timely information for decision making. In Nigeria, the main real-time digital supply chain information system used for vaccine logistics is the Open Logistics Management Information System (OpenLMIS) - an open-source, cloud-based eLMIS built to manage commodity supply chains. OpenLMIS was first introduced in Nigeria in 2021 for tracking COVID-19 vaccines, and was subsequently rolled out for use in Routine and Supplementary Immunization activities in January 2023.

Gavi, the Vaccine Alliance, commissioned the evaluation of the OpenLMIS implementation in Nigeria as part of the monitoring, evaluation, and learning of their Digital Health Information (DHI) Strategy 2022-2025. The objectives of the evaluation were to:

1. Review the current LMIS ecosystem in Nigeria
2. Understand the key enablers and barriers of using OpenLMIS in Nigeria
3. Assess the strength of implementation of the OpenLMIS program in Nigeria
4. Determine the incremental cost-effectiveness of OpenLMIS use in Nigeria

The evaluation was conducted between April and August 2024 and employed a mixed-methods approach, combining quantitative and qualitative data, to gain a multifaceted and nuanced understanding of OpenLMIS's effectiveness, challenges, and cost-implication across Nigeria's vaccines supply chain system. The study covered the entire country (all stores at National, Zonal, State, Satellite and LGA level) through secondary analyses of data extracted from OpenLMIS, and other pre-OpenLMIS sources. In addition, three states (Federal Capital Territory, Niger and Lagos States) and nine LGAs (3 per state) were selected for qualitative interviews and observation to gain deeper insight into OpenLMIS implementation.

Key findings:

The LMIS ecosystem in Nigeria is a multi-layered data collection and reporting system commencing with both paper-based and electronic records at facility level, and then transitioning to predominantly electronic records from the LGA level and above. There are 3 electronic information systems currently being used simultaneously in the immunization space, namely, the National Health Management Information System (NHMIS) (service delivery data across all healthcare facilities), the Electronic Management of Immunization Data (EMID) platform (vaccine utilization at primary health care levels) and the OpenLMIS (vaccine logistics data). The rollout of OpenLMIS represented a strategic move to improve efficiency in tracking vaccine utilization, provide real-time visibility of the supply chain, and align the country's LMIS with global LMIS standards. OpenLMIS has been adopted country-wide with sustained utilization across all stores from LGAs to the national level for vaccine supply chain management, with requests for scale up to other disease areas such as Malaria and neglected

tropical diseases (NTDs). This wide scale introduction and adoption of the system is improving data availability, visibility, and use of logistics data at all levels of the supply chain. There are also complementary systematic data verification processes in place.

Key enablers and barriers affecting the use of OpenLMIS include:

- At the individual (Health worker - Cold Chain Officers)[1] level there is improved OpenLMIS knowledge and digital tool literacy with users able to carry out the majority of OpenLMIS functions independently and effectively. However, there are several factors that have lowered motivation of personnel, such as frequent turnover of trained staff; prohibitive data costs self-funded by users; and inadequate training opportunities, amongst others. There are no gendered-differences in OpenLMIS utilization, however male participants in this evaluation articulated more challenges, while female users focused more on the benefits.
- At the organizational and environmental level, OpenLMIS has benefitted from strong organizational commitment from key stakeholders, including the government (NPHCDA) and partners including Gavi, CHAI and UNICEF which was crucial in rolling out and fostering utilization of the system. There are however current financial constraints that expose the need for increased government ownership of the platform, especially with respect to resource allocation and meeting recurring training needs towards sustainability. There are also significant infrastructural and equipment gaps that threaten effective implementation of OpenLMIS. The unreliable internet networks in many areas of the country, inconsistent power supply and security of equipment are some of the major challenges faced.
- At the technological level, there are several OpenLMIS features that require improvement, with issues such as system generated errors, a complex user interface, browser compatibility issues, limited data extraction/archiving, and difficulty navigating the Cold Chain Equipment (CCE) feature which seems less intuitive to users. There are also other features that need to be introduced urgently, most importantly the offline client, with many users reporting slow system performance linked to internet connectivity issues. There are also requests to utilize barcode scanning, temperature monitoring, and interoperability features.

The strength of implementation of OpenLMIS **showed** enhancements in service delivery of immunization programs, demonstrated by reduced stock-out events and decreased wastage/expiries of essential vaccines. The observed trends did not show clear patterns and due to significant data limitations faced, the evaluation team could not draw any conclusions about the effect of OpenLMIS on these outcomes. The inability to measure effectiveness and the limitations of pre-OpenLMIS data (data not available) prevented analyses under objective 4. The team however envisages that in a few more years with a longer time series and improved data management and archiving systems, measuring the impact of OpenLMIS on these outcomes will be feasible.

1 Cold chain officers at Zonal, State and LGA levels as well as program managers from the National Logistics Working Group (NLWG) as well as Vaccine Security and Logistics (VSL) officers.

The evaluation makes the following recommendations:

User-related Recommendations

- **Capacity building:** Improve user motivation through additional capacity strengthening support, including increased opportunities for training and refresher training, especially in locations experiencing high personnel turnover, as well as localized user-support services below national-level.
- **Motivation:** Consider a rewards-based system with recognition awards or incentives (internet bundles, modems or financial compensation) to maintain high levels of engagement and performance among users in less enabling environments.

Organization/Environmental Recommendations

- **Resource Allocation:** Increased budgetary allocations to cover key OpenLMIS implementation needs, especially provision of sufficient internet connectivity for users.
- **Review Training Quality:** Assess and review the quality and consistency of training programs, with a goal to increase the frequency of training and ensuring that the trainings meet user needs effectively.
- **Infrastructure Upgrade:** Invest in upgrading infrastructure and technology/ devices in stores using OpenLMIS, including provision of backup power sources.

Technology-related Recommendations

- **Feedback Mechanism:** Assess user-feedback on system challenges and develop a standardized process for soliciting and addressing user challenges.
- **Additional Features:** Introduce urgently needed additional features of OpenLMIS, such as the offline client, data archiving and interoperability with the NHMIS and EMID.
- **Policies and Standards:** Develop data management policies and standards including data governance standards and a data management plan, especially with a lot of data management done outside of the OpenLMIS, to improve LMIS data quality, use and security.
- **Historical Data Management:** Explore integration of historical LMIS records with OpenLMIS records for future evaluation needs. This will require extensive data cleaning and mapping processes.

1. Introduction

1.1 Background

Effective electronic logistics management information systems (eLMIS) optimize the flow of health commodities and information across the supply chain, enhancing visibility, operational efficiency, and decision making. By providing access to timely data and streamlining processes eLMIS helps identify bottlenecks, reduce delays, and improve inventory management, ultimately leading to better health outcomes and more responsive healthcare systems. The digitization of supply chain information systems provides countries with end-to-end visibility of health commodities from the point of delivery from manufacturers to the last mile. In Nigeria, the main real-time digital supply chain information system used for vaccine logistics is the Open Logistics Management Information System (OpenLMIS) - an open-source, cloud-based eLMIS built to manage commodity supply chains. OpenLMIS was first introduced in Nigeria in October 2021 for the tracking of COVID-19 vaccines. As a result of its nationwide deployment for the management of COVID-19 vaccines logistics, the use of OpenLMIS was extended to other vaccines in January 2023 and is operational in all 835 cold stores across the country. OpenLMIS is currently being implemented by Clinton Health Access Initiative (CHAI) in partnership with the National Primary Health Care Development Agency (NPHCDA). It is used for vaccine management in cold stores at national, zonal, state, satellite, and local government area (LGA) levels, but is not yet operational at the health facility level. There are significant potential benefits for OpenLMIS to improve end-to-end immunization management and consequently impact the overall healthcare system.

While there are significant potential benefits of OpenLMIS to improve immunization coverage and program quality, few studies have systematically assessed the effectiveness and cost-effectiveness of such interventions on immunization programs. Within Nigeria, while the system has been scaled nationally, there has not been a formal evaluation to understand the extent to which the system is being implemented and used as intended, enablers and barriers to system use, and any improvements in health systems and immunization outcomes. Furthermore, there has been no cost-effectiveness evaluation to document the costs of implementing the system compared to health benefits.

1.2 Objectives

Gavi, the Vaccine Alliance, commissioned this evaluation of OpenLMIS implementation in Nigeria as part of the monitoring, evaluation, and learning activities of their Digital Health Information (DHI) Strategy 2022-2025. The findings from this report are intended to generate evidence of the effectiveness and cost-effectiveness of eLMIS. eLMIS is a key priority area within the Gavi DHI Strategy and also within the NPHCDA's Digital Health Information for Immunization and PHC Roadmap. Under the broad aim to assess the effectiveness of the OpenLMIS system, four specific evaluation objectives, and their sub-objectives are listed below:

Objective 1: To review the current OpenLMIS ecosystem in Nigeria

1.1 To map the current stock management system in Nigeria from the facility to the national level.

1.2 To study the flow of data in OpenLMIS and chart the journey from paper-based data at the facility level to the digital system at higher levels and understand how data is used.

Objective 2: To understand the key enablers and barriers of using OpenLMIS in Nigeria

2.1 To understand the individual, organizational, and technological factors that influence the adoption, utilization, and user experience (including gender-related differences), of OpenLMIS amongst the health workforce across the supply chain in Nigeria.

2.2 To determine the enablers and barriers of the OpenLMIS scale up for COVID-19 vaccination in Nigeria and gather learnings from a rapid deployment and nationwide scale up of OpenLMIS.

Objective 3: To assess the strength of implementation of the OpenLMIS in Nigeria

3.1 To study program adoption (system access, timeliness and completeness), efficiency (reduced wastage, reduced stock-outs), data quality (error rates, mismatches), and performance (stock availability on immunization session days, replenishment response duration, rate of zero stock events).

3.2 To assess the effect of OpenLMIS data use on planning, service delivery, and monitoring within the supply chain management system in Nigeria.

Objective 4: To determine the incremental cost-effectiveness of OpenLMIS use.

4.1 To determine the cost of implementing OpenLMIS in Nigeria, compared to paper-based LMIS.

4.2 To estimate the improvement in immunization coverage and disability-adjusted life years (DALYs) averted, in high, moderate, and low OpenLMIS usage states.

4.3 To determine the incremental cost per DALY averted in high, moderate, and low OpenLMIS usage states.

1.3 Partners

Key stakeholders involved in this research include:

- **Gavi:** Commissioned the evaluation of OpenLMIS implementation, is a major funder of immunization activities in Nigeria.
- **health.enabled:** Lead of the Gavi DHI MEL consortium, overseeing research quality and relevance to Gavi
- **John Hopkins University School of Public Health:** Research partner supporting the consortium on quality assurance as well as ethical and process compliance.
- **NPHCDA:** Responsible for managing and facilitating immunization activities and logistics in the country. NPHCDA provided inputs to the evaluation protocol, and facilitated access to study locations.
- **Clinton Health Access Initiative:** Implementer of OpenLMIS. Provided relevant program and platform data; and facilitated introductions to relevant stakeholders.
- **BroadImpact (BI):** Local research partner responsible for developing the protocol, facilitating data collection, analysis, and report development.

2. LMIS Overview

2.1 Logistics Management Information Systems

An LMIS is a system of paper-based and/or technology-based (eLMIS) records and reports that supply chain workers and managers collect, aggregate, organize, analyse, validate, and display across all levels of the supply chain, and use to make logistics decisions to manage the supply chain. LMIS data elements include stock on hand, losses and adjustments, consumption, demand, issues, shipment status, and cost of commodities managed in the system. The various key features of an LMIS are: forecasting, inventory management, distribution planning, reporting and ordering, order fulfilment, temperature monitoring, equipment maintenance, performance monitoring and routine data management processes.[2],[3] The shift towards digital systems, eLMIS, has increased the potential to improve the accuracy and efficiency of supply chain management by improving data visibility, access, and use, resulting in increased availability of stocks, reduction in waste, and better monitoring of the cold chain to ensure that products remain potent.[4],[5],[6] eLMIS can also be linked to electronic medical records (EMRs) or hospital management information systems for seamless transfer of data. In low-and middle-income countries (LMICs) supply chain activities predominantly rely on paper-based systems, leading to incomplete data, subpar data quality, significant delays between data entry and its availability for practical use.[7],[8],[9] Even when eLMIS solutions are implemented, these countries grapple with challenges related to inadequate network connectivity, limited access to electricity, and the complexities of change management, particularly among users with limited digital literacy.[10]

2.2 LMIS Landscape in Nigeria

Before the global COVID-19 pandemic that led to the introduction of the large-scale use of OpenLMIS in Nigeria, there were other digital tools for supply chain management like Microsoft Navision whose licensing fees limited its ability for use beyond project funding. After the donor funding for Navision had elapsed, the Nigeria Immunization Supply Chain Management Information System (NISCMIS) was terminated on 10 April 2020 due to high operational costs, technical issues, and inadequate capacity transfer to the Government. The National Logistics Working Group (NLWG) developed an open data kit (ODK)-based LMIS as a stopgap measure (and has now been phased out

2 JSI Supply Chain Manager's Handbook
3 Logistics - DHIS2. https://dhis2.org/logistics/
4 Gilbert, S. S. et al. The impact of an integrated electronic immunization registry and logistics management information system (EIR-eLMIS) on vaccine availability in three regions in Tanzania: A pre-post and time-series analysis. Vaccine 38, 562–569 (2020).
5 Prosser, W. et al. System redesign of the immunization supply chain: Experiences from Benin and Mozambique. Vaccine 35, 2162–2166 (2017).
6 Shieshia, M. et al. Strengthening community health supply chain performance through an integrated approach: Using mHealth technology and multilevel teams in Malawi. J Glob Health 4, 020406 (2014).
7 Gilbert, S. S. et al. The impact of an integrated electronic immunization registry and logistics management information system (EIR-eLMIS) on vaccine availability in three regions in Tanzania: A pre-post and time-series analysis. Vaccine 38, 562–569 (2020).
8 Shieshia, M. et al. Strengthening community health supply chain performance through an integrated approach: Using mHealth technology and multilevel teams in Malawi. J Glob Health 4, 020406 (2014).
9 Lydon, P. et al. Vaccine stock outs around the world: Are essential vaccines always available when needed? Vaccine 35, 2121–2126 (2017).
10 Agarwal, S., Perry, H. B., Long, L., & Labrique, A. B. (2015). Evidence on feasibility and effective use of mHealth strategies by frontline health workers in developing countries: Systematic review. Tropical Medicine & International Health, 20(8), 1003–1014. https://doi.org/10.1111/tmi.12525

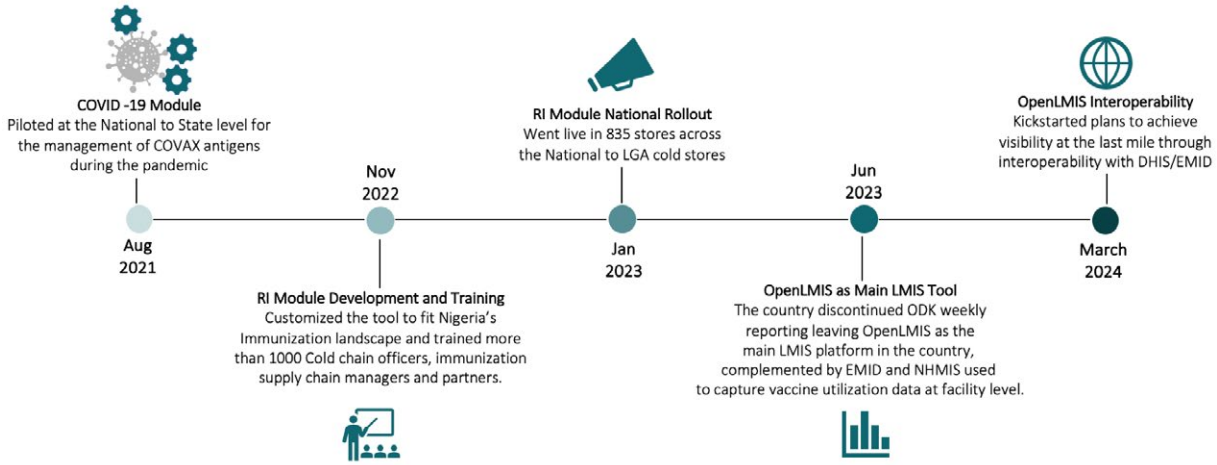
completely) for stock data management, which provides weekly stock visibility across national-, zonal-, state- and LGA-levels for vaccine accountability and distribution decision making. OpenLMIS was subsequently selected as a preferred option by the NPHCDA as an electronic Vaccine and Logistics Management Information System (e-VLMIS) solution for Nigeria that is in line with the Target Software Standards (TSS) for Vaccine Supply Chain Information Systems. There are however other systems still in use, including the Electronic Management of Immunization Data (EMID) platform supported by eHealth Africa, which is used at the PHC level to record data of children immunized and vaccine doses consumed. Currently, the EMID platform has been piloted in two states with plans to scale up. 'Field Supply' is another eLMIS system being used for a variety of programs including HIV, Malaria, Family Planning, Tuberculosis and Maternal, Newborn & Child Health. Field Supply has now enabled over 193 million pharmaceutical interventions (measured by consumption) since 2016. Over 30,000 facilities and 12,746 users are active on the system.[11],[12] These systems operate in isolation and there is currently no data exchange between them.

2.3 OpenLMIS in Nigeria

The main real-time digital supply chain information system for vaccine management in Nigeria is the OpenLMIS. OpenLMIS is an open-source, cloud-based eLMIS built to manage commodity supply chains. OpenLMIS was named a Qualified LMIS Software in 2019 by Gavi and The Global Fund to fight AIDS, Tuberculosis and Malaria based on its compliance with prioritized software standards. OpenLMIS was first introduced in Nigeria in 2021 after it was selected using the Gavi Target Software Standards (TSS) by NPHCDA and partners for tracking COVID-19 vaccines. In August 2021, it was piloted at the national and state levels for the management of COVAX antigens during the pandemic. As a result of the nationwide deployment of the OpenLMIS for COVID-19 vaccine delivery using OpenLMIS, the RI module (for other vaccine preventable diseases) was developed and training was done for over 1,000 Cold chain officers, immunization supply chain managers and partners in November 2022. The RI module went live in all 835 stores across the National to LGA cold stores in January 2023. The OpenLMIS has now been customized by CHAI to include other vaccine-preventable diseases (BCG, Penta, HepB3, Measles, PCV, OPV, HPV etc.) under the Routine Immunization (RI), Non-Polio Supplementary Immunization Activities (SIA), Polio SIA and other health commodities program.

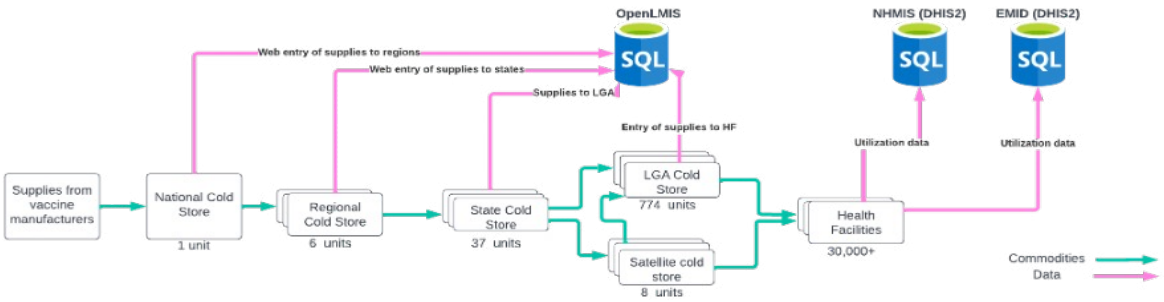
11 Brigden, D. Deploying an electronic LMIS: Making the right choice - TechNet-21. https://www.technet-21.org/en/hot-topics-items/431-data/15270-deploying-an-electronic-lmis-making-the-right-choice#mSupply.
12 FieldSupplyLMIS.pdf.

Figure 1. OpenLMIS Implementation Timeline



In terms of coverage, Nigeria is currently the largest OpenLMIS implementation globally, with OpenLMIS used at the national, zonal, state, satellite, and LGA cold stores, reaching all 835 locations. Of note, OpenLMIS is not being used at the health facility level. The cold chain officers at the 835 cold stores use the platform via a web interface on tablets at the LGA level and laptops at the state and national levels. Opportunities exist to connect OpenLMIS to the health facility level through interoperability with the EMID platform, but this has not yet been done. Figure 2 below depicts the flow of commodities (green arrows) and the flow of data (pink arrows) in the vaccine supply chain and LMIS.

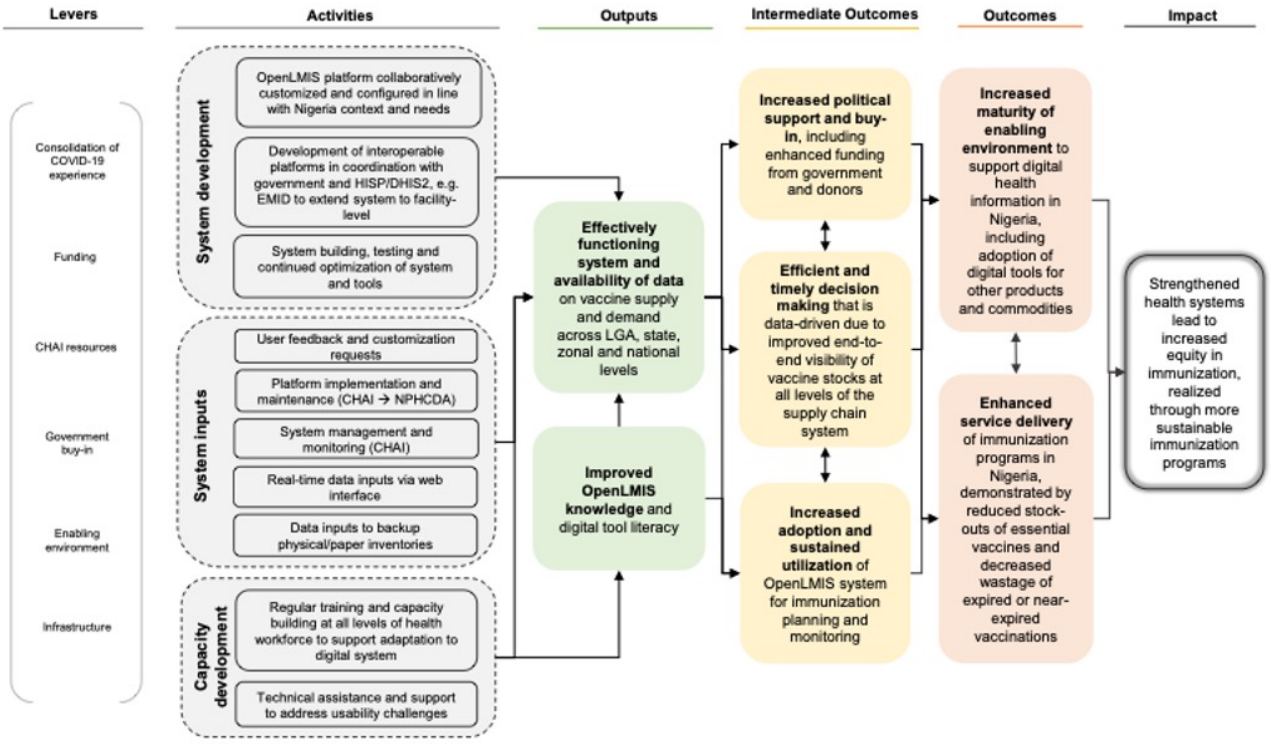
Figure 2. Flow of vaccination commodities and information utilization



2.4 Theory of Change

Figure 3 outlines the theory of change for Open LMIS. The grey boxes depict program activities categorized into three groups: systems development, system inputs and capacity development. Programme activities lead to outputs (green boxes), and then outcomes depicted in varying shades of orange to pink and ultimately impact depicted as a white box. Assumptions underpinning the flow of results are detailed at the base of the diagram.

Figure 3. Theory of Change: OpenLMIS implementation and use in Nigeria



Assumptions: (1) Government buy-in exists holistically across relevant agencies and Ministries (2) Reducing fragmentation using interoperability standards and their implementation remains a priority (3) There is a stable and adequate health workforce at all levels of the health system, i.e. minimal and managed turnover of workforce (4) Health workers have the appropriate technological skills to utilize digital systems and tools, and are not overburdened by administrative and clinical tasks, risking sustained use of OpenLMIS (5) Infrastructure, such as uninterrupted power supply or alternate forms of connectivity exist (6) There are dedicated resources, including user support teams, to troubleshoot issues.

3. Methodology

3.1 Study Design and Setting

The evaluation employed a mixed-methods approach, combining quantitative and qualitative data, to assess the effectiveness of OpenLMIS implementation across Nigeria's vaccine supply chain system. Country-wide quantitative data were extracted from OpenLMIS, HMIS and other pre-OpenLMIS sources such as ODK-based LMIS. In addition, three states and nine LGAs (3 LGAs per state) were purposively selected for qualitative interviews and observation to gain deeper insight into indicators such as user perceptions and enabling factors. Based on the selection criteria, Table 1, the three states were Federal Capital Territory (Northcentral), Niger (Northcentral), and Lagos (Southwest). In each of the selected states, three (3) LGAs (one per senatorial zone) were visited for qualitative data collection.

Table 1: Qualitative Study Selection Criteria

Selection Criteria

- Geographical distribution of the three states.
- States/LGAs where there are Zonal cold chain stores.
- FCT selected due to the presence of National stakeholders.
- Rural, Urban LGAs in each state; infrastructural differences/power supply.
- High, moderate, and low OpenLMIS usage States.[13]
- Security and accessibility to stakeholders.
- Implementation context (training and support).

OpenLMIS Utilization Categories: As OpenLMIS was deployed in all locations across the country at the same time, there was no comparison group to aid effectiveness measures. The evaluation team thereby opted to compare stores in different location by their levels of utilization (High, moderate and low utilization states). The initial categorization was based on any form of utilization (i.e. the number of unique users out of 835 cold stores who logged in to perform stock management tasks within OpenLMIS each week, regardless of the specific function carried out or how well these functions were carried out). The categorization was subsequently revised to be truly reflective of variations in utilization by assessing completeness of reporting across key indicators

13 This categorization was based on initial analysis using the number of unique users out of 835 cold stores who logged in to perform stock management tasks within OpenLMIS each week

and using this to group stores into high, moderate and low utilization categories.[14] This new categorization forms the basis for quantitative results presented in this report, however the old categorization was used for the qualitative and observational assessment. Table 2 below shows the categorization of states across the 3 usage levels.

Table 2: New categories for OpenLMIS Utilization rates by State

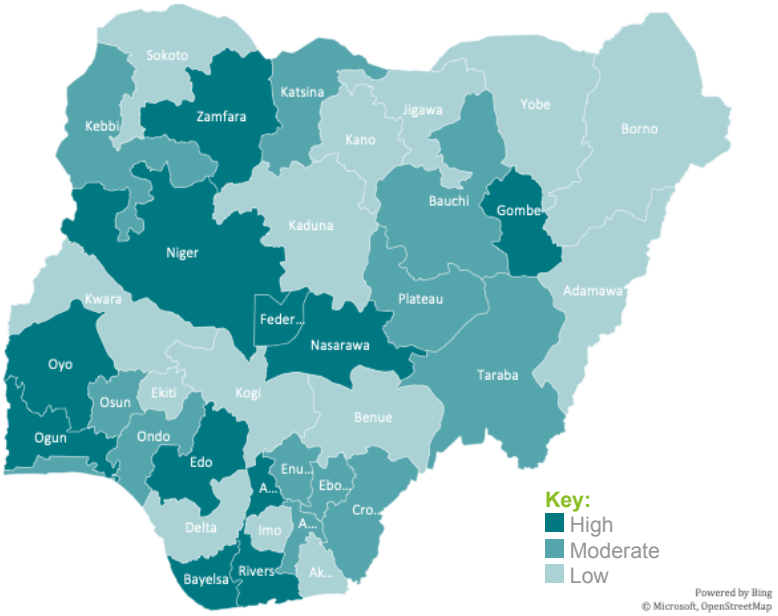
Utilization Category	State
High	FCT, Edo, Ogun, Zamfara, Nasarawa, Anambra, Rivers, Gombe, Bayelsa, Oyo, Niger
Moderate	Ebonyi, Enugu, Ondo, Osun, Lagos, Cross River, Plateau, Taraba, Katsina, Bauchi, Kebbi, Abia
Low	Kwara, Jigawa, Yobe, Akwa Ibom, Sokoto, Benue, Kogi, Kano, Borno, Delta, Kaduna, Ekiti, Adamawa, Imo

3.2 Data Collection and Analysis

The evaluation used the following data-collection methods:

1. **Desk Review:** The study commenced with a desk review that probed programmatic documents, reports, and dashboards related to OpenLMIS implementation, as well as a comprehensive eLMIS literature review that had been completed prior to the evaluation by HealthEnabled and its consortium partners.

Figure 4. Map showing OpenLMIS utilization levels across Nigeria



14 The new OpenLMIS utilization categories were determined based on completeness of reporting in two main reports that are expected to be submitted weekly across stores. These are the stock taking reports and the expiry reports. The analysis examined the percentage of weekly reports submitted in 2023 (the only full year of implementation of OpenLMIS) in both datasets, as an indicator of completeness. Generally the completeness levels are high across all stores, with very few stores recording under 70% completeness. In categorizing, any stores that had over 90% completeness of reporting for both reports were classified as high usage; those with over 90% completeness for one report and less than 90% on the other were classified as moderate; and those with under 90% for both reports were classified as low.

2. **Secondary Data Collection and Analysis:** Secondary data was extracted from OpenLMIS, previous LMIS sources and NHMIS, and analysed with a focus on comparing high, moderate, and low OpenLMIS utilization states.
3. **Direct Observation:** Observation of use of OpenLMIS was conducted as part of the evaluation. Prior to administering the qualitative interviews, the evaluation team observed OpenLMIS usage in real time, enabling them to witness firsthand how the system functions within its real-world setting.
4. **Qualitative Interviews:** The team also conducted complementary in-depth interviews in-person and virtually. These interviews targeted cold chain officers, and program managers and captured their experiences, opinions, and insights on OpenLMIS' implementation. A total of 42 interviewees were consulted. See Annex 4 for list of consultees.

4. Findings

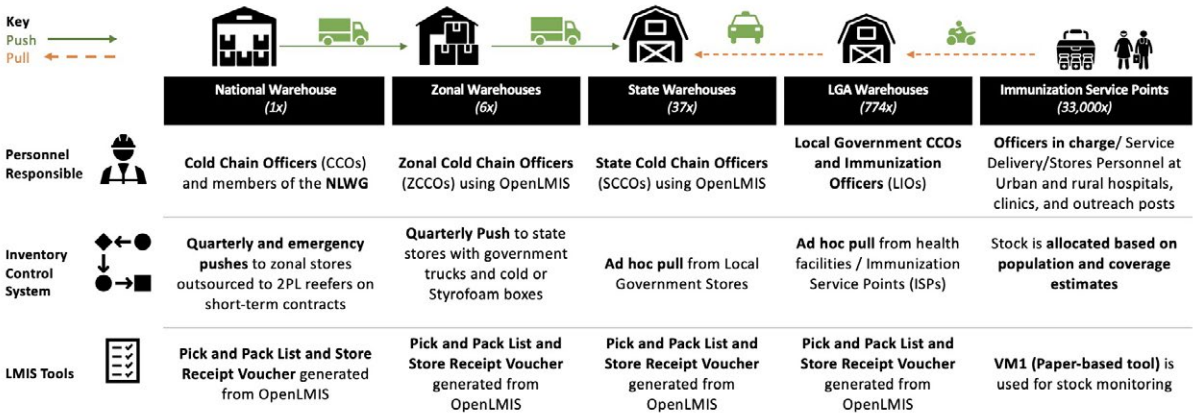
Objective 1: To review the current OpenLMIS ecosystem in Nigeria to review the current OpenLMIS ecosystem in Nigeria)

Under this objective, the evaluation team reviewed the vaccines logistics management system in Nigeria, the rationale for adoption of OpenLMIS and its integration into the vaccines logistics management system.

Objective 1.1 To map the current stock management system in Nigeria from the facility to the national level

The immunization supply chain and logistics (ISCL) program in Nigeria operates a push system for vaccine stock management. However, sub-nationally there are instances where ad hoc pull systems are also in operation.

Figure 5: Stock Management Flow of the Nigeria ISCL



The immunization supply chain in Nigeria comprises five cold-store levels: National (1), Zonal (6), State (37), Satellite (22), and Local Government Authority (LGA) (774), in addition to public health facilities numbering more than (30,000). The flow of vaccines and related supplies begins at the National Strategic Cold Store (NSCS), the central hub that receives vaccines and dry goods directly from national and international manufacturers. These products are received by the NSCS in line with purchase orders (POs) that are created using estimated demand and population size. Stock level data (including stockouts and overstock instances) from the OpenLMIS are used to provide insights on utilization rates and trends to help predict future demand.

On a quarterly basis, supplies received at the NSCS are pushed to the 6 Zonal Warehouses through second-party logistics (2PL) reefers, contracted on a short-term basis.[15] Every quarter, responsible officers at the National warehouse generate pick-

15 National Primary Health Care Development Agency: Visibility & Analytics Network Use Case Baseline Analysis (2015). National Primary Health Care Development Agency, Abuja, Nigeria

pack lists from the OpenLMIS (generated using a prioritized list based on the Vaccine Vial Monitor (VVM) stage, expiry date and stock on hand), they then post shipments to OpenLMIS and print Stock Receipt Vouchers (SRVs) for documentation purposes. Once the products arrive at the 6 zonal warehouses, the Zonal Cold Chain Officers (ZCCOs), manage the stock using OpenLMIS and further push the supplies to state cold stores using government trucks. At the state level, cold stores are managed by State Cold Chain Officers (SCCOs) using OpenLMIS to push vaccines to LGA level.[16] LGA stores push vaccines to over 33,000 immunization service points (ISPs), which include urban and rural hospitals, clinics, and outreach posts. Stock at these service points is allocated based on population size and coverage estimates, with facilities in-charge being responsible for tracking usage to ensure that vaccines are available for the local population. The state level stores also manage ad hoc pulls from the LGA stores, as well as pulls from health facilities from LGAs.[17]

The Minimum-Maximum level inventory control system is implemented to balance the need for sufficient vaccine stock against the risk of overstocking, which can lead to wastage especially for temperature-sensitive items.

Each warehouse, from the national down to LGA stores and ISPs, maintains a minimum and maximum stock level for each vaccine. The minimum level is 25% of stock needed per order period and this indicates minimum quantity indicates that there is enough inventory to meet demand until the next scheduled delivery. The maximum stock is 100% plus a 25% buffer stock which serves to ensure continuous supply during periods of unexpected demand or delays in resupply. The buffer stock levels are calculated based on historical usage data and projected needs, ensuring that there is enough stock on hand to cover gaps between scheduled deliveries. Buffer stock is expected to last for six weeks, four weeks and one week at the national, zonal/ state and LGA stores respectively. When the availability of stock is at 50% of the required amount, re-order requests for the affected product can be made. An overstock is experienced when there is an accumulation of excess stock that has exceeded storage capacity and could lead to expiry of vaccines. The vaccine stock reports are color-coded to show when the stock levels are either insufficient (below buffer), at reorder point (below sufficient or 50% of needs in a location), sufficient (above reorder point) or overstocked (above maximum needs). In cases where a store has exceeded its maximum stock levels, the directive is given to push vaccines to other locations either in need of supplies or that can accommodate the stock without exceeding their maximum stock.

16 Ottih C, Cussen K, Mustafa M. Building strong health supply chain systems: the visibility and analytics network approach to improving the Nigeria immunization supply chain.(2018). J Innov Health Inform. 25(4):199–206.
17 National Primary Health Care Development Agency: Visibility & Analytics Network Use Case Baseline Analysis (2015). National Primary Health Care Development Agency, Abuja, Nigeria

Objective 1.2 To study the flow of data in OpenLMIS and chart the journey from paper-based data at the facility level to the digital system at higher levels and understand how data is used

The LMIS data collection process commences at the facility level using paper-based tools, alongside the other electronic platforms NHMIS and EMID.

Health facilities primarily use paper-based tools such as the VM1A & B forms and immunization summary sheets for recording vaccine and other supplies' utilization data. These forms are filled out by the health facility staff and submitted to the LGA level. Table 3 below lists the forms and the information that they capture and reporting timelines. Facility staff also use the NHMIS and EMID to collect and report LMIS data.

Table 3: Overview of Paper-based LMIS

Form Name	Key information captured	Frequency of completion	Other information
VM1A Form	• Minimum & maximum stock • Opening balance • Doses received & opened • Ending balance • Quantity returned • # of empty vials • Vaccine wastage	End of the month and whenever there is: • a delivery of vaccines and other supplies; • an immunization session; and • a return of items to the LGA.	This report is signed off by the RI focal person at the end of the month.
VM1B Form	• Stock level of vaccine devices and other materials • Minimum & maximum stock of supplies • Opening & Closing balances • Quantity returned to LGA • Status of cold chain equipment at facility	End of the month	

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Form Name	Key information captured	Frequency of completion	Other information
Immunization summary sheet	• # of antigens administered / session • Type of session e.g. fixed, outreach or mobile	Start of the month and at every session	At the end of the month, the antigens are totalled, signed by the RI focal person and the LGA Immunization Officer (LIO), and sent to the LGA. This data is also entered into the NHMIS/ DHIS2 RI module.

There are 3 electronic information systems used in the immunization space, namely: The National Health Management Information System (NHMIS), the Electronic Management of Immunization Data (EMID) platform and the OpenLMIS.

- The NHMIS, developed to manage health service delivery data (including some logistics indicators), was initiated by and is domiciled at the Department of Planning Research and Statistics (DHPRS) of the Federal Ministry of Health (FMoH). Data from the DHIS is used at all levels of the healthcare system (national, state, LGA and facility levels).
- The EMID platform was developed initially to manage COVID-19 vaccination data across the country but is now also used to track immunization data and vaccine stock data at the health facility level. The data from this platform is domiciled at the NPHCDA.
- OpenLMIS is an open source, cloud-based eLMIS used in Nigeria primarily to manage stock data of vaccines, related devices and cold chain equipment.

The NHMIS and EMID platforms (both of which operate on the District Health Information System_DHIS2 software) play a dual role handling both service delivery and logistics data, while the OpenLMIS handles only stock management information for vaccines and related commodities.

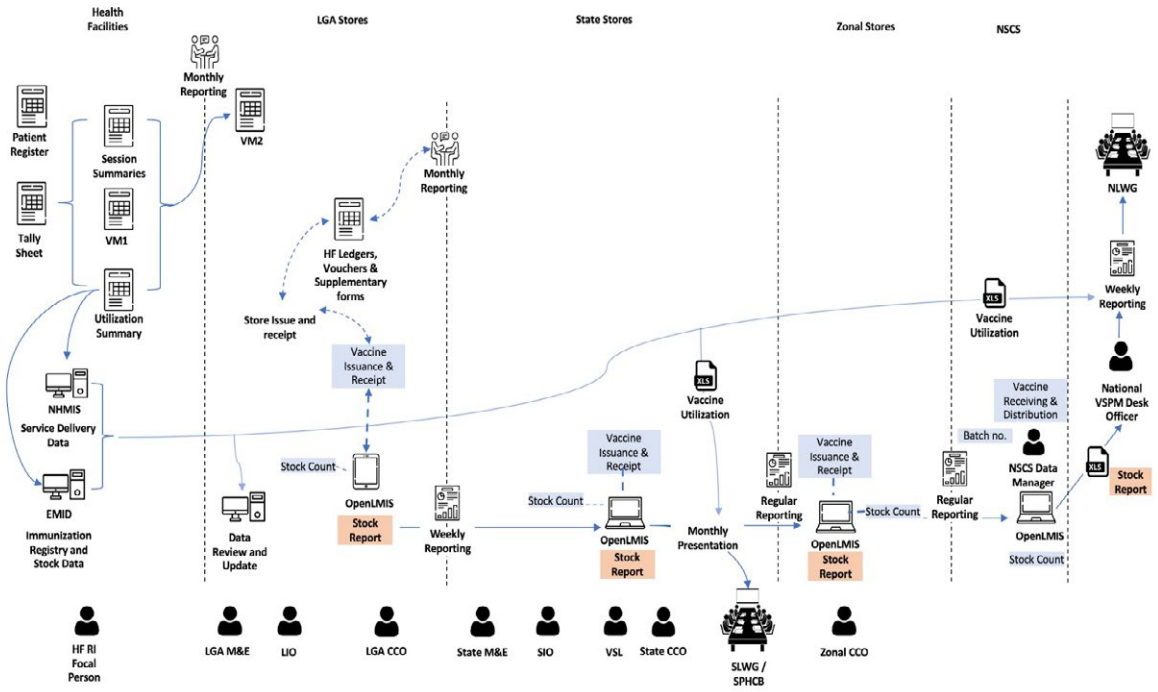
Data Flow and Use

The flow of data starts with both paper-based and electronic records at facility level, and then transitions to predominantly electronic records from the LGA level, where data is consolidated and entered into the OpenLMIS to be transmitted to higher levels.

At the facility level, the RI focal person is responsible for data entry into both paper-based (stock counts into VM1 forms) and electronic forms (utilization reports entered into the EMID and NHMIS). The LGA Monitoring and Evaluation Officer and the Immunization Officer (LIO) receive stock reports from the different health facilities and aggregate using VM2 forms. Respondents opine that this dual data entry at the LGA and facility level creates significant challenges and inefficiencies as it increases the workload, heightens the risk of inconsistencies, and requires time-consuming reconciliation efforts. The LGA Cold Chain Officer (CCO) makes use of the stock reports from VM2 and utilization data/needs to determine stock amounts to push to the facility and updates resulting stock balance on the OpenLMIS; similarly, the information entered at the LGA level is used by the State CCO to inform stock needs and likewise this is done at the Zonal store by the Zonal CCOs and then at the National level. See Figure 6 below.

At the State level, the State M&E and State Immunization Officers (SIO), as well as the Vaccine Safety and Logistics (VSL) Officers from UNICEF support the supply chain decision making processes. Periodic meetings are held at the State Logistics Working Group (SLWG) and State Primary Health Care Board (SPHCB), where stock reports are presented and discussed for decision making. At the National level, logistics officers at the NSCS manage vaccine receipts from purchase orders, inventory and distribution. Decisions are made at the NLWG meetings, where stock utilization reports from OpenLMIS are used to forecast vaccine needs, determine purchase requests and stock distribution to the lower-level stores. Also, program managers reported that they regularly refer to the Vaccine Supply Management (VSM) dashboard and other data outputs from OpenLMIS during weekly and monthly meetings and planning sessions.

Figure 6: LMIS data reporting flow from the health facility to the national level



Data Verification

The process of data verification in the immunization supply chain is systematic and multi-layered, ensuring consistency and accuracy at various levels.

To ensure the reliability of the data within OpenLMIS, there is a practice of cross-verifying the digital records with physical stock counts across the supply chain. This helps to identify any discrepancies and maintain data accuracy. The process flags potential errors, enabling quick corrective actions. At the health facility level, data on vaccine utilization and stock management is recorded using paper-based tools and is later cross-checked with physical stock counts, on a weekly basis. This data is sent to the LGA, where it is captured in OpenLMIS and cross-checked for errors. Additionally, discrepancies, often caused by human error or logistical challenges, are addressed through weekly physical stock counts in stores at all levels and subsequently adjustments are made in OpenLMIS, ensuring that the reported data reflects the actual stock levels. When pushing commodities from the National to lower levels, the receiving stores also do a physical count to verify that what was actually received correlates with the printed SRVs from OpenLMIS.

Objective 2: To understand the key enablers and barriers of using OpenLMIS in Nigeria

This section presents the findings on the individual, organizational, and technological factors that influence the adoption, utilization, and scale up of OpenLMIS as well as user experiences.

Objective 2.1 To understand the individual, organizational, and technological factors that influence the adoption, utilization, and user experience of OpenLMIS amongst the health workforce across the supply chain in Nigeria.

OpenLMIS improved the knowledge and digital tool literacy of CCOs who are able to carry out the majority of OpenLMIS functions independently and effectively. However, there were differences in OpenLMIS proficiency across the three utilization groupings with participants from states with low OpenLMIS utilization having limited expertise to complete certain tasks as compared to others. Using the observational tool[18] designed for this study, 16 Cold Chain Officers across the LGA, State, Zone and National levels were assessed. The officers conducted a range of specific functions on OpenLMIS as applicable to their roles. Overall performance indicates that, on average, the CCOs are able to carry out 80% of the tasks without any challenges. Table 4 shows the performance of respondents across the functions by the level of OpenLMIS utilization in their location (Low, Moderate, and High). This highlights **improved OpenLMIS knowledge and digital tool literacy**, the second output in the OpenLMIS ToC.

The evaluation also assessed CCOs capabilities in using certain system functionalities. In “Creating Physical Inventory”, users found the process cumbersome, especially when handling bulk submissions, and suggested improvements like allowing individual product updates and hiding out-of-stock batches in the OpenLMIS interface. “Issuing Orders” posed difficulties with product listing and the inability to withdraw issued products, leading to recommendations for system enhancements like auto-summation of vaccine quantities and better management of product expirations. “Managing Cold Chain Equipment” emerged as a significant challenge due to insufficient training and system complexity, prompting calls for further training and system improvements. Also, for “Confirming Shipments” some users called for improved communication externally and better record-keeping within OpenLMIS. Lastly, “Generating Stock Reports” (balance, expiry, and distribution),”Rectifying Stock Balance” and “Transferring Stock Items” were relatively easy for users, except in cases where training was lacking.

Participants from low OpenLMIS utilization areas experienced more challenges on average completing the different functions that were tested. These participants reported incomplete training as well as being recently employed as the reason for their limited expertise with these tasks. The tasks that were not conducted properly include: issuing an order, confirming shipment, generating stock balance report, generating a report showing stock expiry status of products, generating a stock distribution report

18 The observational tool was designed to capture the user experience of OpenLMIS and associated individual, organizational, and technological factors that affect utilization. The observational tool measured the ability of the CCO to carry out key functions, state challenges and suggest improvements for carrying out those functions on the OpenLMIS, such as: Create Physical Inventory, Make Issue - Issue an Order, Make Receive - Confirm Shipment, Make Adjustment - Rectify stock balance where there is an over-issue of a commodity, Transfer stock items from one program to another (Non-Polio SIA to RI), Stock on Hand / Stock Status Report - Generate stock balance report, Generate report showing Stock expiry status of products, Generate stock distribution report and Manage Cold Chain Equipment.

and managing cold chain equipment. See Table 4, below, a heat map showing the proportion of participants observed, with the ability to complete OpenLMIS tasks vs their OpenLMIS utilization category (Low, Moderate and High).

Table 4: Heat map showing ability to complete OpenLMIS tasks vs. OpenLMIS utilization level (Low, Moderate and High)[19],[20]

Functions	L	M	H	User Experiences	User Suggestions
Create Physical Inventory	100%	100%	80%	• Users found the process of creating physical inventory initially difficult and cumbersome, particularly when there's a need to carry out bulk submission of antigens. • Users complained about the presence of multiple batch numbers, including those for out-of-stock vaccines.	• Allowing individual product updates (where not all products have to be updated before submitting). • Hiding batches with zero stock to streamline the process and reduce errors.
Make Issue - Issue an Order	83%	100%	100%	• Difficulties with product listing, where products are not listed sequentially and by manufacturer. • Inability to withdraw already issued products and relocate to other facilities as a limitation of OpenLMIS.	• Adding auto-summation of vaccine quantities being issued. • Ability to correct false product expiration flags. • Enhancing the issuance process to avoid the need for one-by-one entries.

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19 A total of 16 Cold Chain Officers participated in the observational survey across the 3 locations; L (n=6), M (n=5), H (n=5)
20 Qualitative analysis of the performance variations across high, moderate and low utilization states can be found in Annex 5 (A5).

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Functions	L	M	H	User Experiences	User Suggestions
Make Receive - Confirm Shipment	50%	100%	100%	• Most users were able to carry out this function without challenges.	• The system should maintain accurate shipment dates and provide real-time stock notifications when attempting to update inventory.
Make Adjustment - Rectify stock balance where there is an over-issue of a commodity	100%	100%	100%	• None of the users found it difficult to carry out this function.	• Enable sorting out some batches from the list. • Allow for other reasons to be inputted when making adjustment asides from the defaults listed.
Transfer stock items from one program to another (Polio SIA to RI)	100%	100%	100%	• None of the users found it difficult to carry out this function, although there were occurrences where the user claimed to not have been trained on this particular function.	• The system should be reconfigured to ask for approval for transfer whilst recording the name of person and the actual date that the transfer was initiated.
Stock on Hand / Stock Status Report - Generate stock balance report	75%	100%	100%	• All the users performed this task save an instance where the user (an assistant CCO), had not been trained at the time of the assessment.	

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Functions	L	M	H	User Experiences	User Suggestions
Generate report showing stock expiry status of products	67%	100%	50%	• Several users claimed that they rarely use this function in their work and others had not been trained on this particular feature.	• There is a need for training on this functionality.
Generate stock distribution report	50%	100%	100%	• There were no challenges for many of the respondents to carry out this function; however, users that could not carry out this function were not trained at the time of this assessment. Users agree that this function is straightforward and helpful for reporting.	
Manage Cold Chain Equipment	33%	100%	100%	• Users that face significant challenges in managing Cold Chain Equipment, report a lack of training and difficulties in navigating the system. Also, some users mentioned the system's lack of detail, compared to the Inventory and Gap Analysis (IGA) tool, and slow loading times further hinder efficient usage.	• There is a need for additional training and system enhancements to improve functionality.

User-related factors affecting utilization of OpenLMIS

Qualitative interviews also revealed user-related factors that play a role in enabling or hindering OpenLMIS implementation. User-related factors refer to the unique characteristics related to individuals' internal influences (attitudes, motivation, and perception) that affect their adoption and utilization of OpenLMIS.

Several factors have lowered motivation of personnel at LGA level such as frequent turnover; prohibitive data costs; and increased workload due to the implementation of OpenLMIS. Conversely motivation has increased at State level and above, with streamlined logistics processes due to improvements in digitalization afforded by OpenLMIS. There are however concerns related to the inadequacy of training opportunities.

The level of commitment and motivation among staff varies widely across locations and is influenced by factors such as limited budgets, delayed salaries, conflicting responsibilities, and perceived importance of OpenLMIS. Many respondents identified high turnover of personnel, often driven by political changes, as a significant barrier to the effective use of OpenLMIS.

> *Out-of-pocket funding of data has been a huge challenge; with delays in paying salaries; which is not unique to just the supply chain but to service delivery in general. Also, change in governance often affects the appointment of the CCOs, creating a huge gap in knowledge and competency*
>
> ***NLWG***

These frequent political interventions in human resource decisions disrupt the continuity and institutionalization of OpenLMIS knowledge alongside other programs and services. As a result, new staff members are unprepared to use OpenLMIS, as they lack the necessary skills and training to use the system effectively, with limited or no training and capacity building opportunities for locations where trainings had previously been conducted.

> *I am not motivated to use the OpenLMIS because I am the one funding the cost of data from my pocket to upload vaccines records. I have had some trainings on the use of the tool but still need more trainings to help me in some other areas of the tool.*
>
> ***CCO***

A recurring theme, especially at the LGA level, is the added workload due to the requirement to maintain both electronic and paper-based records. This is seen as burdensome and has in some cases led to errors on the system during data entry, particularly for users handling large volumes of data or managing multiple tasks. Conversely, at higher levels of the supply chain, respondents state that a positive outcome has been the reduction in paperwork, which has streamlined logistics processes and allowed staff to focus more on critical tasks such as vaccine data utilization.

"It has added to our problem because we don't have supporting hands. We enter the ledger and the OpenLMIS at the same time, so OpenLMIS adds to our workload"

CCO

By digitizing data entry and management, the system has minimized the time and effort required for manual record-keeping, which was previously a significant part of the logistics workflow. The implementation of OpenLMIS has led to a shift in staff roles, with more emphasis now being placed on data management and analysis. This shift reflects the growing importance of digital tools in logistics management, where staff are increasingly required to engage with data-driven decision-making processes. While this has improved accountability and transparency, it has also necessitated an adjustment in skill sets and job functions for those involved.

Respondents also noted a positive effect of increased training opportunities on system utilization and data accuracy. This suggests that adequate training, continuous support and external monitoring activities are crucial for the successful adoption and effective use of OpenLMIS. Additionally, some users reported that personnel fund their OpenLMIS internet needs out-of-pocket, a significant factor that is demotivating OpenLMIS users.

Although there were no gendered-differences in OpenLMIS utilization, the evaluation found some gender differences in users' reports of the benefits and challenges of OpenLMIS. There were also gender differences in staffing patterns across locations assessed.

In describing experiences with OpenLMIS, female respondents tended to focus more on the system's benefits in improving accountability, data safety, and ease of access to data. Male respondents, on the other hand, in addition to describing these benefits reported more technical challenges such as increased workload, equipment issues, and network unreliability. There were also differences in staffing patterns noted in the cold chain stores, with more males in leadership positions in the North and more females in the South. However, these differences do not appear to impact the adoption and use of the OpenLMIS.

Organizational/ Environmental factors affecting utilization of OpenLMIS

Government commitment and partner support have contributed to strengthening OpenLMIS utilization

OpenLMIS has benefitted from strong organizational commitment from various stakeholders, including the government, NLWG, program managers, cold chain officers and implementing partners. This support has been crucial in rolling out and fostering utilization of the system. Support from Gavi, CHAI and UNICEF, have been instrumental in the rollout and implementation of OpenLMIS and this support consists of trainings, provision of resources, and technical assistance. Many respondents acknowledged that initial onboarding, along with periodic refresher courses facilitated by CHAI and NPHCDA, played a critical role in their ability to troubleshoot and navigate the system. Technical support provided by UNICEF via WhatsApp and Zoom also contributed positively. In areas where strong leadership and regular follow-up are present, higher levels of engagement with the system were noted. This finding contributes partly to the first intermediate outcome in the OpenLMIS ToC: **Increased political support and buy in from govt and donors/partners.**

Financial constraints expose weaknesses in the rollout process and a need for increased government ownership of the platform especially with respect to resource allocation and training needs.

From the qualitative interviews, financial constraints were identified as a critical challenge, as the lack of sustainable funding for internet data poses ongoing difficulties. While external support from organizations like CHAI and UNICEF has provided temporary relief, the absence of a long-term financial plan leaves the system vulnerable to disruptions. These challenges often hinder the system's performance and users daily work routines. This is also affecting the perceived value of OpenLMIS among some respondents who report inadequate considerations for resource allocation in the rollout process, and suggest a need for increased government involvement and ownership of the OpenLMIS implementation process. This finding is indicative of challenges with achieving the first intermediate outcome on **increased political support and buy in from govt and donors/partners, especially with respect to funding support.** Additionally, there was notable variation in the frequency and quality of training sessions offered. Some users reported that the training sessions were irregular and sometimes insufficient, highlighting a clear need for more consistent and comprehensive training programs, particularly for new users or those who missed earlier sessions.

Infrastructural and equipment gaps also threaten effective implementation of OpenLMIS.

Significant technological and infrastructure challenges that have hindered the effective use of OpenLMIS were identified by the respondents. One of the most prominent issues is unreliable internet connectivity. The offline client of OpenLMIS is not yet being utilized, so users require reliable internet connectivity which is not available in many areas of the country. Users in remote areas and at lower levels of the supply chain struggle with system accessibility because of frequent internet network downtime. This downtime delays tasks and discourages consistent use of the system, further complicating its adoption. Compounding these challenges are other infrastructural issues, such as inconsistent power supply. In areas with unreliable electricity, users struggle to keep their devices charged, further limiting their ability to use the system consistently. Concerns were also raised about the maintenance and security of equipment as in some locations there were reports of damaged or stolen devices.

Technological factors affecting the utilization of OpenLMIS

Even in areas where adequate infrastructure is available, respondents consistently reported internal technology related issues with OpenLMIS that affect utilization.

OpenLMIS utilization is seen to be benefiting the vaccine supply chain ecosystem, with the platform largely effective and linked to improvements in data availability. However, users highlight several areas for improvement towards better utilization, and suggested extending the platform to health facility level.

OpenLMIS implementation is reported to be largely effective and has brought about efficiencies in vaccine management through its reporting functions, easy integration into workflows, **increasing data availability and utilization**, the first output in the LMIS ToC. Users are now advocating for its expansion to health facilities to enable end-to-end tracking of vaccine stock and distribution through the entire supply chain. However, respondents also suggested additional technological/functionality improvements that are needed, these include:

- **System Speed & Internet Connectivity:** Users described the platform's performance as slow, including long login times, slow report downloads and submission processes. A few reported that there have been improvements in data submission processes. These speed issues are linked to the current reliance on the web-based version of OpenLMIS. Users suggested introducing offline capabilities that would help mitigate these challenges, allowing data entry even in areas with limited or no internet access. Additionally, there were calls for better infrastructure support, including the provision of data bundles and power backup solutions like power banks.

System Errors: Users also reported system generated errors, such as duplicate transaction IDs, discrepancies between system data and downloaded reports. Some of these system errors can only be resolved by national level staff and delays in resolution lead to interruptions in user workflow.

> *We often see discrepancies in the data, that is why we always compare data. The cold chain officer, the monitoring and evaluation officer and I check the data submitted to us by the health facility to know if there is any discrepancies and if there is any, we will go back to the source to compare their data.*
>
> ***LIO***

- **User Interface:** The user interface of OpenLMIS was frequently described as cumbersome and complex, contributing to a negative user experience. Users highlighted the clutter caused by displaying used, expired, or out-of-use vaccines which makes navigation difficult and can lead to inefficiencies in stock management. Updating stock records in OpenLMIS was viewed as lengthy and difficult. Users suggested improvements in the OpenLMIS sorting mechanism with vaccines organized by expiration dates, to facilitate quicker decision-making, as well as a more streamlined view of stock summaries that facilitates easier navigation through stock records during physical stock taking. They also suggested that the system should automatically archive outdated information.

> *I would have loved a situation where the vaccine that have been used are no more displayed in the list, because, this makes the page bulky and difficult to find the particular information you want to work with.*
>
> ***CCO***

- **Browser Compatibility:** Some users reported browser compatibility issues, particularly with Chrome and Firefox browsers.
- **Data Extraction & Archiving:** Many users describe challenges with extracting data or summary reports from the system. One example is not being able to access a summary of stock levels by antigen because OpenLMIS only provides granular data by batch number and per antigen. Another challenge was the

inability to retrieve previous transaction receipts or archive data that will enable the analysis of historical trends. Monitoring currently utilizes weekly or monthly downloaded records saved outside OpenLMIS, as the majority of these records are no longer available once the period has passed. These data are used to conduct data analysis on other platforms/software. There is a need for more robust monitoring and evaluation features within OpenLMIS. Users expressed a desire for real-time analytics, reporting capabilities and an archiving system, which would allow for more informed decision-making and better management oversight.

> *For instance, if I'm going to receive vaccine from the donor store, they are going to issue a receipt to me, and I'm to issue a receipt back to them that this is what I am receiving. Everything is in one place. Now, if I want to find a particular receipt in case I need to sort something out. I won't find it. Not only would I have to check antigen by antigen, I have to check batch by batch to get that work done.*
>
> **SCCO**

- **Barcode Scanning:** Users suggested the introduction of barcode scanners to improve efficiency of stock taking as well as to expedite data entry with a preference for scanning at the carton level to manage larger volumes.
- **Cold Chain Equipment (CCE) Feature:** Many users highlighted difficulties in integrating and recording data related to Cold Chain Equipment (CCE). Inadequacies in training and user-friendliness of this feature has been linked to its underutilization.
- **Temperature Monitoring:** The integration of temperature tracking features was also seen as a crucial missing function to maintain vaccine integrity.
- **Alert Systems:** Many users found reminders and alerts to be beneficial, particularly for tasks like monitoring vaccine expiration dates, preventing stockouts, and ensuring accuracy in physical inventory counts. These features help in maintaining operational efficiency and making informed decisions. A few users expressed concerns about the inconsistency of alerts, particularly for critical tasks like monitoring vaccine expiration or receiving duplicate stock.

It doesn't give me any alerts until I open it, but when am working on the tool it will tell me what and what I'm not doing right. There should be an alert that a vaccine is expiring in three weeks' time so that the careless type who does not open it can know what to do and also to know one doesn't go out of stock, maybe by sending mail.

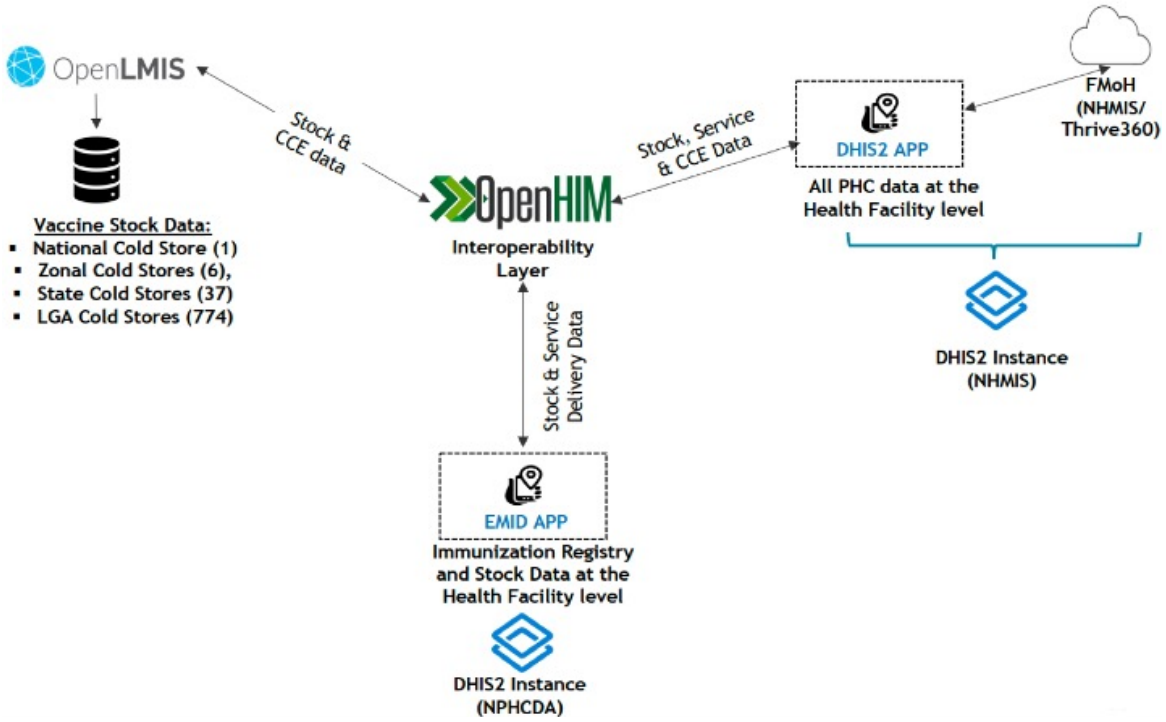
ZCCO

- **Data Validation and Correction:** The system's ability to detect and highlight data entry errors, such as incorrect vaccine counts, was appreciated. This feature helps users correct mistakes before they affect inventory records or decision-making processes, ensuring data integrity. Some users mentioned that certain functionalities of the system, such as error correction, require intervention from the national level, which can be a cumbersome process, affecting their workflows and efficiency.
- **Interoperability:** Leveraging OpenLMIS' interoperability capabilities is urgently needed. It is often used in tandem with service delivery data, such as vaccine utilization reports from DHIS2 and because there is no integration, manual triangulation using platforms such as Thrive360 are being used as temporary fixes. Respondents describe strong government interest and Gavi's support towards achieving interoperability objectives and cite that activities to achieve this are already underway. The expectation is that full interoperability of all systems will be achieved in 2024. The design of the interoperability layer, that aims to link OpenLMIS to both the NHMIS and EMID, (as seen in the figure below), was proposed by the government in collaboration with partners (CHAI, Gavi and others).

There's a need for a stock management tool at the facility level for last-mile visibility and the requirement document for the eLMIS at the facility level has been approved by the NPHCDA and is being developed by eHealth and HISP. CHAI will then ensure its interoperability to link all levels of the supply chain to the last-mile.

NLWG

Figure 7: Proposed flow of data between the OpenLMIS, EMID app and the NHMIS Server

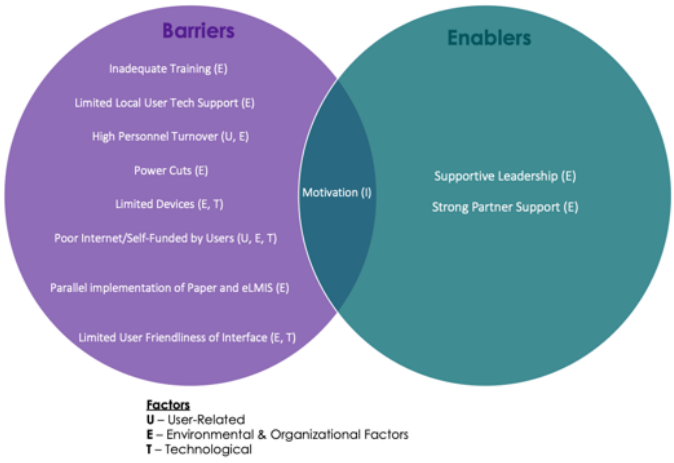


Objective 2.2 To determine the enablers and barriers of the OpenLMIS scale up for COVID-19 vaccination in Nigeria and gather learnings from a rapid deployment and nationwide scale up of OpenLMIS

Enablers and Barriers

The figure below summarizes enablers and barriers associated with OpenLMIS implementation in Nigeria, indicating if they are individual, organizational/environmental or technological barriers. Each of these factors have been described in detail in Objective 2.1 above. These factors influenced the rapid deployment and nationwide scale up of the OpenLMIS.

Figure 8: Enablers and Barriers



Learnings from the Rapid Deployment and Nationwide Scale up of OpenLMIS[21]

The rapid deployment of OpenLMIS for the COVID-19 response and subsequent nationwide scale-up and deployment for RI provided valuable insights into the challenges, successes and recommended best practices for implementing such a system within

21 Source document: OpenLMIS Covid 19 Grant – Retrospective Lessons Learnt

a country's health supply chain. Each phase of the deployment process offers learnings that can improve future deployments, highlighting the importance of effective planning, clear communication, stakeholder engagement, and continuous system support.

What worked

- **The OpenLMIS scope of work and implementation timelines were clearly communicated** with key actors, with GAVI sharing a clear vision and project implementers and developers well aligned on expectations.
- **Majority of initial system analysis and design processes were done timely.** This included proactive procurement processes of a temporary cloud server and domain for the OpenLMIS, as well as design of the system layout, dashboards, functional flows and mock-ups, with a focus on the stock, requisition and order management features of the OpenLMIS.
- **A combination of quality assurance processes put in place to support the go-live process.** This included the set-up of an operations rooms room to monitor the rollout process; deployment of user guides and job aids and video demos; in addition to operations support and site visits.

What did not work

- **The project timeline was unrealistic and the rollout process experienced several delays.** Delays were experienced in signing of the final requirement document; in accessing key tools (NPHCDA domain server, LMIS forms), and obtaining relevant approvals from NPHCDA to begin development, due to long internal processing times. Subsequently there were further developer-related delays especially in building the equipment management and reporting feature, and the delayed upload of health facilities.
- **Inadequate requirements gathering, low clarity on OpenLMIS limitations and redundant user-testing outputs led to a mismatch of certain developed features with NHPCDA expectations and continual changes through project life cycle.** The user testing processes included large number of users than anticipated, and none of the recommended changes implemented by the the Global OpenLMIS community. Also certain features (reporting dashboards and analytics) did not meet NPHCDA expectations.
- **The program and product team were constituted early per the program schedule; however several key stakeholders were excluded from project planning and implementation,** most notably the absence of the NPHCDA ICT team who could have played a key role in supporting key technological requirements.
- **Virtual trainings were used to rollout OpenLMIS across the country in a relatively short timeframe, however this mode of training was not well received by some stakeholders with several implementation challenges including digital literacy gaps, and participation issues faced due to internet access gaps.** Breakout rooms were ineffective as participants were reported to

drop from their assigned rooms and some facilitators at assigned rooms were missing. Digital literacy issues were more at state and LGA level among cold chain officers.

- **There continued to be technological and user-related constraints at rollout,** including inadequate devices, poor internet connectivity in some states, delayed user support and low motivation to use OpenLMIS among some users.

What could have been done differently

- **Key stakeholder mapping and engagement.** The project could have implemented a stakeholder mapping and effectively engaged relevant stakeholders in a targeted manner throughout the project lifecycle. For instance the engagement of the NPHCDA ICT team during project planning, could have facilitated access to key tools and potentially fast-tracked approval processes.
- **Informed and evidence-based planning.** The project initiation and planning phase should include effectively communicating the limitations of the OpenLMIS prior, in addition to detailed needs assessments at all levels of the supply chain, and requirements gathering processes as well as the utilization of user testing outputs to inform deployment plan.
- **Reasonable and contextually feasible implementation schedules.** Adequate start-up time should be factored into project design to allow for lengthy bureaucratic government processes as the relevant sign off and approvals are required for adoption, ownership and sustainability of the system.
- **Significant technological constraints in the country context require flexible approaches** e.g. the use of a hybrid training approach (virtual/in-person); the inclusion of computer literacy training where needed; the deployment of OpenLMIS offline capabilities; as well as including change management processes in the project to support users transition from a paper-based to an electronic system.

Objective 3: To assess the strength of implementation of the OpenLMIS in Nigeria

This section presents the findings on the OpenLMIS adoption, efficiency, data quality, performance as well as the use of the OpenLMIS data in planning, service delivery and monitoring within the supply chain management system in Nigeria

Objective 3.1 To study program adoption, efficiency, data quality, and performance

OpenLMIS Adoption

The rollout of OpenLMIS represented a strategic move to improve efficiency in tracking vaccine utilization, provide real-time visibility of the supply chain, and align the country's LMIS with global LMIS standards. The system has been adopted country-wide with sustained utilization across all stores from LGAs to the national level.

Previous LMIS systems i.e. paper-based LMIS, Microsoft's Navision (NAV) and the NISCMIS, were more complex, expensive, and reported to not be user-friendly tools. Following the discontinuation of previous tools due to issues such as high maintenance costs and inadequate functionality, Gavi and The Global Fund provided guidance[22] for the selection of an eLMIS that met international best practices. Among all the requirements stated in the guidance, the following were considered important in resource-constrained settings and complex health systems such as Nigeria's:

- Ability to support workflows while offline; store the data; and upload and sync the data when the local device is connected to the internet.
- Open data standards to enable automatic data exchange with other supply chain management and HIS applications including DHIS2.
- Proven to work with existing deployments in resource-constrained settings.

Seven software solutions and service providers (including the OpenLMIS) were fully or mostly qualified. The OpenLMIS was selected, being an LMIS that can act as the central point of intersection of many actors and data sources throughout the supply chain, through its interoperable applications that enable automatic supply chain data collection, validation, classification, storage, analysis, and visualizations to serve country supply chain operations.

Consequently, OpenLMIS was introduced as a more efficient solution to streamline vaccine management processes, reduce costs, improve overall operational efficiency, and address the visibility gaps left by earlier systems especially at lower levels. This visibility was especially crucial during the COVID-19 pandemic, where timely and accurate data was essential for effective response and management. The rollout of OpenLMIS during the Covid-19 pandemic served as a pilot for OpenLMIS implementation, with learnings from system adaptation and optimization now being applied to other routine immunization management. In planning for the RI rollout, additional requirement gathering and documentation exercises were conducted as RI rollout necessitated an expansion of the existing reporting functions of OpenLMIS. The system has now been rolled out to 100% of stores in the country from LGA to national level with reporting completeness rates of over 70% across all stores, based on stock on hand reports and stock status reports in the past year. There are now requests to scale up OpenLMIS to other disease areas such as Malaria and NTDs. This is a clear indication of **system adoption and sustained utilization**. The adoption of the OpenLMIS for use in RI, beyond the initial focus on Covid-19, and the suggested expansion to Malaria and NTDs are an indication of **increasing maturity of the enabling environment to support digital health information in Nigeria**. However, several important functions of OpenLMIS are not yet operationalized in Nigeria, most notably the interoperability and offline functionalities.

22 Country Guidance on selecting LMIS accessible at https://www.theglobalfund.org/media/9516/psm_logisticsmanagementinformationsystem_guidancenote_en.pdf

OpenLMIS efficiency, data quality and stock performance

This section presents quantitative findings on **enhancements in service delivery of immunization programs, demonstrated by reduced stock-out events and decreased wastage/expiries** of essential vaccines, that may be linked to OpenLMIS implementation. This is the second outcome in the OpenLMIS ToC. Wastage was measured by evaluating the volume of vaccine stocks that were reported expired in each store. If stocks are expiring before use, then there is an inefficiency in matching supply with demand. Stock-outs were measured by counting the instances where stock supplies were reported as zero on the weekly CSP reports. Greater efficiency in monitoring stock supplies could help mitigate instances where low stocks become zero stock, before a re-supply arrives and when demand for the vaccine type is expected to outpace the supply. Both wastage and stock-out events were analysed by grouping the cold store facilities by their OpenLMIS utilization level. The assumption is that greater efficiencies would be observed in stores with a high use of OpenLMIS than in those with moderate or low use of OpenLMIS, with progressive declines in expiries and stockout events over time.

Please Note:

In reviewing the results below, the evaluation team provides this caveat “It is too early to draw conclusions about the effect of OpenLMIS on wastage and stockout events based on the data on-hand. Limitations are detailed in Section 7 below. Without either pre-OpenLMIS time series or several more years of OpenLMIS use to compare, it is difficult to analyse the trends coherently and control for other variables in the logistics system. We are also not able to determine whether the observed volatility in some of the trends below are cyclical due to seasonality, the impact of OpenLMIS usage, or other supply chain shocks. This will also require a greater number of observation points and metadata than are available at the time of this analysis. Various data smoothing exercises[23] were performed on the data to help visualize existing trends, but we caution against drawing definitive conclusions based on these trends alone.”

23 The 3-month moving average provides a nice smoothing trend over the short time series available.

OpenLMIS efficiency and stock performance

There is an observed decline in the volume of expiries across all OpenLMIS usage categories from December 2023 to August 2024. There were however similarly low expiry volumes before December 2023. A multi-year time trend will enable further insights into this trend.

Analysis of expiry data across 4 vaccines, Measles, BOPV, BCG and Penta was conducted to determine if there were significant differences between states with high versus moderate and low OpenLMIS utilization. The time period of analysis was July 2023 to August 2024[24] based on available data, noting that there were no expiries data available pre-OpenLMIS to compare the trends. Although the volume of expiries[25] declined from December 2023 to August 2024, there were similarly low expiry volumes in preceding months (July to October 2023). No conclusions can be definitively drawn from the data as the observed trends exhibit a significant amount of volatility whose determinants could not be isolated and evaluated with the data on hand. See Figures Figure 9 to 16 below.

Figure 9. BCG, Measles, and Penta Monthly Expired Stock – raw/un-smoothed data trend

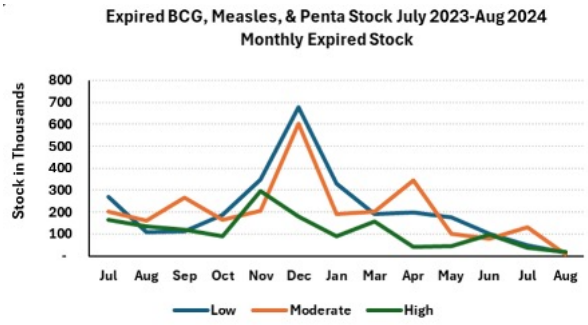


Figure 10. BCG, Measles, and Penta Monthly Expired Stock – 3 Month Moving Average smoothing trend

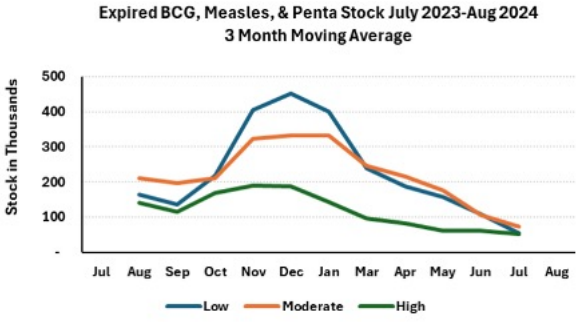


Figure 11. BCG Monthly Expired Stock – raw/un-smoothed data trend

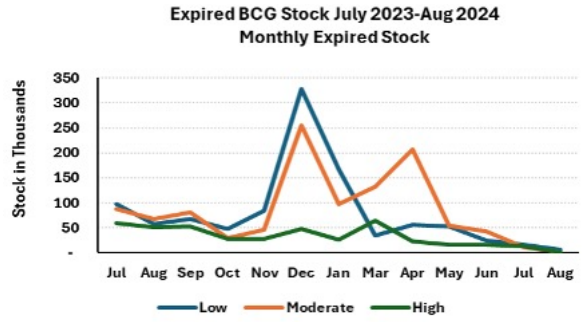
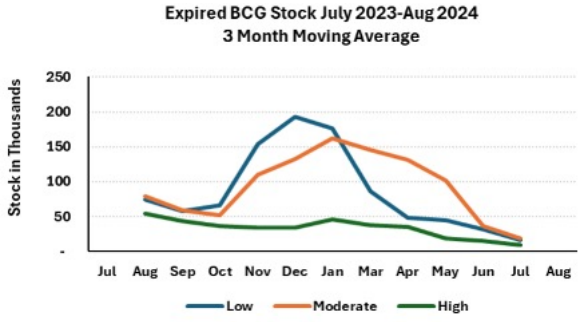


Figure 12. BCG Monthly Expired Stock – 3 Month Moving Average smoothing trend



24 Data for the month of February was unavailable and therefore excluded from the analysis.
25 The actual volumes of expiries across OpenLMIS utilization groups should not be compared , only their respective trends, as the differences in volume may be due to the number and geographical coverage of stores in that category.

Figure 13. Measles Monthly Expired Stock – raw/un-smoothed data trend

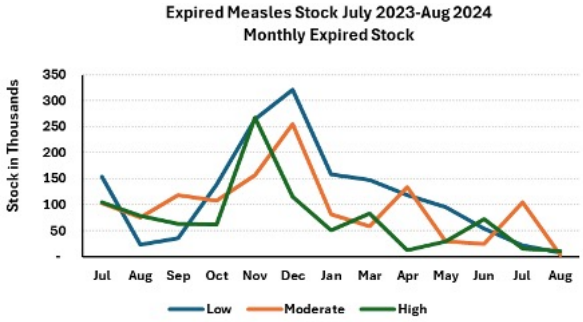


Figure 14. Measles Monthly Expired Stock – 3 Month Moving Average smoothing trend

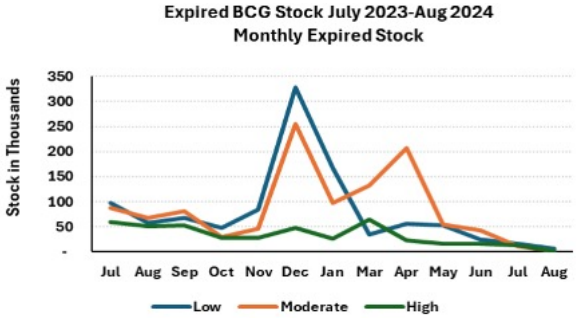


Figure 15. Penta Monthly Expired Stock – raw/un-smoothed data trend

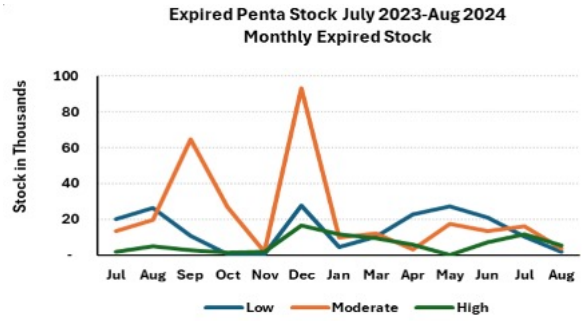
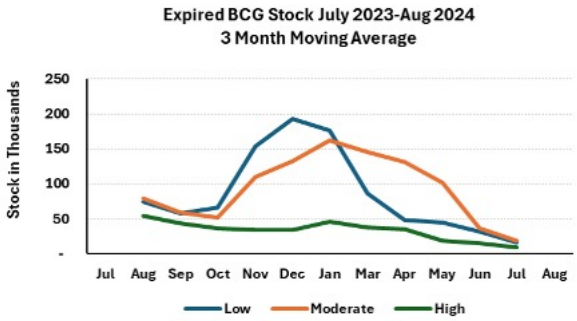


Figure 16. Penta Monthly Expired Stock – 3 Month Moving Average smoothing trend



The stockout event trends are more erratic with no clear pattern observed comparing the pre-Open LMIS period to the OpenLMIS period as well as across the OpenLMIS utilization categories, except for the Measles vaccine with a reduced frequency of stockout events in the OpenLMIS implementation period as compared to the pre-OpenLMIS period.

The evaluation also measured efficiency of OpenLMIS by analysing stockout events of 4 vaccines (Measles, BOPV, BCG and Penta) to determine if there were significant differences in the pre-OpenLMIS and OpenLMIS period, as well as across stores with high, moderate and low OpenLMIS utilization. The time period of analysis was January to December 2022 for pre-OpenLMIS and January to December 2023 for OpenLMIS, based on available data. The trends of both raw and smoothed data[26] are presented in Figures 17 to 26.

26 Smoothing average provides little additional benefit over the un-smoothed data, especially at the individual vaccine stock level, in terms of data interpretation. The smoothed trend for the combined vaccine totals does allow for easier viewing.

Figure 17. BCG, BOPV, Measles, and Penta Stock-out events – raw/un-smoothed data trend

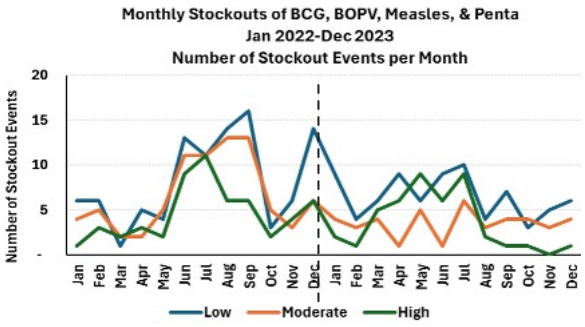


Figure 18. BCG, BOPV, Measles, and Penta Stock-out events – 2 month moving average smoothing trend

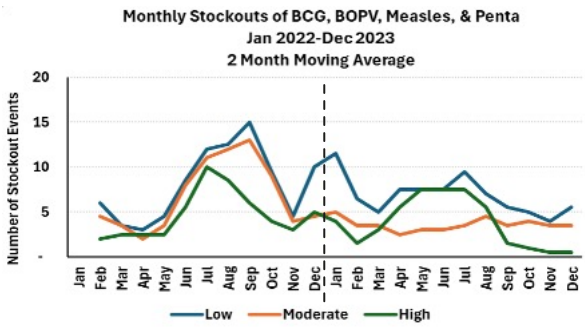


Figure 19. BCG Stock-out events – raw/ un-smoothed data trend

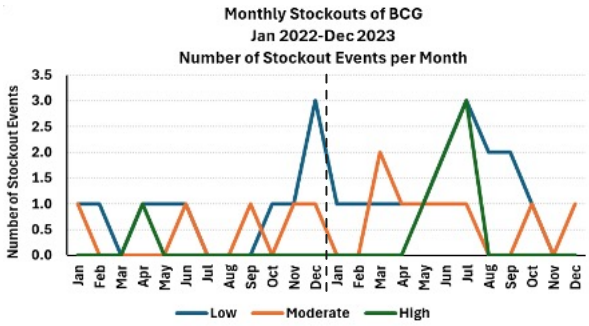


Figure 20. BCG Stock-out events – 2 month moving average smoothing trend

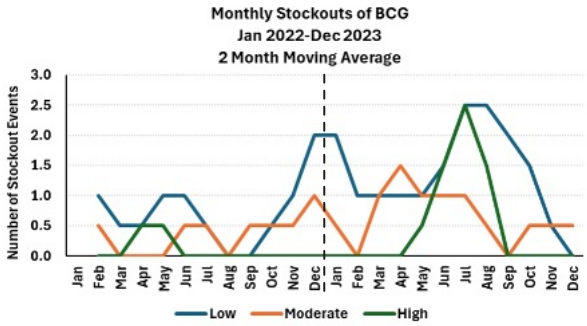


Figure 21. BOPV Stock-out events – raw/ un-smoothed data trend

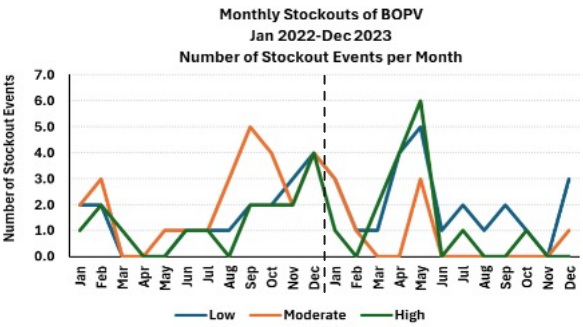
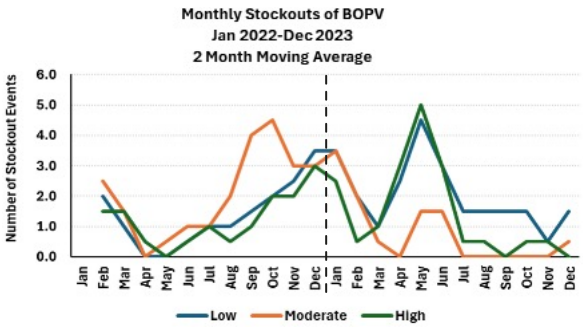


Figure 22. BOPV Stock-out events – 2 month moving average smoothing trend



As with the vaccine expiration data, it is too early to draw conclusions about the impact of OpenLMIS on stockout events without more years of OpenLMIS use to compare, however there are no notable trends except for the measles vaccine with a reduced frequency of stockout events in the OpenLMIS implementation period as compared to the pre-OpenLMIS period. (In the following graphs, the vertical dashed line indicates the point of OpenLMIS implementation).

In addition to visual observations of trends, a Mann-Kendall (MK) trend test was performed on the time series data for both expired stock and stockouts to test for monotonic (upward or downward) trends. A key assumption of the MK test is that the observations represent the true state of the conditions at that point in time.[27] It is not conclusive that the data on-hand meets this requirement given the variability of reporting across facilities and states as well as a lack of clear explanation around the data collection process and resulting outputs that were provided to the evaluators.

Figure 23. Measles Stock-out events – raw/un-smoothed data trend

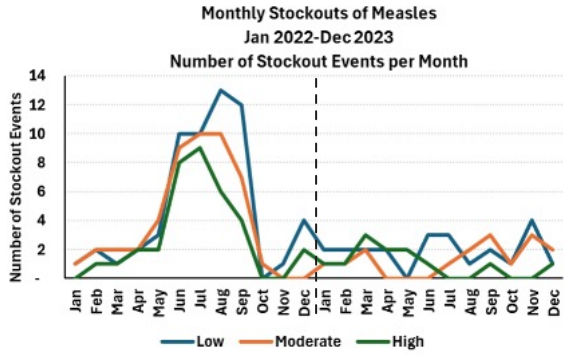


Figure 24. Measles Stock-out events – 2 month moving average smoothing trend

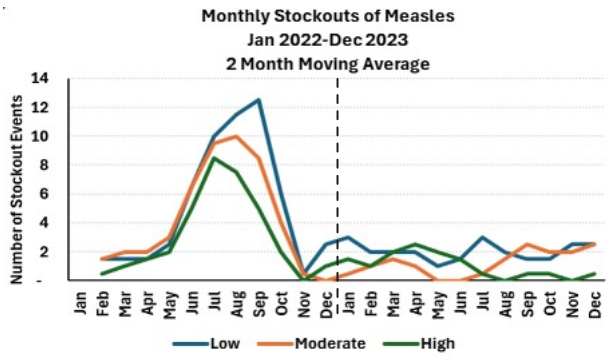


Figure 25. Penta Stock-out events – raw/ un-smoothed data trend

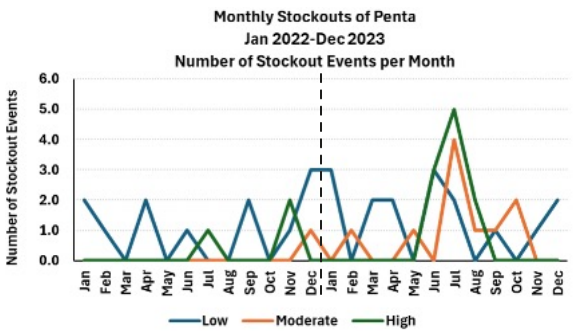
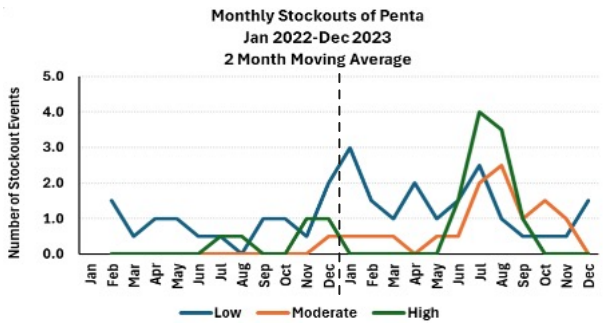


Figure 26. Penta Stock-out events – 2 month moving average smoothing trend



The results of the MK test are shown in Table 6 overleaf. For the expired stock trend, the findings can be considered significant with a p-value less than 0.05 indicating a rejection of the hypothesis that there is no trend in the data (null hypothesis) and acceptance that there is a trend in the data (alternative hypothesis). Given that the tau is less than zero, the trend of expired stock seems to be inversely related to time (i.e. as time increases, the volume of expired stock decreases). The stock-out events data is less significant with p-value = 0.5 indicating that there may be no trend in the data at all (i.e. the null hypothesis cannot be rejected.) The test would benefit from an expanded dataset in the future for both data series.

27 https://vsp.pnnl.gov/help/vsample/design_trend_mann_kendall.htm

Table 6: Mann-Kendall Trend Test Results: Combined time series for all OpenLMIS Utilization Categories

Indicator	Expired Stock	Stock-out Events
Autocorrelation	Data not autocorrelated	Autocorrelation at lag 1[28]
Distribution	Normally distributed	Not Normal
Kendall's tau	-0.46	-0.10
p-value (two-tailed)	0.03	0.50
Outcome	The null hypothesis can be rejected at alpha 0.05. There is a decreasing trend in the data.	The null hypothesis cannot be rejected at alpha 0.05. Data may exhibit no trend.

Objective 3.2 To assess the effect of OpenLMIS data use on planning, service delivery, and monitoring within the supply chain management system in Nigeria.

OpenLMIS supports the daily and periodic decisions taken by the logistics officers, fostering efficient and timely evidence-based decision making.

Program managers reported that they regularly refer to the Vaccine Supply Management (VSM) dashboard and other data outputs from OpenLMIS during weekly and monthly meetings and planning sessions. They cite the system's ability to inform key decisions related to vaccine distribution, forecasting, procurement, expiry identification and much more are helping to prevent stockouts and ensure that vaccines are distributed where they are needed most in a timely manner. OpenLMIS' integration into routine decision-making processes at various levels is evidence of progress towards achieving the first output **(effectively functioning system and availability of data)** and second intermediate outcome in the ToC: **ensuring efficient and timely decision making that is data driven.** Although there is insufficient quantitative data to validate this finding, it is expected that as the system matures through increased utilization, enhanced features, better interoperability, this will lead to end-to-end visibility of vaccine stock and provide more actionable data for decision makers.

28 Data were not bootstrapped for this exercise.

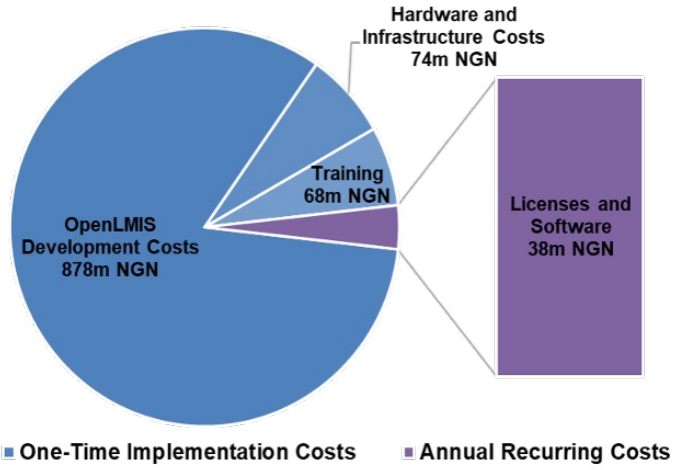
Objective 4: To determine the incremental cost-effectiveness of OpenLMIS use

The cost-effectiveness analysis sought to compare the financial costs and outcomes of implementing an OpenLMIS system with the costs and outcomes associated with the previous vaccine logistics management system. Outcomes of interest ranged from measuring efficiency within the stock storage facilities, e.g. stockouts and wastage, to observing changes in immunization rates among the served communities.

Although some of these outcomes were measured for the OpenLMIS system period, the cost-effectiveness analysis was unfortunately hindered by the lack of comparable data from the pre-OpenLMIS period, including insufficient data on wastage and overall system costs as well as the lack of immunisation outcome data that aligns with the OpenLMIS implementation period. As a result, cost-effectiveness of the OpenLMIS system was not measurable at the time of reporting.

In order to complete the cost-effectiveness analysis in the future, comparable stock storage system costs, vaccine stock wastage, and immunisation outcomes from the pre-OpenLMIS system would be required. In the absence of acquiring this type of historical data, cost-effectiveness could also look at the overall trend of the ongoing use of OpenLMIS in years to come. As more years of costing data are collected in the future, effectiveness could be measured by analysing the ongoing trends of vaccine stock throughput, volume of immunisations performed, and value of expired stock (i.e. wastage) from the time of implementation to 5 or 10 (or more) years in the future.

Figure 27: OpenLMIS Implementation Cost



The total cost[29] of procuring and deploying OpenLMIS in Nigeria was 1.1 billion NGN (approximately 2.63 million USD[30]) according to data provided by CHAI to the evaluators. This includes costs for personnel, hardware, infrastructure, and training. Licenses and software for the OpenLMIS system are a recurring subscription cost, priced at 38 million NGN (approximately 90,000 USD) per year.

29 For both the development/deployment during Covid and scaleup for routine immunisations
30 Nigerian Naira (NGN) To US Dollar (USD) Exchange Rate History for 2021. Exchange-Rates.org. Retrieved 21-February-2025, from https://www.exchange-rates.org/exchange-rate-history/ngn-usd-2021

5. Conclusions

OpenLMIS has been adopted country-wide with sustained utilization across all stores from LGAs to the national level for vaccine supply chain management, with requests for scale-up to other disease areas such as Malaria and NTDs. This wide-scale introduction and increasing adoption of the system have begun to play a central role in the availability, visibility, and use of logistics data, all of which, according to the WHO, are hallmarks of an advanced supply chain system. OpenLMIS has also been well-integrated into routine decision-making processes at various levels (LGA to National). It is expected that as the system matures through increased utilization, enhanced features, and better interoperability, it will improve end-to-end visibility of vaccine stock and provide more actionable data for decision-makers.

Demonstrating the anticipated impact based on the OpenLMIS Theory of Change (ToC) remains premature due to the early stage of its implementation within the immunization ecosystem. Evaluation findings indicate that it is too early to determine the achievement of **Outcome 1: Increased maturity of the enabling environment to support digital health information** and **Outcome 2: Enhanced service delivery of immunization programs.** Nonetheless, progress has been observed toward Intermediate Outcomes 1, 2, and 3. The uptake and expansion of OpenLMIS have been driven by increasing political support and stakeholder engagement from government actors and implementing partners, consistent with **Intermediate Outcome 1: Increased political support and stakeholder buy-in.** Additionally, reports indicate improvements in decision-making timelines and processes, reflecting alignment with **Intermediate Outcome 2: Efficient and timely decision-making.** Furthermore, the growing demand for OpenLMIS deployment at the facility level and its proposed application in other disease areas reflect progress toward **Intermediate Outcome 3: Enhanced adoption and sustained utilization.** Evaluation findings also highlight greater availability of actionable data, which aligns with **Output 1: Effectively functioning system and availability of data.**

There are several enablers and barriers influencing the adoption, utilization, and scale-up of OpenLMIS, including individual, organizational, and technological factors.

- **At the individual level,** there are clear indications of improved OpenLMIS knowledge and digital tool literacy, with users able to carry out the majority of OpenLMIS functions independently and effectively. Evaluation findings report a significant increase in OpenLMIS knowledge across the ecosystem, aligning with **Output 2: Increased OpenLMIS knowledge.** However, there are variations in OpenLMIS proficiency across stores based on their OpenLMIS utilization category. Despite the overall high level of proficiency observed, several factors have lowered the motivation of personnel, especially at the LGA level, such as frequent turnover of trained staff, prohibitive data costs self-funded by users, increased workload due to the implementation of OpenLMIS, and inadequate

training opportunities. Although there were no gendered differences in OpenLMIS utilization, male users seemed to articulate more challenges, while female users focused more on the benefits of OpenLMIS.

- **At the organizational and environmental level,** OpenLMIS has benefitted from strong organizational commitment from key stakeholders, including the government, and partners such as Gavi, CHAI, and UNICEF, which was crucial in rolling out and fostering utilization of the system. However, current financial constraints expose the need for increased government ownership of the platform, especially regarding resource allocation and meeting recurring training needs for sustainability. Significant infrastructural and equipment gaps also threaten the effective implementation of OpenLMIS. The unreliable internet networks in many areas of the country, inconsistent power supply, and equipment security issues are major challenges faced.
- **At the technological level,** there are several features that require improvement and others that need to be introduced, influencing OpenLMIS utilization. Improvements are needed with system-generated errors, a complex user interface, browser compatibility issues, limited data extraction/archiving, inconsistency of the alert systems, and the CCE feature, which seems less intuitive to users. New features needed include barcode scanning, temperature monitoring, the interoperability feature, and, most importantly, the offline client, with many users reporting slow system performance, which is linked to internet connectivity issues.

The evaluation also attempted to measure enhancements in service delivery of immunization programs, demonstrated by reduced stock-out events and decreased wastage/expiries of essential vaccines, that may be linked to OpenLMIS implementation. The observed trends did not show clear patterns, and with the significant data limitations faced, the evaluation team could not draw any conclusions about the effect of OpenLMIS on these outcomes. However, the team envisages that in a few more years, with a longer time series and improved data management and archiving systems, measuring the impact of OpenLMIS on these outcomes will be feasible.

6. Recommendations

The recommendations provided in this section correspond to the gaps identified throughout the evaluation and have been organized by user-related, organization and environment-related and technology-related recommendations with suggested responsible parties tagged. These recommendations are based on the evaluator's viewpoint and are to be validated by government stakeholders. However, based on findings, it is clear that the government (specifically the NPHCDA) has plans in place to implement the offline functions as well as interoperability with other information systems. Although, different stakeholders have also expressed the need for expansion to the facility level, there is no indication for that expansion at the time of this report.

1. User-related Recommendations

1.1 Improve user motivation through additional capacity strengthening support, including increased opportunities for training and refresher training, especially in locations experiencing high personnel turnover, as well as localized user-support services below National-level. **(NPHCDA and Partners)**

1.2 Consider a rewards-based system with recognition awards or incentives (internet bundles, modems or financial compensation) to maintain high levels of engagement and performance among users in less enabling environments. **(NPHCDA and Partners)**

2. Organization/Environment-related Recommendations

2.1 Increased budgetary allocations to cover key OpenLMIS implementation needs, especially provision of sufficient internet connectivity for users. **(NPHCDA)**

2.2 Assess and review the quality and consistency of training programs, with a goal to increase the frequency of training and ensuring that the trainings meet user needs effectively. **(NPHCDA and Partners)**

2.3 Invest in upgrading infrastructure and technology/devices in stores using OpenLMIS, including provision of backup power sources. **(Donors and Partners)**

3. Technology-related Recommendations

3.1 Assess user-feedback on system challenges and develop a standardized process for soliciting and addressing user challenges. **(NPHCDA and Partners)**

3.2 Introduce urgently needed additional features of OpenLMIS, such as the offline client, data archiving and interoperability with NHMIS and EMID. **(NPHCDA and Partners)**

3.3 Develop data management policies and standards including data governance standards and a data management plan, especially with a lot of data management done outside of the OpenLMIS, to improve LMIS data quality, use and security. **(NPHCDA and Partners)**

3.4 Explore integration of historical LMIS records with OpenLMIS records for future evaluation needs. This will require extensive data cleaning and mapping processes. **(NPHCDA and Partners)**

7. Challenges and Limitations

This section summarizes the challenges and limitations faced by the evaluators, as well as resulting changes in methodology.

- **Premature Evaluation:** The evaluation of the OpenLMIS is premature, as the OpenLMIS was only fully rolled out for RI in 2023. Ideally, with any information system, there will be challenges in the first year of use especially in complex settings like Nigeria, so this first year can be viewed as more or less as the deployment phase of the project, with expected variations in efficiency of the system, with users just beginning to hone their OpenLMIS skills. There were also limited functionalities when OpenLMIS was first used for COVID vaccines.
- **OpenLMIS Utilization Recategorization:** The initial categorization was based on any form of utilization (i.e. the number of unique users out of 835 cold stores who logged in to perform stock management tasks within OpenLMIS each week, regardless of the specific function carried out or how well these functions were carried out). The categorization was subsequently revised to be truly reflective of variations in utilization by assessing completeness of reporting across key indicators and using this to group stores into high, moderate and low utilization categories.[31] This new categorization formed the basis for quantitative results presented in the report, however the old categorization was used for the qualitative and observational assessment.
- **OpenLMIS Data Archiving Limitations:** Nigeria's OpenLMIS' current inability to archive data on its database posed a huge challenge in making data available for the evaluation. The current data archiving process involved downloads that are stored in a separate location. These downloads cannot be obtained from the OpenLMIS once the week has elapsed, as the platform has not been configured to archive historical data. The evaluation ended up relying on previously downloaded weekly reports through the first year of the project. Several data elements requested were not available such as Data Quality (Timeliness,

31 The new OpenLMIS utilization categories were determined based on completeness of reporting in two main reports that are expected to be submitted weekly across stores. These are the stock taking reports and the expiry reports. The analysis examined the percentage of weekly reports submitted in 2023 (the only full year of implementation of OpenLMIS) in both datasets, as an indicator of completeness. Generally the completeness levels are high across all stores, with very few stores recording under 70% completeness. In categorizing, any stores that had over 90% completeness of reporting for both reports were classified as high usage; those with over 90% completeness for one report and less than 90% on the other were classified as moderate; and those with under 90% for both reports were classified as low.

Error Rates, Mismatches, Missing data), and Performance indicators (Stock Availability on Immunization Session Days, Replenishment Response Duration, Order Processing Time, Inventory Accuracy). The only elements available were Efficiency indicators (Wastage/Expiries and Stock on Hand and Stock-Out Events), as a result, the secondary quantitative analysis (objective 3) focused mainly on these indicators, a much smaller scope than the original methodology.

- **Limited Immunization Outcome Data Sources:** Data needed to effectively associate the use of the OpenLMIS with immunization outcomes was not available, (notably the absence of national survey data), with the most recent source predating OpenLMIS implementation (NDHS 2018). These data could have been used to control for certain confounders, with a plethora of factors that also contribute to improvements in immunization outcomes, including; access to healthcare facilities, availability of vaccines, healthcare worker capacity and training, public awareness, government support, infrastructure and logistics for vaccine distribution, political stability and security, funding/ resource allocation, among others. The only data source available for immunization outcomes was the NHMIS which is aggregated routine data. There were also some quality gaps identified with NHMIS. These data limitations, compounded with the premature timing of the evaluation, resulted in the evaluation not completing its objective to measure effectiveness and as a consequence it was also unable to measure cost-effectiveness (Objective 4).
- **Multiple LMIS Data Sources with Quality Gaps:** In addition to NHMIS which contains some logistics data, there was also an overlap between the previous ODK-based LMIS and the OpenLMIS during the transition period to OpenLMIS. Although utilization of OpenLMIS for RI began in January 2023, data on expired vaccine stock only started to be captured in July 2023. Before July 2023 (Jan – June 2023), the country was still using the paper and ODK-based vaccine stock performance management dashboard to report stock status (expired, near expiry, safe etc.) and this data were not available. The evaluation team explored using NHMIS data to fill some of the gaps, but experienced challenges with data quality, forcing the team to rely on the limited expiry data from the OpenLMIS which only started from July 2023.
- **Data Security:** The manual data archiving process involves storing LMIS datasets in local storage devices, including a non-sovereign 3rd party storage solution managed by the implementing partner on behalf of the government. This practice raises concerns about data security, accessibility, and long-term preservation.
- **Delays in Data Provision:** Due to bureaucratic challenges, the evaluation team was unable to access LMIS data until August 2024[32]. The data provided were in raw, uncleaned formats, lacking any standardized metadata. This necessitated extensive data cleaning and pre-processing before it was analysed. The absence of a data management guide further complicated the process, as there was no clear understanding of data definitions, relationships, or quality standards.

32 Data Request was sent on May 21st, 2024; Stock data was obtained on the 8th of August; Costing data was received on the 12th of August, 2024.

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Annex

A1. References

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A2. Data collection tools

A2.1.1 OpenLMIS Observation Checklist

Date: _____ Location: _____ User Role: _____

General Instructions:

- Observe users interacting with the OpenLMIS platform. If the user is not implementing specific tasks to be observed, ask the user to demonstrate at least 3 relevant tasks to their role.
- Document any challenges, or suggestions expressed by the user regarding specific functionalities.

Function to Observe	Was the user able to complete the process?	Did they encounter any challenges?	Describe the challenges	Ask the user for Improvement suggestions
Create Inventory[33]	Yes ✔ No ✔ N/A ✔	Yes ✔ No ✔		
Request Stock[34]	Yes ✔ No ✔ N/A ✔	Yes ✔ No ✔		
Approve Requisition[35]	Yes ✔ No ✔ N/A ✔	Yes ✔ No ✔		
Fulfil an Order[36]	Yes ✔ No ✔ N/A ✔	Yes ✔ No ✔		
Confirm Shipment[37]	Yes ✔ No ✔ N/A ✔	Yes ✔ No ✔		
Request emergency stock[38]	Yes ✔ No ✔ N/A ✔	Yes ✔ No ✔		
Approve Emergency stock requisition[39]	Yes ✔ No ✔ N/A ✔	Yes ✔ No ✔		
Convert Requisitions to Actual Physical Order[40]	Yes ✔ No ✔ N/A ✔	Yes ✔ No ✔		

33 Create a new inventory record/update an existing inventory record on the OpenLMIS software/platform.
34 Demonstrate the requisition and approval process.
35 Demonstrate the approval/review process for a facility/LGAs requisition.
36 Demonstrate fulfilling an order and show stock balance of the vaccines on the platform.
37 Demonstrate how to confirm a shipment / manage proof of delivery.
38 Demonstrate how an emergency stock is requested using the OpenLMIS
39 Demonstrate how to approve and edit an emergency stock request on the OpenLMIS.
40 Demonstrate how a requisition is converted to an actual order to be physically delivered.

Function to Observe	Was the user able to complete the process?	Did they encounter any challenges?	Describe the challenges	Ask the user for Improvement suggestions
Manage Cold Chain Equipment with RTM[41]	Yes ✔ No ✔ N/A ✔	Yes ✔ No ✔		
Analyse vaccine stock management and distribution	Yes ✔ No ✔ N/A ✔	Yes ✔ No ✔		

A2.1.2 Interview Guide Questions for OpenLMIS Evaluation in Nigeria

- **Implementers and Program Managers**

CHAI, NPHCDA, Director Logistics and Health Commodities, Members of the National Logistics Working Group. National Strategic Store - Logistics Officers, State Director Immunization/ Disease Control, and Vaccine Security and Logistics Officers - UNICEF

A. OpenLMIS and its role within the EPI Programme

1. What was the rationale for the rollout process of OpenLMIS for COVID-19 vaccination and subsequently Routine Immunization (RI) implementation?

   - *Are there any differences in how the application is used in RI vs COVID-19 vaccination?*

2. Describe the role OpenLMIS currently plays within the EPI program.

   - *To what extent do you rely on OpenLMIS data for planning immunization campaigns, allocating resources, and monitoring program performance? Please give examples of how you used OpenLMIS for any of these functions.*

3. How has OpenLMIS impacted your decision-making and program management?

B. Barriers and facilitators to adoption, data quality, and use of OpenLMIS

4. What are the main barriers to the adoption, use, and data quality within OpenLMIS?

   - Pr*obe for any specific user groups (Cold Chain officer/Program manager) within the program/supply chain who have difficulty adopting or using OpenLMIS effectively, and why*
   - *Probe further for specific factors (individual, organizational, and/or technological)*
   - *Probe for variations in OpenLMIS usage in different States/LGAs and reasons for this.*

41 Demonstrate fulfilling an order whilst investigating alerts/alarms on any of the shipments. Also, ask the respondent to demonstrate how to update the functionality status of a Cold Chain Equipment (CCE).

5. What factors have facilitated the successful implementation and use of OpenLMIS?

- *What strategies have been successful in overcoming barriers to OpenLMIS adoption and improving data quality?*

C. Perceptions on the link between OpenLMIS data use and immunization coverage

6. Have you noted any links between OpenLMIS data use and immunization coverage, completion, and timeliness?[1]

- Describe specific correlations between data use and improved program outcomes (e.g., higher coverage rates in higher LMIS usage locations). Is there any evidence to support these findings?

7. Has the use of the OpenLMIS led to any unexpected effects on vaccine delivery or staff roles? Describe these changes.

D. Learnings and recommendations from OpenLMIS utilization for COVID-19 vaccination

8. What unique lessons were learned (positive and negative) from using OpenLMIS for COVID-19 vaccination, and what recommendations do you have based on these lessons that can be applied to future large-scale campaigns and outbreak response?

- *Are there any specific features or functionalities you would recommend adding to OpenLMIS to prepare for future outbreaks or mass vaccination needs?*

- **Cold Chain Officers**

Zonal Cold Chain Officers, State Cold Chain Officers, Vaccine Security and Logistics Officers - UNICEF, Satellite Cold Chain Officers, LGA Cold Chain Officers, RH Coordinators.

A. The stock management system and flow of data from paper-based to OpenLMIS

1. Describe the stock management system you currently use for vaccine stocks
2. Describe the flow of data from health facilities to higher levels of the supply management system.

- *How often were there any discrepancies between recorded and actual stock levels? Can you share any specific examples?*

B. OpenLMIS user experience, benefits, enablers, and barriers

3. What are the main benefits of using OpenLMIS, compared to the paper-based system?

- *Probe for specific examples of how OpenLMIS has improved their work.*

4. How easy is OpenLMIS to use in your daily work?

- *Probe for specific tasks in their daily work that OpenLMIS makes easier or harder.*
- *Probe for how well OpenLMIS integrates with their existing workflow.*
- *If it integrates well, probe for an example of how OpenLMIS integrates well with their workflow. If not, probe for where it creates friction.*

5. Are there any features of OpenLMIS you find particularly helpful or unhelpful?

- *Probe if there are any features or functionalities they wish OpenLMIS had that they need to perform their job effectively, or any existing features they rarely use, and why.*
- *Probe the value of the decision-support algorithms, alerts, and reminders, and if this actually helped them prevent stockouts or make better decisions. Ask for an example.*

6. What factors have enabled you to effectively use OpenLMIS in your work?

- *Probe further for specific factors (individual, organizational/environmental, and/or technological).*
- *Ask them to describe the training and support they have received to enable the implementation of OpenLMIS.*

7. What challenges have you experienced with using OpenLMIS?

- *Probe further for specific factors (individual, organizational/environmental, and/or technological)*
- *Ask if they feel they have the necessary skills and training to use OpenLMIS effectively. If not, ask what additional support they need.*

C. Recommendations for improvement

What improvements would you suggest to make OpenLMIS more effective for future mass vaccination campaigns as well as routine immunization?

A3. Data cleaning process

The datasets for the analysis of stockouts and wastage were process and analysed as follows:

4.3.1 A3.1.1 Stockouts dataset

1. Pre-OpenLMIS data was collected from the *National Vaccine Stock Report Dashboard (ODK)* file.
2. OpenLMIS data was collected from the weekly CSP reports. The data in the reports were converted into a database format for analysis.
3. Dataset consolidation
    a. Data were organized by state and store for each stock volume entry. Entries were further organized by report date.
    b. Vaccines included: BCG, BOPV, Measles, Penta, & four COVID vaccines.
    c. Only entries of zero stock were considered for the stockouts analysis.
    d. A stockout entry was noted when the stock of a single vaccine type at a store was recorded as zero on a weekly report. Multiple instances of reported zero stock for the same vaccine type at the same store were not counted twice within the same month. If the stock continued to be recorded as zero into the following month, then it would be counted again as a stockout event at that store.
    e. Pre-OpenLMIS report data were used for January 2022 to May 2023. OpenLMIS report data were used for June 2023 to March 2024.
4. OpenLMIS Categorization
    a. OpenLMIS utilization rates were assigned by state based on the use of the OpenLMIS system to produce reports on the vaccine stocks.
    b. The categories used were High, Moderate, and Low.

4.3.2 A3.1.2 Stock Expiries/Wastage dataset

1. The Stock Expiries/Wastage data was collected from the stock status reports which included information on stock-on-hand, vaccine batch numbers, and batch expiration dates and status.
2. Expired stock volume is the volume of stock-on-hand when a batch was reported as expired per the report and expiration date. Subsequent reporting on the same expired batch was not re-counted as additional expired volume for the analysis.
3. Time period covered by the weekly reports was July 2023 to August 2024 with missing reports for February 2024.

A4. Consultee List

Location	Name	Designation/Organization
FCT	Pharm Hauwa Tense	Director Logistics and Health Commodities, NPHCDA
	Yoms Ishaku	Member of the NLWG, NPHCDA
	George Uzoigwe	Member of the NLWG / Cold Chain Officer - NSCS
	Umar Liman Mohammed	Member of the NLWG, NPHCDA
	Likpata Umar	Member of the NLWG, NPHCDA
	Joshua Oniwaye	Member of the NLWG, NPHCDA
	Badamasi Mohammed	Member of the NLWG, NPHCDA
	Leo Yakubu	Member of the NLWG - UNICEF VSL
	Precious Nwiko	Member of the NLWG - CHAI
	Pharm. Amina Sali Usman	State Logistics Officer
	Madame Jovita	State Cold Chain Officer
	Adam Abubakar Sadiq	Astt. Cold chain officer
	Usman Babale	State VSL, UNICEF
	Olusola Seun Ayodeji	LGA Cold Chain Officer - AMAC
	Ngbede Inaigwu	LGA Cold Chain Officer - Gwagwalada
	Bala Ibrahim	LGA Cold Chain Officer - Kuje
Lagos	Temilola Esther Ibiyemi	Asst. Zonal Cold Chain Officer
	Modupe Kolapo Otitoju	Zonal Cold Chain Officer
	Akinpelu Matthew	Immunization Program Coordinator
	Bola Orefejo	Vaccine Security and Logistics Officer
	Kemi Oshodi	State Immunization Officer
	Adams Philomina	State Cold Chain Officer
	Ekujumi Mosunlola	Cold Chain Officer Ojo
	Shoremekun Tolulope A.	State Immunization Officer Ojo
	Adeshina Adekunbi	LGA Immunization Officer Mushin
	Simon Taiwo	LGA Immunization Officer Mushin
	Awofodu Abimbola A.	LGA Immunization Officer Epe
	Agbaje Malik A.	LGA Immunization Officer Epe

Location	Name	Designation/Organization
Niger	Abba Sani Abdullahi	Vaccine Security and Logistics Officers
	Suleiman Chiroma	Zonal Cold Chain Officer
	Dr. Samuel Jiya	State Director Immunization/ Disease control
	Abubakar Usman Kpantu	State Immunization Officer
	Fatima Y. Mohammed	State Cold Chain Officer
	Abubakar Hussami	Asst State Cold Chain Officer
	Abdulmalik Aliyu	LGA Immunization Officer - Chanchaga
	Kasimu Ibrahim D.	LGA Immunization Officer - Lapai
	Abdullahi Sani	LGA Immunization Officer - Suleja
	Adamu Isyaku	LGA Cold Chain Officer - Chanchaga
	Zaynab Musa Kalu	LGA Cold Chain Officer - Lapai
	Aminu Yahaya	LGA Cold Chain Officer - Suleja
	Idris Ibrahim	Asst. LCCO Suleja
	Joseph Iyakwari	Asst. ZCCO

A5. Performance Variations Across High, Moderate and Low Utilization States.[42]

	High-Utilization (reporting rate >80%)	Moderate-Utilization (reporting rate between 60-79%)	Low-Utilization (reporting rate <60%)
Digital Literacy	Most users were digital literate, however Local Immunization Officers were less skilled and untrained.	At inception, users were digitally literate, but ongoing support was said to be necessary due to frequent transfers/ reassignments.	Many users lacked digital skills, reducing system usability and motivation.
Internet Connectivity Related System Performance Issues	Efficient data entry and reporting but affected by occasional challenges with internet access, resulting in system lag and occasional data loss.	Functional engagement with OpenLMIS but disrupted by frequent episodes of network instability, leading to duplicate data entries.	Poor internet access, leading to frequent system errors, long login times, and data synchronization failures.
Hardware & Device Access	Devices generally available, reducing hardware-related barriers.	Many users had to rely on personal mobile devices due to damaged or missing tablets.	Limited access to functional devices, reducing system relevance.

Common Factors Across All Categories

Financial Constraints

Users reported the lack of sustained financial support for internet services where they had to fund their own data costs due. This was said to be further exacerbated by the economic hardship which made it unsustainable for users to continue paying for data.

Technical Support & Training

Users reported that the training and support is limited and can be improved on, especially with the onset of sporadic staff turnovers during political handovers and increased workload at lower levels of the supply chain, where both paper and digital reporting is required.

42 Data is based on key informants across the 3 States and 9 LGAs. It should be stated that some of the factors occur across utilization categories but at varying degrees. Also note that this utilization categorization is based on the initial definition, using the number of unique users out of 835 cold stores who logged in to perform stock management tasks within OpenLMIS each week

Network & Connectivity Issues

Although network issues were more severe in low utilization sites; it was a recurrent theme across all the respondents that led to many issues ranging from inconsistencies in data entry to system inaccessibility.

Power Supply & Infrastructure

Similarly, respondents across locations raised concerns around power supply and infrastructure; although power supply was said to be generally more stable in high utilization sites with the help of back up sources, which was lacking in moderate and (more severe in) low utilization sites.