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

## Main insights from the cross-country analysis in Guinea, Honduras, Rwanda, and Tanzania

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# TABLE OF CONTENTS

## LIST OF ABBREVIATIONS

| | |
|---|---|
| ABC | Activity-based Costing |
| BCG | Bacillus Calmette Guerin vaccine |
| BMGF | The Bill and Melinda Gates Foundation |
| CERGAS | Center for Research on Health and Social Care Management |
| DHIS2 | District Health Information System version 2 |
| eIR | Electronic vaccination registry |
| eLMIS | Electronic Logistics Management Information System |
| GDP | Gross domestic product |
| HDI | Human Development Index |
| HF | Health Facility |
| HMIS | Health Management Information System |
| LMIC | Low- and middle-income countries |
| LMIS | Logistic Management Information System (paper version) |
| MEV | Vaccine-preventable diseases |
| MIS | Management Information Systems |
| MMGH | MMGH Consulting GmbH |
| NIP | National Immunization Program (Expanded Program on Immunization) |
| QA/QC | Quality Assurance / Quality Control |
| SMT | Stock Management Tool |
| TMN | Maternal and Neonatal Tetanus |
| ToC | Theory of Change |
| VPI | Inactive Polio Vaccine / Injectable Polio Vaccine |
| WHO | World Health Organization |
| WUENIC | WHO/UNICEF Estimates of National Immunization Coverage |

## INTRODUCTION

With the increasing digitalization of health systems in low and middle-income countries (LMICs), there is growing interest from governments, donors and implementing partners to introduce and scale-up digital systems to support more effective and efficient immunization service delivery. Upon the request by the Bill and Melinda Gates Foundation (BMGF), the World Health Organization (WHO) and Gavi, the Vaccine Alliance, a multi-country evaluation was performed with the overall aim of generating robust actionable evidence to enable future decisions on the introduction and scale-up of electronic immunization registries (eIR) and electronic logistics management information systems (eLMIS) in low- and middle-income countries (LMICs).

The following definitions of eIR and eLMIS were used in the evaluation. An eIR is a computerized, confidential population-based system capturing individual-level information on vaccine doses administered. It collects and consolidates vaccination data from vaccination providers for better immunization strategies. Its goal is to facilitate immunization coverage estimation, allow for individualized follow-up on defaulters (persons who are overdue for a vaccine dose), generate information for provider assessment and feedback, and ultimately provide vaccination clinical decision support (PAHO, 2017). An eLMIS is a computerized system used to capture vaccine consumption (both actual and forecasted), stock and ordering data from all levels of the immunization logistics system. Its goal is to inform logistics decisions and manage the supply chain (Gavi, 2018). These definitions of an "ideal system" should be taken as archetypical references, informing but not necessarily reflecting, the reality of system implementation on the ground, nor a country's vision and goals for their design and implementation.

This evaluation was conducted in four LMICs, Guinea, Honduras, Rwanda and Tanzania, by local Principal Investigators (PIs) and their research institutions which planned, conducted and managed the fieldwork. The initial data cleaning and analyses was performed in close collaboration with the Center for Research on Health and Social Care Management (CERGAS) at SDA Bocconi School of Management, Bocconi University and MMGH Consulting GmbH (MMGH). Additional joint analysis guided the development and finalization of report for each country, as well as this cross-country report. Local PIs and research institutions included: Africa Health Consulting in Guinea, senior consultants Edith Rodriguez and Luis Castillo in Honduras, the Centre for Impact Innovation and Capacity Building for Health Information and Nutrition (CIIC-HIN) in Rwanda and the National Institute for Medical Research – Mbeya Medical Research Center (NIMR-MMRC) in Tanzania.

This evaluation builds upon earlier work and documented experiences with eIR (Danovaro-Holliday et al., 2014; Nguyen et al., 2017; Dumit et al., 2018; Dolan et al., 2019) and eLMIS (Chindove and Mdege, 2012; PAHO, 2019; Pisa and McCurdy, 2019; Fritz et al., 2019). While current evidence suggests that these electronic tools can contribute to improved data quality and use, and ultimately positively impact the functioning of immunization programs, many were not rolled out at scale. Similarly, while evaluations to date have explored critical factors influencing the success of their implementation, they have offered little insights into their costing and affordability. Where innovations around digitalization have failed, it was often because the specific country context, user requirements and/or issues related to interoperability with existing health management information systems (HMIS) were overlooked. Importantly, no impact has been observed from technological interventions alone. Other parallel activities, including capacity building of health workers and change management for the sustained use of new technologies, were deemed essential (WHO, 2021).

As such, this evaluation further explored those critical areas and aimed to generate evidence on the practical experience of implementing these systems and on their effectiveness, affordability and sustainability. Four specific country reports exploring the challenges and opportunities around developing and implementing these digital systems, the associated costs and the programmatic and economic impact in each unique context have been developed. This cross-country report synthesizes the main insights from four diverse contexts, draws common lessons learned and posits recommendations for future investments, both domestic and external, in digital systems to improve immunization service delivery.

The primary audiences for this summary report are decision-makers and technical staff, such as government health officials, immunization program managers, donors and implementing partners. Other stakeholders, including those from academia and the private sector, including electronic tool developers, may also benefit from the findings and recommendations.

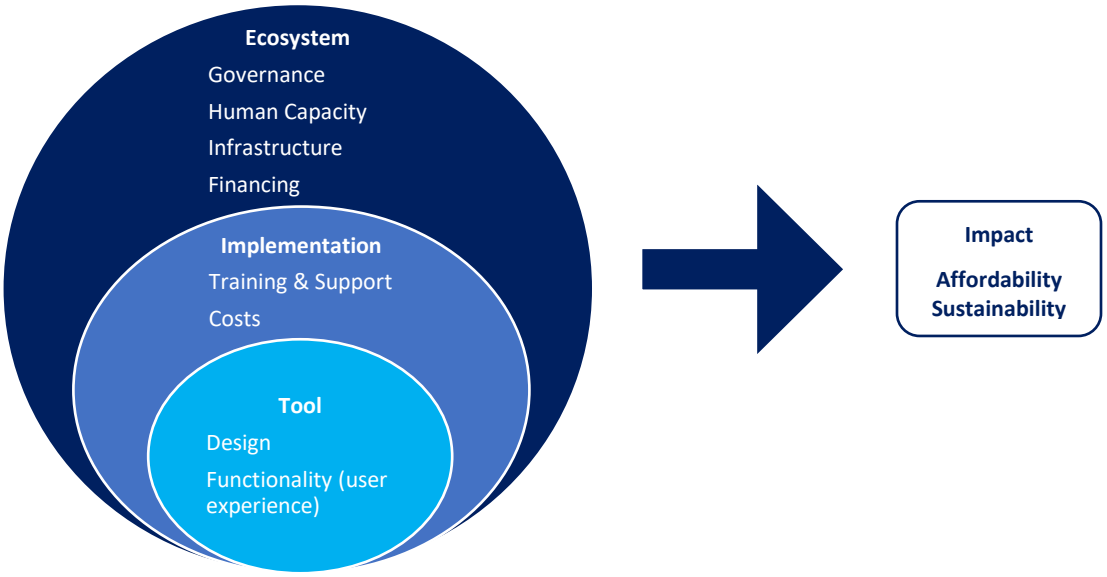
## EVALUATION FRAMEWORK

This evaluation is based on an evaluation framework supported by a Theory of Change (ToC), as depicted in *Annex 1*. According to this framework, implementation and sustained use at scale of eIR and/or eLMIS should improve data quality and data use for decision making, enhance effectiveness and efficiency of health workers (HWs), strengthen the tracking of un- or under-immunized children and increase access to vaccines and supplies. Ultimately, these outputs should contribute to better immunization program performance and result in higher and more equitable immunization coverage. If well-embedded into a country's information architecture, the implementation and sustained use at scale of these electronic tools are expected to be affordable and financially sustainable, therefore an investment providing value for money in the medium to long-term.

The evaluation has been structured to cover the following relevant domains: i) the ecosystem in which these tools are used; ii) design and functionalities of the tools; iii) key aspects of their implementation; iv) their impact from a programmatic and economic perspective; and v) their affordability and sustainability. This is represented in *Figure 1* below.

Each of these domains was explored by addressing a series of more nuanced questions tailored to each country context.

*Figure 1: Evaluation framework*




## METHODOLOGY

### RESEARCH DESIGN

Overall, this evaluation explored both the programmatic and economic impact of the roll-out and use of eLMIS and eIR, adopting a mixed methods approach. Primary and secondary data were collected, and both quantitative and qualitative analyses performed.

Programmatic impact was assessed in terms of input (i.e., hardware, internet, electricity, governance mechanisms, personnel, training), process (i.e., availability of data, data quality, data use) and output (i.e., vaccine stock-outs, wastage, HW satisfaction) indicators related to immunization service delivery. Specific data collection tools were used to gather programmatic information on the use of the electronic tools, infrastructure and workforce requirements, technical competency of users, data quality, impact on immunization program performance and user experience and perception by HWs and their clients. Programmatic data collection instruments were developed or adapted from pre-existing and validated tools including the Modular Data Quality Assessment Protocol with Electronic Immunization Registry Component (PAHO,

2017), a range of data instruments used in the Evaluation of the Better Immunization Data Initiative (Mott MacDonald, 2019); and the eIR Readiness Assessment Tool, jointly developed by WHO, UNICEF, US CDC with support from Gavi.

The economic evaluation aimed to provide an estimate of: i) the upfront financial expenditures at national level of implementing the tools in each country; ii) the routine operating costs of managing data using the tools; iii) the difference in current operating costs for data management using the eIR and/or eLMIS compared to paper-based registries and reporting systems; and iv) the financial affordability and sustainability of maintaining the electronic systems based on each country's economic outlook, current expenditures on health and dependence on external funders. For each objective, a specific methodology was used, as summarized in *Table 1*.

*Table 1: Economic Analysis*

| | **1. Financial expenditures of implementing the eIR/eLMIS** | **2. Routine operating costs of using eIR/eLMIS** | **3. Cost impact of the eIR/eLMIS** | **4. Financial sustainability of the eIR/eLMIS** |
|---|---|---|---|---|
| Scope of the analysis | Design & development and roll-out expenditures of the systems | Routine operating costs related to the management of immunization data and vaccine stock data using the systems | Difference in the operating costs of managing immunization data and/or vaccine stock data with the electronic tool(s) as compared to not using the tool(s) | Affordability of the system in terms of the country's health or Expanded Program on Immunization (NIP) expenditures (total and domestic) |
| Type of analysis | Descriptive analysis | Activity Based Costing analysis | Cross-sectional or before and after depending on implementation status | Operating costs against macroeconomic and immunization-specific indicators |
| Sources of data | Financial reports/data from Implementing partners | Surveys, other in-country secondary data (i.e., from HMIS) | Surveys, other in-country secondary data | International Monetary Fund (IMF), WHO and country report indicators |

An activity-based costing approach (ABC) was employed for the analysis of routine operating costs and data collection instruments were developed to support the ABC primary data collection. The ABC approach consisted of identifying a series of activities performed by the staff of health facilities (HFs) including dispensaries, health centers and district hospitals, tracing direct and indirect costs to these activities and using cost-drivers to calculate a cost per unit of product or service (Udpa, 1996). The activities considered were limited to those related to the management of immunization and vaccine stock data.

Finally, based on the estimated operating costs of using the eIR and/or eLMIS at various administrative levels, and depending on the status of the implementation in each country, simulations were performed to estimate the cost impact of a nationwide systems scale-up (i.e., Tanzania) and/or of progressively transitioning to electronic processes (i.e., Guinea, Rwanda, Honduras).

## COUNTRY SELECTION AND SAMPLING

Following an extensive selection process, four LMICs were identified for inclusion in the evaluation. These countries had rolled out electronic solutions meeting at least some of the basic requirements of an eIR or eLMIS, as characterized by the *Electronic Immunization Registry: Practical Considerations for Planning, Development, Implementation, and Evaluation* (PAHO, 2017) and the Target Software Standards for Vaccine Supply Chain Information Systems (Gavi, 2018), respectively. Additional selection criteria, depending on the country context, included the time and scale of implementation of the tools, geographical (regional) and language or cultural diversity. At the time of the selection, two similar evaluations were already being planned in Pakistan and Vietnam so that the focus for this assessment shifted to Africa and Latin America. The final

selection led to the inclusion of the following systems in four countries: eLMIS in Guinea, eIR in Honduras and Rwanda and combined eIR/eLMIS in Tanzania.

In each of the four countries, a purposive sampling of regions/provinces, districts and HFs was adopted. The following criteria guided the sampling processes of HFs (sampling frame) to achieve a balanced mix of HFs representative of the national use of the tool, as below in *Table 2*.

*Table 2: Selection Criteria*

| | Rationale | Country examples/specificities |
|---|---|---|
| **Implementation status** | To achieve a balanced sample of HFs using (intervention group) and not using the electronic tool(s) (control group), where not implemented nationwide. | In Rwanda, the eIR was rolled out nationally, so assessment of use for sampling was based on frequency of use for reporting of immunization data. Guinea and Honduras first rolled out processes and tools nationally, followed by a partial (either at center or regional level) implementation of the digital components of the systems. |
| **Time from first implementation** | HFs were selected in the intervention group which had been using the tools for a sufficient time to ensure that an effect/ impact could be observed. | Regions in Tanzania which had introduced the tools first and had already been evaluated were selected for comparison. In Guinea HFs which had received training at least 3 months before the data collection were selected to ensure that sufficient time had elapsed between the introduction of the tool and the evaluation. |
| **Health facility geographical distribution** | Different regions and districts were selected to reflect the different state of implementation and conditions and to achieve a balanced mix of urban and rural HFs. | In Guinea only 4 rural HFs had introduced the system at the time of data collection, and this resulted in an over-sampling of urban centers. |
| **Health facility type** | To arrive at a representative sample HFs across selected districts and regions were selected to reflect different conditions of use of the systems (access to electricity and internet, availability of computers, number of personnel and training) | Health facilities selected include dispensaries, health centers and hospitals in Tanzania; public and private HFs in Rwanda; communal medical centers and health centers in Guinea; Integrated Health Centers (CIS) and Primary Health Care Units (UAPS) in Honduras.<br>Access limitations and of security issues were considered in Honduras and Guinea. |
| **Other indicators** | Other programmatic characteristics were considered to ensure that facilities with diverse performance and needs were included. | Other indicators included the size of HF catchment population (Rwanda and Honduras); number of doses delivered per month (Tanzania); DTP3 coverage (Guinea and Honduras); DTP1-3 and DTP1 to MR1 drop-out rates (Rwanda). |

The final samples were considered representative with regards to the above criteria of the overall HFs in the selected regions of each country. The final number of HFs and health offices included in each country are provided in *Table 3*.

*Table 3: Sample sizes*

| | Guinea | Honduras | Rwanda | Tanzania |
|---|---|---|---|---|
| Health Facility | 43 | 80 | 24 | 61 |
| District Health Office | 7 | - | 12 | 30 |
| Regional Health Office | - | 8 | - | 10 |
| **Total** | **50** | **88** | **36** | **101** |

Data were collected across the four countries between October 2021 and September 2022: October and November 2021 in Tanzania, February and March 2022 in Rwanda, April 2022 on Guinea and in September 2022 in Honduras.

## ANALYSIS

The analytical approach varied across countries as we had to adapt the methodology applied to the actual status of implementation and the characteristics of the electronic systems in use. The four countries had approached the implementation of the tools in different ways, and a mismatch had become apparent in some of the countries between aspiration (i.e., a priori expected use) and implementation (i.e., assessed use) of the electronic tools or of the system altogether, with either fewer HFs implementing the tool(s) than anticipated and/or the tool(s) being used only for a few activities with limited scope.

Consequently, where possible, the analysis was based on comparisons between the situation before and after the introduction of the electronic tools (i.e., pre-post), such as in Rwanda and between those HFs which used the electronic tools or electronic components of the systems and those who did not (i.e., users vs. non-users), such as in Guinea, Honduras and Tanzania. Furthermore, in order to respect the specificity of each context, we defined user categories as follows:

Guinea: *Users* included HFs that had implemented the electronic tool (eLMIS), had received trainings at least three months before the evaluation and were actively transmitting reports (whether electronically via eLMIS or its paper version, LMIS). *Non-users* included those HFs which only operated the paper LMIS version.

Honduras: Despite being implemented nationwide, only a small proportion of HFs were equipped to digitize and use eIR data using the SINOVA software. This subgroup was defined as the *user* group. The *non-user* group included HFs that had no direct access to the SINOVA software but were sending paper forms to other HFs or to the regional office where these would be entered into the eIR.

Rwanda: Since the system was implemented nationwide, *users* were considered those "frequently" using the electronic tools and compared to "non-frequent" users. Frequency of use was determined based on responses to a standardized HW survey.

Tanzania: *Users* included those HFs which used exclusively the electronic tools as well as those which use these in parallel with a paper-based system. *Non-users* included those HFs which were no-longer using the electronic tool, or where the tool had never been introduced and which were therefore using paper systems.

Finally, in the countries where it was possible, a further subgroup analysis was performed to compare HFs between urban and rural setting and between different types of HFs.

## SYNTHESIS OF KEY EVALUATION FINDINGS

### Characteristics and status of use of systems

The status of the eIR and/or eLMIS availability and use in each country during the evaluation period is summarized below in *Table 4*.

*Table 4: eIR and eLMIS status across four countries*

| | Guinea (eLMIS) | Honduras (eIR) | Rwanda (eIR) | Tanzania (eIR + eLMIS) |
|---|---|---|---|---|
| **Name** | eSIGL | SINOVA | e-Tracker | TImR (eIR)<br>VIMS (eLMIS) |
| **IT platform** | OpenLMIS | Custom development | DHIS2 Tracker | SanteIMS (eIR)<br>OpenLMIS (eLMIS) |
| **Implementation start date** | 2015 as pilot outside NIP<br>2018 in NIP | 2012 | 2019 | 2014 (eIR)<br>2015 (eLMIS) |
| **Scale** | Paper forms and process: Nationwide<br>Digital: 59/444 facilities (at the time of the evaluation) | Paper forms and process: Nationwide<br>Digital: A regional and municipal level only | Nationwide | 15/26 regions (eIR+eLMIS)<br>Nationwide, down to district level (eLMIS) |

| | | | | |
|---|---|---|---|---|
| | 253/444 as per December 2022 | | | |
| **Implementation status**<br><br>**Note: Electronic data are not the 'official' source of immunization data for decision-making in any country* | Dual paper-electronic reporting process. Paper forms used nationwide at HFs with data digitized in eLMIS if HF had computer available. eLMIS used at district and regional levels, but National Immunization Program (NIP) still reliant on legacy paper/Excel tools (i.e., SMT) | Data digitized either at HF level (mid-level primary care centers) or at regional offices. No electronic tools exist at lower- level HFs. | System used solely by NIP. Varied use at HF level with parallel paper process. Data digitized by data clerks; data entry being transitioned to clinical HWs/vaccinators. Transitioned to fully electronic system on 1 Oct. 2022. | System used solely by NIP. VIMS implemented down to district level; eIR down to HF level providing interface with VIMS. In many instances abandoned; one third of HFs visited anticipated to be using the eR were no longer using it. Parallel paper processes still in place. |
| **Integration and interoperability with other HMIS** | System shared across 9 health programs (5 more to be rolled out). Interoperable with DHIS2 at central level. | System used solely by NIP. No interoperability with eLMIS nor CRVS. | System used solely by NIP. Interoperable with CRVS and RapidSMS (client reminder system) as of 1 Oct. 2022. | System used solely by NIP. eIR and eLMIS interoperable (with challenges). eIR not yet interoperable with CRVS. |

## Main insights from the-cross-country analysis

### ECOSYSTEM

#### *Insight 1: Donor and partner expectations were often not aligned with national objectives.*

As expected, the aims of implementing the electronic tools were different and reflective of the different country settings and goals. However, even more importantly – and perhaps unexpectedly – there were oftentimes mismatched expectations between country stakeholders and programs, donors and technical partners on the intended use, technical potential and expected impact of the tools.

In ***Guinea***, the initial goal of the eLMIS was to monitor performance (i.e., consumption and stock levels) of key medical products including selected vaccines. As such, the system was used to report a limited number of key vaccine indicators. Functionalities linked to vaccine management, such as forecasting and ordering, were not yet available and thus impacted the ability to comprehensively manage the NIP stocks (though roll-out of ordering functionalities is planned for 2023). Nonetheless the NIP program, with support of WHO and UNICEF, plans to continue using the legacy SMT system and to upgrade it to a fully electronic system. This may lead to the existence of two parallel eLMIS tools, which will be interoperable and, in principle, capable of performing the same tasks.

In ***Honduras***, the purpose of the eIR was to obtain better quality and more granular immunization data at the national and regional level to monitor the overall program performance rather than improving the daily work of HWs or the efficiency of activities at the service delivery level. HWs largely did not have access to the electronic component of the eIR and continued to manage the program based on the existing legacy paper-based tools. Furthermore, the lack of integration with the CRVS impacted the ability of program managers to improve defaulter tracking and outreach activities, and ultimately impacting vaccine coverage and dropout levels.

In ***Rwanda***, there was a stated desire to use the eIR to facilitate the identification and tracking of zero-dose children. The country planned for integration with the CRVS at the outset, but this was not in place at the time of data collection. Similarly, while HFs have initially been equipped with the infrastructure to fulfil responsibilities with electronic tools, some of the electronic materials (i.e., tablets) had been repurposed for the COVID-19 response. A full tracking or reminder system of defaulters is, thus, yet to be implemented.

In ***Tanzania***, where both the eIR and eLMIS met the basic requirements of "ideal" systems, the tools were designed and developed independently, and requirements not consistently aligned. Synchronization challenges between the tools at the HF level have resulted in some tools being inaccessible and forced HWs to abandon their use.

While all countries had national strategies that promoted digitalization, there were various models of digital health governance and policies in place. This is most poignantly reflected in the countries' differing approaches to integration and interoperability, with Guinea integrating its eLMIS across many health programs (i.e., HIV, malaria, immunization, etc.), Tanzania trying to integrate its eIR and eLMIS tools within the immunization program, and Rwanda attempting to achieve interoperability between the eIR and the CRVS integration. Interoperability of the eIR has not been a priority in Honduras. Decisions regarding integration and interoperability reflect the varying government priorities and potential donor priorities influencing requests for financial support. Overall, it seems as if the utility and feasibility of integrated/interoperable tools for the daily work of HWs at the service delivery levels has, unfortunately, not been the primary focus of any of the country decisions on digitalization.

### *Insight 2: Funding streams and implementation strategies determined the degree of dependence on external support.*

The evaluation revealed a spectrum of governance mechanisms, funding sources, policy environments and political support structures for the introduction and implementation of the tools, with a general overreliance and dependence on external partners and support (e.g., funding and technical assistance). This was perceived to potentially distort priorities and goals, as well as hamper the long term financial and operational sustainability of the systems.

> "I didn't know I was supposed to continue using the tool. I thought it was an external partner project and that it was over."
>
> *– Health Facility, Tanzania*

For example, Tanzania's reliance on an external eIR developer resulted in the government not being able to respond to users' requests for fixing technical glitches. At the same time the external server was reaching capacity which was impeding data processing. At the time of writing, neither the eIR or the eLMIS were accessible and the MoH was unable to further contract the external eIR developer, resulting in the MoH considering the adoption of a new tool.

As with many other LMICs, Guinea was heavily reliant on external funders and technical partners for the ongoing implementation and operation of the eLMIS. However, the technical partner developing the tool used local personnel and with the active involvement of MoH staff created the conditions for full independence, at least on the technical side, from external support. Unfortunately, technical immunization partners and some government directorates appear not fully aligned on an integrated digitalization strategy and are pursuing the implementation of a separate eLMIS tool in support of the NIP with resulting duplication of information flows, thereby threatening a comprehensive adoption of the eLMIS across all health programs.

In contrast, although Rwanda also relied upon financial and technical support for implementation of its system, the government exerted strong ownership making wide-ranging decisions towards the full digitalization of the eIR and putting an end to the parallel paper system. It leveraged local capacity to implement the eIR and is independent of external support to maintain its eIR.

Honduras seems to have rolled out SINOVA in replacement of a very similar legacy system as part of a regional drive towards digitalization. The tool was developed using internal technical resources and by leveraging external funding. Unfortunately, the goal of the implementation was minimal and with the ambition limited, at least at outset, to providing an improved reporting system rather than of improving the immunization program performance. Government ownership in this case did not translate in a meaningful contribution to the immunization program.

### *Insight 3: Constraints in access to infrastructure significantly impeded the adoption and sustained use of electronic tools.*

Better access to infrastructure facilitated better use of the tool. However, across all countries, access to the internet, electricity and to sufficient hardware hindered tool adoption, irrespective of rural or urban location, as below in *Table 5*.

> "When the internet connection is good, using the tablet is quicker than paper."
>
> *– Health Facility, Tanzania*

*Table 5: % of users with sufficient access to infrastructure (internet, electricity, and hardware)*

| User type | Rwanda | Tanzania | Guinea | Honduras* |
|---|---|---|---|---|
| **Non-User** | **67%** | **52%** | **29%** | **15%** |
| Rural | 60% | 56% | NA | 12% |
| Urban | 70% | 49% | NA | 18% |
| **User** | **81%** | **84%** | **39%** | **27%** |
| Rural | 80% | 79% | NA | 28% |
| Urban | 82% | 88% | NA | 26% |

** CIS = urban, UAPS = rural / % = centers that have at the same time a computer (hence electricity and access to internet)*

> "It will be too risky to use tablets when outside the health facility; the risk of theft is too high."
>
> *– Health Facility, Honduras*

Infrastructure limitations greatly diminished the potential impact of the implementation of the electronic tools. Both in Honduras and Guinea, lack of hardware prevented the provision of real-time information and inhibited the elimination of paper forms. Poor internet connectivity hindered the ability of the systems operating in the cloud (i.e., of district and regional levels providing real-time input and support). It also impacted data security requiring local back-up of data. Finally, intermittent access to electricity was a major obstacle which suggests that portable hardware (e.g., laptops or tablets) would have been a better choice for the standard hardware, to allow for continuity of operations.

## TOOLS

### *Insight 4: Technical limitations and design choices were a significant barrier for wider use.*

While the focus of this evaluation was not on the technical aspects of the tools' design and functionality, technical limitations were noted to be a significant barrier to use of both eIR and eLMIS.

> "The district is using the eIR + eLMIS in immunization services but the system is not stable, so they have introduced data templates in excel format to avoid losing data."
>
> *- District, Tanzania*

> "Easy to use and ensures consistence of data but hampered by network problems and insufficient staff."
>
> *– Health Facility, Rwanda*

Two main design approaches were adopted: (i) adaptation of existing open-source platforms, as in the case of the eLMIS in Guinea and Tanzania which were built off the OpenLMIS platform – or for the eIR in Rwanda which was built off DHIS-2 and (ii) design of bespoke solutions, as for the eIR in Honduras and Tanzania. Regardless of the platform used, almost no direct data entry was taking place at the service delivery point in any of the four countries. For example, most of the lower-level and almost half of the higher-level HFs in Honduras did not have access to hardware to perform data entry in real-time. Similarly, Rwanda was still largely relying on data back-entry by data clerks at the HF level until 1 October 2022 when the parallel paper process was officially removed. HWs in Tanzania were only able to perform direct data entry when the tool was fully functioning, which was reportedly infrequently. In some instances, this resulted in HWs in Tanzania purchasing personal notebooks to again capture immunization events on paper. Finally in Guinea, the digitization was mostly taking place at district level.

Lack of access at the service delivery point proved especially problematic for the eIR in Honduras, preventing HWs to use the systems to support immunization activities by proactively identifying defaulters, performing effective follow-up activities, or improving the quality of campaigns and outreach sessions. Additionally, the lack of any interface with the CVRS inhibited the ability of the eIR of identifying zero-dose-children, as registries would contain only children who have showed up in a HF to receive their first dose. At the same time, because CVRS entries were often delayed between a few months to a year, unless birth records were updated within the first 6 weeks, the first series of pediatric vaccines (i.e., Pentavalent, Pneumococcal, Rotavirus) would not benefit from eIR support.

Lastly, for maximum use, both tools should be designed having in mind the full range of indicators required for operating the NIP, and existing indicators should be reflected in any new tools to ensure full user buy-in. This has not been the case of the

eLMIS in Guinea, for example. The phased approach across multiple programs has resulted in the absence of specific indicators and functionalities required for vaccine management (i.e., indicators necessary to carry out ordering and forecasting functionalities). While there are plans for those shortcomings to be eliminated with the next phases of the roll-out, this situation has prevented the eLMIS from replacing the legacy information processes and systems used by the NIP.

## IMPLEMENTATION

### *Insight 5: Training of users was perceived as inadequate, despite a high level of user satisfaction.*

> "e-Tracker speeds up our work and gives us the information we need easily."
> *– Health Facility, Rwanda*

Despite the functional shortcomings, HWs were overall satisfied with the electronic tools, as summarized below in *Table 6.* They considered them to be user-friendly and reportedly contributing toward improvement of the work environment. However, the tools were not yet seen to be consistently contributing to efficiencies in daily work due to the continued parallel use of paper and electronic systems. For example, in Honduras, the new form SINOVA-1 (nominal) used to capture vaccine recipient and caregiver information to be then digitized in the SINOVA software which mirrored almost completely the existing LINVI tool, necessitating HWs to input the same data twice. In many instances, across all countries, additional staff were required, or staff had to be reorganized to respond to the additional needs of these dual systems. No significant differences between rural and urban users were noted.

*Table 6: User satisfaction at HF level (%)*

| User type | Rwanda | Tanzania | Guinea | Honduras |
|---|---|---|---|---|
| **Non-User** | **38%** | **64%** | **17%** | **78%** |
| Rural | 55% | 69% | NA | 78% |
| Urban | 28% | 58% | NA | 78% |
| **User** | **67%** | **93%** | **79%** | **83%** |
| Rural | 67% | 90% | NA | 100% |
| Urban | 67% | 95% | NA | 80% |

> "…users are competent in using the system, however they were unable to generate the defaulter report, so we asked the district supervisor to retrain them."
> *– Health Facility, Tanzania*

Successful implementation of these systems necessitated intentional and targeted support. While the majority of HWs felt comfortable with their level of digital literacy and showed interest in working with electronic tools, almost all HWs did not feel sufficiently trained to properly carry out their responsibilities, again, with little notable difference between rural and urban users, as below in *Table 7*. HW competency assessments revealed greater proficiency in data entry activities, than in generating and interpreting reports.

*Table 7: Perception of being adequately trained on electronic tools (HF %)*

| User type | Rwanda | Tanzania | Guinea | Honduras |
|---|---|---|---|---|
| **Non-User** | **38%** | **57%** | **57%** | **66%** |
| Rural | 0% | 18% | NA | 64% |
| Urban | 40% | 22% | NA | 68% |
| **User** | **63%** | **43%** | **89%** | **37%** |
| Rural | 33% | 43% | NA | 26% |
| Urban | 17% | 50% | NA | 71% |

### *Insight 6: Supportive supervision and direct personal assistance raised attention on data quality.*

Supportive supervision, including technical software and hardware support and direct personal assistance from district or regional levels, were seen to positively impact tool adoption and use. For instance, in Guinea, direct data quality checks during routine supervision were positive elements in reinforcing the correct use of the eLMIS and establishing QA/QC processes. Supervision activities were also seen to have benefited from the use of the tools, with many HWs reporting that supervision

had improved since their introduction, including informing the content of supervision, providing, and receiving feedback, and the tracking of supervisory feedback, as below in *Table 8*.

Users were also more likely than non-users, including those using the tools less frequently or who had abandoned the use of the tools, to appreciate the quality of IT support received for tool implementation.

*Table 8: Perception of helpful supervision in supporting use of the electronic tool/s (HF) (%)*

| User type | Rwanda | Tanzania | Guinea | Honduras |
|---|---|---|---|---|
| **Non-User** | **32%** | **64%** | **NA** | **68%** |
| Rural | 80% | 71% | NA | 64% |
| Urban | 22% | 75% | NA | 72% |
| **User** | **68%** | **93%** | **NA** | **93%** |
| Rural | 88% | 90% | NA | 100% |
| Urban | 100% | 95% | NA | 91% |

### *Insight 7: A policy driven, time-bound roll-out strategy supported sustained adoption of the electronic tools.*

All four countries had different tool implementation experiences. Rwanda was able to implement the eIR rapidly at a national scale, though efforts were thwarted by the COVID-19 pandemic. Honduras, similarly, implemented its eIR at national scale, using a stepwise approach that rolled-out the system between 2012 and 2019, though the system was still not available at lower-level HFs. By comparison, Tanzania opted for a stepwise roll-out of the eLMIS, which has to date been introduced in all districts and regions, and of the eIR, which was in use in 15 regions at the time of the evaluation. The eLMIS in Guinea had also been introduced in a phased manner.

While no implementation plan will suit all countries, there is a consistent need for decisive policies and costed transition plans to support the practical shift from a paper to fully electronic system at the outset. The experience across all four countries demonstrates that parallel systems (i.e., paper and electronic systems) are both burdensome, costly and, ultimately, inefficient and ineffective.

The findings of this evaluation provide no clear evidence supporting one implementation approach over another. While a phased approach presents the opportunity for iterative, adaptive learning and course correction, it may hinder the more robust rollout and scale up. In Tanzania, while several subnational pilots were done, the overall implementation experience was less than optimal with several regions and districts having abandoned the use of the tools. The value-add of pilot introductions, particularly in small geographical areas, has not been immediately evident. On the other hand, an immediate full rollout as done in Rwanda has equally left a few HFs struggling with the use of the tools. A phased, but time-bound, approach could be conceived as a useful middle ground, as the tools require a critical mass to be fully beneficial, particularly in the case of eIRs where data shared between HFs could improve the daily experience of HWs and potentially the beneficiaries and caregivers.

Beyond the scale of introduction, the need emerged for decisive policies and costed transition plans to support the shift from a paper to a fully electronic system at the outset. The experience across all four countries shows that parallel systems (i.e., paper plus electronic systems) are burdensome and costly and thus inefficient and ineffective.

## IMPACT

eIR and eLMIS are complex interventions whose efficacy and effectiveness in terms of immunization outcomes are mediated by a variety of contextual factors. Establishing a causal link between use of the tools and immunization outcomes is particularly challenging and requires the use of robust methodologies. However, it was not possible to clearly identify such links in any of the countries evaluated. This was mainly due to a lack of suitable data for using quasi-experimental approaches and the onset of the COVID-19 pandemic which acted as an important confounder, especially in those countries where implementation of the tools was more recent. Simple observation of variations in immunization outcomes before and after the implementation of the tools was deemed as inappropriate and, therefore, the impact of the eIR and eLMIS on the uptake of vaccines and other immunization outcome measures was not directly evaluated. Instead, the analysis focused on process and output measures related to immunization data management (i.e., data quality and data use for decision-making).

Improvements in such process indicators may ultimately result in changes in immunization outcome indicators such as coverage, timeliness and drop-out rates.

### *Insight 8: Perceived data quality improved with the use of the tools.*

There was a shared perception among HWs that data quality (i.e., data accuracy, completeness, timeliness, and visualization) had improved since the introduction of the tools, as summarized in *Table 9,* though evidence to support this was limited. On the other hand, abundant data backlogs negatively impacted data completeness and, overall, paper registries were still considered the most reliable source of data across all countries, particularly at the HF level. Only if access to data and tools was more reliable, such as at higher system levels (e.g., district and regional offices) would data derived from electronic tools be considered to be reliable. On-site data accuracy assessments suggested that the most unreliable data were found in a dual system and that accuracy was greatest in environments which were exclusively electronic or exclusively paper. For example, in Honduras, inconsistencies between the legacy nominal tool LINVI and the SINOVA-1 nominal paper form and the electronic report were indicated as problematic in the HF not digitizing locally (i.e., not undergoing a regular data QA/QC). On-site accuracy checks between different sources of data, confirmed that the more frequent the electronic tools were used, the more accurate were the data entries. This reiterates HWs convictions that electronic tools had the potential for improving data quality, but that inconsistent tool access and policy decisions to not remove paper processes impeded their long-term adoption.

*Table 9: Perception of improved information quality at HF level (%)*

| User type | Rwanda | Tanzania | Guinea | Honduras |
|---|---|---|---|---|
| **Non-User** | **33%** | **58%** | **70%** | **82%** |
| Rural | 33% | 67% | NA | 84% |
| Urban | 33% | 50% | NA | 80% |
| **User** | **71%** | **91%** | **78%** | **97%** |
| Rural | 70% | 91% | NA | 96% |
| Urban | 72% | 91% | NA | 100% |

### *Insight 9: Data for decision-making was limited at the service delivery level.*

Different factors impacted the ability of the systems to influence program decisions. For both systems, there was limited use of electronic data for analysis and interpretation, as well as limited use for decision-making at the lower health system levels.

> "The electronic tool simplifies work, as there is currently no need to prepare reports because the data can be accessed through the system."
>
> *– Region, Tanzania*

While the eLMIS in Tanzania was used for active stock management, the eIRs and the eLMIS in Guinea ended up being mainly used for reporting purposes. In Guinea, missing critical indicators (e.g., average stock levels and reordering times) and processes (e.g., ordering and forecasting) in the system design prevented the use of the eLMIS as active tool for vaccine management even if the more accurate data on consumption and stock levels were considered as very useful. In Honduras, the absence of computers and the continued reliance on the legacy paper tools (e.g., LINVI) prevented SINOVA to be used as a decision-supporting tool.

On the other hand, at the higher levels of the health systems, there was a perception of being better equipped to identify performance gaps, with users reporting improvements in the quality of decisions made since the introduction of the tools. Electronically generated data also increasingly guided supervisory activities (see above) and contributed to a virtuous cycle: better data quality led to improved data use which led to improved data generation.

### *Insight 10: Use of an eIR positively impacted certain service delivery processes.*

Target population estimates were not impacted by using an eIR in the countries evaluated due to the lack of interoperability with a CRVS and the inconsistent use of the tool at the HF level. In Honduras, data were sourced directly from the statistical office and leveraged legacy paper immunization registries (LINVI) with no use of SINOVA. Nevertheless, users saw benefits of the eIR in supporting the estimation of drop-out

> "In the past the outreach session was done only once, but by using the electronic data from the system the sessions were now increased to three."
>
> *– Health Facility, Tanzania*

rates, informing defaulter tracking and in supporting the planning and implementation of outreach services. These perceived benefits were, however, limited due to the constrained use of the tool. In Honduras, the roll-out of the SINOVA process led to the inclusion of caregiver contact data as part of the information collected, which was not the case with the older system. While mostly captured only on the paper form, this information was seen as the most important contribution of the new system to the operation of the immunization program.

Similarly, users were more likely than non-users to state that the eIR helped track individuals outside of their catchment areas, to identify children that were registered at a different facility and to generate a list of defaulters.

> "The eIR makes the job easier by helping children to be vaccinated and reducing dropouts and paperwork; it reduces the budget and increases the quality performance of immunization activities."
>
> *–District, Rwanda*

While historically the eIR in Tanzania sent reminders, this functionality was no longer available at the time of the evaluation. SMS reminders were, however, considered effective by HWs who had experience using them to notify caregivers of upcoming or missed vaccinations. Interoperability with SMS messaging in Rwanda had not yet been implemented.

> "… the system is good but sometimes it takes us longer to complete our work and that makes parents unhappy with the service, as they wait so long…"
>
> *– Health Facility, Tanzania*

Although limited, there was some evidence to suggest that caregivers found HFs which used the tool to be more organized, with less waiting times, as show below in *Table 10*. It was also reportedly easier, in some instances, to search for a child if the caregiver did not bring their vaccination card. Conversely, when the tool was not working optimally, or in instances of a dual system, caregivers found the tool to increase waiting times.

*Table 10: Experience of caregivers in HFs using an eIR*

| | Rwanda (n=57) | Tanzania (n=30) |
|---|---|---|
| Waiting times are less | 28% | 73% |
| Waiting times are more | 11% | 13% |
| The facility is more organized | 28% | 10% |
| It is better than when they just used the paper tools | 35% | 10% |

### *Insight 11: Use of an eLMIS positively impacted vaccine management.*

Users reported that the eLMIS assisted in achieving more quality and transparency in consumption and stock levels data, hence improving decision making on vaccine management.

> "When TImR (and VIMS) was working, stock management was easier, and it took less time to accomplish everything."
>
> *– Health Facility, Tanzania*

In Tanzania, the eLMIS allowed automatically calculating stock balances, generating monthly reports, ordering new supplies, and speeding up the process of receiving and putting-away of vaccine supplies. Users of the fully electronic system in Tanzania were less likely to have experienced vaccine stock-outs than non-users. Over a three year-period, regions using the fully electronic system experienced the least number of stock-outs, compared to those with only the eLMIS, and those with a parallel paper system, as below in *Table 11*.

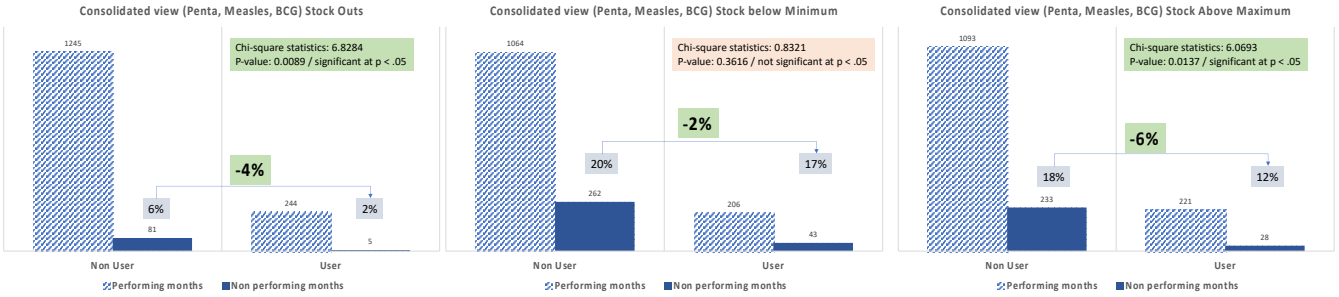
*Table 11: Average number of stock-outs, Tanzania (regional level)*

| | 2019 | 2020 | 2021 | Average |
|---|---|---|---|---|
| **eLMIS (n=6)** | 3,4 | 3,9 | 4,2 | **3,8** |
| **eLMIS + eIR + paper IR (n=1)** | 1,8 | 5,3 | 8,1 | **5,1** |
| **eLMIS + eIR (n=3)** | 3,4 | 3,9 | 2,3 | **3,2** |

In Guinea, while vaccine and stock management activities remained based on the NIP's legacy system SMT (i.e., excel and paper based), the roll-out of the eLMIS led to more complete and accurate data to be captured, a more robust QA/QC process and the more regular inclusion of vaccine consumption and stock data in the supervision activities. The use of eLMIS appeared

to be linked to improvements in stock levels for the three vaccines analyzed (i.e., BCG, Pentavalent and Measles), as demonstrated in *Figure 2* below. There was also a reduction in the number of stock-outs and in the number of months in which centers had stock levels outside the appropriate range for these vaccines. This impact was reinforced in health centers where supervision activities included a review of eLMIS data. Since full vaccine management process was not yet part of the eLMIS, those improvements were considered an indirect effect of the use of the system.

*Figure 2: Improvement of stock levels in Guinea – difference in number of non-performing months (i.e., months with stock out/above or below target thresholds) between users and not-users – consolidated view (BCG, Pentavalent, Measles)*




## COSTS OF EIR AND ELMIS

### *Insight 12: There was mixed evidence on the cost-saving potential of both electronic tools.*

The **upfront investment** for the design, development and roll-out of the systems was mostly covered by external donors and was driven by hardware and training costs. In terms of their design and development, notably higher costs were observed for the bespoke or highly customized tools in Tanzania (International dollars -I$- 8 M combined), while considerably lower costs were observed for Rwanda and Guinea who opted for off-the-shelf solutions, as summarized in *Table 12* below. In Honduras, a single programmer was contracted for the design and development of the eIR. Note, the investments reported here represents the expenditures by the Government and probably underestimates the true cost of developing the system. Furthermore, regarding the roll-out, Tanzania incurred substantially higher costs for the eIR as this was implemented down to the HF level, while the eLMIS down to district level. Overall, Guinea incurred the smallest upfront costs per HF for the implementation of the eLMIS down to HF level, which can be attributed to the fact that it is a multi-program tool which allowed significant economies of scope to be achieved.

*Table 12: Upfront investments for the implementation of the eIR and eLMIS per country, in I$ 2021*

| Country | System | Design & Development | Roll-out | Total | Total cost per HF |
|---|---|---|---|---|---|
| Honduras | eIR | 33,949 | 5,399,946 | 5,433,894 | 4,393 |
| Rwanda | eIR | 317,649 | 4,411,877 | 4,729,526 | 8,725 |
| Tanzania | eIR | 3,968,986 | 21,768,297 | 33,009,132 | 9,926 |
| | eLMIS | 3,826,829 | 3,445,021 | | |
| Guinea* | eLMIS | 639,105 | 1,067,563 | 1,706,667 | 3,843 |

** The eLMIS costs apportioned to the NIP correspond to 6.5% of the total cost (reflecting 12/185 of the tracer-products managed through the system for the NIP). Labor costs are excluded.*

The **routine operating costs** of the electronic systems and the **cost impact** of the use of digital tools compared to performing data management activities using paper tools are summarized in *Table 13*. Labor costs accounted for most of the operating costs across all countries. The organization of outreach immunization sessions was the costliest activity in Tanzania, while report generation and transportation were the main cost drivers in Guinea. In Honduras and Rwanda, child registration was the costliest activity, which included digitization of data first captured in paper forms. With respect to their location, a subgroup analysis of HFs using the electronic tools showed that urban HFs in Rwanda and Tanzania had lower routine operation costs for data management compared to rural HFs. Such a comparison was not possible to be drawn in Guinea and Honduras, as at the time of the evaluation only 4 rural HF had the eLMIS in Guinea and no rural HF in Honduras had the eIR installed.

*Table 13: Routine operating costs and cost impact of the eIR and eLMIS at HF level per country, in I$ 2021 (95% CI)*

| Country | System | Annual operating cost^ of users of electronic systems | Cost impact per HF compared to non-users of electronic systems | Affordability, % of annual immunization expenditures (% domestic expenditures)[p] |
|---|---|---|---|---|
| Honduras | eIR | 5,342 (4,753; 5,930) | 535 (441; 702) | 15% (16%) |
| Rwanda | eIR | 1,211 (1,047; 1,376) | 278 (75; 482) | 1.1% (9%) |
| Tanzania | eIR+eLMIS | 4,002 (3,166; 4,835) | -1,770 (-2,990; -550) | 6.5% (11.3%) |
| Guinea | eLMIS | 679 (188; 1,170)* | -36 (-176; 102) | 1.9% |

*^ Cost of performing immunization and/or vaccine stock data management activities. [p] Domestic expenditures on immunization based on secondary sources such as national financial documents and Comprehensive Multiyear Plans (cMYPs)*
**Exception: The annual operating cost in Guinea considered only the LMIS/eLMIS process and excluded the NIP legacy information flow, thus representing an incremental cost to the latter.*

There was mixed evidence on the **cost impact** of introducing these systems. Compared to the use of paper registries alone, the cost of managing immunization and vaccine stock data with the electronic tools was found to be higher in Honduras and Rwanda, lower in Tanzania and almost negligible in Guinea.

Notably, in three of the four countries, the implementation of a new process inclusive of electronic tools, was additional to the existing paper-based processes that remained in place with some adjustments (i.e., in Guinea, the excel/paper-based process remained totally independent). This duplication of processes resulted in higher costs for data recording compared to the paper registries with the only exception of Tanzania. However, in Guinea, these higher costs were offset, compared to the one incurred in centers operating the paper-based process of the new eLMIS, by reduced costs for report transportation and printing. Furthermore, in Tanzania, avoided costs were captured from activities such as more efficiently delivering outreach sessions and not needing emergency vaccine replenishments, an improvement in the processes that may have benefited from the improved availability of good quality data through the electronic systems.

> In Tanzania, the savings generated over time - as estimated in this evaluation - would recover the initial investment after a relatively short amount of time (8 years), after which using the tools would start to free up NIP resources. This could result in a positive indirect effect on immunization outcomes.

This evaluation suggests that the cost impact of the introduction of electronic systems and the potential for these systems to generate cost savings were linked to whether paper-based processes were maintained in parallel with electronic processes, and to the extent to which the data generated by electronic systems were used to support the daily activities of frontline HWs.

## AFFORDABILITY AND SUSTAINABILITY OF EIR AND ELMIS

### *Insight 13: Affordability and sustainability were directly proportional to the level of actual use of the electronic tools.*

The annual total operating costs of managing immunization data using eLMIS and eIR accounted between 1.1% and 15% of the total immunization expenditure. Therefore, these costs appear as **affordable,** even in contexts where the paper processes have not been eliminated and where duplication of processes still are in place. Furthermore, the results from the **simulation exercises** suggests that cost-savings of up to 40% of the costs for data management incurred currently can be achieved with the systems nationwide scale up and with the elimination of the paper-based processes. Overall, scenario simulations in all countries suggest that if the electronic tools were used as the primary source of information, managing immunization and vaccine stock data by electronic means would be cheaper than with paper-based systems, even if maintaining the latter exclusively as back-up.

However, achieving such savings is possible only if investments are dedicated to strengthening the ecosystem where eIR and eLMIS are rolled out (i.e., infrastructure and local capacity), enabling greater sustainability. Uncoordinated and/or siloed investments in the tools or specific parts of the ecosystem are unlikely to realize the programmatic and financial impact observed in this evaluation.

Importantly, the **macroeconomic situation** did not noticeably influence any decisions on the scale-up and maintenance of the systems as these were mainly supported by external sources (i.e., BMGF, Gavi, USAID, JSI and WHO), though affordability and sustainability were determined to be linked to political will. The findings of this evaluation suggest that at present there is insufficient financial planning and budgeting for transition to domestic ownership and maintenance of the tools.

## LIMITATIONS

This evaluation was originally planned for the period 2020-2021. The **COVID-19 pandemic** caused a delay of more than one year in the performance of the field data collection and affected multiple aspects of the analysis: firstly, the performance of the immunization programs; secondly the roll-out of the tool in the countries where this was ongoing; and thirdly the use of the system, particularly in view of HW constraints, who were prioritizing COVID-19 response. With routine immunization services severely impacted during the first two years of the COVID-19 pandemic, it became practically impossible to determine whether the electronic tools had impacted any of the main immunization outcome indicators such as coverage, drop-out, stock level and timeliness. In addition, direct conclusions on whether electronic systems were cost-effective were not possible to be drawn due to the reported difficulties in measuring the impact on immunization outcomes.

The timing of the evaluation also presented challenges affecting the scope of the analysis. In Rwanda, the system did not reach the full scale-up state and the complete transition to electronic. In fact, it was only after the evaluation that the decision to remove the parallel paper-based system was implemented, which hampered the possibility to evaluate the system at its full scale. Similarly, in Guinea, the timing of the evaluation coincided with the scale-up of the roll-out of the digital functionality of the system, allowing only for a very limited measurement of the impact on output indicators (e.g., stock levels and stock out) in the few HFs already operating with the electronic tool. Furthermore, the roll-out of ordering and forecasting functionalities was still pending at the time of the data collection, making the scope of the evaluation limited to only a portion of the eLMIS functionalities.

In terms of data, data availability was also a constraint when attempting to adopt more robust approaches such as quasi-experimental methods. In most countries, pre-roll out data on relevant indicators, such as timeliness of vaccination, was not existent or estimated with much higher impreciseness which limited their usability. In addition, the primary data collection often reflected perceptions reported by HWs, both for the programmatic data and many of the economic components. To reduce the resulting recall bias, triangulation of primary data sources was done across levels of the health system where possible. In addition, alternative secondary sources were explored to increase the validity and reliability of the estimates obtained from primary data sources. Complete official financial data for the economic analysis were specifically challenging to obtain in some countries, necessitating the use of budget and proxy data in conjunction with additional assumptions in the estimation of the economic impact of the electronic tools.

Finally, the use of purposive sampling may have led to imbalances in the sample, although care was taken to select HFs to be representative of the entirety of HFs offering immunization with regards to several a-priori criteria. The evaluation is characterized by sample sizes which are comparable to those of similar primary research conducted on eIR and eLMIS or on immunization costing studies in LMICs.

## RECOMMENDATIONS

Investments decisions must be made in the context of the overall country and the specific aims of the NIP. However, an inability to meet a set of criteria for success, as well as a lack of clarity on specific goals for the introduction of these tools, should be seen as a warning that investments might be at risk of not delivering the expected results.

As governments and health financing institutions make investment decisions about the introduction and scale-up of eIR and eLMIS, we recommend using the following **checklist,** which reflects key insights from this evaluation, to guide the process:

- A national digital health policy is in place which will favor the introduction and scale-up of the tools.
- There are adequate investments in IT infrastructure, including the necessary hardware (plus maintenance), electricity and internet connectivity, in the targeted geographies for the introduction and scale-up of the tools.

- A use case for the tools is clearly articulated and reflected in their design (i.e., if reaching zero-dose children is a priority, the eIR must be interoperable with the CRVS).
- The design of the tools includes the potential for integration and/or interoperability with the existing health management information system.
- Local capacity, expertise and resources are leveraged across all phases of the design, adaptation, implementation, maintenance and updates of the tools, with minimal to no reliance upon external support.
- The MoH has a clear operational plan for quickly phasing out any legacy parallel paper system with the introduction of the tools.
- There are adequate investments in the training and supervision of frontline health workers to use the hardware and software.
- There are adequate investments in building the capacity across the health system for data analysis and use.
- Monitoring and evaluation activities are planned at the outset of implementation, as well as continued once the tools are fully scaled up with all functionalities.

Having a set of criteria for success like in the above checklist will support evidence-based decision making and ensure that investments in these tools take into consideration the many learnings to date and reflect the current guidance available on eIR and eLMIS, respectively.

## CONCLUSIONS

Despite notable differences between an eIR and eLMIS in terms of how they are used and how their impact can be evaluated, this evaluation suggests that greater use of these electronic tools for decision support through an integrated, cross-programmatic approach could assist in better managing immunization programs, as well as health systems more broadly. With the elimination of paper processes, use of the electronic tools could generate significant savings and improve the use of resources, increasing the likelihood for these interventions to be cost-effective. Investments in promoting the uptake and use of the electronic systems could be a good value for money and may be offset by the savings resulting from such enhancement.

However, the inability to meet a set of criteria for success, as well as a lack of clarity on specific goals for the introduction of these electronic tools, should be seen as a warning that investments might be at risk of not delivering the expected results. This evaluation has highlighted several limitations of the current use of the tools across each country. Unless these shortcomings can be addressed, funding through national or international immunization budgets would not be recommended and other interventions with more direct impact on immunization outcomes should be prioritized.

More research is needed to understand whether removing barriers of implementation and promoting use of these systems to inform decision-making would enable immunization programs and health systems more broadly to achieve improved immunization outcomes. Given the challenges of evaluating electronic tools, in those countries planning to implement or scale-up such systems, monitoring and evaluation activities should be carefully planned at the onset of implementation, as well as continued once the systems are fully scaled up with all functionalities. This type of adaptative learning will allow for course correction to ensure that the tools are used for maximum impact.

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## ANNEXES

### *Annex 1: Theory of Change*

| | | |
|---|---|---|
| Vision | Reduce morbidity and mortality from VPDs by enhancing equitable access to vaccines and strengthening immunization delivery within PHC | |
| Mission | Improve immunization program performance by sustained use of the electronic systems:<br>• eIR: equitable coverage and system efficiency<br>• eLMIS: vaccine availability and equitable access; logistics management efficiency | |
| Strategic Outcomes | eIR | eLMIS |
| | • Functioning eIR as part of a broader health information system<br>• Improved immunization data quality<br>• Increased use of immunization data for decision-making<br>• More efficient, affordable, and sustainable eIR use<br>• Increased stakeholder satisfaction and engagement | • Improved eLMIS functionality<br>• Improved vaccine forecast accuracy<br>• Improved inventory and stock levels<br>• More efficient, affordable, and sustainable eLMIS use<br>• Increased stakeholder satisfaction and engagement |

### *Annex 2: Research Questions*

- Can eIR and eLMIS systems in LMICs improve immunization service delivery? *[Impact]*
  - To what extent do these systems comply with established norms and standards? *[Tool]*
  - What are the barriers and opportunities for implementing these systems? *[Ecosystem, Implementation, Tool]*
  - What is the impact of these systems on national immunization programs (i.e., cost saving, efficiencies, timeliness, coverage)? *[Impact]*
- What is the short- and medium-term economic and financial impact of implementing and scaling-up eIR and eLMIS in LMICs? How affordable and sustainable are these systems? *[Impact, Affordability and Sustainability]*
- How interoperable are eIR and eLMIS with health information management and civil registration systems? *[Ecosystem, Tool]*
- How can new evidence on tools and technologies, modalities, and governance of eIR and eLMIS inform investments by countries, health financing institutions and technical partners for the sustained implementation of these systems? *[Ecosystem, Impact, Affordability and Sustainability]*

### *Annex 3: Indicators informing Tables*

**Access to infrastructure at HF level (%)**

My facility or office has a connection to the internet that is adequate for us to effectively use the <<electronic tool>>

My facility or office has consistent access to electricity that is adequate for us to effectively use the <<electronic tool>>

I can access computers/tablets/smartphone in my workplace when I need them to use the <<electronic tool>>

**User satisfaction at HF level (%)**

Overall, I am satisfied with the <<electronic tool>>

The <<electronic tool>> is easy to use

I can finish my tasks faster by using the <<electronic tool>>

The <<electronic tool>> improves my productivity / makes me more effective

The <<electronic tool>> has a positive impact on the quality of my work

I am confident that the <<electronic tool>> makes immunization services better

I trust that the data in the <<electronic tool>> will not be lost

I think that caregiver's satisfaction has improved since we have started using the <<electronic tool>>

**Perception of information quality at HF level (%)**

The <<electronic tool>> provides sufficient information to enable me to do my tasks

I am satisfied with the accuracy and completeness of the vaccine stock and immunization records in the <<electronic tool>>

With the <<electronic tool>>, I am able to access the information I need, when I need it

The <<electronic tool>> is in a format that quickly gives me the information I need