Evaluating the impact of electronic Logistics Management Information Systems (eLMIS) in low- and middle-income countries:

GUINEA

February 2023

SDA Bocconi SCHOOL OF MANAGEMENT

GLOBAL HEALTH CONSULTING

TRAVAIL JUSTICE SOLIDARITE

Africa Health Consulting

For questions, please contact: Viviana.Mangiaterra@sdabocconi.it

CONTENTS

LIST OF ABBREVIATIONS

ABC	Activity-based Costing
QA/QC	Quality Assurance / Quality Control
ANSS	National Health Security Agency
BCG	Bacillus Calmette Guerin vaccine
BMGF	The Bill and Melinda Gates Foundation
CERGAS	Center for Research on Health and Social Care Management
CMC	Community Medical Center
DHIS2	District Health Information System version 2
DNPM	National Directorate of Pharmacy and Medicines
DPS	Prefectural Health Directorate
DRS	Regional Health Directorate
DVD-MT	District vaccines and data management tool
eIR	Electronic vaccination registry
eLMIS	Electronic Logistics Management Information System
HF	Health Facility
HMIS	Health Management Information System
HDI	Human Development Index
LMIS	Logistic Management Information System
MEV	Vaccine-preventable diseases
MIS	Management Information Systems
MMGH	MMGH Consulting GmbH
MSHP	Ministry of Health and Public Hygiene
WHO	World Health Organization
PCG	Pharmacie Centrale de Guinée S.A.
EPI	Expanded Program on Immunization
GDP	Gross domestic product
LMIC	Low- and middle-income countries
TMN	Maternal and Neonatal Tetanus
MVE	Ebola Virus Disease
LMIS	Logistic Management information system (paper version)
SMT	Stock Management Tool
VPI	Inactive Polio Vaccine / Injectable Polio Vaccine
ToC	Theory of Change
WUENIC	WHO/UNICEF Estimates of National Immunization Coverage

EXECUTIVE SUMMARY

INTRODUCTION

Led by the Centre for Research on Health and Social Care Management (CERGAS) at SDA Bocconi School of Management, Bocconi University, a partnership was formed with MMGH Consulting GmbH (MMGH) to perform a comprehensive evaluation of electronic immunization registries (eIR) and electronic logistics management information systems (eLMIS) in four low-and middle-income countries (LMICs): Guinea, Honduras, Rwanda and Tanzania. The Bill and Melinda Gates Foundation (BMGF), together with the World Health Organization (WHO) and Gavi, the Vaccine Alliance, have provided support to this work with the overall aim of generating robust actionable evidence to enable future decisions on the introduction and scale-up of these digital technologies.

In Guinea, this evaluation was conducted in collaboration with Africa Health Consulting which oversaw the planning, conducting, and managing of the fieldwork. At the request of the Government of Guinea, a technical committee and a steering committee were established to provide strategic direction and oversight to the whole process and to provide a directive counterpart to the researchers deployed in the field. Different stakeholders were represented in the two committees. Participatory meetings on the data analysis and report writing guided the development and finalization of the current report.

BACKGROUND

In 2015, at the end of the Ebola epidemic, an eLMIS based on OpenLMIS (version 2) was developed under the leadership of the Ministry of Health and Public Hygiene (MSHP) in Guinea, with technical assistance from Chemonics. The aim was to facilitate the logistical management of health commodities across the country. In 2017, the country outlined its transition plan to introduce and scale the new eLMIS system based on a phased approach, starting with the introduction of basic data processing and report generation functionalities. With the financial and technical support of the Global Fund and USAID (via Chemonics), Guinea deployed its eLMIS in 2018. The initial version included a first set of reporting functionalities across nine health programs, including the national Expanded Program on Immunization (EPI). The COVID-19 pandemic strongly influenced the roll-out, interrupting deployment at health center level. As of October 2022, Guinea's eLMIS was present in all 8 regional health directorates (DRS), 38 prefectural/district health directorates (DPS) and 37 hospitals, as well as in 57% of the country health centers (253 out 444).

In the context of the EPI, Guinea operates a dual reporting system for vaccine stock management through the eLMIS plus a paper version LMIS mirroring the electronic. The latter is compiled before data entry into a computer. The EPI also maintains its legacy information flow for vaccine stock data management through the Stock Management Tool (SMT) at central level, the DVD-MT tool and DHIS2 at district level, and paper forms or Excel spreadsheets at health center level.

OBJECTIVE

This evaluation is part of a larger multi-country evaluation. The specific objective in Guinea was to assess the economic and programmatic impact of the current hybrid and partially rolled-out version of eLMIS as well as to understand the key strategic factors that have affected its implementation to date. In addition, this evaluation aimed to assess the sustainability and affordability of eLMIS, as well as to explore the impact of its nationwide roll-out. It was envisaged that the findings could provide actionable data to inform future MSHP decisions on national investments to support expansion of the eLMIS functionalities and scope, in addition to contributing to the creation of a broader body of evidence on the introduction and scale up of eLMIS in other LMICs.

METHODS

The evaluation adopted a purposive sampling approach with the aim of obtaining a balanced sample of health facilities which implemented eLMIS (the intervention group) and ones that has not implemented (the control group). At the time of the data collection in March 2022, only 59 out of the 444 health facilities providing immunization services (private and public) had implemented the eLMIS in 3 regions (i.e., Bokè, Kindia and Labè) and the metropolitan district of Conakry. Of those, 42 were selected (20 with the eLMIS and 22 without), as well as an additional 7 district offices.

The evaluation adopted a mixed methods approach, exploring both the programmatic and economic dimensions of the eLMIS implementation and operation. The evaluation's main axis of analysis was based on a stratification of the health centers between users and non-users of the eLMIS. The programmatic impact was assessed in terms of programmatic performance by measuring stock levels and number of stock-outs. Process performance was also assessed by evaluating data timeliness and completeness, perception of data quality, and data use for decision. The economic impact evaluation aimed to provide an estimate of the following: upfront financial expenditures at national level of implementing the eLMIS; routine operating costs of managing vaccine stock data using the eLMIS; difference in incremental costs with the eLMIS compared to only using its paper version (LMIS); impact of the system to the EPI budget; and a scenario analysis of its future scale-up and improvement.

FINDINGS

In recent years, Guinea has experienced an unstable macroeconomic performance and strong political instability, conditions made worst by the Ebola epidemic and COVID-19 pandemic. Despite this difficult context, the Government of Guinea has shown strong national ownership of the eLMIS from its initial decision through development and implementation, though there has been a heavy reliance upon external programmatic and financial support.

The eLMIS, to date, has been rolled out in a phased approach as an integrated tool across 14 health programs under the ownership of the National Directorate of Pharmacy and Medicines (Direction Nationale de la Pharmacie et du Médicament – DNPM). At the start of 2022 (during the evaluation period), only the data entry and reporting functionalities of the eLMIS were operational, with the ordering functionalities scheduled to be introduced in 2023. This approach reflects the country's coordinated decision-making and systems-based approach in the governance and use of data for health more broadly. The decision to implement a multi-program tool has resulted in significant economies of scope, with the cost of implementation for the EPI estimated at only USD 288 per health center.

Despite the advantage of this approach, the design of the tool decided at central level has not fully captured the full range of indicators required by the EPI for adequate vaccine management (e.g. indicators necessary to carry out ordering and forecasting functionalities). This has partially prevented the eLMIS from replacing the legacy information processes and systems used by the EPI. Furthermore, this has been an influencing factor in the current discussion between the MSHP, WHO and UNICEF country offices on whether or not the country should consider the adoption of a parallel system, the eSMT, as a vaccine management tool interoperable with the eLMIS.

In addition, the eLMIS in Guinea has faced several systemic challenges to its implementation and effective use. This has included: intermittent access to electricity and internet, limited availability of hardware, under-staffing and inadequate training of personnel at HC level. These factors likely hinder both the current use of the system, as well as its future potential as a unique electronic data reporting system.

Despite these challenges, a reduction in the number of stock-out events and on the overall stock levels was observed for BCG, Pentavalent and Measles. This impact appears to be reinforced in health centers where supervision activities included a review of eLMIS data. The evaluation indicates high user satisfaction of the eLMIS based on the reported ease of use and on the users' perception of improved data quality. Data quality checks and routine supervision by the DNPM were identified as positive elements in reinforcing the correct use of the eLMIS and correcting data errors through the establishment of QA/QC processes. Stock improvements registered, therefore, were considered as an indirect effect of the use of the eLMIS. More extensive adoption of the tool, in combination with building further IT competencies and responsibilities for data management, has the potential to yield even more positive results.

From an economic lens, the routine operating cost of using the current hybrid process has been estimated at USD 285 per health center per year, covering for a process where data is first transcribed on paper (LMIS) and later back-entered using a computer (eLMIS). This cost is driven by the two principal activities - report generation and transportation - and represents an incremental cost to the legacy paper-based EPI reporting process. Overall, the implementation of the hybrid LMIS/eLMIS increased the costs sustained by the country to manage vaccine logistics data by USD 137k per year. However, compared to health centers only operating the paper version (LMIS), those who use the hybrid LMIS/eLMIS were observed to incur lower costs (USD -15 per year) for

the vaccine stock data management activities, as transportation and printing costs in some instances were able to be avoided.

The additional impact of the current eLMIS on the health budget is minimal at an increase of 2%. As a multi-program tool, the eLMIS is affordable for the EPI; however, as previously noted, its current configuration does not meet the comprehensive needs of the EPI.

Based on a scenario analysis, scaling-up the eLMIS to national level and progressively introducing process changes whereby reliance on paper is gradually reduced, can result to an estimated 40% reduction in costs for vaccine stock data management activities. Achievement of the full cost benefit, however, is conditional upon change management efforts and on ensuring that critical systemic factors, such as adequate human capacity and infrastructure, are in place, which may imply further investments in the eLMIS. Furthermore, if the legacy EPI paper-based tools are to be replaced, additional investments will be needed to include the missing indicators required by the EPI. Importantly, this would mean phasing out the paper tools and investing significantly in human capacity and organizational changes.

Finally, national ownership, in combination with concerted financing support by external partners, is considered critical to the sustainability of the eLMIS. Guinea is still reliant upon Chemonics for the purchasing of servers, hardware, and monthly internet bundles for health facilities. Although the additional budgetary investment in the eLMIS for EPI is currently minimal, an increase in the budget to support the full eLMIS adoption may prove difficult. In the absence of the necessary features for the EPI, it is not possible for the current eLMIS to be used for decision-making regarding vaccines planning and ordering, and thus the risk remains that the eLMIS will be used solely as a reporting and monitoring tool used centrally for data management.

Together, these main findings provide an overview of the key learnings which have emerged from the early implementation of the eLMIS in Guinea. Additional reflections are provided as answer to the main research questions of this evaluation, summarized below.

Has the implementation of the eLMIS improved the delivery of immunization services? [Impact]

- Due to the limited extent of implementation and the effect of the COVID-19 pandemic on both immunization delivery and the roll-out of the eLMIS, use of the eLMIS was not expected to have a sizeable impact on immunization outcome indicators (e.g., coverage, timeliness, or drop-out rates). As EPI decision-making is still based on data from the EPI legacy information tools (SMT, DHIS2, Excel, paper registries), the evaluation prioritized assessing impact using process and output indicators, specifically those reated to data quality and stock management.
- There was an improvement in the perceived data quality, as well as in reduced stock-out events and improved stock levels (measured as reduction of the number of months during which stock levels are not considered adequate). These were largely driven by robust supervision and by the establishment of a QA/QC mechanism by the DNPM. In addition, users reported high rates of satisfaction with the tool.
- Despite improvements, eLMIS adoption and use were hindered by limited access to internet and hardware. Furthermore, the level of IT skills, training on the use of the eLMIS, and clarity on roles and responsibility in the eLMIS processes varied across the staff using the system, suggesting that further trainings and clear allocation of responsibilities are still needed to ensure consistent use of the system.

To what extent is the eLMIS interoperable with the national health information and management system (DHIS2, stock management system) [Ecosystem, Tool]

- The eLMIS is well integrated in the overall health information data infrastructure, with national strategies outlining the future of the tool and its expected contribution to the health system.
- Integration between the eLMIS and DHIS2 is achieved at district level, where vaccine stock indicators reported in the eLMIS are transferred to the DHIS2. DHIS2 is then used as a monitoring tool by the MSHP across all programs.

What is the short- and medium-term economic and financial impact of implementing and scaling-up the eLMIS? How affordable and sustainable is it? [Impact, Affordability and Sustainability]

- The total financial expenditure incurred in 2018 for the design, development and deployment of the eLMIS across 9 programs was USD 716,309 (2021 USD value). Of this total, the 6.5% share apportioned to the EPI based on the number of EPI products in the system was USD 46,560. All expenditures were incurred by the Global Fund and USAID Chemonics and equally shared between the two. Chemonics also oversaw the implementation of the system. Of the total expenditure, 37% was spent on the design and development of the system, and 63% was spent on or budgeted for the deployment in 8 regions.
- Additional costs for personnel incurred by Chemonics for the design, development, and deployment of the eLMIS were estimated at USD 374,296, of which USD 24,329 apportioned to the EPI.
- The average annual cost for data entry and reporting activities was estimated at USD 284.9 for each health center using the eLMIS, with the main cost driver being personnel costs (40%) and the most costly activities being report generation and transportation.
- Compared to only using paper (LMIS), the eLMIS users incur USD 15 less costs. This was a result of reduced costs for consumables and services associated with physical report transportation.
- The total annual incremental cost for using the eLMIS for reporting activities related to the EPI was estimated at USD 137,518, in addition to the operation of the parallel EPI legacy system. This cost represents 2% of the annual budget allocated to routine immunization activities.
- Based on a scenario analysis, Guinea would benefit to a small extent from the national scale-up of the current system. Larger cost benefits could be observed if Guinea moves towards a fully electronic-based reporting system. Further gains may also be obtained if the eLMIS is able to provide the EPI with all vaccine management features needed, allowing for the replacement of the current SMT based system.
- Overall, the adoption of the eLMIS has led to incremental costs, as this system is operated in parallel to the EPI legacy tools, leading to duplication of reporting and efforts.

How can information on eLMIS and its modality of use and governance inform future investments (i.e., national resources, health financing institutions and technical partners) for sustainable implementation of eLMIS systems? [Ecosystem, Impact, Affordability and Sustainability]

- In order to ensure programmatic and financial sustainability, eLMIS should be designed such that all vaccine-specific features necessary to support decision-making by the EPI are present. This will enable the replacement of the current system. Based on the current understanding, no structural limitations exist in eLMIS that prevent the achievement of such a goal. It is highly recommended that Guinea fully adopts the eLMIS in such an integrated approach across health programs, including the EPI, and avoids duplication of efforts through operating parallel systems. This will likely require investments in a stepwise transition with alignment of both internal and external stakeholders.
- Targeting a fully electronic system whereby the paper-trail is eliminated should be the ultimate goal. Given the context of Guinea, it is most likely that data capturing and data management for vaccine logistics will continue in parallel using two information flows and both paper and electronic tools (LMIS/eLMIS) at health center level. Thus, investments should be prioritized at harmonizing information data sources on a single source of information in the short-term. This is expected to result in a reduction in the costs of vaccine stock data management as incurred currently.
- Investments in strengthening digital infrastructure, enabling greater access to internet and hardware, as well as in capacity building, will allow for a better adoption of the tool. These are foundational for the sustainability of the eLMIS before transition to a fully digital system.
- An overreliance on external financing partners is cautioned against. It is recommended that investments in the enabling environment are planned according to a long-term view of the program needs in such a fashion that ultimately allows Guinea to have full financial ownership of the tool.

CONCLUSIONS AND RECOMMENDATIONS

The further scale-up and use of the eLMIS to support analysis and decision making on vaccine management of the EPI should be prioritized. This should happen by fully leveraging the integrated approach adopted thus far and avoiding the creation of parallel processes and/or the adoption of parallel tools. To do so, adequate long-term planning and budgeting of resources is recommended, taking into account the evolving needs of users and health programs requirements. The sustainability of the eLMIS is conditional upon the improvement of digital infrastructure (e.g., computers, internet connectivity, electricity), as well as on the enhancement of human capacity. Both conditions are also pre-requisites for the transition to a fully electronic system in the long-term, a set-up that will deliver the most financial gains. To achieve these ambitious goals, it is recommended that technical partners align to the plans of the Minister of Health and provide the necessary technical assistance to facilitate the full integration of EPI in the eLMIS.

I. INTRODUCTION

With the increasing digitalization of health systems in low- and middle-income countries (LMICs), governments, donors and partners have expressed a growing interest in introducing and scaling up electronic management and logistics information systems (eLMIS). Although the existing global guidance frames eLMIS as a tool to improve the quality and use of vaccine management data (Village Reach, 2020; USAID, 2020), the case studies currently available do not provide a complete assessment. Evaluations to date have explored critical factors influencing the success of eLMIS implementation, such as consideration for the country context, the specificity of user needs and issues related to interoperability with existing health management information systems (Wright, Drury, Jackson & Thomas, 2016; Thondoo et al., 2015; PATH, 2015; Expert Panel on Effective Ways of Investing in Health (EXPH), 2019) but have offered little insights into their costing, affordability and sustainability.

This report attempts to fill the evidence gap. It draws on the findings from field research conducted in Guinea in 2022 and on a review of recent literature documenting experiences with eLMIS in LMICs (Chindove and Mdege, 2012; PAHO, 2019; Pisa and McCurdy, 2019; Fritz et al., 2019). It estimates the effectiveness, affordability, and sustainability of the roll-out and management of the first module of Guinea's eLMIS focused on data processing, reporting, and monitoring activities across 14 national health programs, including the Expanded Program on Immunization (EPI).

The research in Guinea is part of a multi-country evaluation of the impact of electronic solutions, inclusive of eIR and eLMIS, in support of immunization in Guinea, Rwanda, Honduras, and Tanzania aiming to inform future decisions on the introduction and management of digital tools in LMICs. Policy makers and technical staff at the national level, such as government officials, program managers, donors and partners involved in the implementation of these tools are the main audiences for this report. Other stakeholders, including those in academia and the private sector, may also benefit from the findings of this research.

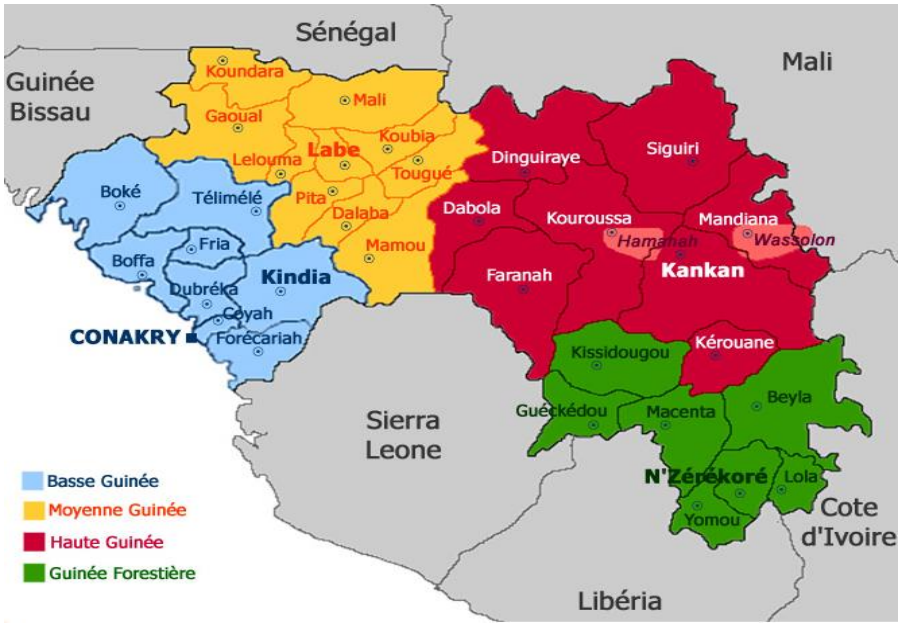
A. CONTEXT

Despite the many natural resources, Guinea is among the poorest countries in the world. In 2018, it ranked 175th out of 186 countries on the Sustainable Human Development Index (HDI). From 2010-2014, health expenditure represented only 2.4% of the total government budget, likely negatively influencing the quality of health services across the country. However, of recent, resource allocation trends have seen a positive change. In 2017, the national budget allocated to health increased to 4.9% and was followed by another increase to 10% in 2021, potentially creating a more favorable context for the introduction of health technologies, inclusive of digital solutions. Additional information about the Guinean context can be found in **Annex 1**.

HEALTH SYSTEM

The public health system in Guinea is managed centrally by the Ministry of Health and Public Hygiene (MSHP), which is responsible for regulating the health sector, coordinating, and allocating resources. The health system mirrors the administrative structure of the country and is divided into 8 Regional Health Directorates (DRS) and 38 Prefectural and District Health Directorates (DPS), as well as 444 health centers, which include also Communal Medical Centes (CMCs) which are usually larger than health centers and provide a wider range of services. Below the health center level, which functions as the primary point of service delivery, health posts are found primarily in rural areas and usually operate under the supervision of health centers.

Figure 1: Map of the administrative structure of Guinea



A major challenge in Guinea remains the full recovery of its health system after the 2013-2016 Ebola Virus Disease (EVD) epidemic and the ongoing COVID-19 pandemic. While both have negatively impacted the ability of the health system to delivery routine care, including vaccination, respectively they have also driven the introduction of new strategies and approaches to healthcare system organization and management (République de Guinée, 2017).

VACCINATION IN GUINEA

Vaccination services in Guinea are provided in health centers, CMCs and health posts (Technical Committee, 2022), but not in hospitals (UNICEF, 2018). Coverage is generally low for the key infant vaccines as reported in *Table 1*.

Table 1: Comparison of different vaccination coverage rates (percentage values)

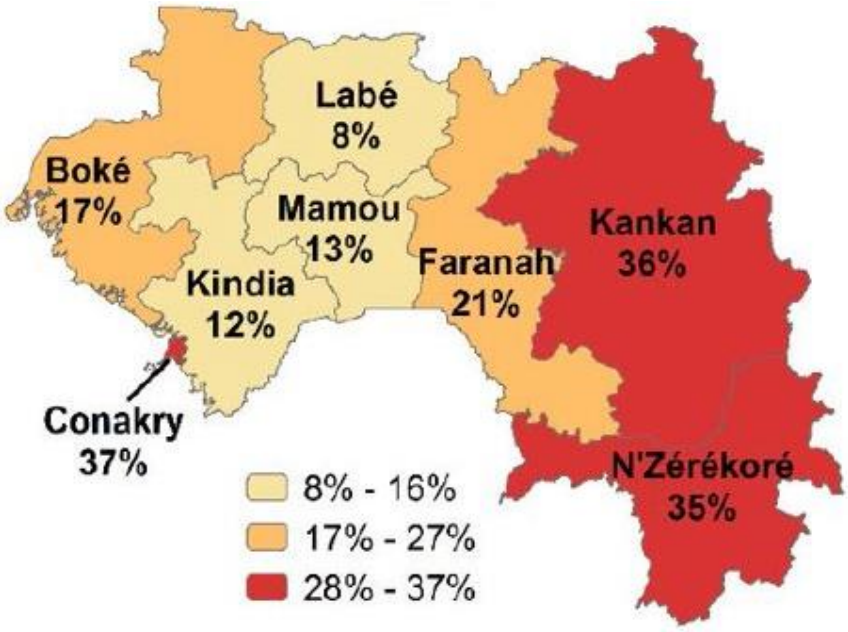
	Source	2017	2018	2019	2020	2021
BCG	WUENIC	73	73	73	73	72
	Official	91	91	85	86	80
	Admin	99	102	95	91	92
DTP3	WUENIC	47	47	47	47	47
	Official	70	75	82	85	60
	Admin	99	100	94	90	87
MCV	WUENIC	47	47	47	47	47
	Official	65	75	80	85	60
	Admin	100	99	93	90	87

Immunization data quality is problematic in Guinea as highlighted by the differences between the multiple sources of vaccination coverage data for the key vaccines, including those reported by the country (i.e., official, and administrative) and those validated by WHO and UNICEF. This is summarized above in *Table 1*.

Despite such inconsistencies, the information from the Demographic and Health and Survey (DHS), as below in *Figure 2*, provides a more granular overview of the state of the immunization program in Guinea. In 2018, only 24% of children aged 12-23 months had received all the basic vaccines (i.e., 1 dose of BCG, 3 doses of Pentavalent (DTP-HepB-Hib), 3 doses of Polio and 1 dose of measles-containing vaccine) and 19% had received them at the appropriate age (i.e., before 12 months). In the same year, 22% had not yet received any of the EPI vaccines. Notably, the proportion of children who received all routine vaccines was higher in urban areas than in rural

areas (31% versus 21%). The results stratified by region reflect a range of coverage from a minimum of 8% in Labé to 36% in Kankan and a maximum of 37% in Conakry (Institut National de la Statistique (INS) ICF, 2018).

Figure 2: Immunization coverage by region in Guinea (2018). Percentage of children aged 12-23 months who received all basic vaccines (Institut National de la Statistique (INS) and ICF, 2018)



Officially reported coverage rates for 2020 and 2021 suggest that the continuity of routine immunization in Guinea was negatively affected by the COVID-19 pandemic, as the already limited human resources in immunization shifted their focus to the pandemic response and away from routine immunization activities (e.g., polio campaigns, measles campaigns, etc.). In a study on the early effect of the COVID-19 pandemic on administrative immunization coverage in Guinea, a decline for IPV and Pentavalent vaccines of 20% was recorded for both vaccines in 2020 (Dabo, et al., 2020). This drop resulted from the interruption of immunization services, with the greatest impact recorded in the prefectures of Yomou, N'Nzérékoré, Macenta, Kankan, Madina, Dinguiraye, Mamou, Koubia, Mali, and Conakry, as well as a delay in supplementary immunization activities. The overall situation improved during the second part of the year (UNICEF, 2021).

MEDICAL PRODUCTS LOGISTIC AND SYSTEMS

The National Directorate of Pharmacies and Medicines (DNPM) is the entity within the MSHP responsible for ensuring the availability and accessibility of quality medicines and healthcare throughout the country. In 2017, the Logistics Management Unit, a subdivision of DNPM, was created to manage the supply chain with the goal of improving the availability of key medical products.

The Central Pharmacy of Guinea (PCG) manages all medical products, except vaccines (GHSC-PSM, 2019). The PCG network includes the central medical stores in Conakry and six regional warehouses: Boké, Conakry, Faranah, Kankan, Labé and N'Zérékoré. Each warehouse serves the health facilities in the surrounding geographical area (USAID Global Health Supply Chain Program, 2019). Vaccines, as discussed below, are managed directly by the EPI program with the EPI central warehouse as the entry point for vaccines in Guinea.

An eLMIS based on OpenLMIS (version 2), the open-source electronic logistics management information system, was developed in 2015 at the end of the Ebola epidemic with technical assistance from Chemonics. The goal of the system was to allow the electronic management of medical commodities across all health programs, including EPI. The eLMIS was piloted in Kindia for 6 months, with a focus on few medical products relevant for the outbreak response and allowed the recording and monitoring of products' consumption data. Vaccines were not initially included.

In 2017, Guinea's Ministry of Health National Strategic Plan (USAID, 2019) outlined the transition to the eLMIS system in a phased fashion starting with the introduction of data processing and report generation

functionalities. It was envisaged that this first step would be followed by the subsequent introduction of electronic documents and records allowing for the digitation of the ordering and planning processes. The goal of the roll-out was to progressively replace the legacy paper-based LMIS. In the old configuration, paper forms were filled at the peripheral level and consolidated in paper-based and excel-based reports combining the lower levels data and serving as the base for ordering and planning activities.

In 2018, with the financial and technical support of the Global Fund and USAID (via Chemonics), Guinea deployed its eLMIS which included a first set of reporting functionalities. The roll out included nine health programs (i.e., National Malaria Program, National Safe Motherhood Program, National STI/HIV/AIDS Treatment and Prevention Program, National Tuberculosis Program, National Blood Transfusion Center, and EPI), with the remaining five national program planned for inclusion in 2022-3. The system started consolidating information on a weekly basis on the national consumption of 185 "tracer commodities," of which 12 were used by the EPI. **Annex 2** provides the list of the tracer products.

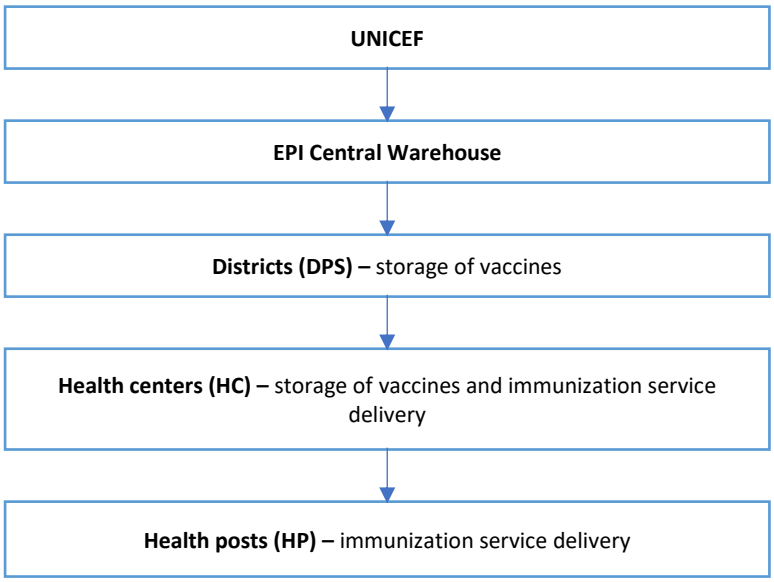
The roll-out was impacted by the COVID-19 pandemic and at the beginning of April 2022. However, as of October 2022, the roll out has significantly accelerated with the eLMIS now being present in all regional health directorates (DRS) (8), prefectural/district health directorates (DPS) (38) and hospitals (37), as well as in 57% of the country health centers (253 out of 444).

The roll-out has adopted a progressive deployment approach. As a result, the current configuration of the eLMIS in Guinea is hybrid both from a functionality standpoint (i.e., only data entry, consolidation and reporting are included in the electronic system, with ordering and forecasting still managed with the legacy system) and from a geographical standpoint (i.e., with almost 1/3 of the health facilities still operating with the legacy paper system across all functionalities).

VACCINE MANAGEMENT AND SYSTEMS

Vaccine procurement and supply chain management is a distinct process to the other medical products in Guinea. Some vaccines are procured by UNICEF with funding from Gavi, the Vaccine Alliance, and co-financed by the Guinean government (i.e., Pentavalent, Measles, IPV, Meningitis A and Yellow Fever) while others are directly purchased by the government using local funds or donors' financial support (i.e., BCG, Td, OPV). Unlike other medical products that are managed by the PCG, immunization products, including vaccines, are managed directly by the EPI program (USAID, 2019).

Figure 3. Vaccine distribution in Guinea managed by the EPI, as described and adapted from USAID (2019).



The EPI central warehouse is the entry point for vaccines in Guinea. It has 5 cold rooms (i.e., four positive and one negative), 14 refrigerators and 8 freezers. Vaccine stocks from the EPI central warehouse are transported to the Prefectural Health Directorates (DPS). Health centers and health posts replenish their vaccine supplies by visiting the DPS stores (USAID , 2019). Vaccine procurement at central level takes place on a semestrial-basis, while the DPS replenishes its supply every three months and health center and health post levels monthly (Guinea Technical Committee, 2021). *Figure 3* below provides an overview of the flow of vaccines through the EPI supply chain.

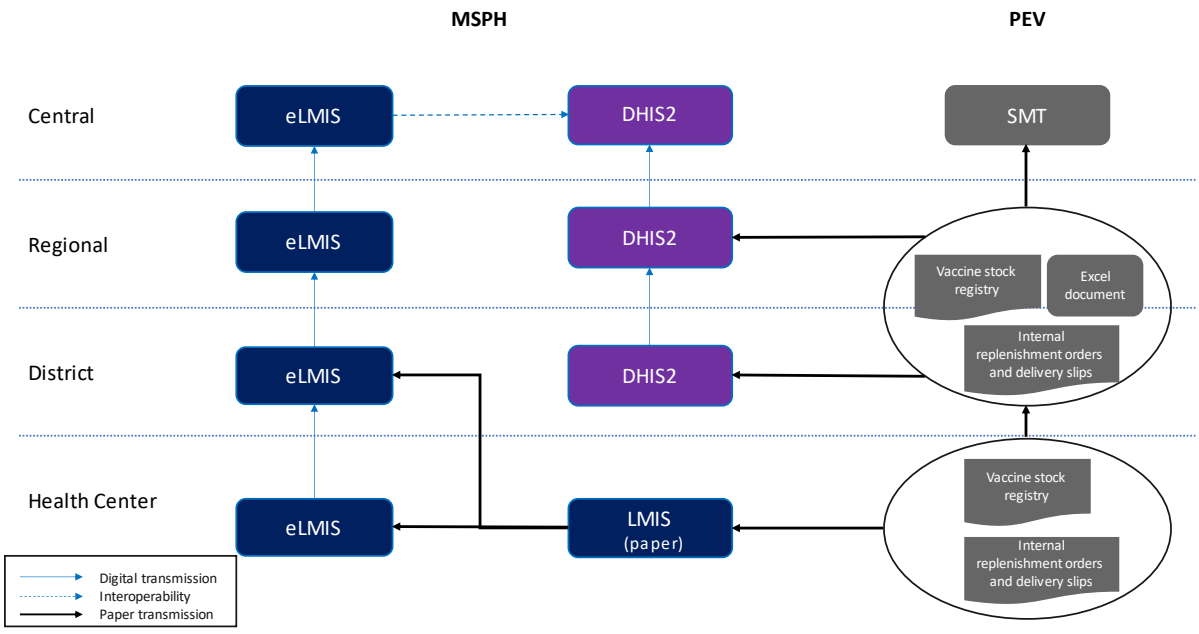
Health centers equipped with cold chain equipment (CCE) provide more frequent immunization services, while health posts which lack CCE are responsible for outreach immunization services. The latter requires health workers (HW) to travel to collect vaccines from health centers that have CCE (Stammer, et al., 2022). At present, 100% of health centers and DPS are covered by the country's cold chain (World Health Organization, 2021). Recently, the government of Guinea installed solar refrigerators in all health centers and health posts (World Health Organization, 2021).

Twelve immunization products are included in the list of tracer products: 7 vaccines including BCG, bOPV, Pentavalent, IPV, Measles, Meningitis-A, and Tetanus-Diphtheria adults (Td), as well as other ancillary items, such as syringes. These 12 products represent 6.5% of the total number of items managed through the eLMIS system for nine programs (Guinea Technical Committee, 2021).

VACCINE STOCK DATA MANAGEMENT AND INFORMATION FLOWS

Historically, vaccine management has been performed by the EPI at the central level using the Stock Management Tool (SMT), an excel-based tool which consolidates data from stock management paper registries at health center and district level. At the peripheral level, paper forms used for the daily management of vaccines were consolidated using the DVD-MT tool, also excel based. At district level, the DVD-MT consolidation functionalities are now performed the District Health Information System 2 (DHIS2). The progressive deployment of the eLMIS has created a scenario where two parallel flows of information are now in place. This is shown below in *Figure 4* which illustrates the parallel flow of vaccine stock information for health centers both through the legacy EPI tools (grey) and through the LMIS/eLMIS information flow (blue).

Figure 4: Data flow for health centers with eLMIS (blue), the legacy tools (grey) and DHIS2 (purple)



EPI staff in all health centers capture consumption data and track stock levels in vaccine stock registries and purchase orders and delivery slips. These documents serve as the primary source of information for both the legacy information flow (grey) and the LMIS/eLMIS flow (blue). The process as the eLMIS is rolled out nationwide, is such that health centers input consumption and stock data on the paper LMIS forms and, if a computer is available, directly in the eLMIS. The paper LMIS forms mirror the electronic data fields. If a computer is not available, the paper forms are transported to the district level where the data entry is performed in the eLMIS.

The eLMIS process captures only selected indicators on vaccine consumption and stock levels relevant for reporting purposes with a focus on the centres and with information gaps at central and district level. In the specific, the following indicators required by the EPI are currently not included in the eLMIS design:

- Stock levels for the district / central warehouses (the eLMIS only captures stock level for centers);

- Number of doses received per month and per district;
- Anticipated end of stock date (availability of the number of months of stock) across all levels;
- Stock losses and average loss rate across all levels;
- Coverage rate of doses needs by district;
- Maximum and minimum stocks at national level.

DPS maintain their own vaccine stock registries consolidating the district data, manage vaccines via purchase orders and delivery slips, as well as manage the eLMIS for input of district data and consolidation of health center data. The DPS also manages DHIS2 (Guinea Technical Committee, 2021) which captures the number of vaccine doses administered. Vaccine stock data from the eLMIS is synchronized into DHIS2 every 25th day of the month, and the DHIS2 is further integrated in the digital National Health Information System (SNIS) platform (USAID , 2019).

Two reports are generated at district level: i) a report on vaccine stock indicators by LMIS/eLMIS and ii) the legacy EPI reporting. These are sent both electronically and on paper to the regions. Once the region has validated the data received, it is consolidated into a monthly report containing aggregate vaccine and immunization data by region and sent to the MSHP at central level.

Vaccine procurement takes place at central level outside the eLMIS. The EPI estimates the needs of the regions and districts based on their historical consumption patterns and the reported stock. Once received at national level, vaccine supplies are transported from the central level to the health districts (i.e., procurement by allocation), through the regional health offices. When there are delays in vaccine procurement at central level or stock are depleted, districts issue an order and go to the central level to replenish their stock. Doses ordered are captured in order forms. Order and delivery forms are entered into the SMT which allows for a consolidated view at central level.

B. EVALUATION FRAMEWORK

OBJECTIVE OF THE EVALUATION

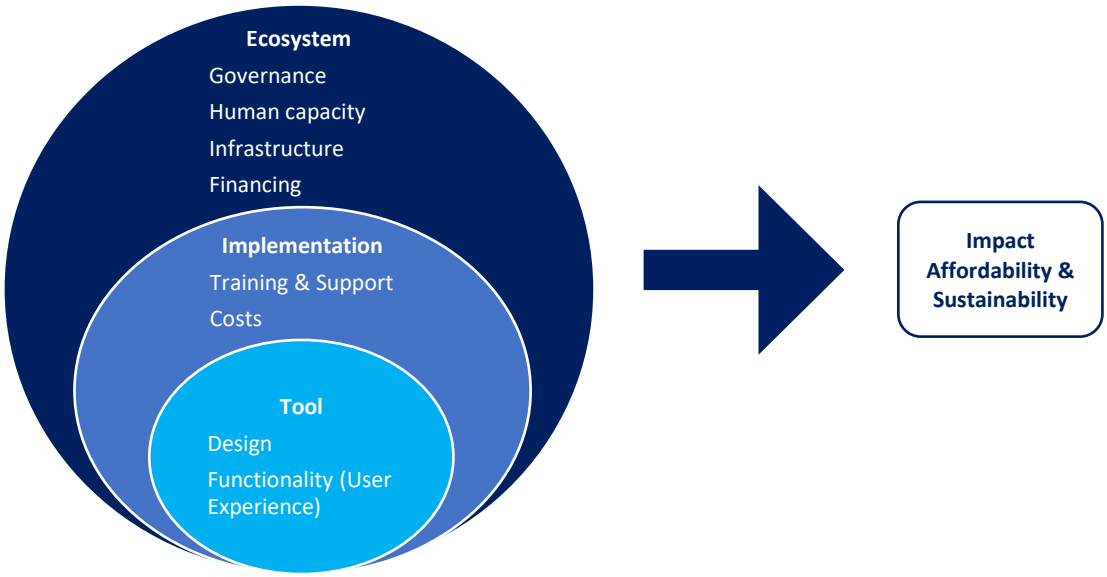
The objective of the evaluation in Guinea is to assess the economic and programmatic impact of the eLMIS in its current configuration limited to data capturing and reporting generation, as well as to understand the key strategic factors that have affected its implementation to date. In addition, this evaluation aims to assess the sustainability and affordability of eLMIS in its current hybrid form, as well as to explore the impact of its nationwide roll-out. The findings aim to provide actionable data to inform future MSHP decisions on national investments to support expansion of the eLMIS functionalities and scope, in addition to contributing to the creation of a broader body of evidence on the introduction and scale up of eLMIS in other LMICs settings.

THEORY OF CHANGE

The evaluation in Guinea is part of a multi-country study guided by a theory of change (ToC), as reflected in **Annex 3**. The hypothesis explored in context of Guinea is that the implementation and sustained use of eLMIS at scale contributes to improved immunization program performance by ensuring appropriate stock levels and better data quality. It is also hypothesized that the investment in an eLMIS is good medium- to long-term investment providing value for money if it is well both integrated into the country's processes and data architecture, as well as affordable and financially sustainable.

The ToC provides the basis for the evaluation framework used to guide the interpretation of the main findings of this evaluation. This framework focuses on the contextual factors (ecosystem), the design and function of the tool, its implementation, impact, and sustainability, as shown in *Figure 5*.

Figure 5: Evaluation Framework



RESEARCH QUESTIONS

The following outline reflects the principal research questions for this evaluation in Rwanda. The research questions have been mapped against the domains of the evaluation framework above to ensure clear reporting of the findings and their implications.

The following outline reflects the principal research questions for this evaluation in Guinea:

- Has the implementation of the eLMIS improved the delivery of immunization services? *[Impact]*
  - To what extent does the system comply with established norms and standards? *[Tool]*
  - What were/are the obstacles and opportunities for the implementation of the eLMIS in the country? *[Ecosystem, Implementation, Tool]*
  - What is the impact of the eLMIS on the national immunization program (i.e., cost savings, efficiency, timeliness, vaccine coverage, stock levels)? *[Impact]*
- What is the short and medium term economic and financial impact of implementing and scaling up this system across the country? To what extent is eLMIS user-friendly and sustainable? *[Impact, Affordability and Sustainability]*
- To what extent is the eLMIS interoperable with the national health information and management system (DHIS2, stock management system)? *[Ecosystem, Tool]*
- How can new evidence on tools and technologies, modalities, and governance of eLMIS inform further investments in other countries from domestic sources, health financing institutions and technical partners for its sustained operation? *[Ecosystem, Impact, Affordability and Sustainability]*

EVALUATION GOVERNANCE

At the request of the Government of Guinea, a technical committee, and a steering committee were established to provide strategic direction and oversight to the whole process and to provide a directive counterpart to the researchers deployed in the field. Different stakeholders were represented in the two committees.

The technical committee met on a weekly basis with the research team to provide input and feedback on the research and research tool. The technical committee was also directly involved in the data collection process.

II. METHODOLOGY

A. PROGRAMMATIC AND ECONOMIC IMPACT ASSESSMENT

In view of the current design implementation status of the eLMIS in Guinea (i.e., a system with functionalities limited to data capturing and reporting that is undergoing a progressive deployment with many centers still operating only the paper LMIS, a cross-sectional approach has been adopted to allow for a direct comparison between health facilities using the electronic system and those health facilities that are not yet using the electronic system (details on the sampling strategy are described below).

PROGRAMMATIC IMPACT ASSESSMENT

A mixed-methods approach, involving both quantitative and qualitative methods, has been used to analyze the impact of the reporting and monitoring functionalities of the eLMIS on the performance of the immunization system as assessed by three vaccines (i.e., BCG, Pentavalent and measles). These routine vaccines have been in place for a long time in the country. They are now fully rolled out, are managed by stable programs from a design and resourcing standpoint and have not been affected by major global shortages in recent times. Therefore, in absence of external shocks, the performance of vaccine management for those vaccines can be attributed almost exclusively to local dynamics, including the impact of the eLMIS.

Two key direct measures of programmatic performance were included for analysis: stock levels and number of stock-outs. In addition, two measures of process performance were included: data quality measured in terms of timeliness, completeness, and overall perception of data quality and data use for decision.

ECONOMIC IMPACT ASSESSMENT

The scope of the economic assessment included the costs directly associated with the eLMIS system and reporting process, as it is currently used for the EPI. These costs represent the incremental costs from implementing the eLMIS system in addition to the legacy system still in operation in Guinea for vaccine stock management by the EPI. The economic assessment provides an estimate of: (i) the financial expenditures at national level, for the implementation of the eLMIS in total as a multi-program system, as well as the proportion of the expenditures attributed specifically to the EPI (i.e. rate apportioned to EPI); (ii) the routine operating costs of vaccine data management following the LMIS/eLMIS hybrid monitoring and reporting process, including the costs of its maintenance and operation at central level; and (iii) the difference in operational costs between the eLMIS system and the paper-based LMIS version only.

A simplified activity-based costing (ABC) approach was used to estimate the operational costs (i.e., at health centers, CMCs, and DPSs). This approach consists of identifying a series of activities carried out by the health facilities and establishing the direct and indirect costs of these activities (Udpa, 1996). The activities considered are limited to those related to vaccine stock data management and where the use of eLMIS can have an impact (i.e., report generation and transmission, monitoring and evaluation of immunization program data). Other activities that are generally relevant when costing immunization programs, such as those related to the provision of routine immunization services at the facility level, maintenance of the cold chain, or vaccine preventable diseases surveillance, were considered out of scope (Brenzel, 2015). When estimating the difference in operating costs with and without eLMIS (i.e., using only LMIS), the analysis considered the cost of emergency vaccine replenishments which, although not directly attributable to immunization data management, could be affected by the way vaccine management is performed. Through a better and more accurate estimation of the monthly vaccination cohorts, HFs were hypothesized to be able to better manage vaccine stock based on the expected forecasted demand and better planning of immunization services. This would lead to a reduction of stock-outs and, thus, in fewer emergency vaccine stock replenishments during the year.

In addition, the economic evaluation also includes a sustainability and affordability analysis aimed at informing decision-makers on the management and/or resource allocation for the eLMIS. The analysis is based on secondary macroeconomic data to provide additional information on the long-term financing of the eLMIS. In addition, the future costs of running the eLMIS are analyzed under different scenarios whereby the country progressively moves towards a digital process for vaccine stock information management.

B. SAMPLING STRATEGY

As of March 2022, only 59 out of the 444 health centers and CMCs providing immunization services, private and public, had implemented the eLMIS in 3 regions (Bokè, Kindia and Labè) and the metropolitan district of Conakry. Of those 59, only four were rural. A purposive sampling approach was adopted with the aim of obtaining a balanced sample of health facilities where the eLMIS was implemented (i.e., intervention) and where it was not implemented (i.e., control). A randomized approach to sampling was not feasible given: i) the limited level of eLMIS implementation overall, ii) the concentration of the roll-out in certain regions and urban districts, and iii) the need to incorporate enough health centers having implemented eLMIS to allow for the cross-sectional analysis.

The sampling approach was structured in three steps. Firstly, regions were selected. Of the 4 regions where the eLMIS has been rolled-out by March 2022, the metropolitan prefecture of Conakry, Boké, and Kindia were selected. Labé was excluded because of logistical and security challenges in accessing health facilities to collect data. Among the regions without eLMIS, Mamou and N'Zérékoré were included as they represented the smallest and largest regions of Guinea in terms of territorial extension and number of facilities as well as because they allowed to coverage an internal region (N'Zérékoré). They were purposely selected against the other two regions (i.e., Faranah and Kankan) where the eLMIS hadn't been rolled out to ensure diversity in the sample and overall representativeness of the country. This regional sampling approach is summarized below in *Table 2*. As a result, the metropolitan prefecture and the 3 regions sampled included a total of 143 health centers, of which 48 having implemented eLMIS.

Table 2: eLMIS distribution across health centers, number of districts, target population in 2021 and Penta 3 coverage in 2020 per region. Selected regions are shadowed and in italics.

Region	# of HC with eLMIS	# of HC without eLMIS	Total # of HCs (% with eLMIS)	# of districts per region	Target Population, 2021**	Total population per region, 2021*	Penta3 Coverage , 2020***
Boké	*14*	*28*	*42 (50%)*	*5*	*47,882*	*1,330,079*	*91%*
Conakry	*19*	*24*	*43 (83%)*	*5*	*73,428*	*2,039,725*	*77%*
Kindia	*15*	*43*	*58 (35%)*	*5*	*56,407*	*1,916,276*	*100%*
Labé	11	47	58 (12%)	5	43,898	1,219,391	77%
Faranah	0	49	49 (0%)	4	41,625	1,156,311	88%
Kankan	0	69	69 (0%)	5	86,754	2,409,867	97%
Mamou	*0*	*41*	*41 (0%)*	*3*	*32,309*	*897,518*	*93%*
N'Zérékoré	*0*	*84*	*84 (0%)*	*6*	*77,529*	*1,330,079*	*103%*
Total	**59**	**385**	**444 (13%)**	**38**	**459,832**	**12,907,394**	**91%**

** Source: Population Projection for 2021 estimated by the National Statistical Institute of Guinea in the last available Statistical YearBook – 2018. The total population of Guinea in 2021 according to the World Bank Source is 13,5 million; however, this source does not provide the population distribution by region.*

*** The target population represents 4% of the total population according to the Ministry of Health.*

**** Source: EPI, Guinea*

Secondly, the district selection within the identified regions was made by the Technical Committee of Guinea considering the following criteria: i) the number of health centers with eLMIS implemented; ii) the target population size (i.e., under 24 months of age); iii) the total population of the district; and iv) the vaccination coverage of the third dose of Pentavalent vaccine. Districts considered as representative of each region and allowing sufficient variety in terms of the above characteristics were selected. More districts were selected in the regions with eLMIS to reach a sufficient number of health centers with eLMIS for selection in the final sampling step. As a result, 7 districts were included in the sample. A total of 84 health centers of which 21 had an eLMIS were included in this selection.

Table 3: eLMIS distribution across health centers, target population in 2021 and Penta 3 coverage in 2020 per district in the 5 selected regions. Selected districts are shadowed and in italics.

Region	District	# of HC with eLMIS	# of HC without eLMIS	Total # of HCs (% with eLMIS)	Target Population, 2021	Total population per district, 2021	Penta3 Coverage, 2020
Boké	*Boffa*	*2*	*6*	*8 (25%)*	*10,443*	*261,085*	*85%*
	Boké	*5*	*8*	*13 (38%)*	*22,108*	*552,704*	*93%*
	Fria	3	3	6 (50%)	5,015	125,376	93%
	Gaoual	2	6	8 (25%)	4,751	118,795	92%
	Koundara	2	5	7 (29%)	6,384	159,602	91%
Conakry	Dixinn	2	2	4 (50%)	6,006	135,788	86%
	Kaloum	4	1	5 (80%)	2,763	62,457	91%
	Matam	*2*	*2*	*4 (50%)*	*6,337*	*143,255*	*64%*
	Matoto	3	8	11 (27%)	29,460	665,908	58%
	Ratoma	*8*	*11*	*19 (42%)*	*28,862*	*652,406*	*84%*
Kindia	Coyah	3	3	6 (50%)	13,667	341,689	102%
	Dubréka	*4*	*8*	*12 (33%)*	*17,116*	*427,915*	*96%*
	Forécariah	2	9	11 (18%)	12,591	314,786	110%
	Kindia	5	10	15 (33%)	22,772	569,301	91%
	Télimelé	1	13	14 (7%)	14,749	368,737	86%
Mamou	Dalaba	0	10	10 (0%)	6,930	173,272	100%
	Mamou	*0*	*18*	*18 (0%)*	*16,539*	*413,480*	*71%*
	Pita	0	13	13 (0%)	14.419	360,484	109%
N'Zérékoré	Beyla	0	16	16 (0%)	16,917	422,927	98%
	Guéckédou	0	13	13 (0%)	15,066	376,670	97%
	Lola	0	9	9 (0%)	8,900	222,512	92%
	Macenta	0	18	18 (0%)	14,444	361,119	114%
	Nzérékoré	0	18	18 (0%)	20,565	514,129	104%
	Yomou	*0*	*10*	*10 (0%)*	*5,929*	*148,238*	*114%*
	Total	**48**	**220**	**268 (18%)**	**322,733**	**7,892,635**	**93%**

Finally, the selection of health centers within the selected districts was performed with the primary aim of ensuring a balance between the intervention and the control group. The need to include enough health facilities with eLMIS in the sample when only 59 out of nearly 444 have eLMIS led to an over-representation of facilities with eLMIS (48% vs. 25%) as shown in *Table 4*. For the same reason, the distribution of rural and urban facilities in the sample was not representative of the distribution at the country level as only 4 rural health centers out of 59 had adopted the eLMIS for vaccine stock management at the time of the study. The sample, thus, included an over-representation of urban health centers (67% vs. 52%). In terms of typology of health centers, the sample was representative of the selected districts population (11-12% CMC vs. 88-89% HC). The characteristics of the health centers selected in the sample with respect to eLMIS implementation, location, and typology are summarized below in *Table 4* against the total population in the selected districts.

Table 4: Characteristics of the health centers: sample vs population of selected districts

		Selected District (n=84)		Sample (n=42)	
Criteria	**Detail**	**With eLMIS**	**No eLMIS**	**With eLMIS**	**No eLMIS**
Type of health facility	Communal Medical Centers (CMC)	5 (6%)	4 (5%)	5 (12%)	0 (0%)
	Health centers (HC)	16 (19%)	59 (70%)	15 (36%)	22 (52%)
Location	Rural	2 (2%)	39 (46%)	2 (5%)	12 (29%)
	Urban	19 (23%)	24 (29%)	18 (43%)	10 (24%)
Total		**21 (25%)**	**63 (75%)**	**20 (48%)**	**22 (52%)**

C. DATA COLLECTION TOOLS

The programmatic data collection tools, in the form of questionnaires, were adapted from various pre-existing tools, including the Modular Data Quality Assessment Protocol (PAHO, WHO, CDC) and a set of data instruments used in the evaluation of the Better Immunization Data initiative (Mott MacDonald, 2019). Adaptations were implemented to make the tools specific to the Guinean context and to the local health and immunization system design.

The economic data collection tools were developed *ad hoc* through a consensus driven process. The intent was to collect information about the volume and the value of the human resources, goods and services and utilities required for the implementation on an eLMIS, as well as the management of those operational activities carried out both in a paper based and an electronic system. First, the research group confirmed with experts the main activities required for the design, implementation and the roll-out of the eLMIS. Second, activities which could be transferred from a paper-based management to an electronic one were identified and questionnaires then tailored according also to the Technical Committee's advice.

The instruments used for data collection, summarizing the purpose of each instrument and the number of respondents, are included in *Table 5* below. All data collection instruments are available in **Annex 4**.

Table 5: Data collection tools

Health System Level	Data collection tools	Purpose of the data collection tool	Number of respondents
Health Centers	Programmatic: Interview	Collect information on infrastructure (electricity, internet, computers); training and supervision; the process of data reporting, transmission, and use; data quality; immunization program performance.	43
	Economic: Interview	Collect information to quantify the costs on infrastructure (electricity, internet, computers) and the time spent on activities associated with vaccine stock data management with and without the use of eLMIS.	43
	Programmatic: Competency assessment	Assess the competence of staff using the eLMIS.	43
	Programmatic: Data accuracy assessment	Assess the accuracy between different data sources.	43
	Programmatic: User Experience Survey	Capture more qualitative aspects of the user experience along 6 different dimensions.	43
Prefectural Health Directorates (DPS)*	Programmatic: interview	As for health facilities but adapted to the DPS.	7
	Economic: Interview	Adapted from the economic interview guide used at the health facility level.	6

	Programmatic: Survey	As for health facilities but adapted to the DPS.	7
	Programmatic: Data accuracy assessment	As for health facilities but adapted to the DPS.	7

**It is important to note that the DPS assumes the function of the health district, including that of vaccination supervisor for the associated health centers. The reference to "DPS" in this report is therefore synonymous with the district level.*

The evaluation protocol and data collection instruments received research and ethics clearance on 1 November 2021 according to procedures established by the National Health Research Ethics Committee (CNERS) of Guinea.

D. DATA COLLECTION

Primary data collection was performed under the supervision of the Technical Committee, with input from the consulting firm Africa Health Consulting. It took place in 43 HCs, of which 5 were CMCs, as well as in 7 DPS over 3 weeks in April 2022 using the open-source mobile data collection platform ODK (https://getodk.org/). Before the start of the data collection, a 2-day training was administered to the data collection teams by Bocconi/MMGH staff in Conakry. During the training the questionnaires were further refined. Finally, two health centers were used as pilot facilities for testing the questionnaire and data collection tools before data collection commenced.

Data were collected by four teams using tablets where the ODK questionnaires were uploaded and synchronised daily on a central server via the Kobo Collect application (https://www.kobotoolbox.org/). The list of health centers visited is presented in **Annex 6**, with indication of their level of the electronic system use. In the final sample one health facility was eliminated due to high inconsistencies in the data collected, resulting in a total of 42 health facilities, including the 5 CMCs. Moreover, at regional level, economic primary data was collected only from 6 out of the 7 DPS.

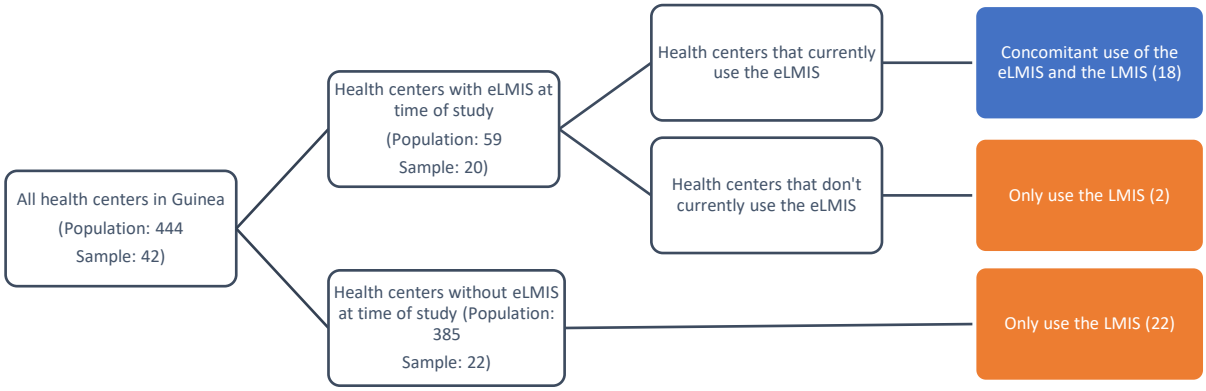
After completion of the data collection, the files generated by Kobo Collect were imported in Microsoft Excel to allow for an in-depth process of data cleaning in collaboration with members of the Guinea Technical Committee. All activities were documented.

Secondary data was also requested in parallel from various partners involved in the implementation of the eLMIS. In the specific, secondary data were collected on the deployment of the eLMIS from Chemonics and on staff salaries, electricity, and internet financing systems from the members of the Technical Committee. Data on stock levels, immunization coverage and other programmatic indicators were provided by the EPI.

E. DATA ANALYSIS

The cross-sectional analysis was based on a stratification of the health facilities between users (i.e., intervention group) and non-users (i.e., control group) of the eLMIS. A health facility was classified as having implemented the eLMIS if the system was rolled out, irrespective of its use (54). Among the facilities that had eLMIS implemented at the time of the data collection, a health facility was defined as "user" when it met the following criteria: i) eLMIS implementation took place at least 3 months prior to the survey and ii) health facility generated electronic reports and sent them to the next level. For the first criteria, it was estimated that a minimum of three months was required for full operation of the system, including training of staff, preparation and installation of computer equipment and data entry. Health facilities which had the eLMIS but did not use it were considered as “non-users.” 18 health facilities out of 42 having implemented eLMIS were identified as users and served as the intervention group (Figure 6).

Figure 6: Process of classifying health centers (HCs) into users (blue) and non-users (orange) of the system for EPI reporting (number of HCs in parentheses)



PROGRAMMATIC ANALYSIS

The analysis of the programmatic data adopted a mixed triangulated approach. Firstly, a descriptive analysis of the primary data was carried out; uni- and bi-variate frequency distributions and summary measures were generated to provide an overview of the use of the system. Basic quantitative analyses were carried out at the health center level to compare the performance across the different variables included in the questionnaires between the centers using the eLMIS and the ones not using it. A qualitative analysis of the open questions in the survey was also carried out. Finally, the secondary data sources were analyzed for completeness and relevance and included in the analysis.

BCG, pentavalent and measles containing vaccine stock levels were used as a measure of programmatic performance for the 35 health facilities (out of 42) for which these data were available. Monthly data were collected from January 2021 onwards to eliminate the potential bias of the COVID-19 pandemic that affected in a unique and sizeable way access to supplies during 2020 independently from the performance and use of the eLMIS. Specifically, for each facility, the number of months when stock-outs occurred (measured as months where a facility had 0 doses of vaccine in stock), and the number of months where stocks were below the minimum threshold or above the maximum threshold (based on the targets provided by the EPI program) were adopted as performance indicators.

The total number of '**non-performing months**' (i.e., months when stock levels were at 0 or outside the desired range) and '**performing months**' across all 35 health facilities were calculated. For each center, the analysis looked at those performance indicators starting 3 and 6 months after the roll-out of eLMIS to capture the time it takes for processes to be fully operational and integrated into the way staff work.

The main analysis focused on exploring if the implementation of current eLMIS functionalities had a positive impact on the performance of the health facility, as measured by stock level. Importantly, this analysis had to take into consideration the fact that the use of eLMIS in EPI is currently limited to reporting and consolidation and that it is not yet actively used as a tool for vaccine management (i.e., forecasting and ordering).

Based on the results of the preliminary analyses, the effect of confounding factors was evaluated. A stratified analysis was conducted based on the variables that emerged as most likely to influence performance and be associated with use of the tool: urban and rural location, type of health facility, availability of a computer, level of training and expertise in vaccine management and logistics, and performance and supervision of vaccine management. Some variables, such as type of data use and reporting, were excluded because all the facilities behaved similarly along these two dimensions. *Table 6* below summarizes the dimensions of the programmatic analysis.

Table 6. Summary of the programmatic analysis

Indicator	Unit	Source	Comments
Number of non-performing months	Number of months	Calculation	Calculated as number months when stock levels were at 0, above the maximum or below the minimum
Number of performing months	Number of months	Calculation	Calculated as number months when stock levels were between the maximum and the minimum
Monthly stock levels for BCG, Pentavalent and VAR vaccines	Number of doses	eLMIS database	15 months of data starting from January 2021
Minimum stock level	Number of doses	EPI	
Target stock level	Number of doses	EPI	
Maximum stock level	Number of doses	Calculated	Target stock level x 2
Date of eLMIS introduction	Time	Programmatic questionnaire	Duration of use of the tool
Type of health facility	Urban/Rural	Programmatic questionnaire	
Availability of a computer	Yes/No	Programmatic questionnaire	Q.B1. "Is there a computer/laptop/tablet available for vaccination activities?"
Health facility staffing	Number of people trained	Programmatic questionnaire	Q.G3. "Among the staff working in the field of immunization, how many are trained in vaccine consumption and stock management activities in the health facility?)
Level of competency		Competency assessment questionnaire	Q.3. "Can the health workers being assessed demonstrate how to use the eLMIS to generate a report on vaccine consumption?" Q.4. "Can the assessed health workers demonstrate how to correctly access the eLMIS information on vaccine consumption in DHIS2 and, based on this information, determine whether the region, or specific districts/health centers, are overstocked, understocked or at risk of product expiry? Are they able to produce accurate forecasts to activate appropriate replenishment (including appropriate actions)?" Q.5. "Can the assessed health workers demonstrate how to use the DHIS2, or any other relevant system, to generate relevant reports on vaccine management (stock levels, forecasts of future consumption, closed and open wastage)? ")
Supervision activities	Yes/No	Programmatic questionnaire	Q.G17. "How many supervisory activities has the district or higher level conducted with the health facility in the past year specifically looking at vaccine logistics data? "

Using the number of performing and non-performing months, two quantitative analyses were performed:

- A calculation of the change in the percentage of non-performing months for each of the vaccines and indicators, where a negative absolute change (e.g., reduction of the number of months of stock out, or months outside the target range) suggests an improvement in stock performance.

- The performance of a statistical test (Chi-Square) to test the association between categorical variables. A significant test result (p-value < 0.05) was considered to provide an indication of a potential association between stock performance and the use of eLMIS. Although the non-random sampling does not allow for statistical significance testing, a directional indication of the strength of the association can, nevertheless, be provided.

ECONOMIC ANALYSIS

The economic analysis used a mix of primary and secondary data and different methodological approaches, as summarized in *Table 7*.

Table 7: Summary of economic analysis

	a. Financial Expenditures	**b. Routine operating costs of the eLMIS**	**c. Cost impact of using eLMIS vs. only LMIS**	**d. Affordability of the eLMIS**	**e. Scenario analysis**
Scope of the analysis	Costs of the current eLMIS design, development, and deployment.	Economic costs of vaccine supply chain data management with eLMIS.	a. Economic costs of vaccine supply chain data management with LMIS b. Avoided or incremental costs specific to vaccine supply chain management from using the eLMIS	Financial sustainability of maintaining the ongoing operations of the systems, using national resources	Simulation of the cost impact in 2 scenarios: - “Scale-up”: eLMIS nationwide - "Improved efficiency": Some activities performed only with eLMIS and some only with LMIS.
Type of analysis	Descriptive analysis	Descriptive and stratified analysis of eLMIS data based on Activity-Based Costing (ABC) data	Cross-sectional analysis (users vs. non-users) (based on Activity-Based Costing data)	Descriptive and comparative analysis. Total system cost analysis based on Activity Based Costing	Simulation
Outputs	Total cost of eLMIS implementation and deployment	Annual cost of managing vaccine supply chain data using eLMIS	The incremental costs of the eLMIS compared to the LMIS.	Macroeconomic and sustainability indicators for health expenditures. % financial resources needed for eLMIS / Total EPI costs % costs covered by national payers	Net cost of the system, either on paper or electronically.
Data Source	Secondary data : Chemonics	Primary data : ABC questionnaires Secondary data : Chemonics, salaries by Technical Committee	Primary data : ABC questionnaires - eLMIS Secondary data : Chemonics, salaries by Technical Committee	International Monetary Fund (IMF), WHO and national report indicators, primary data	Primary data : ABC questionnaires Secondary data : Chemonics, salaries by Technical Committee
Costs inputs	Personnel, consumables, durables, services, indirect costs				

The results of the economic analysis were reported as the total annual cost per health center. A stratified analysis was also conducted comparing the economic costs of using the current eLMIS setup between urban and rural health facilities. All cost estimates were adjusted to actual 2021 values using the World Bank's GDP deflator index and converted to USD using the World Bank's average exchange rate in 2020 (1 USD = 9,565.08 GNF).

A) FINANCIAL EXPENDITURE RELATED TO THE IMPLEMENTATION OF THE ELMIS

The perspective used for this analysis is that of a "third party payer." This perspective includes expenditures by external funders (e.g., international organizations and/or private funders) and national funders (e.g., national, or sub-national authorities) (van de Ven, 1994). Financial expenditure data for the eLMIS design and development, as well as for the implementation to date were obtained from Chemonics. This data reflects the expenditures incurred by the Global Fund and Chemonics in 2018, as the two implementers of the project. These two organizations were equally responsible for financing the design and development of the system and its deployment, with domestic contributions from the Government of Guinea.

A descriptive analysis was conducted classifying the financial expenditures according to i) the design and development of the system for the EPI program (i.e., costs for setting up the system centrally and customizing it to the needs and context of the EPI program in Guinea) and ii) implementation (i.e., purchase of hardware, such as tablets, desktops, servers; and training). The approach mirrors the one adopted by Mvundura et al. (2019) on the costs of designing, deploying, and maintaining electronic systems for immunization in Tanzania and Zambia.

B) ROUTINE OPERATIONAL COSTS OF USING THE ELMIS

The analysis of the ongoing operating costs of the current eLMIS deployment (i.e., reporting and monitoring only) was based on secondary data coming from national reports (USAID, 2019) and primary data collected in the questionnaire on the costs of a set of activities related to immunization data management. These activities were defined based on a literature review and subsequently refined in consultation with experts on electronic immunization systems, as summarized in *Table 8*.

Table 8: Description of vaccine stock data management activities

Activity	Description
Activities related to immunization data management	
Creation of reports	Time to research and record data for inclusion in weekly, monthly, or annual reports for immunization and stock management.
Transmission of reports	Time and consumable goods and services required for transmission of weekly/monthly reports to the next administrative level.
Determining the quantities of vaccine to be ordered	Time required for processing of information and data on vaccine doses needed and consumption trends to determine the appropriate vaccine quantities to be supplied next
Printing	Cost of consumables required printing of registries, stock cards, accounts, reports, etc.
Maintenance	Time required, and costs on consumables and durable goods as well as services for a recurrent activity that involves reviewing the materials, equipment and systems used for recording and reporting immunization data
Monitoring of performance indicators	Time to review data for performance gaps (i.e., not on track to meet coverage targets for the current month).

During interviews and surveys, respondents were asked to provide estimates of the time spent by the staff of the facility on each of the activities, as well as of any cost incurred on average for the equipment, consumables, and services directly attributable to each activity. Information was also collected on the average frequency of each activity, and on the printing and maintenance costs that were directly attributable to vaccine stock data management (i.e., costs of printing reports and maintaining computer equipment). As printing and maintenance are not stand-alone activities performed where vaccine stock data is managed, but rather indirect activities which facilitate and enable the management of information on vaccine stocks, these were considered as shared costs across all vaccine stock management activities. Information was collected for both users and non-users of the eLMIS system.

Staff time was converted into monetary values using the national reference salaries for health staff (Appaix, Bah, & Maritano, 2019). **Annex 8** provides further details on the approach used to match the health worker profile reported in the primary data collection with the job titles and salaries published in the evaluation of the *Program d'Appui à la Santé en Republique de Guinée.* The cost per minute of health staff was then calculated assuming a monthly capacity of 20 days per month and 8 hours per day, and a 20% reduction in capacity to allow for sick

leave, training, and breaks. In addition to the primary data collected, printing costs were also obtained from secondary data sources.

All direct costs of shared activities, such as printing and maintenance costs of the computer equipment were distributed among all the activities evaluated by multiplying their costs, for each health facility, by the percentage of time required by health workers to undertake this activity.

Given that eLMIS is a tool shared across multiple health programs, all indirect costs, such as internet and electricity charges, were allocated to the vaccine management activities using staff time as a cost driver (i.e., by allocating a percentage of these costs equal to the time spent on each activity for vaccine management relative to the total available staff time of the health centers). The allocation factor applied for indirect costs was 6.5%.

All direct operating costs of using the eLMIS and the LMIS reported in the analysis are covered by the Government of Guinea and represent the costs incurred at both health center and district levels, with the district costs apportioned to the sampled health centers based on the total number of health centers under the administration of the respective DPS.
The differences in costs impact of using eLMIS for vaccine data management activities between health facilities that use the eLMIS and those that do not was estimated together with the avoided costs for activities related to vaccine stock data management. The average difference in costs was calculated using the data collected through the questionnaires.

C) FINANCIAL SUSTAINABILITY OF THE ELMIS

The time series data (i.e., GDP, GDP per capita, share of public debt to GDP) was obtained from the International Monetary Fund (IMF) (International Monetary Fund, 2022). These macroeconomic indicators were used for a descriptive analysis of the Guinean economic context and current available resources for financing the eLMIS continued use.

In addition, the total net cost of managing vaccine stocks in Guinea was compared against the current total expenditure for routine immunization derived from the WHO Joint Reporting Form (JRF). The current level of sustainability of the eLMIS use was expressed as a percentage of the average routine immunization expenditure in 2019 and 2020, including vaccine costs, of USD 7,412,947.8.

D) SCENARIO ANALYSIS ON THE USE OF THE LMIS/ELMIS SYSTEM

The data collected on costs and resources linked to the current use of the eLMIS were used to simulate the economic impact of a gradual transition from the current dual process to a fully electronic one. To do so, different scenarios were defined based on assumptions related to changes in the use of paper and the process of reporting activities. Two scenarios were built and compared against the current use of the LMIS/eLMIS, where in all health centers: i) eLMIS is rolled-out and used (i.e., termed “scale-up” scenario) and ii) some activities that are currently paper-based are executed electronically, such as report generation and transmission, while paper is kept as back-up (i.e., a so-called “improved efficiency” scenario).

III. FINDINGS

The findings presented hereafter provide an overview of the key aspects of eLMIS implementation in Guinea and its status across all health facilities. They also provide information on the impact of this roll-out on the immunization program in selected areas, including stock management, data quality and supervision. Finally, they provide insights on the implementation costs and operational costs of the current setup of the eLMIS, as well as on some preliminary view on its long-term sustainability. Below is a summary of the main findings. Further details on the economic results can be found in **Annex 7**.

A. USE OF ELMIS

Findings from this evaluation demonstrate that the use of eLMIS varies widely between health centers. Currently, vaccine logistics and management are performed using the SMT tool at central level. Data entry and reporting for the EPI are carried out predominantly by health agents and pharmacists on paper tools and only subsequently transferred into eLMIS using a desktop computer or laptop. For health facilities where a computer is not available, data entry in the eLMIS is done at the district level by a data clerk (e.g., data manager, statistics officer, pharmacist, etc.). Health centers using eLMIS send monthly EPI reports to the DPS both electronically and on paper, a hybrid use of the system.

TOOL DESIGN AND FUNCTIONALITIES

As described above, the eLMIS does not currently provide full vaccine stock management functionalities (i.e., the ordering workflow and forecasting), hence it serves a limited function as a reporting and monitoring tool across health programs. In addition, for the EPI, a set of indicators required by the program for its daily operation are not available in the system. The consequence of this situation is the continued use of the EPI legacy system based on SMT in parallel with the new eLMIS with a duplication of efforts for all its data capturing and reporting activities. In accordance with the progressive implementation of the system, Guinea plans to migrate to OpenLMIS v3.

In terms of interoperability with other digital tools, the interoperability of the eLMIS with DHIS2 happens at the MSHP at the central level which facilitates the visibility and central management of vaccine stock and consumption data. However, both at central as well as at the lower administrative levels, and under different governance responsibilities, multiple information systems and tools capturing data relevant to vaccine stock data were detected. There were running in parallel and not entirely complementary, but rather duplicative (ref. Figure 4).

B. PROGRAMMATIC FINDINGS

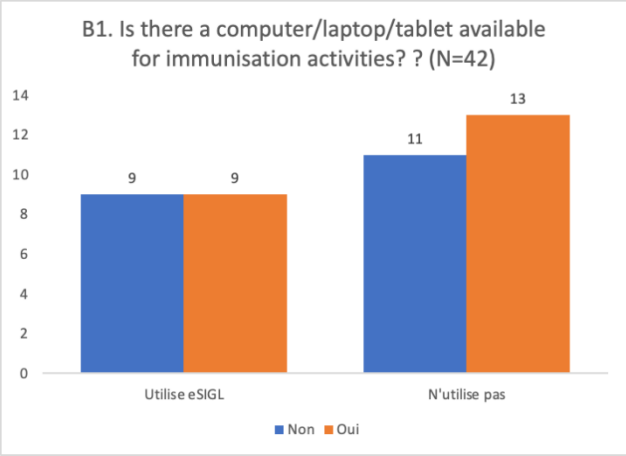
The analysis of programmatic findings included data obtained from the 42 health centers in the sample for all sections except for the impact analysis where only 35 centers[1] were included because data on vaccine stock levels were only available for these facilities.

ECOSYSTEM: INFRASTRUCTURE AND HUMAN CAPACITY

The **availability of computers** in health centers is limited, with just over 50% of immunization staff having access to those electronic tools to support their work. No meaningful difference was recorded in access to computers between facilities that have deployed eLMIS and those that have not yet done so as below in *Figure 7*. Similar proportions are also recorded when stratified by location (urban/rural) or type of health facility. Respondents overwhelmingly indicated that insufficient access to computers was a problem. However, it was reported that even in health centers that have fully implemented the current eLMIS functionalities and have a computer available, data are still transmitted in paper format.

[1] Stock data were not available for the following centers that were excluded from the programmatic analysis: CMC Kondeya (Kindia), CSR Bady (Kindia), CSR Bowé (Nzerokoré), CSR Diécké (Nzerokoré), CSU Ansoumania (Kindia), CSU Loppet (Mamou), CSU Solidarite (Conakry)

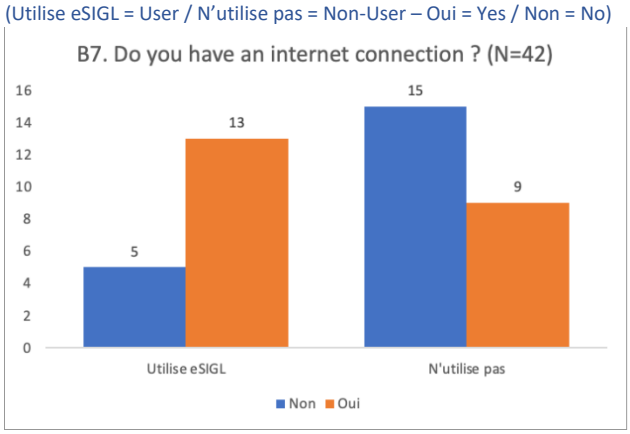
Figure 7: Number of health centers with computers
(Utilise eSIGL = User / N'utilise pas = Non-User – Oui = Yes / Non = No)



Respondents reported that **internet access is more widely available in health centers using eLMIS** (70% of facilities have some form of access) than in health facilities not using it (38% have only some form of access) as below in *Figure 8*. Stratified analysis by location and type of facility suggests that urban health centers generally have more access to the internet than rural ones (60% compared to 41%). The type of data package used has a particular impact on the availability of consistent internet access. The majority (19 out of 22) rely on a mobile data package with a maximum traffic included. This may result in access being interrupted once the data package has been exhausted if a new package is not immediately available or renewable. By report, it was common for health facility staff to purchase internet passes out of pocket or to use their own passes to carry out tasks required by their health facility.

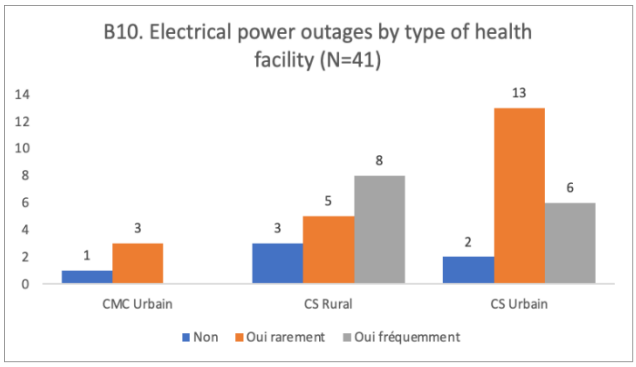
Respondents reported that difficulties accessing the internet hindered the effective integration of health facilities into a national real-time decision-making infrastructure as lack of access to an internet connection did not allow for the possibility of working in the cloud. Additionally, it also effects data transmission. Without internet access, health workers must physically transport data to the DPS/DCS level, even when the data is in electronic format.

Figure 8: Number of health centers with internet connection
(Utilise eSIGL = User / N'utilise pas = Non-User – Oui = Yes / Non = No)



Access to a source of electricity is widespread in all the health centers surveyed through solar energy/solar panels (57%) and/or direct access to the Electricité de Guinée network (40%). No difference was observed in the source of electricity between urban and rural centers or between the different types of centers (CMC, CSA) as presented in Figure 9. Solar is the predominant source of electricity, particularly for the operation of the cold chain.

Figure 9: Number of health centers that experienced power cuts in the last year (Urbain = urban / Rural = rural – Non = No / Oui rarement = Yes, unfrequently / Our fréquemment = Yes, frequently)



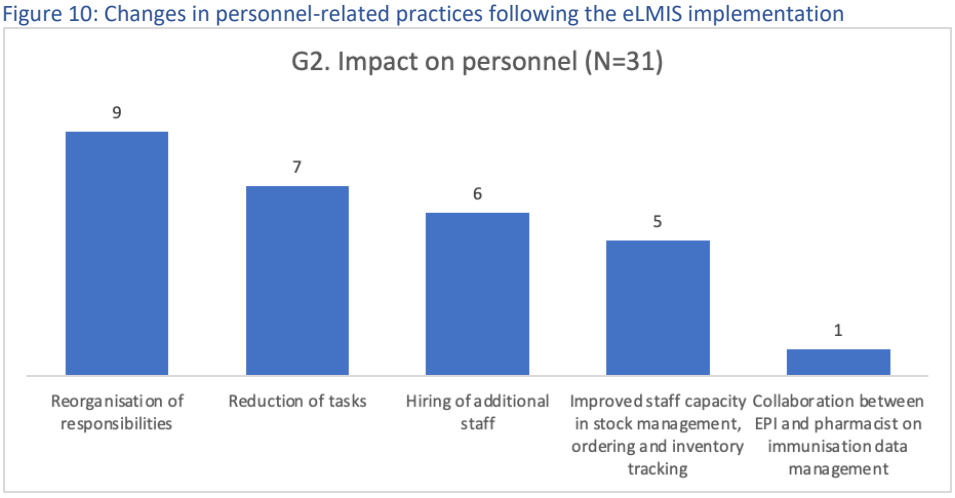
Power cuts are very common and affect the functioning of computers, printers, etc. They were reportedly experienced by 86% of the facilities, although only 36% reported these events as frequent. There were minimal differences reported between facilities using eLMIS and those not using it. However, differences are found between rural and urban centers, with the former experiencing more frequent interruptions. Health centers using solar panels also had more frequent interruptions compared to other facilities (42% and 19% respectively).

Given the current use of eLMIS, which is mainly focused on data transmission and consolidation above the health center level, with one exception, these interruptions did not prevent the regular transmission of data. This may, however, become an issue for more "online" use of the eLMIS in the future to support decision making and active management of vaccine supplies both at the health center and central level (i.e., updated data may not be available in real time).

Immunization staff numbers have been impacted by the implementation of the current eLMIS setup in 6 health facilities that reported needing to hire additional staff related to the deployment of the new tool. The number of staff working on immunization varied greatly between the facilities surveyed, with most centers having between 2 and 5 staff. There was no significant difference between the health facilities that had implemented eLMIS and those that had not. Staffing levels were slightly higher in urban centers than in rural centers.

The implementation of the current setup of the eLMIS reportedly led to a reorganization of responsibilities for almost half of the health centers surveyed and to a perceived simplification of the tasks performed in more than 1/3 of the health centers (Figure 10). The perceived changes in vaccine management practices, however, were more limited and indirect since the process still entirely run independently of eLMIS (e.g., by EPI using the SMT-based legacy paper system).

Figure 10: Changes in personnel-related practices following the eLMIS implementation

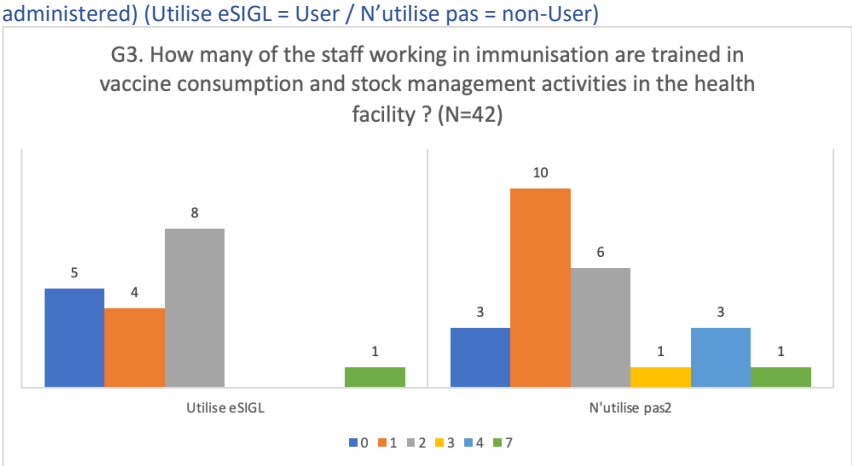


IMPLEMENTATION OF THE TOOL: TRAINING AND SUPERVISION

Training on vaccine management and logistics for health staff was not performed in conjunction with the deployment of the eLMIS. However, 34 out of the 42 centers surveyed reported having on its roster at least one (and often more than one) staff that have received vaccine management and logistic training in the past as part of the EPI training curriculum, as below in *Figure 11*, though those training appeared as not recent since more than 50% of the facilities had not received any specific training in this area in the previous year.

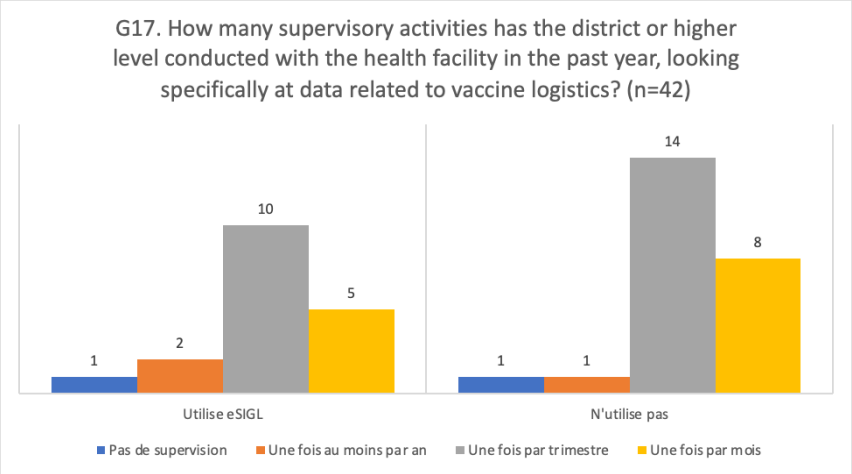
By comparison, the vast majority (80%) of facilities using the eLMIS indicated that they had received **targeted training on the use of tool** to perform their function. These activities focused mainly on data entry, data cleaning and general use of the eLMIS tool. These trainings were administered by MSHP or Chemonics staff. Overall, respondents favorably viewed these eLMIS training activities.

Figure 11: Number of staff trained in stock management and logistics (independently from the year when training was administered) (Utilise eSIGL = User / N'utilise pas = non-User)



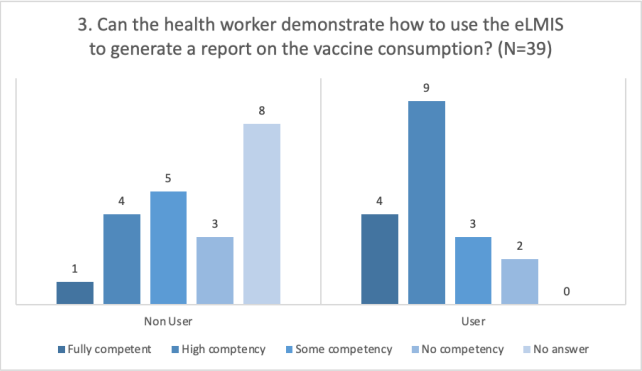
Supervision complemented the roll-out of the eLMIS. All but one of the health facilities reported having access to support from the higher organizational level (i.e., DPS, DRS) in the event of problems with the use of eLMIS. Supervision, with focus on vaccine management and logistics, was carried out in all but 2 health centers, most often on a quarterly basis if not more frequently (*Figure 12*). In 2/3 of the health centers using the eLMIS, supervision activities made use of data extracted from the eLMIS.

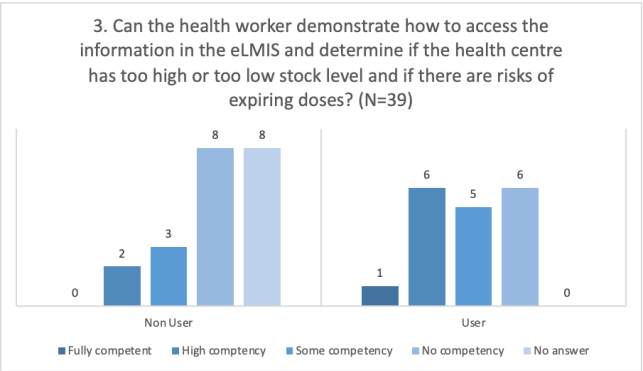
Figure 12: Number of supervision activities that took place in health centers by DPS and above in the last year. (pas de supervision = no activity; une fois au moins par an = at least one time during the year; une fois par trimester = one time per quarter ; une fois par mois = once per month)



Based on the results of the competency assessment performed during the primary data collection, **skill levels linked to the eLMIS and vaccine management** were found to be adequate in the health facilities currently using eLMIS. 72% of health workers in these facilities showed a good or very good level of competence in generating reports on vaccine consumption compared to 24% of health workers in health facilities that have not yet deployed the eLMIS (Figure 13). However, only 39% of health workers in health centers using eLMIS demonstrated a good level of competence in advanced skills of accessing stock information to assess stock levels and risk of wastage.

Figure 13: Level of competence of health workers in using eLMIS.





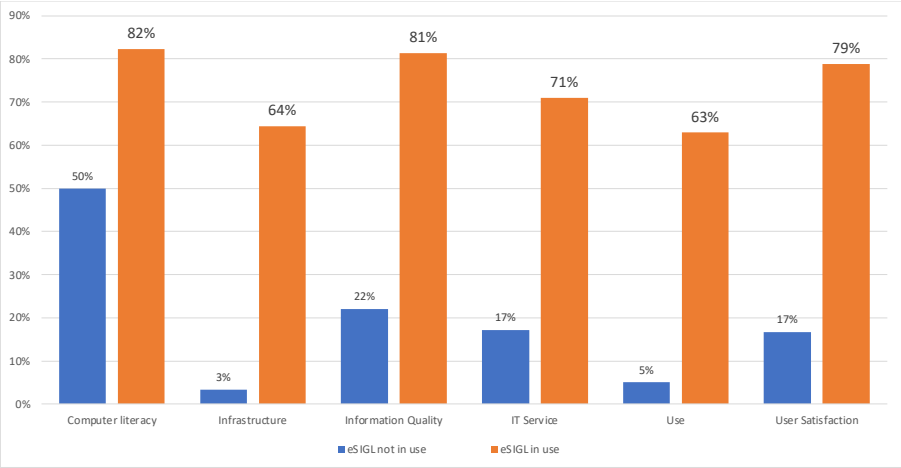
IMPLEMENTATION OF THE TOOL: USER EXPERIENCE

Varying experiences between users and non-users were reported across all fields. This is summarized below in *Figure 14*. Significant differences were recorded in the scores related to perceived quality of information (i.e., 22% in non-users compared to 81% in users) and overall user satisfaction (i.e., 17% in non-users compared to 79% in users).

Qualitative comments further highlight four key areas related to the use of eLMIS: i) the contribution that eLMIS can make to more effective vaccine management, particularly if specific EPI requirements are incorporated (7 comments); ii) improved efficiency in reporting and decision making (7 comments); iii) the importance of the availability of electronic tools to support vaccine management activities and of eLMIS supporting all vaccine

management tasks (5 comments); and iv) the critical role of training on eLMIS for successful roll-out and the call for expansion of the scope and scale of such training (11 comments).

Figure 14: Comparison of user satisfaction levels across 6 categories



IMPACT: DATA QUALITY

80% of the health centers reported that data on vaccine stocks and consumption had improved after the introduction of eLMIS, 10% indicated no change and only 10% indicated that data quality had deteriorated. At the same time, 55% of center using the eLMIS and 64% of those not using eLMIS indicated that they had experienced problems with stock and consumption data. Among those, insufficient training, lack of paper forms and errors in primary sources (i.e., stock sheet) were the most frequently reported problems perceived to affect the data quality across all health centers.

While the introduction of the eLMIS has increased the perception of data quality among users, about half of the facilities still reported problems in data on vaccine stocks and consumption, as below in *Figure 15*, particularly mismatches with the data contained in the EPI paper forms.

Figure 15: Number of health facilities that encountered problems during eLMIS data analysis (Utilise eSIGL = User / N'utilise pas = Non-User – Oui = Yes / Non = No / Pas sûr = Do not know)

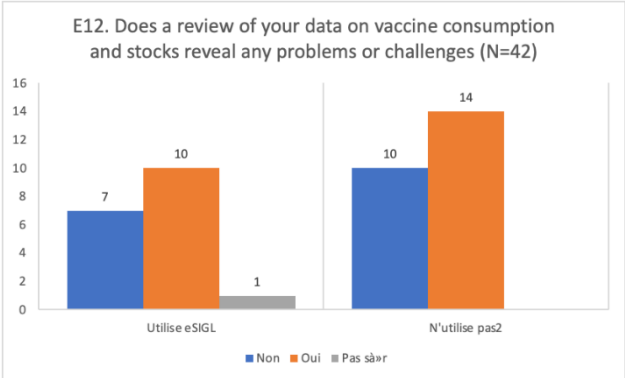
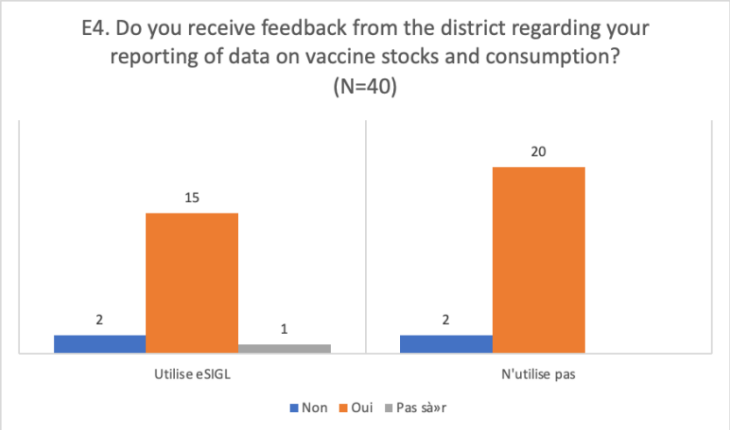


Figure 16: Number of health facilities receiving feedback from DPS on EPI reports (Utilise eSIGL = User / N'utilise pas = Non-User – Oui = Yes / Non = No / Pas sûr = Do not know)



Quality assurance and quality control (QA/QC) processes for eLMIS data were established and strengthened with the tool roll-out of eLMIS. All but two facilities audit their data monthly; the remaining ones do so at longer intervals. Reports for those audit activities are produced by only about 30% of facilities, with no significant difference between facilities that use the eLMIS and those that do not. Most facilities receive feedback from the DPS via supervision session on data quality (*Figure 16)*.

Citing the period of over the last 6 months, respondents reported that data transmission had been regular in all centers, and 40 out of 42 health centers of submitted data on time every month.

IMPACT: USE OF DATA

The time required to register the arrival of new quantities of vaccines using the electronic form was shorter in 61% compared to the same process using the paper forms (it is worth reminding that both processes are in place in all facilities). The registered reductions are generally sizeable, with around 50% less time required, with a peak of 83% (Figure 17 E8/E9). The differences observed between time required using the electronic compared to the paper forms seem to be more substantial with reference to the communication/transmission of data (Figure 17 E10/E11). The filling of electronic forms requires less time than the paper form in 53% of the health facilities, with half of them recording a shorter duration of 90% or more compared to the "legacy" forms. This increased efficiency linked to the use of electronic forms provides a potential area for efficiency gain in the moment the paper forms will be discontinued.

Figure 17: Differences in the time (%) needed to register new supplies and to transmit data using electronic and paper forms (only users included)

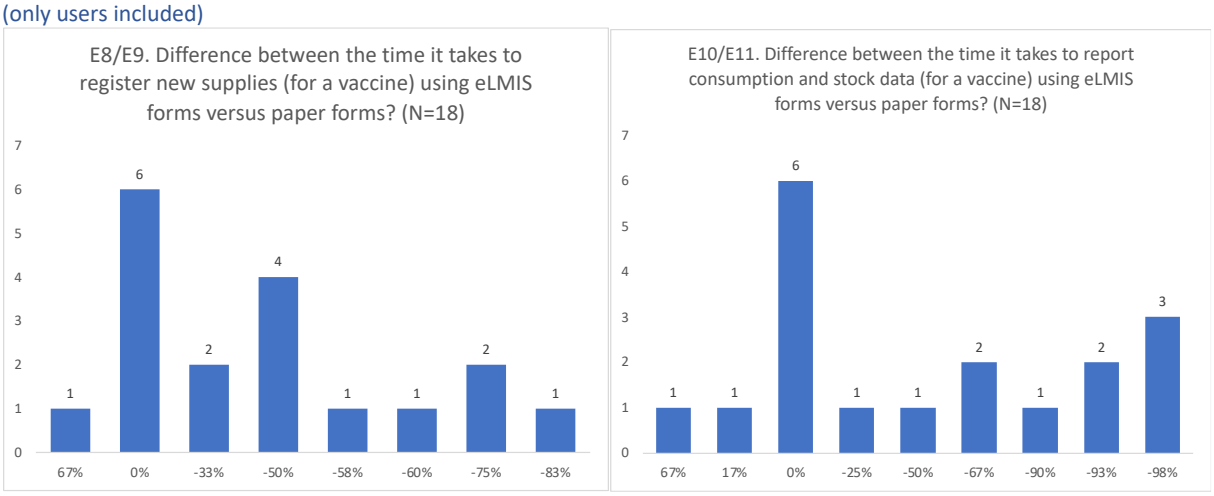
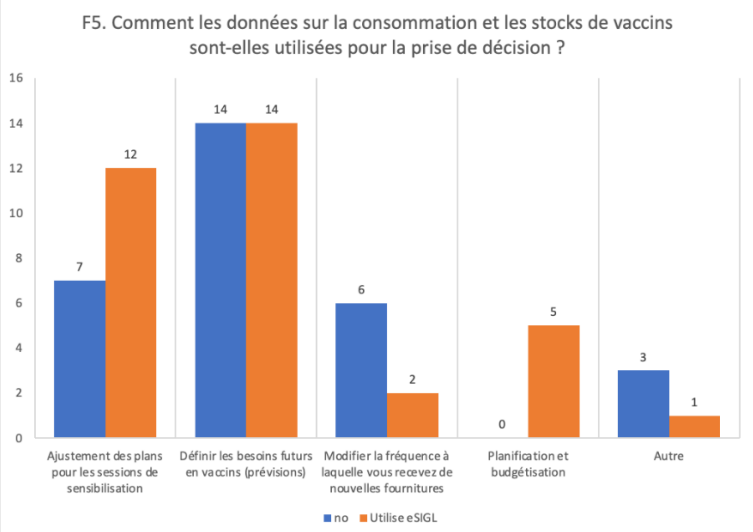


Figure 18: Differences in the use of vaccine management data for decision-making (multiple responses allowed not all centers provided responses)



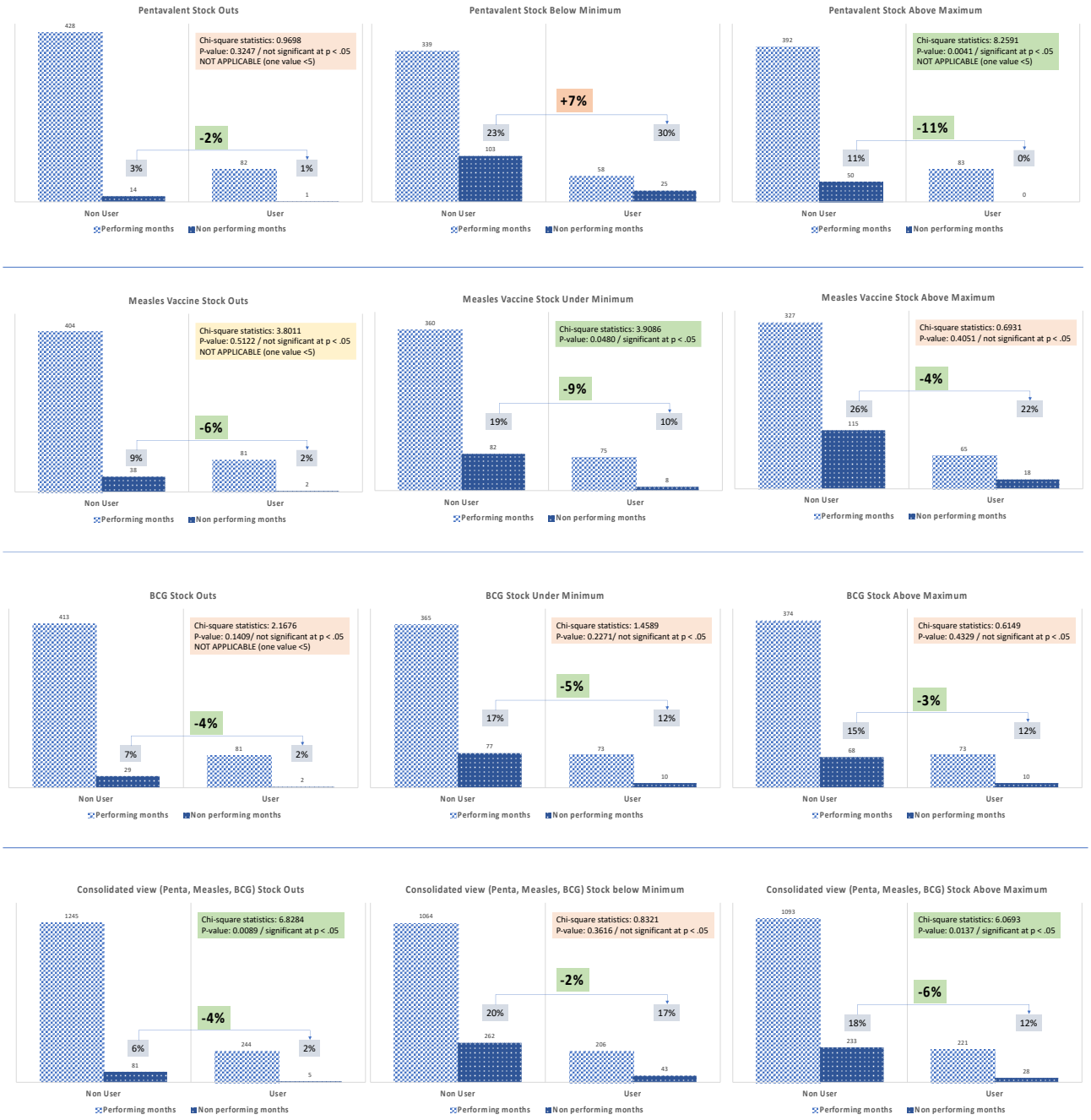
All but two of the health centers reported having a dashboard in place to monitor performance and consumption of vaccine stocks. Similarly, all facilities hold regular meetings where consumption and stock data are analyzed and discussed. This data is mainly used to forecast future orders, to refine outreach plans and to support planning and budgeting. The latter two activities are carried on more frequently in health centers using eLMIS than in those not using it (*Figure18*).

Comments were collected as part the primary data collection regarding the use of the eLMIS data for decisions-making. Respondents most frequently reported that data were used for: monitoring stock levels; triggering orders when stock is below the minimum level; monitoring monthly consumption; checking consumption data outliers; contributing to planning activities; and monitoring closed-vial vaccine wastage.

IMPACT: EPI PERFORMANCE

Use of the eLMIS was linked to a reduction (between 1 and 11%) in the number of non-performing months (i.e., months when the stock level are above or below the target levels, including stock outs). Chi-Square tests performed on the differences resulted in a p-value below 0.05 in 4 out of the 12 tests, indicative of a potential positive impact of the eLMIS on stock management performance.

Figure 19: Comparison between the number of "performing months" and the number of "non-performing months" for BCG, Pentavalent and Measles and for the consolidated view totaling the number of months for the three vaccines. Percentage difference and Chi-Square statistical test.



To assess the validity of the 3-months threshold for a center to be considered as user of the eLMIS a comparison was performed by changing this inclusion criterion from 3 to 6 months. The improvements recorded in centers using the eLMIS compared to non-users were reduced for all three performance measures and for all three vaccines (in absolute terms: -1% for stock-outs, -3% for stocks below the minimum and -2% for stocks above the maximum).

When the analysis was repeated for the use of eLMIS in supervisory activities, an activity directly related to the use of the system, slightly larger reductions (between 1 and 21%) were recorded in the number of non-performing months.

To exclude the role of other factors in these performance increases, tests for potential confounders were carried out for four variables could have had a differential impact (i.e., confounding effect) on stock management performance. This included the following areas:

1. VACCINE MANAGEMENT TRAINING: A sufficient level of staff with vaccine management training also resulted in a positive impact (measured as a reduction in "non-performing months") for centers using the eLMIS compared to centers not using it. A test to verify the potential association between the presence of staff having received vaccine management training and reduction in the number of non-performing months to verify the existence of a confounding effect was performed. In the test of association (e.g., the comparison of the improvement in performance for centers with staff with vaccine management training and centers with staff not having it, irrespective of their eLMIS status, 7 out of 9 cases demonstrated that presence of staff with vaccine management training did not have a positive impact on stock performance, excluding training as a confounding factor.

2. LOGISTICS SKILLS: A sufficient level of logistics skills also resulted in a positive impact (measured as a reduction in "non-performing months") for centers using eLMIS compared to centers not using it. A test to verify a potential association between the presence of sufficient level of logistic skills and the reduction in the number of non-performing months to check for the existence of a confounding effect was performed. The results demonstrated that in 6 of the 9 cases the presence of sufficient logistic skills did not have a positive impact on stock performance, excluding logistical skills as a confounding factor.

3. MONTHLY LOGISTICS SUPERVISION: Monthly logistics supervision has a minimal impact on stock performance. In only one case does the incremental impact exceed 10% and worsen performance, also excluding supervision as a confounding factor.

4. COMPUTER AVAILABILITY: Computer availability resulted in a positive impact (measured as a reduction in "non-performing months") for center using eLMIS compared to centers not using it. A test to verify a potential association between the availability of computers and the reduction in the number of non-performing months was performed to check for the existence a test of association to check for the existence of a confounding effect. The results demonstrated that in 7 of the 9 cases the availability of a computer did not have a positive impact on stock performance, excluding the availability of a computer as a confounding factor.

C. ECONOMIC FINDINGS

A) FINANCIAL EXPENDITURES

The total financial expenditure incurred in 2018, and reported in 2021 USD value, for the design development and deployment of the eLMIS across 9 programs was USD 716,309. Of this total, the 6.5% share apportioned to the EPI (i.e., the proportion of the expenditures attributed specifically to the EPI) was USD 46,560. All expenditures were incurred by the Global Fund and USAID Chemonics, shared equally between the two, while Chemonics also oversaw the implementation of the system. Of the total expenditure, 37% was spent on the design and development of the system, and 63% was spent on or budgeted for the deployment in 8 regions.

Figure 20: Illustration of the total (blue) and apportioned to the EPI (orange) expenditures for the implementation of the eLMIS per phase in USD, 2021.

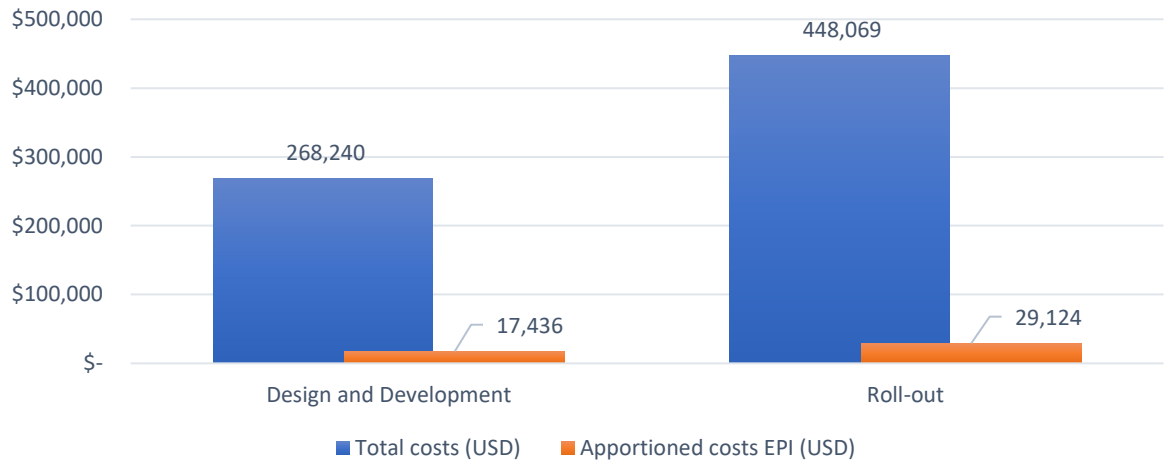


Table 9 below provides an analytical breakdown of the expenses incurred in each phase (i.e., design, development and deployment), indicating the total costs of the system for the 9 programs and the apportioned costs for the EPI.

Table 9: eLMIS costs reported in 2021 USD for the design and development as well as deployment of the eLMIS in Guinea.

	Total cost (USD 2021)	Apportioned cost to EPI (USD 2021)
Design and Development		
System configuration	128,755	8,369
Servers	139,485	9,067
Sub-total	268,240	17,436
Deployment		
Trainings	257,511	16,738
Laptops	125,537	8,160
Computers	32,833	2,134
Servers	32,189	2,092
Sub-total	448,069	29,124
Total	**716,309**	**46,560**

The system development and design phase costed USD 268,240, of which USD 17,436 were apportioned to the EPI. This phase specifically included costs for the configuration of the system and training of the trainings in the amount of USD 120,000 for the 9 programs, of which USD 8,369 are apportioned to the EPI. These funds covered 4 workshops for 30 people per workshop which supported the development of the system requirements and training materials, the execution of User Acceptance Testing, and the training of the trainers. The expenditures for the design and development phase also included the purchase of 2 servers at USD 65,000 each.

The deployment phase costed USD 448,069, with the portion attributed to the EPI at USD 29,124. Training of health staff on the use of the eLMIS in all the 8 regions of Guinea costed USD 257,511, of which USD 16,738 are

apportioned to the EPI. While roll-out and trainings were only partially completed by the time of this evaluation, USD 30,000 had been allocated per region for the training of a total of 560 health staff across the entire country. Deployment costs also included the purchase and installation of an extra server to increase data storage capacity, 130 laptops, and 34 desktop computers in the amount of USD 190,558, of which USD 12,386 were apportioned to the EPI.

In terms of human resources, during both phases, the full-time equivalent (FTE) labor of 1 Management Information System (MIS) advisor (expatriate) and 1 MIS assistant (local) for two years were reported. While data on the salary scale of this personnel was not obtained, the labor costs were calculated by assigning an annual salary of USD 164,000 to an expatriate senior MIS advisor (Glassdoor, 2022) and USD 10,200 to the local MIS assistant profile (Technical Committee, 2022). Based on this information, the personnel costs for the design, development, and deployment of the eLMIS in Guinea were estimated at USD 374,296, of which USD 24,329 apportioned to the EPI. These would have to be considered in addition to the totals for the country and the EPI reported above.

B) ROUTINE OPERATING COSTS OF ELMIS USE

The average annual cost of performing activities related to data entry and reporting for each health center using the eLMIS was estimated at USD 284.9 (95% confidence interval (CI): 79.1; 490.6), as shown below in *Table 10*.

This cost category includes cost of personnel related to various type of activities as well as consumable and services costs (e.g., fuel, ticket for public transport, daily allowances, etc.) linked to the transmission of reports which frequently require staff from health centers to travel to the DPS. Costs were also collected for the supervision and the emergency vaccine replenishment activities, inclusive of the movement of persons and/or suppliers. Due to the very recent implementation of the eLMIS, no refresher training for users had been conducted; therefore, the cost for this activity was not included. These costs will likely be incurred in the coming year, and a rough estimate is included in the subsequent sustainability analysis.

The main cost-driver is the cost of staff, representing 49% (USD 140) of the average total annual eLMIS operating cost per each user health center. Direct costs for consumables, services, and durable goods for maintenance (e.g., spare parts, per-diems, transportation costs, etc.) and printing activities (e.g., eLMIS reports) represent an equally high portion, 47% (USD 133.4), of the total annual cost and are mainly driven by the costs of maintenance and printing activities. Indirect overhead costs (e.g., internet and electricity) represent 4% (USD 11.4) of the total annual cost of using eLMIS for one health center. Most health centers reported that they received 125 USD annually from Chemonics to cover the internet costs for the use of the eLMIS across all health programs, while 1 health center reported to have received 226 USD annually from the DPS to cover all internet costs. With respect to electricity costs, most health centers rely on solar panels and 30% on the national electricity grid (Electricité de Guinée, EDG). While indirect costs seem to take up the smallest portion of the economic cost of performing the activities summarized in table 9, as stated in the programmatic part, they represent a critical minimum requirement for the function and use of the eLMIS by HCs.

Table 10: Average annual cost of vaccine stock data management activities using the eLMIS per health center (n=18), in USD

		Activities					
		Report generation	Report transmission	Determining quantities of vaccine to be ordered	Monitoring of performance indicators	Supervision	**Total**
Inputs	Staff	63.6 (-28.5;155.7)	56.0 (5;107)	16.4 (3.2;29.6)	4.0 (0.03;7.9)	0.1 (0.04;0.2)	**140 (33.9;246.1)**
	Consumables + services + durable goods	34.9 (1.3;68.5)	46.8 (16.8;76.9)	14.2 (-8.7;37.1)	21.6 (-2.5;45.7)	15.9 (-7.7;39.6)	**133.4 (72.6;194.2)**
	Total direct costs **(a)**	98.5 (-21;218)	102.8 (40.5;165.2)	30.6 (4.9;56.3)	25.5 (0.1;50.9)	16 (-7.7;39.7)	**273.4 (131.4;414.6)**
	Total indirect costs **(b)**	1.4 (0.6;2.2)	0.9 (0.3;1.6)	1.6 (-0.1;3.3)	1.9 (-0.9;4.8)	5.6 (0.2;10.9)	**11.4 (5;17.8)**
	Total costs (a) + (b)	**99.9 (-19.7;219.4)**	**103.8 (41.5;166)**	**32.2 (5.7;58.7)**	**27.4 (2;52.9)**	**21.6 (-2.3;45.5)**	**284.9 (79.1;490.6)**

The creation and transmission of reports was the most expensive activity, with an average time of 3 hours each spent to generate a report and transmit it. These represented 36% and 39% of the average total annual cost of eLMIS, respectively. The main cost-drivers for the transmission of a report were the direct costs (e.g., per diems and fuel) incurred for the round trip from the health center to the DPS leading to an average cost per trip of USD 80. While it was expected to observe health centers with the eLMIS to transmit reports electronically, thus avoiding the costs of transportation, this was not the case as the parallel LMIS reporting on paper is maintained.

Finally, the total annual routine operating cost of vaccine data management at central level is estimated at USD 126,960 of those 6.5% are apportioned to the EPI program for a total of USD 8,252.4 (ref. *Table 11*).

Table 11: Annual cost of operating the eLMIS system at central level apportioned to the EPI, in USD

eLMIS operational cost item at central level	Annual cost (USD)	Cost attributed to EPI (USD)
Personnel	54,600	3,549
Internet	30,360	1,973
Routine maintenance	7,200	468
Data hosting	24,000	1,560
Security licenses	10,800	702
Total	**126,960**	**8,252**

The ongoing operation of the eLMIS at the central level necessitates the full-time employment of 7 staff, whose total cost is estimated based on an average salary of USD 650 per month (Technical Committee, 2022). While 3 out of those 7 staff are volunteers, their labor cost has been accounted for in the central management costs of eLMIS. The cost of one senior manager of the EPI department responsible for vaccine management at the central level using the SMT (full annual salary of USD 7,800) is not included in this cost estimate not being involved in the operation of eLMIS. Besides personnel costs, several other cost items are incurred at central level, such as internet, system maintenance, data hosting and data licenses. The annual cost for those items is apportioned to the EPI programs based on a 6.5% allocation factor.

C) COST IMPACT OF USING ELMIS VS. LMIS

The total costs for a health center using the eLMIS was compared to the cost of managing vaccine data using only the paper version (LMIS), as illustrated in *Figure 21* and summarized in *Table 12*. A detailed breakdown of the costs of using the paper LMIS system for vaccine stock data management is provided in Annex 8.2.

Figure 21: Mean difference in average cost per activity between eLMIS users (n=18) and non-users (LMIS) (n=24), in USD

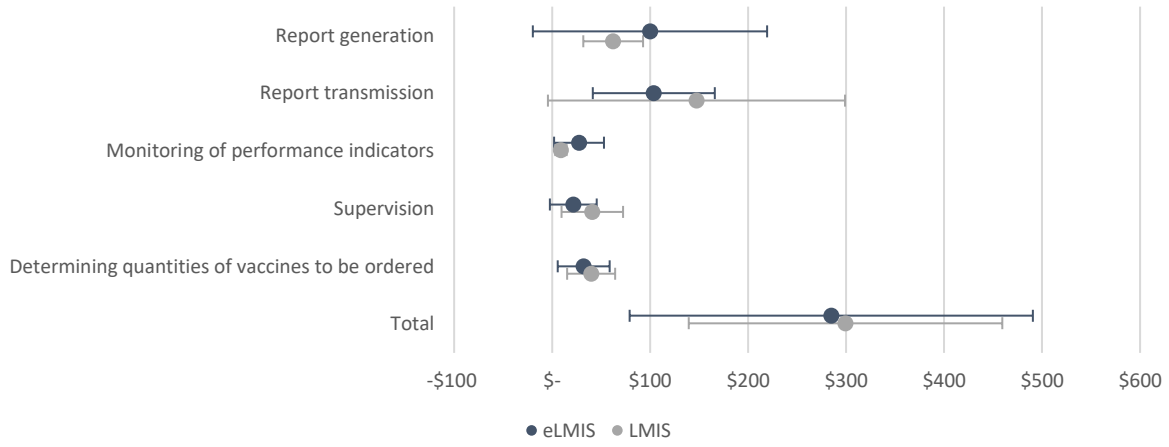


Table 12: Mean difference in average cost per activity between eLMIS users (n=18) and non-users (LMIS) (n=24), in USD

Activity	eLMIS costs (USD) (95% CI)	LMIS cost (USD) (95% CI)	Mean cost difference per health center in USD (95% CI)*
Report generation	99.9 (-19.7;219.4)	62.3 (31.8;92.9)	37.5 (28.5;46.6)
Report transmission	103.8 (41.5;166)	147.3 (-4.3; 298.9)	-44 (-91.2;3.3)
Monitoring of performance indicators	27.4 (2;52.9)	9 (3.2;14.8)	18.5 (16.7;20.3)
Supervision	21.6 (-2.3;45.5)	41 (9.6;72.5)	-19.5 (-29.3;-9.7)
Determining quantities of vaccines to be ordered	32.2 (5.7;58.7)	39.8 (15.3;64.3)	-7.6 (-15.2;0.03)
Total	**284.9 (79.1;490.6)**	**299.4 (139.4;459.6)**	**-15.1 (-73.6;43.4)**

** Positive mean cost differences indicates that eLMIS user costs are higher than LMIS user costs for that activity.*

Overall, no substantial differences in costs were found between health centers that use and do not use the eLMIS. Users were observed to incur slightly less costs by USD 15.1 (95% CI: -73.6; 43.4) for vaccine data management activities. As expected, this difference is driven by a reduction in the costs for the **transmission of reports** to the next administrative levels observed in eLMIS users, attributable to decrease of consumables and services costs for users (46.8 USD, 45% of total costs) compared to non-users (109 USD, 74% of total costs). The ability to enter data into the eLMIS at the health center level has led to a reduction in direct expenditures for fuel, allowances, public transport, and printing costs all related to the physical transmission of the reports. Furthermore, decremental costs (USD -19.5) for eLMIS users were also observed for **supervision activities** related to data quality and appropriate use of the system and forms. This was also driven by a decrease in costs for consumables and services, which can be explained by the reduced needs for travel due to the accessibility of data in the eLMIS platform to all administrative levels.

However, the use of eLMIS was associated with increased costs for the **creation of reports** on vaccine stock management by USD 37.5 (95% CI: 28.5, - 46.6) and for **performance monitoring** by USD 18.5 (95% CI: 16.7-20.3). The difference in costs between user and non-user health centers, even if small, was the result of the concurrent use of electronic and paper systems for the same activity, resulting in increased staff workload, and subsequently additional costs for those health centers using eLMIS.

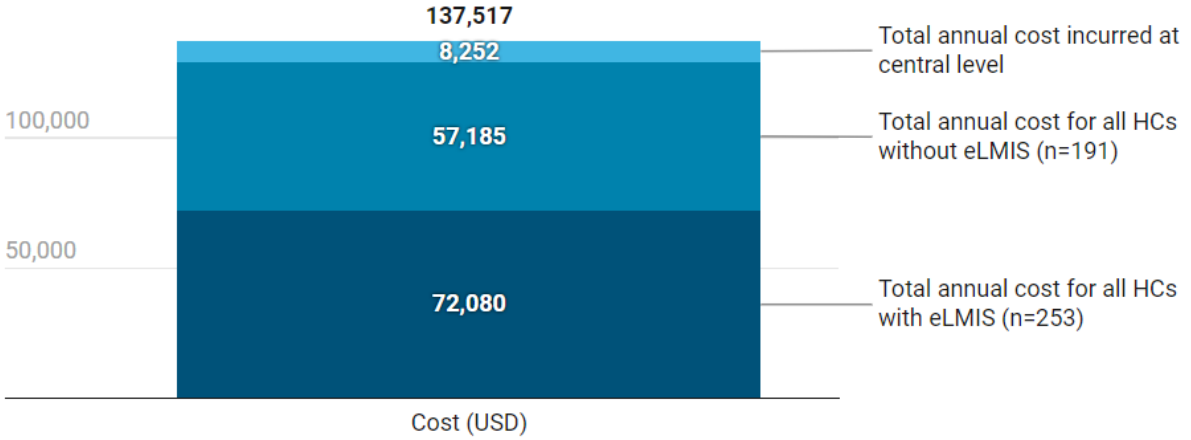
When looking at the stratified analysis between urban and rural health centers, urban health centers are observed to incur lower costs than rural health centers by an average USD 119.7 (95% CI: -181.4;117.2). Decremental costs are observed for all activities except for report generation and transportation, however these findings are inconclusive to the limited number of rural health centers in the sample and the country (n=4) at the moment of the evaluation.

D) TOTAL NATIONAL COST OF USING THE ELMIS FOR THE EPI

The total costs currently incurred by the country to perform reporting activities on vaccine consumption and stock levels using the eLMIS has been calculated based on two assumptions: i) the sample (42 health centers) is representative, from a costing perspective, of the 444 health centers in the country providing immunization services, and ii) all 253 health centers where the eLMIS has been introduced to date are using the system.

The estimate of the total cost that Guinea currently sustains for vaccine data management for immunization through the LMIS/eLMIS process is approximately USD 138k, as illustrated in *Figure 22*. With a cost of USD 284.9 per health center using the eLMIS (on top of the LMIS), the current annual incremental cost of managing national vaccine consumption data electronically across the country was estimated at USD 72,080 for the 253 facilities that have eLMIS. This value included the operational costs of the eLMIS at the DPS. A cost of USD 299.4 per health center was used for the 191 health centers that perform reporting activities for vaccine management and logistics on paper (LMIS) for a total of USD 57,185. The annual operating costs of the LMIS/eLMIS process at central level, including hardware, licenses and personnel needs, as apportioned to the EPI, were USD 8,252.

Figure 22: Average annual data management costs of the vaccine stock in Guinea today, in USD.

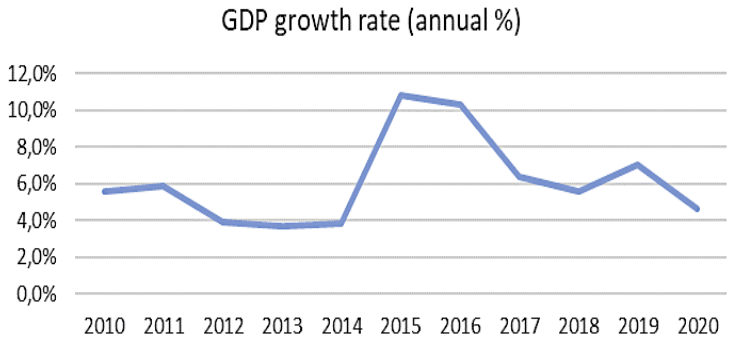


E) AFFORDABILITY AND SUSTAINABILITY

MACROECONOMIC AFFORDABILITY

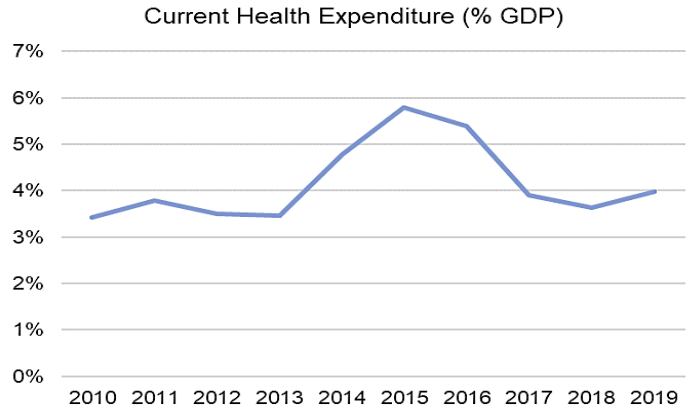
The incremental cost of operating the eLMIS for the EPI program was considered within the general macroeconomic context of Guinea. Specifically, *Figure 23* shows the intermittent growth of Guinean GDP at constant price over the past ten years and reflected in other macroeconomic variables that follow a similar pattern, although there is greater stability post-Ebola (see the 10% peak in 2015 and 2016 achieved through external donations). For example, the share of public debt in GDP has decreased considerably over the last decade, from 69% in 2010 to 38%-39% as of 2018 and is expected to remain around this figure for the next few years. These figures place Guinea at moderate risk of debt distress. According to the African Development Bank Group, the fiscal year 2021 marks an improvement in the budget deficit (2.3% of GDP compared to 2.9% of GDP in 2020), as the digitalization of the financial system has led to an increase in tax revenues. In addition, GDP is forecast to grow by 4.9% in 2022 and 5.7% in 2023, driven by new mining projects, increased energy availability and infrastructure investment. In this scenario, however, inflation is expected to remain above 10%, peaking at 12.6% in 2022 before falling back to 12.5% in 2023 (African Development Bank Group, 2021). From a sustainability perspective, one would expect a growth of possible resources to be invested in the health system and its logistic tools even if inflation reduces the trend's impact.

Figure 23: Percentage growth trend in GDP 2010 - 2020 (PPP USD), (Source: World Bank Open Data)



Current health expenditure to GDP was 3-4% between 2010 and 2019, peaking at 10% in 2015 – 2016 after the first Ebola outbreak in 2014. Current pro-capita health expenditure (PPP and USD) also increased from USD 57 to USD 119 in ten years. The government's involvement in funding health expenditure shows an increase in these last years (i.e., from 10% in 2010 to 27% in 2019), while external health expenditure has decreased from 19% to 11%. On the other hand, private domestic health expenditure has not changed significantly, with a decrease from 70% to 67% of total health expenditure. There are also indications of a greater public commitment to public health by noting the increase in the index of domestic public spending on epidemic preparedness and response, from 3.88% in 2016 to 10.02% in 2021. This means that despite the changes in donor and government funding, the burden on private citizens remains relevant.

Figure 24: The evolution of current health expenditure. Source: OpenData World Bank



According to WHO financial indicators for immunization in 2021, Guinea's total expenditure from all sources for routine immunization, including vaccines, was approximately USD 7,412,948. While the financial expenditures related to design & development, and deployment of the eLMIS were fully covered by external sources, the annual cost of managing vaccine stock data, (i.e., USD 137,518) is financed by the Government of Guinea. This amount represents about 1.9% of the total average budget allocated to routine immunization activities in 2017-2019 (inclusive of both external and national sources).

LONG-TERM FINANCIAL SUSTAINABILITY OF A FULLY ELECTRONIC SYSTEM

Health centers presently find themselves operating a hybrid system (i.e., both an electronic and paper-based system) for tracking vaccine consumption and generating reports for local and central planning, and it is foreseen that this will persist in the short-term. Given the current weakness in IT infrastructures and the need for a stronger digital culture along with more widespread trust in digital tools, implementation of the eLMIS at national scale likely will not result in the immediate use of a fully electronic system.

As a result, two scenarios were defined in addition to the current situation to simulate the impact of moving progressively towards an increasingly electronic monitoring system. These are summarized below in *Table 13*. Importantly, these scenarios refer to activities related to monitoring and reporting, as per the current use of the eLMIS in Guinea, and do not cover the full scope of an ideal eLMIS. The two scenarios represent simulations based on the extent of use of the system both in terms of quantity (i.e., the scale up at national level, effectively increasing the number of health center using the system) and quality (i.e., the efficiencies gained from moving

towards an electronic system of vaccine stock data management while keeping paper as a back-up). A third, full-electronic scenario could not be simulated as this would imply the complete replacement of the legacy tools used by the EPI for vaccine stock management (e.g., Excel-based tools, paper and SMT) by the eLMIS, which currently is not comparable to the legacy tools in terms of programmatic functionalities nor in terms of costs.

The first scenario, "scale-up," anticipates the expanded use of the LMIS/eLMIS across the country, whereby electronic reporting is performed in addition to the paper reporting. The second scenario, "improved efficiency," foresees a situation where paper plays a role only as a backup to the electronic system and does not imply a duplication of a paper-based report generation. Different assumptions were defined across the main cost-driving activities for reporting: i) report generation; ii) report transmission; and iii) printing of reports, as described in *Table 13*.

Table 13: Current use of eLMIS and LMIS for the EPI against the list of assumptions for three theoretical scenarios compared to the current situation.

Activity		**Scenarios**		
Activity	**Description of process, time spent and costs**	**Current Situation (253 HCs using LMIS/eLMIS and 191 HCs using LMIS only)**	**"Scale-up" (nationwide use of LMIS/eLMIS process)**	**"Improved Efficiency" (activities primarily performed electronically, paper used as back-up)**
Report generation	1-2 HWs (ex. EPI officers) to generate the LMIS report and 1-2 data managers to generate the eLMIS report. Data entry and report generation on paper only (LMIS) takes approx. 30 minutes each time, while with the addition of the eLMIS it takes approx. 40 minutes. The activity costs annually USD 62.3 with LMIS and USD 99.9 with the LMIS/eLMIS.	253 HC x USD 99.9 (LMIS/eLMIS) 191 HC x USD 62.3 (LMIS)	444 HC x USD 99.9 (LMIS/ eLMIS)	444 HC x 37.6USD (eLMIS)
Report trans-mission	HWs physically transmit paper LMIS reports to the DPS by private or public transport, which costs USD 147.3 annually. The eLMIS users may avoid report transportation, thus incur USD 103.8 for report transportation in a year.	253 HC x USD 103.8 (LMIS/eLMIS) 191 HC x USD 147.3 (LMIS)	444 HC x USD 103.8 (LMIS/ eLMIS)	HWs don't physically transport LMIS reports to the DPS as they only serve as a backup to the eLMIS data entry in health centers (444 HC x USD 0)
Printing	This activity considers the printing and photocopying (for back-up) of eLMIS reports. LMIS users incur USD 12.1 per year for printing and eLMIS users USD 3.6	253 HC x USD 3.6 (LMIS/eLMIS) 191 HC x USD 12.1 (LMIS)	444 HC x USD 3.6 (LMIS/ eLMIS)	**Paper back-ups** are maintained at the health facility **as printouts** despite no physical transportation of reports (444 HC x 3.6)
Central level costs	These cover internet, data storage, maintenance, and security needs for the continuous operations of the eLMIS for the EPI	USD 8,252.4	A scale-up and increased use of the eLMIS will necessitate an additional server and internet access to cover all 444 health facilities (USD 11,692.2)	

Based on the above assumptions, the total costs for vaccine stock data management under the different scenarios were calculated and are reported in *Table 14*. The calculation included the costs of all data management activities investigated in this evaluation and incorporated the changes described in *Table 13*. As estimated, the completion of the roll-out of the monitoring and reporting functionalities across all 444 health centers in Guinea would lead to an annual saving of USD 4,702 based on the current set-up of the LMIS/eLMIS system. Moving the reporting activities closer to digitalization, more substantial annual cost savings of USD 50,852 can be achieved compared to the current situation. These savings, as described in the assumptions, can

be driven by the optimization or elimination of activities that rely on paper (i.e., transporting paper reports or printing of the paper LMIS/eLMIS reports).

Table 14: Total incremental costs and affordability of transitioning from the current situation to a fully electronic reporting system for vaccine stock management in all 444 health centers (including district costs) of Guinea.

	0. Current situation	**1. "Scale-up": LMIS/eLMIS nationwide**	**2. "Improved efficiency"**
Total incremental cost for vaccine stock data management (USD)	137,518	132,815	86,666
Affordability (% of annual EPI expenditure)	1.9%	1.8%	1.2%

It must be noted, however, that the total costs of each scenario still represent incremental costs to the Government of Guinea for the management of vaccine stock data, as the EPI remains depends on the operation of the legacy information flows still in place based on paper tools and the SMT at central level.

IV. DISCUSSION

The evaluation in Guinea aimed to assess the programmatic impact, costs, and sustainability of the eLMIS to generate actionable evidence for the MSHP to support future operational and investments decisions on the national expansion of the eLMIS. It adopted a mixed-methods approach to address the complexity and specificity of the implementation of the eLMIS and its contribution to the EPI program which, to date, has been primarily limited to reporting and monitoring functions.

This discussion section follows the structure of the evaluation framework previously described (Figure 5). It also notes the limitations of the evaluation and provides a brief description of the impact of the COVID-19 pandemic on the use of eLMIS in Guinea as a potential confounder influencing the results of this evaluation. Finally, recommendations to guide it future deployment and expansion to all health facilities, as well as considerations for increasing its long-term sustainability, are provided.

A. ECOSYSTEM

Guinea has experienced, in recent years, an **unstable macroeconomic performance** marked by the Ebola epidemic, the COVID-19 pandemic, and political instability. Several factors have affected Guinea's development prospects and continued work on the digitalization of health information: i) an ongoing political transition that started in 2021; ii) often fluctuating trends in key macroeconomic variables linked to exogenous (e.g., COVID-19 pandemic) and endogenous elements (e.g., lack of infrastructure, dependence on external donor funding); and iii) several public health threats, such as epidemics, combined with low public investment in the health system. While these aspects may present challenges in the implementation of digital solutions for health, they also uniquely represent areas where significant gains from better and more accurate information can be achieved.

In this challenging context, the Government of Guinea has been progressively adopting integrated digital solutions across the different public health programs, demonstrating strong interest and a political commitment in the digitization and streamlining of health information. In the specific case of eLMIS, Guinea has shown strong national ownership throughout the development and implementation phases, as represented by its eLMIS design process and roll-out strategy. These efforts have been aligned with a clear vision for digital health outlined in its national strategies.

Despite this movement towards digitization and an increasing financial and programmatic commitment to health, Guinea is a country that remains programmatically and financially heavily reliant on external support. As a result, the country is subject to influences by multiple stakeholders with diverse priorities, which may lead to fragmentation and creation of program-specific "silos." In the specific case of vaccine stock data management, this is confirmed by the fact that an electronic version of the SMT (i.e., the legacy tool) is being considered for development and deployment by the WHO and UNICEF country offices, without full consideration of the opportunities offered by the existing eLMIS to serve all functionalities sought by the EPI.

In addition, the implementation and use of the eLMIS has also been influenced by several aspects of the ecosystem related to infrastructure and human capacity, as well as governance of information systems and processes.

In terms of infrastructure, **intermittent access to electricity** and internet, as well as **limited availability of hardware** were highlighted as perceived inhibiting factors for the use of the eLMIS. However, due to the continued use of paper forms and the parallel reporting/vaccine management process through the EPI's legacy tools, vaccine stock management is not conditional on the availability of electronic devices nor a continuous and reliable power supply. In general, ensuring adequate infrastructure will be necessary in the future to allow the eLMIS to operate as a routine data management tool by the EPI, as well as in the future prospect of being able to effectively replace the legacy tools. It is recommended, therefore, that the Government of Guinea equip each health center with a laptop computer to enable operation even in conditions of temporary power outages and consider the option of broader use of solar energy as a power source to ensure continuity of the electronic data management activities.

Similar issues arise with respect to **internet availability**. While internet bundles provided by Chemonics and CRS were made available to health centers by the central level, these were reportedly not reaching the health centers on a regular basis which led health operators to use personal internet packages for the use of eLMIS,

subsequently discouraging its use and reducing reporting efficiency. The Government of Guinea and ita supporting partners must demonstrate greater accountability, considering both the roles and responsibilities, as well as the financial costs (i.e., USD 10 per HC monthly), for providing internet access to the health centers. Access to the internet is a prerequisite for cloud operations and live data monitoring. Thus, should the Government of Guinea take on this expenditure in the future, a timely exploration of available internet options, such as flat rates or a national contract with a telecommunications company, is recommended.

The infrastructure-related challenges reported here confirm the findings of USAID's evaluation of Guinea's national supply chain (USAID , 2019). USAID found that only 18% of hospitals reported that the internet was always or almost always available. 21% reported that the internet was available but often not working, while the remaining 55% reported that the internet was unavailable in their health facilities. In addition, a large proportion of the health staff interviewed indicated that they often used their personal internet data plans to submit mandatory LMIS reports. This reflects the findings of this evaluation as well.

In terms of **human capacity**, under-staffing and inadequate training of personnel at HC level were observed which may hinder the actual use of the system as well as its future potential as a unique electronic data reporting system. More specifically, training activities focused on vaccine management should be strengthened and combined with the expansion of the eLMIS roll-out as to set the foundations for the use of the tool also beyond its current limited scope of reporting and monitoring.

Finally, in terms of **governance**, the eLMIS is centrally managed by the DNPM directorate. While this is an encouraging sign of integration and efficiency (i.e., coordinated decision-making, health-systems approach in the governance and use of data for health), the eLMIS has not yet replaced the legacy information processes and systems in place used by the EPI. The primary sources of information used for decision-making by the EPI remain the legacy tools, suggesting that there has been limited engagement from the EPI in the governance of eLMIS. Further involvement of the EPI in the operations of the eLMIS is recommended to encourage the use and utility of the tool for the program at all levels. An example and best-practice of ownership of the tool is provided by the National Malaria Control Program in Guinea, which has ensured that all required indicators and functionalities required for the management of the supply chain and logistics of its products are captured in the eLMIS as well as that all malaria-related commodities are included in the eLMIS.

B. DESIGN AND FUNCTIONALITY OF THE TOOL

As a multi-program tool, the eLMIS implementation represents a step forward towards the cross-cutting management of health programs and reporting activities to ensure the availability of essential medicines at the first point of care for patients. The decision to implement a multi-program tool saw significant economies of scope achieved, whereby the cost of implementation just for the EPI was estimated at as low as USD 288 per health center.

However, as the tool was not designed to cover all the specific needs of the EPI in Guinea, many remain unaddressed. As a result, the EPI has made use of the eLMIS as a reporting tool covering only a few vaccine stock indicators. The limitation of the eLMIS design in capturing all required EPI-related indicators for vaccine stock management has hindered the tool from being fully adopted as a unique source of information by the EPI. As a result, it still relies upon the legacy paper-reporting tools and DHIS2 and SMT at peripheral and central levels, respectively. There appear to be no technical obstacles for the inclusion of the missing EPI indicators in the eLMIS: specifically, we can expect that , once the ordering and planning functionalities of the system are rolled out and used by the EPI, the eLMIS may replace the old legacy system. Further investments and involvement of the EPI in the design of the tool are needed to ensure that the full scope of needs (e.g., presence of all needed vaccine stock indicators, ordering and forecasting capability) are addressed. This would enable the eLMIS to become an efficient routine reporting system for vaccine stock management.

With respect to information flow and interoperability, it is recommended that the MSHP addresses the current design of information flows. Nowadays, EPI legacy flow provides the whole range of indicators, while only some of them are provided also by eLMIS. Moreover, a report by UNICEF et al. (2020) shows how the whole range of relevant indicators to the EPI is captured on paper tools at health center level and in the SMT tool at central level (See Figure 4). Concluding, the current information flow configuration is a multi-tool system for vaccine

stock management (i.e. DHIS2, eLMIS and/or SMT) in which the MSHP should invest in interoperability procedures at all vaccine system's levels for guaranteeing that information reaches all actors in a timely manner.

C. IMPLEMENTATION

The implementation of the eLMIS commenced in 2018 with the programmatic and financial support of Chemonics and the Global Fund. The roll out is still ongoing with the goal of covering the entire country and all 14 health programs by 2023. Importantly, the current use case includes only reporting and monitoring functions, though additional functionalities are planned in the coming months for some of the health programs.

This evaluation found that training was a critical component for the implementation phase, supporting the adoption of the tool by users. Unsurprisingly, most of the costs (36%) have been incurred for this activity. Beyond building specific IT skills for the use of the eLMIS, long-term investments in developing additional competences are also necessary. While reportedly low staff turnover rates have enabled health centers to build on existing logistic and vaccine management skills without the need for trainings for new staff, the eLMIS has a diverse set of users whose competences in data management varies according to their role. Findings from this evaluation suggest that this has influenced the quality of data entered in the system and their further ability to be used for decision-making.

Other aspects of human resources have also influenced the implementation, particularly the lack of clarity in relation to roles and responsibilities for data management. EPI data are first collected on paper by the EPI agents of the HC and then uploaded in the system by non-EPI staff. The absence of a focal point within each HC with specific data management responsibilities resulted in this task often being shifted to the health center manager and/or another delegated staff. It is recommended that one dedicated person, such as a data manager, is identified in each health center to perform data entry into the eLMIS covering all programs. This should allow for improved efficiency of the data management and consequently better quality of data. Furthermore, significant economies of scope (e.g., production of services reduces the cost of producing another related service) can be expected as having a resource dedicated to data management can contribute to establish and reinforce a more robust culture of data provision and use.

The **role of supportive supervision on eLMIS operations** has emerged as pivotal for the success of the implementation. Data from the eLMIS are reviewed and acted upon through routine supervision to positively impact stock management activities at health center level, both through supervision by the DNPM to improve the eLMIS data quality and supervision by the EPI to strengthen immunization service delivery. Data from the eLMIS are accessible at higher levels to monitor data quality and to enable the performance evaluation of health centers and DPSs. With the central-level interoperability of eLMIS with DHIS2 plus data verification performed by the DPS and DRS, the decentralization of the data monitoring and supervision activities, in combination with the EPI supervisory visits, are encouraged to synergistically strengthen vaccine stock management.

Strong engagement of the DNPM in the eLMIS roll out was found to be a critical element in the successful adoption of the tool and in reinforcing its routine use. As the expansion of eLMIS across the country is still ongoing, it is recommended that the Government of Guinea allocates the necessary time and resources to support organizational adjustments, further clarify process and roles for the current vaccine reporting and monitoring activities, strengthen supervision activities based on data, and develop a plan for the eLMIS to become the only tool for vaccine management covering all activities, specifically including ordering and forecasting.

The design, development and deployment of the eLMIS in Guinea for the EPI was estimated at only USD 46,560. This low investment can be explained by the fact that the system is shared across multiple health programs, and by the low customization costs incurred. The latter are a result of leveraging an open-source platform and performing the customization using in-country Chemonics consultants vis-à-vis from abroad. As such, the eLMIS in Guinea provides a good example of an economy of scope, whereby various programs benefit from a single shared investment (i.e., resources, capacity, hardware, etc.).

Finally, it must be noted that the tool in its current configuration does not meet the requirements of a full eLMIS as only the reporting and monitoring functionalities are available, and the legacy paper system is still fully in place. On this basis, costs cannot be compared to those of other eLMIS, such as the Vaccine Information

Management System (VIMS) in Tanzania whose design and development alone costed more than 1 million USD. In the event of a program-specific scope of expansion to cover all eLMIS functionalities required to meet the EPI requirements, the government of Guinea and external funders will have to consider the necessary investments.

D. IMPACT

PROGRAMMATIC IMPACT

The findings of this evaluation indicate high **user satisfaction** with the eLMIS based on the reported ease of use. The constructive and focused feedback of the users indicates goodwill and positive expectations from the health workforce which reportedly sees great potential in the roll-out of a national tool across multiple programs to allow full transparency and access to updated information on the flow of goods. This should be taken into consideration as the Government of Guinea and its partners reflect on the future use and wider reach of the eLMIS. Together, with some of the other practical suggestions provided by the users (e.g., more training, availability of portable electronic devices, request for stable continued internet connectivity), these insights can provide specific guidance on how to further improve the quality of the implementation of the eLMIS moving forward.

Users also experienced a **perceived increase in data quality** with use of the eLMIS. However, this was not validated by evaluation, and systemic problems of misalignments between data sources (e.g., for target population) seem to affect data quality. Quality assurance can provide HCs with an easy-to-use tool for self-assessment and data quality improvement. By taking advantage of the active feedback process of DPSs and linking it to formative supervision, HCs can be supported in the process of analyzing and resolving other data quality issues which will not be solved by use of the tool alone.

Interestingly, some of the programmatic findings of this evaluation contrast those captured in research commissioned by USAID (2019) after the initial introduction. The latter highlighted poor data quality and errors in the reporting process because of challenges in data archiving, insufficient training on the use of the eLMIS, delays in providing feedback and human resources. At the time of the USAID analysis, however, the eLMIS was still in its very early stage of roll-out and, in the specific case of immunization, used in very few HCs. Furthermore, the DNPM has since put in place a QA/QC process whereby reports are sent back to facilities in case of errors or missing data, and supervision has been strengthened thus reinforcing the attention to data quality. This could partially account for any differences.

As the eLMIS is used only as a reporting tool for EPI, functionalities for vaccine stock management and decision-making (i.e., forecasting and ordering) are not yet available. The data structure does not cover all EPI needs. As a result, the legacy EPI tools still function in parallel and serves as the primary source of information for the whole process of vaccine management (i.e., from ordering to dispatching doses in the field). The impact of the eLMIS on the management of vaccine stocks appears to be limited and functions mainly as a complementary source of data verification for a few indicators.

Use of the eLMIS continued throughout the pandemic with no evidence of major stock-outs nor excessive levels of wastage of expired products overall. As it relates to the performance of the EPI, the use of eLMIS appears to be linked to some improvement in stock management performance for the three vaccines analyzed (i.e., BCG, Pentavalent and Measles). A reduction in the number of stock-outs and the number of months in which centers have stock levels outside the range deemed appropriate was observed for these vaccines. This impact appears to be reinforced in centers where supervision activities include a review of eLMIS data.

However, the observed improvement in stock management performance for the three vaccines should be considered an indirect effect of the use of the eLMIS as the system is not currently used widely by the EPI for stock management. The effect may be the result of a perceived improvement in the quality of vaccine stock levels at the health center (based on qualitative data only). Evaluating after a longer implementation period (i.e., 6 versus 3 months) may demonstrate further improved performance, as it takes some time for any new system to start having a positive impact on behavior (i.e., use of data for decisions) and data quality through supervision and quality checks.

It is recommended that an assessment of the link between eLMIS and vaccine stock management performance be executed soon (i.e., early 2024) with a larger sample size that may allow more robust conclusions to be drawn about the impact of eLMIS. Once the eLMIS is fully deployed at HC level, a deeper analysis of data quality and data management systems at the health center level will be essential to investigate the link between eLMIS's implementation, the quality of vaccine stock data, the impact on the broader vaccine management processes, and finally the impact on EPI decision-making at different levels. This could support a root cause analysis of vaccine stock management issues, as well as improvements in the EPI's performance.

ECONOMIC IMPACT

The annual routine operating cost for performing vaccine stock data management activities using the current eLMIS (USD 207) represents an incremental cost to the legacy paper-based EPI reporting process and its associated cost. This incremental cost is mainly driven by the report generation and transportation, which are the two principal activities for which the eLMIS is used. This effectively increased the costs sustained by the country to operate this parallel information flow by USD 137k per year.

HCs which use the eLMIS were observed to incur comparatively lower costs (USD -15 per year) for the vaccine stock management activities of this evaluation compared to HC which only use the paper LMIS. While this does not represent a substantial finding, and may be a random difference, it provides an indication, and a point for further investigation, that the addition of the electronic system does not increase costs. Given its promising programmatic impact, this economic finding is encouraging and supports continued expansion of the electronic system since it does not present an additional cost burden to the country. This finding, however, would need to be validated once the eLMIS has reached more than half of the HCs of the country, including a higher concentration of rural HCs.

The expansion of the eLMIS to reach national scale is considered a pre-requisite to investigate potential economies of scale and synergies across programs. The country should consider investing in the requirements necessary to support a growing user base, such as server capacity, purchasing of new computers, trainings and trouble-shooting mechanisms and resources supporting the change management necessary for the adoption of the tool. While the economic findings support the continued expansion, a word of caution must be noted. The eLMIS adoption and integration in the routine processes and management of HCs might take time. As change management is often lengthy process, the economic impact at a larger scale might not be immediately detectable, as with the limited cost impact between paper LMIS and eLMIS observed in this evaluation.

E. AFFORDABILITY AND SUSTAINABILITY

The proportion of the budget for immunization taken up by the routine operating cost of the eLMIS as it is used currently for vaccine stock management is small (2%). In these terms, the eLMIS can be characterized as affordable for the EPI. It must be noted, however, that once the additional functionalities for vaccine stock ordering and planning are enabled in the system, and the tool is taken up by the EPI, the operating cost of the eLMIS will likely account for a higher proportion of the immunization budget. While the affordability of the system is expressed in terms of the total EPI expenditures, the eLMIS is not financed nor operated currently by the EPI. Nonetheless, given its high affordability, it is recommended that the EPI considers integrating the tool in its information flows and processes.

The scenario analysis suggests that a scale-up of the eLMIS to national level and the introduction of process changes for report generation and transportation can increase efficiency and reduce the reliance on paper and, thus, the costs associated to printing and physical report transportation. This will effectively decrease the annual operating costs of the eLMIS by approximately 40%. These economic findings demonstrate that the move toward a more digital management of data and reporting has the potential to confer cost savings compared to the current hybrid process in place. As above, such process efficiencies are dependent on change management efforts and on ensuring that critical ecosystem factors for the success of the eLMIS, such as adequate human capacity and infrastructure are in place. This may imply the investment of further resources.

It is recommended that the Government of Guinea, through the DNPM as well as by the programs themselves, should monitor the impact over time of the hybrid LMIS/eLMIS system. Attention should be paid to process efficiencies such as the ones simulated in the scenario analysis to explore how the eLMIS can be best integrated in the data management processes of each program. Ideally, an effort should be made to reduce any duplication

of work and eliminate the most expensive and inefficient activities, such as reports' transportation. It will be important to fully understand the culture and reasons behind any identified inefficiencies.

At present, the eLMIS in its hybrid use represents a duplication of work for reporting and incremental costs for the management of vaccine stock data for the EPI. If the legacy paper-based tools are to be replaced, a substantial investment will be needed to upgrade eLMIS to the OpenLMIS v3 platform, which includes all of the EPI indicators currently captured on the legacy tools, as well as phasing out the tools and investing significantly in human capacity and organizational changes.

External financing partners also play a role in the sustainability of the eLMIS. Guinea is still reliant upon Chemonics for the purchasing of servers, hardware, and monthly internet bundles for health facilities. In an ideal scenario, all capacity to support the system would be domestically available. This is unlikely in the context of Guinea at present. However, an overreliance on external third parties must be cautioned against. Adequate long-term planning and budgeting of resources is recommended to be put in place and revisited routinely in accordance with the evolving needs of the user base and system and program requirements.

National ownership of the eLMIS is critical for its sustainability. The DNPM of the Guinean Government has demonstrated strong commitment and ownership of the eLMIS through its governance and management of the system, with the rigorous supervision and data quality reinforcement highlighted by this evaluation. However, the same cannot be said for the EPI with regards to the eLMIS. As observed with the Malaria program in Guinea, the utility of the system is dependent on the interested party. If the eLMIS is not taken up by the EPI, which would imply its upgrade to OpenLMIS v3 first, it will remain solely a reporting and monitoring tool used centrally for the purpose of data management and visibility of the supply chain performance of stocks of health programs, rather than an assisting tool for daily vaccine stock and logistics management.

V. LIMITATIONS

There are several limitations to this evaluation. Firstly, there was a relatively short period between the roll-out of the eLMIS (most of the centers rolled the system out in 2022) and the collection of data (Q1 2022), which did not allow for covering a long period of use of the tool, nor did it allow for initial implementation problems to be resolved. Secondly, the sample of 42 health centers and 6 DPSs coupled with the purposive sampling strategy may have an impact on the external validity of the results. As stated before, the low number of health centers with eLMIS in rural areas in the total population lead to an overrepresentation of urban health centers with eLMIS in the sample, thus the investigation or conclusions of the programmatic and economic impact of using the eLMIS in rural health centers is very limited. Thirdly, the quality check of stock data at the health centers did not yield usable results. Users entered data for the number of doses received, the starting stock level, consumption and releases relating to different periods/durations, which prevented the calculations from being performed correctly. Therefore, the analysis of data quality is not informed by indictors. Finally, the data collected and reported consisted mainly of perceptions reported by health staff in interviews, both for the programmatic and economic components. This method of conducting the evaluation had an inherent information bias as the data was self-reported and subject to recall bias by the interviewee. Recall bias might have been particularly relevant in the analysis of the cost impact between the eLMIS and the paper-based system.

VI. INFLUENCE OF THE COVID-19 PANDEMIC

The COVID-19 pandemic is a notable confounder in this evaluation. The pandemic shifted Government priorities and influenced and delayed the country's eLMIS implementation plan and reduced the availability of hardware and human resources which were redirected towards the COVID-19 response. At the same time, it impacted routine immunization services and reduced the demand for routine vaccinations because of the repeated lockdown measures and other COVID-19 related accessibility factors. Together this has influenced the findings of this evaluation making it challenging to demonstrate the anticipated impact of the tool on primary immunization outcomes, including coverage, timeliness of vaccinations and drop-out rates. This evaluation, as a result, focused on the input and more proximal process and output measures to ascertain directional progress in the implementation and impact of the tool.

VII. CONCLUSION

While the implementation of the eLMIS in Guinea remains in its initial phase, preliminary conclusions can already be drawn and recommendations posited in this evaluation.

With reference to the contribution of the eLMIS implementation to the delivery of immunization services, programmatic performance appears to have been positively impacted in terms of improved stock management, as measured by the number of performing and non-performing months, as well as on the perception of data quality. This might be the result of an increased focus on data quality and completeness which had a positive impact on supervisory activities, as well as the benefit of a unified cross-program approach under DPNM responsibility that provided a single framework for the eLMIS operation. Ensuring the full roll-out of the eLMIS with all its functionalities and its adoption by the EPI will be critical to leverage all the potential programmatic and economic gains and can pave the way to a leaner monitoring of stocks at HC level.

The sustainability of these results, the success of scaling up and the ability to take full advantage of the roll-out of the eLMIS will depend on the establishment of a robust digital infrastructure (e.g., computers, internet connectivity, electricity and sufficient skilled and supported staff dedicated to the tasks) that allows for the migration to a fully electronic system. In addition, the complete integration of EPI activities into eLMIS will be essential to reap the full benefits of the eLMIS roll-out. To do this, the design of eLMIS will need to evolve to fully meet the requirements of the EPI for ordering and forecasting functionalities. On this basis, the potential of the eLMIS tool to address the comprehensive needs of the EPI by investing in OpenLMIS v3 is a path that the MSHP of Guinea must consider, alongside prioritizing investments to address the ecosystem-related challenges. This presents a unique opportunity for streamlining of data, processes and governance not only for the EPI, but also for the MSHP as a whole.

Looking at the future setup and investment, Guinea has been progressively moving towards full digitalization of its logistics systems in response to a major public health crisis, the Ebola epidemic, and is renewing its efforts following the COVID-19 pandemic. It has done so by adopting an integrated approach across all programs under strong leadership by the DNPM, an important factor in ensuring sustainability. Furthermore, it did so by building on local human resources avoiding creating dangerous dependencies on external consultants. Although preliminary, the results of this evaluation regarding implementation challenges and learnings can inform the scale-up of the eLMIS in Guinea, especially in addressing critical areas regarding infrastructure and capacity. This must be done in collaboration with solid and streamlined resource and financial planning across all health programs, in particular the EPI. Specifically, technical partners must align to the plans of the Minister of Health and provide the necessary technical assistance to facilitate the full integration of EPI in the eLMIS solution, refraining from supporting other solutions.

Finally, with reference to the findings and recommendations of this evaluation, appropriate follow-up and the updating of this research in 2024 will allow firmer conclusions to be drawn and will further guide future work on eLMIS in Guinea. Such follow-up evaluations could consider covering areas such as: offline capability of the tool, the impact of the transition to v3, and the impact of ordering and forecasting capabilities using the system, for example. There is great potential to use these finding to support future investments decisions.

VIII. ANNEXES

Annex 1: Guinea context

The Republic of Guinea is in West Africa and bordered by Guinea Bissau to the northwest, Senegal and Mali to the north, Côte d'Ivoire, and Mali to the east, Liberia, and Sierra Leone to the south and the Atlantic Ocean to the west. The country is bordered by 300 km of coastline and extends 800 km from east to west and 500 km from north to south. Its total area is 245,857 km². The last General Census of Population and Housing in 2014 put the Guinean population at 10,628,972 and it is projected to be 13,261,638 in 2022, with 51.42% of the population being female. In 2022, the crude death rate is 7.9% and the crude birth rate is 34.97%; moreover, while natural growth rate is estimated at 2.42% compared to 2021 with a total fertility rate of 5.11. last, and with life expectancy at birth at 58.9 years.

Guinea's health system evolved in 4 phases: a colonial period characterized by hospital-centrism and mobile teams, a period of socialist policy from 1958-1984 characterized by equity of access to care; a liberal policy from 1984-2000 characterized by the operationalization of primary health care and cost recovery in the framework of the implementation of the Bamako Initiative and hospital and pharmaceutical reform; and finally, the period 2000-2014 characterized by the fragmentation of the health system into a multitude of vertical projects and programs.

Annex 2: Tracer commodities by program

PROGRAMS			
Products of PNLP			
1	AL (AD)	6	MILDA
2	AL (GE)	7	QUININE SULFATE 300MG TABLET
3	AL (NN)	8	SP COMP 500/25 MG
4	AL (PE)	9	TDR MALARIA
5	ARTESUNATE INJ 60MG/ML	10	ARTESUNATE SUPPO 100 MG
Mother and child products and contraceptives			
Contraceptive Products			
1	INTRAUTERINE DEVICE (IUD)	5	MICROGYNON
2	DMPA-IM	6	MICROLUT
3	DMPA-SC	7	FEMALE CONDOM
4	IMPLANT	8	MALE CONDOM
Maternal, Child and New-born Health Products			
1	AMOXICILLIN 250MG DISPERSIBLE TABLET	15	HAEMACEL (MODIFIED GELATINE) 500 ML
2	AMPICILLIN 1G INJECTABLE	16	THERAPEUTIC MILK F100
3	RESUSCITATION DEVICE	17	THERAPEUTIC MILK F75
4	CAFFEINE INJECTION	18	LIDOCAINE 2% 20 ML
5	CEFTRIAXONE 1G INJECTABLE	19	MAGNESIUM SULPHATE 50% 10ML
6	CHLORHEXIDINE 20% SOLUTION	20	MISOPROSTOL 200 MICROGRAM TABLET
7	CLOXACILLIN 500MG TABLET	21	OXYTOCIN 10 UI INJECTABLE 1ML
8	DEXAMETHASONE 4MG/ML INJECTION	22	PHYTOMENADIONE (VITAMIN K1)10MG/ML INJECTABLE
9	IRON FOLIC ACID (FAF) 60/0.25 MG TABLET	23	SRO 20.5G POWDER
10	LUBRICATING GEL, P/2000	24	SRO-ZINC
11	GENTAMICIN 40MG/ML 2ML INJ	25	1% TETRACYCLINEOPHTHALMIC
12	CALCIUM GLUCONATE 10%.	26	VITAMIN A
13	GLUCOSE 5% +PERF SOLUTION, FL/ 500ML	27	ZINC 20MG TABLET
14	GLUCOSE HYPER 50%, SOL INJECT, AMP 10ML, B/20		
P3 - NHSP Products			
HIV Products - ADULTS			
1	ABACAVIR 300MG, TABLET, BOX 60	9	LAMIVUDINE 300MG+TENOFOVIR 300MG, COMP, BOX 30

2	ABACAVIR 600MG+LAMIVUDINE 300MG, TABLET, BOX 60	10	LAMIVUDINE150MG+ZIDOVUDINE300MG+NEVIRAPINE 200MG, COMP,B/60
3	ATAZANAVIR 300MG+RITONAVIR 100MG, BOX 30	11	LOPINAVIR 200MG+ RITONAVIR 50MG, BOX 120
4	DARUNAVIR 600MG, TABLET, BOX 60	12	RALTEGRAVIR 400MG(ISENTRESS), TABLET, BOX 60
5	DOLUTE GRAVIR 50MG, TABLET, BOX 60	13	TENOFOVIR 300MG, TABLET, BOX 30
6	EFAVIRENZ 600MG, TABLET, BOX 30	14	TENOFOVIR 300MG+EMTRICITABINE 200MG, COMP, BOX 30
7	ETRAVIRINE 100MG, TABLET, BOX 120	15	TENOFOVIR 300MG+EMTRICITABINE 200MG+EFAVIRENZ 600MG, CP,B/30
8	LAMIVUDINE 150MG+ZIDOVUDINE 300MG, COMP, BOX 60	16	TENOFOVIR 300MG+LAMIVUDINE 300MG + EFAVIRENZ 600MG,CP, B/30
HIV commodities - CHILDREN			
1	ABACAVIR 60MG+LAMIVUDINE 30MG, BOX 60	5	LOPINAVIR 100MG+RITONAVIR 25MG, TABLET, BOX 120
2	EFAVIRENZ 50MG, TABLET, BOX 30	6	NEVIRAPINE SYRUP 10 MG/ML
3	LAMIVUDINE 30MG+ZIDOVUDINE 60MG + NEVIRAPINE 50MG, COMP, BOX 60	7	ZIDOVUDINE 50MG/5ML, SOL. DRINKABLE, FL/240ML
4	LAMIVUDINE 30MG+ZIDOVUDINE 60MG, COMP, BOX 60		
HIV testing			
1	BIOLINE HIV 1-2, BOX 25	3	PIMA CD4 TEST B/100
2	DETERMINE HIV 1 AND 2, COMPLETE KIT, BOX 100	4	SYPHILIS DUO TEST HIV 1-2 , TEST, B/25
P4 - NAPLAT products			
Products against multidrug-resistant tuberculosis			
1	AMIKACIN 500MG/ML, SOLUTION FOR INJECTION, 2ML	12	MOXIFLOXACIN 400MG, TABLET
2	AMINOSALICYLIC ACID 4G, POWDER	13	PROTHIONAMIDE 250MG, TABLET
3	BEDAQUILINE 100MG, TABLET	14	PYRAZINAMIDE 400MG, TABLET
4	CLOFAZIMINE 100 MG, TABLET	15	Sensitive TB products
5	CYCLOSERINE 250MG, TABLET	16	ETHAMBUTOL 100MG, TABLET
6	DELAMANID 50MG, TABLET	17	ISONIAZID 100 MG DISPERSIBLE, TABLET
7	ETHAMBUTOL 400MG, TABLET	18	RIFAMPICIN 150MG+ISONIAZIDE 75MG, TABLET
8	ISONIAZID 300MG, TABLET	19	RIFAMPICIN 150MG+ISONIAZIDE 75MG+PYRAZINAMIDE 400MG+ETHAMBUTOL 275MG, TABLET
9	KANAMYCIN 1G, SOLUTION FOR INJECTION	20	RIFAMPICIN 75MG+ISONIAZIDE 50 MG, TABLET
10	LEVOFLOXACIN 250MG, TABLET	21	RIFAMPICIN 75MG+ISONIAZIDE 50MG+PYRAZINAMIDE 150MG, TABLET
11	LINEZOLID 600MG, TABLET		
P5 - EPI products			
EPI Consumables			
1	BS-5L	4	SDILUTION-2ML
2	SAB-0.05	5	SDILUTION-5ML
3	SAB-0,5		
EPI vaccines			
1	BCG	5	VAR
2	PENTAVALENT	6	VPI
3	Td	7	VPO
4	VAA		

P6 - Trade Revenues PCG			
1	ACETYL SALICYLIC ACID 500 MG TABLET	7	COTRIMOXAZOLE 480 MG TABLET
2	KETAMINE 50MG/ML, SOLUTION INJECT. FL/10ML	8	DOXYCYCLINE 100 MG TABLET
3	PARACETAMOL 125MG/5ML, DRINKABLE SUSPENSION, FL/ 60ML	9	ERYTHROMYCIN 250 MG TABLET
4	PARACETAMOL 500 MG TABLET	10	METRONIDAZOLE 250 MG TABLET
5	AMOXICILLIN 500MG, GELULE, BLISTER, B/10X100	11	METRONIDAZOLE 500MG/100ML INFUSABLE
6	CIPROFLOXACIN 500MG, COMP, BLISTER, B/10X10		
P7-Suture products			
1	RESORBABLE SYNTHETIC SUTURE 0 NEEDLE 1/2 30MM ROUND SINGLE USE	9	EXAMINATION GLOVE (PIECE)
2	RESORBABLE SYNTHETIC SUTURE 1/0 NEEDLE 3/8 30MM TRIANGULAR STERILE SINGLE USE	10	GYNECOLOGICAL GLOVES (PAIR)
3	RESORBABLE SYNTHETIC SUTURE 2/0 NEEDLE 3/8 36MM TRIANGULAR STERILE SINGLE USE	11	LACTATE RINGER +PERFUSER, SOL.PERF, FL/ 500ML
4	ALCOHOL	12	MEBENDAZOLE 100MG TABLET
5	GAUZE PAD 40X40 CM, STERILE, 12 PLY 17 THREAD, P/10 PCS	13	POLYVIDONE IODINE 10% FL/200 ML
6	COTTON WOOL 500G, ROLL	14	SYRINGE 10ML UU, 3PCS +NEEDLE 21G, P/100
7	DIAZEPAM 10MG INJECTABLE	15	SODIUM CHLORIDE 0.9% INFUSION SOLUTION 500 ML
8	SURGICAL GLOVE (PAIR)	16	NON-WOVEN PLASTER TNT 2,5CMX5M, P/8
P7 - CSTA Products			
1	PHYSIOLOGICAL WATER	7	TD HEPATITIS B
2	HEMOCUE + MICROCUVETTE	8	TD HEPATITIS C
3	RHESUS PHENOYPAGE KIT (C, C, E, E) AND KELL	9	TD HIV-1/2
4	BLOOD POCKET	10	EDTA TUBE
5	COOMBS REAGENT	11	DRY TUBE
6	RPR /TPHA	12	VACCINOSTYLE
P8 - Sanitary safety products			
1	BLOUSE	15	CHLORINE C SOLUTION
2	SAFETY BOX	16	JAVEL WATER
3	BOOTS	17	DISINFECTANT GEL
4	HEADER	18	CALCIUM HYPOCHLORITE (HTH) 70% 2 5
5	COMBINATION	19	SOAP
6	FACE SHIELD/VISOR	20	ANTIVENOM SERUM INOSERP PANAFRICA INJ
7	CLEANING GLOVES	21	TYPHIM VX BOTTLE 0,5ML
8	PROTECTIVE GLASSES	22	AMARIL VACCINE
9	FACE MASK OR SURGICAL MASK	23	EBOLA VACCINE "RVSV ZEBOV
10	SURGICAL TROUSERS WOVEN UNDER THE SUIT IN 13795	24	CHOLERA VACCINE
11	PULVERIZER	25	RABIES VACCINE VERORAB INJ
12	MORTUARY BAG	26	MEN AC VACCINE (MENINGO VACCINE)
13	TABLIER	27	MEN ACYW 135 VACCINE (MENINGO VACCINE)
14	SURGICAL TUNIC, WOVEN / SURGICAL, WORN UNDER THE SUIT IN 13795		
P9 - DNL products			
1	GLUCOMETER STRIP	8	PHYSIOLOGICAL SERUM
2	GRAM DYE KIT 4X450 ML	9	GIEMSA SOLUTION 500 ML BOTTLE

3	DISINFECTANT	10	TDR AGHBS
4	ABO GROUP	11	TDR CHOLERA
5	SLATS COVER OBJECT PACK OF 100	12	TDR PREGNANCY URINE
6	HEMOGLOBIN REAGENT FOR AUTOMAT	13	TDR MENINGITIS
7	HEMOGLOBIN REAGENT FOR READER	14	TDR SYPHILIS

Annex 3: Theory of Change

Vision	**Reduce morbidity and mortality due to PVD by improving equitable access to vaccines and strengthening the delivery of immunization services within the PHC framework (IA2030).**				
Mission	Improve immunization program performance (vaccine availability and equitable access; efficiency of logistics management) through sustained use of eLMIS.				
Strategic outcomes	**(a)** Improved functionality of the eLMIS	**(b)** Improving the accuracy of vaccine forecasts	**(c)** Improved inventory and stock levels (use of data for decision making)	**(d)** More efficient, affordable, and sustainable use of eLMIS	**(e)** Increased stakeholder satisfaction and engagement
Outputs	a. The eLMIS is functional and interoperable with other HMIS. b. Data flow and feedback mechanisms between administrative levels are improved.	a. Data on vaccine stocks are complete, sufficiently granular, accurate and timely. b. The eLMIS stock balances correspond to the physical count. c. The need for ad hoc (emergency) transport to replenish vaccine stocks is reduced.	a. Vaccine stocks are always sufficient and at all levels of the health system. b. Stock-outs leading to disruption of immunization services are reduced. c. Losses in closed bottles (due to temperature differences or expiry) are reduced to a minimum. d. Losses in open bottles are reduced to a minimum.	a. Country ownership of eLMIS is enhanced by adequate governance of the system. b. Health workers at all levels are empowered to make data-driven decisions to improve vaccine management. c. There are sufficient financial resources to support the eLMIS system. d. The time required to monitor the temperature of cold chain equipment and produce monthly reports is reduced.	a. The time and knowledge savings increase the motivation of workers to use the system. b. User perception of eLMIS data quality is improved. c. Caregivers' satisfaction with the availability of vaccines has increased, for example by not having to come back when they are out of stock.
Data & Processes **External environment; Human resources; Systems and tools**	c. Vaccines can be tracked in a timely manner from their arrival in the country to the point of service delivery. d. An appropriate IT and hardware infrastructure (security, integrity) is in place.	d. Good quality data to monitor the performance of the eLMIS is generated at all levels. e. The competence and forecasting skills of eLMIS users at all levels are ensured.	e. Real-time data is available at all levels on inventory and stock levels. f. The ability of HR to use data for decision making is enhanced (i.e., for early stock replenishment).	e. A policy environment for eHealth is in place. f. Sufficient technical and governance capacity is generated. g. The eLMIS is continuously maintained and updated (i.e., a	d. Feedback from stakeholders (government, funders, users, customers) is used to continuously improve the system. e. Social workers are empowered to use the

	e. The data recording and reporting functions are user-friendly and efficient. f. Interoperability or integration with eLMIS and other health sector LMIS is possible. g. Integration with other electronic health systems h. (Remote) temperature monitoring systems are in place.	f. Data quality and consistency checks and periodic data quality audits are carried out. g. Standard operating procedures, job aids, training, and supervision tools for the use of eLMIS are available.	g. Interactive dashboards are available to visualise the data. h. Improved use of stock data leads to an increase in the size of vaccination sessions.	helpdesk available to correct problems in a timely manner). h. The costs of implementing eLMIS and the costs avoided by its use are known. i. A budget line exists for the maintenance and updating of the eLMIS.	time saved more effectively.

Note:
When using ToCs as the basis for the assessment approach, the following should be done:

1. The existing challenges that need to be addressed by electronic systems will be included in the introductory presentation.
2. Final health outcomes at the vision levels will potentially be modelled: morbidity, mortality (DALYs, QALYs).
3. Mission-level logistics management performance indicators will be added: for example, the number of vaccines in sufficient stock at all levels; the number of stock-outs leading to disruption of immunization services; the extent of wastage of closed vials; and the accuracy of vaccine forecasts.
4. Evaluation indicators will be further defined for each of the final input and output parameters.
5. The calculation of costs per activity and the estimation of avoided costs will be carried out.
6. The assessment will use historical comparisons (reference to previous assessments/data) and geographical comparisons.

Annex 4: Tools for data collection

Attached

Annex 6: List of health districts and health facilities surveyed

Region	District	Health Center	Location	eLMIS implemented?
Boké	Boffa	CSR Tamita	Rural	Yes
	Boffa	CSU Boffa	Urban	Yes
	Boké	CSR Kassopo	Rural	Yes
	Boké	CSA Sangarédi	Rural	Yes
	Boké	CSU Correrah	Urban	Yes
	Boké	CSU Dibia	Urban	Yes
	Boké	CSU Koulifanya	Urban	Yes
	Boffa	CSR Doupourou	Rural	No
	Boffa	CSR Tougnifily	Rural	No
	Boké	CSR Kolaboui	Rural	No
Conakry	Matam	CMC Coleah	Urban	Yes
	Matam	CMC Matam	Urban	Yes
	Ratoma	CSU Hadja Djene Kaba	Urban	Yes
	Ratoma	CSU Kobaya	Urban	Yes
	Ratoma	CSU Lambandji	Urban	Yes
	Ratoma	CSU Sonfonia	Urban	Yes
	Ratoma	CSU Wanindara	Urban	Yes
	Ratoma	CMC Flomboyant	Urban	Yes
	Ratoma	CMC Ratoma	Urban	Yes
	Matam	CSU Madina	Urban	No
	Ratoma	CSU Koloma	Urban	No
	Ratoma	CSU Kaporo	Urban	No
Kindia	Dubréka	CSR Tanene	Rural	Yes
	Dubréka	CSU Mafoudya	Urban	Yes
	Dubréka	CSU Ansoumania	Urban	Yes
	Dubréka	CMC Kondeya	Rural	Yes
	Dubréka	CSR Bady	Rural	No
	Dubréka	CSR Khorira	Rural	No
	Dubréka	CSR Wassou	Rural	No
	Dubréka	CSU Gbereire	Urban	No
Mamou	Mamou	CSR Konkoure	Rural	No
	Mamou	CSR Ourekaba	Rural	No
	Mamou	CSR Soyah	Rural	No
	Mamou	CSU Hore Mamou	Urban	No
	Mamou	CSU Loppet	Urban	No
	Mamou	CSU Poudriere	Urban	No
	Mamou	CSU Sabou	Urban	No
	Mamou	CSU Sere	Urban	No
N'Zérékore	Yomou	CSR Bowé	Rural	No
	Yomou	CSR Diécké	Rural	No
	Yomou	CSR Péla	Rural	No
	Yomou	CSU Yomou	Urban	No

Annex 7: Economic data analysis

ANNEX 7.1: INPUT DATA FOR COSTING

Official salary scales for selected health center staff

Personnel profile	Health Center typology	Gross salary / month (GNF)
Healthcare worker	HC	17,472,000
	CMC	18,720,000
Pharmacist	HC	24,960,000
	CMC	29,952,000
Nurse	HC	21,216,000
	CMC	22,464,000
Cost of paper (per page)*		750

*Information provided by the Guinean technical committee

ANNEX 7.2: COST IMPACT

LMIS costs

Average annual cost of vaccine data management activities using the paper-based LMIS system for vaccine stock data management by activity per health center (n=24), in USD

		Activities					
		Report generation	Report transmission	Determining quantities of vaccine to be ordered	Monitoring of performance indicators	Supervision	Total
Inputs	Staff	40.4 (10.8;70)	37.82 (10.7;64.1)	17.3 (4.9-29.7)	3.3 (0.6;5.9)	0.4 (0.2;0.5)	**99.1 (56.8;141.4)**
	Consumables + services + durable goods	21.7 (8.6;34.8)	109.5 (-42.3;261.4)	21.7 (1.7;41.8)	5.6 (0.4;10.9)	31.8 (10;53.5)	**190.3 (35;345.6)**
	Total direct costs **(a)**	62.1 (31.5;92.7)	147.3 (-4.7;298.5)	39 (15.2;62.9)	8.9 (3.1;14.6)	32.2 (10.3;53.9)	**289.4 (131.3;447.4)**
	Total indirect costs **(b)**	0.3 (-0.1;0.6)	0.4 (-0.04;0.8)	0.8 (-0.2;1.8)	0.1 (-0.1;0.4)	8.9 (-2.1;20)	**10.5 (-0.6;21.6)**
	Total costs (a) + (b)	**62.3 (31.8;92.9)**	**147.3 (-4.3; 298.9)**	**39.8 (15.3-64.3)**	**9 (3.2;14.8)**	**41 (9.6-72.5)**	**299.5 (139.4;459.6)**

ANNEX 7.3: SUBGROUP ANALYSIS

Urban vs Rural

Average annual cost of using eLMIS in USD (95% CI) based on direct and indirect costs of vaccine stock data management activities by urban (n=14) and rural (n=4) health centers. P-values for the significance of the difference between the means of the two groups are shown at the 95% confidence level.

Activity	Urban (USD)	Rural (USD)	Mean difference (USD)
Report generation	103.5 (-50;257.1)	87.1 (5.7;168.6)	16.4 (1.33;74.2)
Transmission of reports	105.2 (27.1;183.3)	98.7 (18.9;178.6)	6.5 (-5.3; 51.5)
Determining the quantities of vaccines to be ordered	23.2 (4.3;42.3)	63.5 (-40.3;4.3)	-40.3 (-53.9;11.9)
Monitoring of performance indicators	15.9 (-1;33)	67.5 (-29.6;164.7)	-51.5 (-64.2;-2.8)
Supervision	10.3 (0.91;19.7)	61 (-42.2;164.2)	-50.7 (-64.2;0.9)
Total	**258.3 (20.5;496)**	**378 (-78.5;834.5)**	**-119.7 (-181.4;117.2)**

REFERENCES

African Development Bank Group. (2021). *Guinea Economic Outlook*. Retrieved from https://www.afdb.org/en/countries/west-africa/guinea/guinea-economic-outlook

African Development Bank Group. (2021). *Guinea Economic Outlook*. Retrieved from https://www.afdb.org/en/countries/west-africa/guinea/guinea-economic-outlook

Appaix, O., Bah, A., & Maritano, M. (2019). *Assistante Technique au « Projet d'Appui à la Santé en République de Guinée (PASA) ».*

Dabo, M., Samah, Y., Kande, M., Somapre, D., Camara, A., Mamadou Dian, B., . . . Sidiki, M. A. (2020). *Early effect of the COVID-19 epidemic on vaccine coverage of major antigens in Guinea: an analysis of the interrupted time series of national immunization coverage.* medRxiv.

DHIS2. (2022). *About DHIS2*. Retrieved from https://dhis2.org/

Expert Panel on effective ways of investing in Health (EXPH). (2019). *Assessing the impact of digital transformation of health services.* European Commission.

Institut National de la Statistique (INS) et ICF. (2018). *Enquête Démographique et de Santé en Guinée.* Conakry: INS.

Institut National de la Statistique. (2020). Retrieved from https://www.stat-guinee.org/#

International Monetary Fund. (2022). *International Financial Statistics*. Retrieved from IMF Data Access to Macroeconomic and Financial Data: https://data.imf.org/?sk=4C514D48-B6BA-49ED-8AB9-52B0C1A0179B&sId=1409151240976

Ministère de la Santé. (2015). *Plan de Relance du Système de Santé (2015-2017).* Ministère de la Santé.

Ministère du Plan et du Developpement Economique. (2018). *La Guinee en Chiffres.* Guinea: Institut Nationale de la Statistique.

Mott MacDonald. (2019). *Evaluation of the Better Immunization Data Initiative.* Mott MacDonald.

Mvundra, M., Di Giorgio, L., Lymo, D., Dien Mwansa, F., Ngwegwe, B., & Werner, L. (2019). *The costs of developing, deploying and maintaining electronic immunisation registries in Tanzania and Zambia.* BMJ Global Health.

Mvundura, M., Di Giorgio, L., Lymo, D., Dien Mwansa, F., Ngwegwe, B., & Werner, L. (n.d.). *The costs of developing, deploying and maintaining electronic immunisation registries in Tanzania and Zambia.* BMJ Global Health.

PATH. (2015). *Next-generation immunization supply chains are needed to improve health outcomes.* PATH.

République de Guinée. (2017). *Plan National de Développement Economique et Social 2016-2020.* République de Guinée.

Stammer, E., Teklemariam, L., Barry, A., Millimono, R., Chweya, A., Danfakha, N., . . . Alva, S. (2022). *A tale of 2 countries: Implementation of the Cold Chain Equipment Optimization Platform in Guinea and Kenya.* Global Health: Science and Practice.

Thondoo, M., Strachan, D., Nakirunda, M., Sozinho, N., Muiambo, A., Kallander, K., . . . The InSCALE Study Group. (2015). *Potential roles of Mhealth for Community Health Workers: Formative research with end users in Uganda and Mozambique.* JMIR Mhealth Uhealth.

Udpa, S. (1996). *Activity Cost Analysis: A tool to cost medical services and improve quality of care.* Managed Care Quarterly.

UNICEF. (2018). *Optimisation de la chaîne d'approvisionnements des vaccins et aures commodités en Guinée: Introduction à l'approche de la conception des systèmes.* Conakry: Unicef.

UNICEF. (2021). *Guinea - Country Office Annual Report.* UNICEF.

UNICEF. (2022). *Guinea: WHO and UNICEF estimates of immunization coverage: 2021 revision.* Retrieved from https://cdn.who.int/media/docs/default-source/country-profiles/immunization/2022-country-profiles/immunization_gin_2022.pdf?sfvrsn=590dceb1_3&download=true

USAID . (2019). *Guinea National Supply Chain Assessment Capability and Performance.* USAID Global Health Supply Chain Program - Procurement and Supply Chain.

USAID. (2020). *eLMIS Selection Guide.* USAID.

van de Ven, W. (1994). *Forming and reforming the market for third-party purchasing of healthcare*. Social Science & Medicine.

Village Reach. (2020). *Landscape Analysis of Electronic Immunization Registries: lessons learned from a landscape analysis of EIR implementations in LMICs.* Village Reach.

World Health Organization. (2021). *Guinee - Rapport Annuel OMS 2021.* World Health Organization.

World Health Organization. (2022). *Immunization Dashboard*. Retrieved from Reported cases of vaccine-preventable diseases (VPDs) globally: https://immunizationdata.who.int/

Wright, C., Drury, P., Jackson, S., & Thomas, M. (2016). *Critical success factors for deploying digital LMIS.*

For questions, please contact: Viviana.Mangiaterra@sdabocconi.it