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

TANZANIA

SDA Bocconi SCHOOL OF MANAGEMENT

GLOBAL HEALTH CONSULTING

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CONTENTS

LIST OF ABBREVIATIONS

ABC	Activity-Based Costing
AEFI	Adverse Event Following Immunization
BCG	Bacille Calmette-Guérin
BID	Better Immunization Data
BMGF	Bill and Melinda Gates Foundation
CAGR	Compound Annual Growth Rate
CC	City Council
CHAI	Clinton Health Access Initiative
CHMG	Council Health Management Team
CHW	Community Health Worker
CI	Confidence Interval
cMYP	comprehensive Multi-Year Plan
CRVS	Civil Registration and Vital Statistics
DC	District Council
DIVO	District Immunization and Vaccine Officer
DQA	Data Quality Audit
eIR	Electronic Immunization Registry
eIS	Electronic Immunization System
eLMIS	Electronic Logistics Management Information System
EPI	Expanded Program on Immunization
Gavi	GAVI the Vaccine Alliance
GDP	Gross Domestic Product
HF	Health Facility
HFR	Health Facility Register
HIS	Health Information System
HMIS	Health Management Information System
HPV	Human Papillomavirus
HR	Human Resources
HW	Health Worker
ICAN	Immunization Costing Action Network
ICT	Information and Communication Technology
IMF	International Monetary Fund
IR	Immunization Registry
IT	Information Technology
IVD	Immunization Vaccine Development
JRF	Joint Reporting Form
JSI	John Snow Inc.
LMIC	Low Middle-Income Country
LMIS	Logistic Management Information System
MC	Municipal Council
MCSP	Maternal and Child Survival Program
MIVO	Municipal Immunization and Vaccine Officer

MoH	Ministry of Health
MR	Measles Rubella
OPV	Oral Polio Vaccine
PHC	Primary Health Care
PCV	Pneumococcal Conjugate Vaccine
RHC	Reproductive and Child Health
RIVO	Region Immunization and Vaccine Officer
ROI	Return On Investment
SE	Standard Error
SOP	Standard Operating Procedures
TC	Town Council
TImR	Tanzania Immunization Registry
TIIS	Tanzania Immunization Information System
ToC	Theory of Change
Tz-HIE	Tanzania Health Information Exchange
TZS	Tanzanian Shilling
USAID	United States Agency for International Development
USD	United States Dollar
VIMS	Vaccine Information Management System
VPD	Vaccine Preventable Disease
WHO	World Health Organization
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 (Gavi), 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 Tanzania, this evaluation was conducted in collaboration with the Mbeya Medical Research Center of the National Institute for Medical Research (NIMR-MMRC).

BACKGROUND

Digitalization has been an important part of the overall health landscape in Tanzania for almost over a decade. The Tanzania eHealth Strategy 2013 – 2018 prioritized establishing eHealth standards, rules and protocols for information exchange and protection, as well as comprehensive health facility, provider, and client registries (Nsaghurwe et al., 2021). This was followed by the Health Sector Strategic Plan (2015 – 2020) which focused on achieving interoperability and the rapid deployment of information and communication technology (ICT) for improving administrative processes, patient/client recording and reporting, and communication (Nsaghurwe et al., 2021). Acknowledging the presence of over 160 digital health or health-related systems in the country, the National Digital Health Strategy 2019-2024 aimed to: strengthen the digital health governance and leadership; improve the client experience through efficient provision of high-quality health services; empower health care providers and managers to take evidence-based actions; sustain availability of human resources; and standardize the information exchange (Ministry of Health, Community Development, Gender, Elderly and Children, 2019).

Against this background, two digital tools supporting immunization delivery, an eLMIS (i.e., the Vaccine Information Management System, VIMS) and an eIR (i.e., the Tanzania Immunization Registry, TImR), have been introduced. The TImR is an eIR which was originally deployed down to health facility (HF) level in 15 regions, though is no longer in use in all of these facilities. It is intended to be used exclusively, or in parallel, with a paper-based Immunization Registry (IR). The VIMS is an eLMIS deployed down to district level in all 26 regions. The integrated electronic immunization system (eIS) consists of the eIR plus eLMIS at all health service delivery levels, intended for the aforementioned 15 regions.

VIMS was launched as a collaborative initiative in 2015. Led by the Immunization and Vaccine Development (IVD) Program, it brought together multiple donors and implementing partners, including the BMGF, USAID, John Snow, Inc. (JSI), the Clinton Health Access Initiative (CHAI), PATH and Village Reach, and combined three supply chain management tools in use – the District Vaccine Data Management Tool (DVD-MT), the Stock Management Tool (SMT), and the Cold Chain Inventory Tool (CCIT). VIMS was based on the OpenLMIS platform and customized to accommodate all data monitoring requirements and indicators for the vaccine supply chain in Tanzania.

The development of the eIR was a phased process commencing in 2013. It was overseen by a partnership between the MoH and the Better Immunization Data (BID) Initiative which aimed to address identified challenges in the country's immunization data collection, quality and use. After the first iteration of the tool, the Tanzania Immunization Information System (TIIS), was shelved, TImR was developed in 2015 from an established open-source electronic medical records (EMR) platform, OpenIZ (now known as SanteDB, SanteSuite), which allowed online and offline functionalities, scalability, and customization.

The integration of TImR and VIMS took place between June 2016 and January 2018. After being piloted in the Arusha region, there was a phased rollout in facilities delivering immunization across 26 districts and 924 health facilities in the Tanga, Arusha and Kilimanjaro regions. Tanzania had planned to implement the integrated VIMS+TImR over four years (2016 – 2019) in 15 regions. However, use of the tools varies, and no region has yet moved to a fully electronic system across all levels of the health system.

OBJECTIVE

The evaluation in Tanzania consisted of a programmatic and economic assessment of TImR and VIMS, as well as of the integrated system, VIMS+TImR (=eIS).

The objective of the evaluation was to assess the implementation and use, interoperability, impact, costs, affordability, and sustainability of the two digital tools and to generate actionable evidence for the Government of Tanzania, as well as for health financing institutions and technical partners to support future decisions on the management and further development of these tools and other digital technologies.

Compared to previous operational research, this evaluation provides an updated assessment of the tools several years after their first implementation and extends the geographical scope of previous evaluations to include regions where the tools were more recently rolled out. From an economic standpoint, this evaluation is the first to provide a comprehensive assessment of the implementation costs for both VIMS and TImR in all regions where they were implemented and to estimate the cost impact for the whole country, including across all administrative levels, for immunization and vaccine stock data management (as compared to the use of only paper registries at the health facility level). Overall, the evaluation is based on a clear Theory of Change and makes use of standard assessment tools to allow comparisons across countries, as well as with other recent programmatic evaluations.

METHODS

A purposive sampling strategy was used to identify a representative sample of regions, districts, and health facilities for inclusion in the evaluation.

Ten regions were purposively selected considering the following strata: regions with full electronic use of the VIMS+TImR; regions which used VIMS+TImR together with a parallel paper-based IR; and regions which had not yet introduced TImR and were only using the VIMS at district and regional level in combination with paper-based IRs across all levels. All regions where previous evaluations of the systems had taken place were included in the sample to allow for comparisons of the findings and to collect information on the use of the systems over time.Within each selected region, three districts were randomly selected.Within each selected district, two health facilities were purposively selected, taking into account location (i.e., urban/rural), health facility (HF) type (i.e., hospital, health center, dispensary), and size of the HF catchment area. The resulting sample included 10 regions, 30 districts and 61 HFs. One additional HF was included in the Dodoma Region, a region which had stopped using the TImR, to allow for a more detailed exploration of this recent discontinuation of use. The sample of HFs was considered representative of the overall sampling frame of health facilities in the selected regions.

The field work for data collection was coordinated by NIMR-MMRC and executed over a period of 3 weeks in October and November 2021. Five teams of 3-4 members each visited two paired regions, one region with the tools in use and a neighboring region as the 'control.' In each region, all selected districts and HF were visited, where interviews and observations were conducted.

Both quantitative and qualitative methods were used to evaluate the programmatic impact of the use of the electronic systems. Impact was evaluated in terms of service delivery processes including: (i) data quality; (ii) data use for decision-making; and (iii) program and process efficiencies, including vaccine stock levels.User experience and perception of the tools by health workers (HWs) and their clients was also evaluated. The evaluation aimed to identify and explore factors critical for the successful implementation and further scale-up of these tools.

The economic impact evaluation aimed to provide an estimate of: (i) the upfront financial expenditures at national level of implementing both VIMS and TImR ; (ii) the routine operating costs of managing immunization data using VIMS+TImR; and (iii) the difference in current operating costs of VIMS+TImR as compared to operating the VIMS+paper IR. Analysis of upfront financial expenditures was based on secondary sources collected from the identified implementing partners (i.e., MoH, PATH and JSI).An activity-based costing approach (ABC) using the primary data collected was employed for the analysis of routine operating costs for immunization and vaccine stock data management at HF, district and regional levels. The observed difference between HFs using the tool and those not using it in each region was then extrapolated to calculate the cost impact, at the national level, of the current state of implementation (i.e., VIMS implemented nationwide and TImR implemented in 15 out of 26 regions). Further analyses were conducted to estimate the return on investment (ROI) of the interventions based on the current state of implementation, as well as the cost impact and affordability of expanding the use of both tools to all regions in the country.

FINDINGS

The data yielded findings which were categorized into four domains: ecosystem; tool design and functionality; implementation experience and costs; and impact and sustainability of the TImR and VIMS.

Despite a clear commitment to digitalization, as outlined in Tanzania's National Digital Health Strategy 2019-2024, this evaluation revealed that the **combined use of the VIMS+TImR was limited across the country**. At the time of the evaluation, the VIMS+TImR was only in use in three of the six regions (i.e., Kilimanjaro, Mwanza and Tanga) anticipated to be exclusively transitioning to fully electronic use of VIMS+TImR. However, only two of the six sampled HFs in Kilimanjaro and three of the six sampled HFs in Mwanza were found to be in fully electronic mode. System implementation was variable in the remaining districts and HFs of the three regions, with some using VIMS+TImR+paper IR and others using only the VIMS+paper IR. In the region of Arusha, the VIMS+TImR was used in parallel with a paper IR. The regions of Dodoma and Njombe, which had introduced TImR in 2019, have since abandoned the use of VIMS+TImR and have reverted back to using only the VIMS+paper IR.

Interview findings at all levels suggests that the decline in use of these tools was partly due to inadequate access to hardware, internet and data bundles at all levels. Respondents also suggested that there was limited capacity to maintain, enhance, and manage the current electronic systems at all levels. In addition, although VIMS+TImR was perceived as user-friendly and dependable with the belief that the data in the system would not be lost, only half of the respondents reported that the tool was actually functioning at the HF level when required. Software issues were said to be abundant. Issues, such as the system "sticking," being slow or unstable, and challenges with synchronization and interoperability between the systems were specifically mentioned. These issues appear to have impacted the uptake of the VIMS+TImR, resulting in the tools being abandoned in places. Most recent national information also reveals that the combined tool (VIMS+TImR) is currently malfunctioning due to the server being at capacity.

Despite these challenges, most **staff expressed an interest in continuing to work with both tools**. VIMS+TImR users were more likely than those who no longer used the tools to think that the system provided access to sufficient information to enable them to do their work. **Staff emphasized their desire to be re-trained in the use of the tools and to be provided with updated standard operating procedures (SOPs) to allow their full use**. Other user requests included improving data visualization and building in checks to improve data quality, which would need to be taken up in the further development of the tools.

Despite limited use, the tools may still have had a positive impact on immunization program management in the areas of data quality, supervisory activities, and stock management. The evaluation was unable to assess the impact of the use of the tools on immunization outcome indicators such as immunization coverage or dropout rates, partly due to the interfering COVID-19 pandemic and its repercussions on the routine immunization system, as further discussed below. The evaluation, therefore, used more proximal process indicators to assess impact.

When the tools were working with stable IT infrastructure in place, users were generally satisfied with their use. Users of VIMS+TImR were seen to be competent in adequately completing new immunization records and in generating reports at the HF level. HWs reported some improvement in the accuracy and completeness of immunization data at the HF level with the use of VIMS+TImR. There was, however, a discordance between HW perception of data accuracy and the assessed accuracy of data across various sources, with most HWs being overly optimistic about their own data precision. Evaluation findings suggest that data quality was challenged by the apparently poor synchronization between the systems, limited internet access and limited HR capacity and capabilities.

The **use of the VIMS+TImR appears to have aided decision-making for program management** across all health system levels. This included improvements in the quality of decisions made in critical areas such as supportive supervision, vaccine stock management, defaulter tracing, the preparation and conduct of immunization sessions (including outreach), the identification of performance gaps, and resource planning. At district and regional levels, both tools were perceived by users as having simplified work and decreasing the overall workload.

Vaccine stockouts appeared to have been substantially less frequent in HFs using the VIMS+TImR at all levels compared to HFs using only paper records. The VIMS+TImR was reportedly useful for receiving and putting away vaccine supplies, as well as for generating monthly reports, identifying vaccine doses close to expiry, ordering new supplies, and performing stock management activities faster.

Given the COVID-19 pandemic and its effect on routine immunization services, it was not expected that this evaluation could demonstrate an impact of the VIMS+TImR on immunization outcome indicators such as immunization coverage, timeliness or drop-out rates. Nevertheless, a national DHIS2 extract of these indicators was reviewed for the pre-intervention period (2015 and 2016) and compared to the post-intervention period (2020 and 2021). No consistent associations were found between the use of the VIMS+TImR and any change in first or third dose pentavalent vaccine coverage (Penta), in Measles Rubella (MR) first dose and MR second dose coverage, or in Penta1 to Penta3, MR1 to MR2, or Penta1 to MR drop-out rates. Even before the COVID-19 related decrease, immunization coverage rates in the country had started to decline in 2016, and the introduction of the VIMS+TImR had not visibly impacted this trend (WUENIC, 2022).

From an economic perspective, the total expenditures to date for implementing the VIMS+TImR, includingnation-wide use of the VIMS, the design and roll-out of TImR in 15 regions and its further improvement, have been estimated at USD 12.8M. Expenditures for the design and development and initial roll-out of the TImR component amounted to approximately USD 4.25M. Hardware costs, specifically tablets and computers, accounted for 42% of the funds used for the roll-out for both tools. Despite this major initial investment, expenditures for the procurement and distribution of hardware continued to be a relevant cost item after the initial roll out, accounting for 53% of the funds budgeted for the continuous improvement of the tools in 2021, including the introduction of additional modules and indicators, nationwide expansion and technical repairs. This sustained expenditure for hardware may be due to reported challenges with broken and/or missing hardware. The overall funds for training, accounting for 24% of the total costs of the roll-out (i.e., initial and scale-up) of both tools, appeared to be insufficient to satisfy the needs of users.

The average cost of performing immunization data management activities using the VIMS+TImR was estimated at USD 1,550.8 (95% Confidence Interval: 1,227.4, 1,874.2) per HF, or 0.54 per vaccine dose administered. Most of this cost was absorbed by human resources, which accounted for 59% of the total cost. Findings from this evaluation suggest that implementing the VIMS+TImR could generate an annual savings of USD 686 per HF through improvements in the efficiency of managing immunization and vaccine stock data. Such savings may result from the decreased time required to perform data management-related activities. However, the attribution of this savings to the use of the electronic tools was not always clear, particularly given the reported implementation challenges. For activities such as defaulter identification and report generation, for example, users noted that the tool had contributed to reducing their workload, suggesting that the observed cost differences compared to the non-users may have been attributable, at least in part, to the tools.

The reported savings, of note, may have been partially offset by the fact that most users of the VIMS+TImR maintained the parallel paper system. It is expected that removal of the paper registries will reduce task duplication for HW, further reducing costs. A quantification of the avoided costs that would be generated by removing paper was not possible due to the limited number of HFs in the sample actually using the electronic tool.Even in the current scenario (i.e., with most HFs maintaining the parallel paper system), however, this evaluation suggests that if the observed savings were to be totally attributed to the use of the electronic tools, use of the tool may generate savings for up to USD 6.2M annually.

While extrapolation to a broader context of such complex interventions is challenging and these findings are to be taken with caution, should the savings be confirmed, it was estimated that upfront investments to implement the tool in the current 15 regions in Tanzania would be recouped after approximately 8 years from the start of the implementation phase. After such period, using VIMS+TImR would free EPI resources with potentially positive indirect effects on immunization outcomes.

CONCLUSIONS AND RECOMMENDATIONS

The findings of this evaluation confirm that the TImR, VIMS and VIMS+TImR were perceived by HWs at all levels of the health system to be a valuable contribution to the management of immunization data. In particular, there were perceived improvements in both vaccine stock and immunization data quality since the introduction of the tools, including improved access to real-time information. Supervisory activities were also positively impacted by the use of the tools, including improvements in the quality of decisions made by DIVOs and RIVOs and enhanced processes for providing and receiving feedback. Users perceived the TImR as providing assistance in the tracking of individuals outside of their catchment areas or registered at a different facility. In some instances, the TImR was reportedly helpful in defaulter identification and tracking, as well as positively impacting the management of outreach services. Use of the tools was associated with improved vaccine stock management and made the processes of receiving and putting-away of vaccines more efficient. Users of the fully electronic systems were less likely to experience stock-outs than users using the parallel system or those with only the VIMS in place. When the tools were working and there was enabling IT infrastructure in place (e.g., electricity, connectivity, hardware, etc.), users were generally satisfied and considered the tools to have positively influenced the quality of their work, improved the services delivered and, overall, made their jobs easier.

From an economic perspective, the use of the tools was associated with substantial cost-savings to the immunization program. However, the full programmatic and economic benefits of the tools are unlikely to be realized without addressing the identified challenges around the introduction and sustained use of the tools.

Limitations within the ecosystem (e.g., internet and electricity), coupled with repeated hardware and software problems, led many users to abandon the use of the tools. Local capacity and country ownership will need to be strengthened to sustainably resolve these challenges, including those related to the further synchronization and interoperability of the tools with the existing HMIS and the CRVS. Ensuring adequate access to stable internet, sufficient and robust hardware and high-quality, regular training will be critical for enhancing the continued use of the tools. This will necessitate further prioritized investments. Improved local management and continued monitoring of the systems by the MoH of Tanzania may ensure their long-term programmatic and financial sustainability.

The Government of Tanzania is called upon to consider developing the internal capacity to implement, adapt, upgrade, and maintain the TImR and VIMS, whilst responding to the software and system challenges currently experienced by users. Further domestic funding will need to be made available to respond to the infrastructure requirements, including access to internet and hardware and capacity building.

Once a platform which enables the successful implementation of the tools (i.e., with sufficient internal capacity and IT infrastructure) has been established, the MoH should plan for the elimination of paper registries. This will significantly reduce HW work load and enhance data quality by focusing on a single electronic process of recording and reporting immunization data. The existing monitoring framework will need to be further enhanced to continuously assess tool adoption and its impact on HW activities, as well as any potential cost savings. Defaulter tracking mechanisms and SMS reminders for caregiver notification should be activated and a feasibility assessment done to further explore potential interoperability between the eIR and the national CRVS or local birth registries.

Despite the reported challenges, the continued use of these tools could well be associated with cost-savings to the immunization program after a relatively short period required to recover the initial investments. Further investments are encouraged to resolve such challenges, specifically including those related to the enabling environment, and support the introduction and sustained use of electronic tools.

The main findings summarized above have been mapped to the guiding research questions of this evaluation to provide a snapshot of the key learnings from early implementation of the VIMS and TImR in Tanzania.

Has the implementation of the TImR and VIMS improved immunization service delivery?

- Due to the COVID-19 pandemic and its repercussions on routine immunization services, it was not expected that the evaluation would be able to assess an impact of the use of the electronic tools on immunization outcome indicators such as coverage, timeliness and drop-out rates.
- The evaluation could, however, show an impact related to more proximal indicators:
    - There was a perceived improvement in **data quality** since the introduction of the tools.
    - The tools assisted in tracking individuals **outside of their catchment areas** and in identifying children that were registered at a different facility.
    - The tools were regularly used to **generate a list of defaulters** and used in **outreach and mobile services**.
    - The tools impacted the process of providing and receiving feedback from supervisors, as well as **the quality of decisions** made in critical areas such as supportive supervision, defaulter tracing, the preparation and conduct of immunization sessions, the identification of performance gaps, and resource planning.
    - The use of the tools was associated with improvements **in vaccine stock management,** including reducing the number of **stock-outs.**

  Of note, at HF level, it was not feasible to separate out any impact of the VIMS from that of the TImR since the latter was used as the data entry interface to both tools.
- Overall, HWs were satisfied with the use of the tools and thought that they improved their productivity and made them more effective in their daily work. Caregiver and client satisfaction also improved to some extent, partly as a result of shorter waiting times.

What is the short- and medium-term economic and financial impact of implementing and scaling up these systems in the whole country? How affordable and sustainable are the systems?

- The full initial investment of developing and deploying the TImR down to the service delivery level in 15 regions was approximately USD 9.3 million, while the VIMS the investment amounted to USD 2.16 million. Most implementation-related expenditures were attributed to hardware for TImR (USD 4.8 million). Training was the second highest cost item accounting for 24% of the combined cost of deployment for both tools (USD 1.5 million for TImR and USD 0.7 million for VIMS).
- The use of the VIMS+TImR was associated with a **decrease in the costs for immunization and vaccine stock data management** activities by 31% compared to using only VIMS+paper IR. The average annual cost for performing these activities with the VIMS+TImR was USD 1.551 per HF, or USD 0.54 per dose. The majority (59%) of this cost was accounted for by costs for personnel. The costliest activity was that of organizing outreach sessions (24% of the total cost).
- When extrapolating the estimated savings at the HF level to the whole county, the total **costs for immunization and vaccine stock data management** activities in the current scenario (i.e., with VIMS+TImR implemented in 15 Regions) was estimated at approximately USD 10.5 million per year. This cost included additional investments for the further development of the tools and represents approximately 6.5% of the estimated budget of the IVD program in 2019-2020. Compared to a scenario with only VIMS + Paper IR, approximately USD 6.2 million savings may be generated every year.
- The reported annual savings may be even higher should the system be implemented in all regions, potentially resulting in further savings of USD 4.2 million per year compared to the current situation.
- Given its current scale and annual savings, the VIMS+TImR, if fully used in all HFs in which it is presently rolled out, is expected to provide returns on the initial investment after 8 years, After this period, use of the tools would free resources from the IVD budget, thus contributing to ensuring its sustainability.
- Resolution of technical issues and reinforced capacity building, coupled with further investments in the digital infrastructure of the health sector in Tanzania would, however, be pre-requisites for such cost benefits to be realized.

How interoperable is the TImR and VIMS with the national health management information and civil registration systems?

- The VIMS and TImR were designed to be interoperable. At the HF level, HWs require TImR as the data entry interface for accessing VIMS. Current challenges with the TImR prevent synchronization of data between the tools and have resulted in limited data access. This has partly contributed to the abandonment of the tools in many locations.
- The MoH digital health policy prioritizes interoperability and standardized information exchange between tools within its Health Management Information System.
- There is no immediate plan to integrate the TImR with a CRVS or birth registry system, although it is technically feasible. This is limiting the ability of the tool to assist in reaching zero dose children.

How can new evidence on tools and technologies, modalities, and governance of the TImR and VIMS inform further investments from domestic sources, health financing institutions and technical partners for the sustained implementation of these systems?

- Many HFs are discontinuing the use of electronic tools in the face of multiple challenges. Large financial investments in specific tools, such as an eIR, without investments in the entire digital health ecosystem, including technical infrastructure, internet connectivity, human capacity and strengthened IT support, are insufficient to allow the tools to realize their programmatic benefits. Further investments in **strengthening the digital health ecosystem** are necessary and encouraged.
- An over-reliance on external partners, including software developers, is concerning. The absence of local capacity to provide timely support has reportedly impeded the sustained use of the tools. Investments in **local capacity building and technology transfer** should be prioritized to enable independent development, local adaptation, and the sustained use of electronic tools.
- Further domestic investments in the TImR and VIMS appear to be warranted, in parallel with fostering an enabling environment. This should include:
  - Strengthened in-house capacity at the national and regional level to manage and monitor use of the tools;
  - Improved server capacity and resolution of software issues; and
  - Improved technical integration and interoperability of the two tools with the health information exchange platform.
- Lessons learned from earlier attempts to remove the parallel paper registries should be reviewed and comprehensive plans made for the removal of paper registries. The implementation of a fully electronic systems should allow for the full benefits of the tools to be realized.

I. 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 electronic immunization registries (eIRs) and electronic logistics management information systems (eLMIS). While current evidence suggests that these digital tools may contribute to improved data quality and use, many are never rolled out nationally, nor rigorously evaluated. Where innovation around digitalization has failed, it was often because the specific local context, user requirements and/or issues related to interoperability with existing systems were ignored. Importantly, technological interventions alone are not the panacea. Understanding the human factors around technology transfer and change management for use are critical.

This report builds upon recent literature which documents experiences in LMICs with eIRs and other health and medical registries (Danovaro-Holliday et al., 2014; Nguyen et al., 2017; Dumit et al., 2018; Dolan et al., 2019), as well as eLMIS (Konduri et al., 2018; Agarwal et al, 2020; Fritz et al, 2021). It answers the calls for more evidence to estimate the effectiveness, affordability and sustainability of these interventions. This report specifically explores the challenges and opportunities around developing and implementing Tanzania's eIR and eLMIS, the associated costs and the programmatic and economic impact. Of note, this report is part of a multi-country evaluation of the impact of digital tools across Guinea, Honduras, Rwanda and Tanzania. Similar reports have been developed for each country, as well as an overarching report which synthesizes the cross-country learnings to support future decisions on the introduction and management of eIR and eLMIS in LMICs.

The primary audience for this report is decision-makers and technical staff, such as government officials, program managers, donors and implementing partners. Other stakeholders including those from academia and the private sector may also benefit from the findings.

II. BACKGROUND

A. EXPANDED PROGRAM FOR IMMUNIZATION (EPI) IN TANZANIA

The United Republic of Tanzania ("Tanzania") has 26 regions with a total of 10,477 health facilities (i.e., hospitals, dispensaries and clinics) on Tanzania Mainland (i.e., without Zanzibar) serving an estimated population of 61.5M (World Bank, 2022). Of those health facilities, 5,497 are registered to deliver immunization services (Health Facility Registry, 2022). Notably, an estimated 43% of health facilities in Tanzania are owned by faith-based organization and the private sector (non-for-profit or commercial), but mostly run under the regulations of the public health services (Health Facility Registry, 2022).

Tanzania's birth cohort of 2.3 million children (WUENIC, 2022) receives free vaccinations through the Expanded Program for Immunization (EPI). The country's EPI, called the Immunization and Vaccines Development Program (IVD), forms part of the Reproductive and Child Health (RCH) unit of the decentralized Ministry of Health (MoH). The central level of the IVD is responsible for policymaking, development of strategies and guidelines; vaccine and supply procurement and distribution to the regional level, central storage and management of vaccine stock; and reporting on coverage and other performance data. Human resources are also centrally managed by the President's Office, Public Service Management and Good Governance, and financed by the Ministry of Finance. Implementation of the IVD Program is overseen by a team of Regional Immunization and Vaccine Officers (RIVOs) and District Immunization and Vaccine Officers (DIVOs). Regions are responsible for managing vaccine storage and distribution to districts, as well as for providing supervision, while districts are responsible for overseeing the supply chain to facilities, performing supportive supervision of health facilities (HFs), monitoring of immunization delivery, adverse events and disease surveillance, in addition to direct service delivery (Tanzanian Ministry of Health, n.d.).

While Tanzania has historically achieved high infant immunization rates, coverage has declined in recent years, with the COVID-19 pandemic further affecting service delivery and access, resulting in low routine immunization coverage. For example, coverage of the third dose of diphtheria toxoid, tetanus toxoid, pertussis, *Haemophilus influenzae* type B and hepatitis B vaccine (Pentavalent vaccine) decreased from 96% in 2015 to 89% in 2019, i.e., already prior to the COVID-19 pandemic, and further declined to 86% in 2020 and 81% in 2021 during the pandemic. Further, coverage of the first dose Measles-Rubella (MR1) vaccine decreased from 95% in 2015 to 88% in 2019, 84% in 2020 and 76% in 2021 (WUENIC, 2022).

B. DIGITAL LANDSCAPE IN TANZANIA

Digitalization has been an important part of the overall health landscape in Tanzania for over a decade. The Tanzania eHealth Strategy 2013 – 2018 prioritized establishing eHealth standards, rules, and protocols for information exchange and protection, as well as comprehensive health facility, provider and client registries. MoH. From 2014 – 2019 the MoH developed an integrated, interoperable health information system, supported by the U.S. Agency for International Development's (USAID) Maternal and Child Survival Program (MCSP) The project, known as the Tanzania Health Information Exchange (Tz-HIE) worked to enable cross-program data exchange through an interoperability layer. It was managed by the ICT department of the MoH and leveraged off the country's established Health Information System (HIS) that collects and reports data across multiple health programs.

Further, the Health Sector Strategic Plan (2015 – 2020), MoH focused on achieving interoperability and the rapid deployment of information and communication technology (ICT) for improving administrative processes, patient/client recording and reporting, and communication. This was followed by the National Digital Health Strategy 2019-2024. Acknowledging over 160 digital health or health-related systems in the country, the strategic goals of this strategy include: the strengthening of digital health governance and leadership; improved client experience through provision of high-quality health services; empowered health care providers and managers to take evidence-based actions; sustained availability of human resources; and standardized information exchange (Ministry of Health, Community Development, Gender, Elderly and Children, 2019). Despite such political commitment, the lack of governance, cohesion, and electronic data exchange has impeded service delivery and, as seen in a recent assessment, resulted in a duplication of work, poor data quality and inappropriate use of data (Nsaghurwe et al., 2021).

C. OVERVIEW OF DIGITAL TOOLS SUPPORTING IMMUNIZATION DELIVERY IN TANZANIA

Two digital tools supporting immunization delivery, an eLMIS (i.e., the Vaccine Information Management System, VIMS) and an eIR (i.e., the Tanzania Immunization Registry, TImR) have been introduced in Tanzania.*Table 1* below provides a description of the tools with details on their use and implementation.

Table 1: Summary of digital tools for immunization in Tanzania

Tool	Description
TImR	eIR deployed down to health facility (HF) level in 15 regions. Used exclusively, or in parallel, with a paper-based Immunization Registry (IR).
VIMS	eLMIS deployed down to district level in all 26 regions.
eIS	Integrated electronic immunization systems (eIS) which consists of VIMS plus TImR in 15 regions across regional, district and HFs levels.

VACCINE INFORMATION MANAGEMENT SYSTEM (VIMS)

VIMS was launched as a collaborative initiative in 2015. Led by the IVD Program, it brought together multiple donors and implementing partners, including the Bill and Melinda Gates Foundation (BMGF), USAID, John Snow, Inc. (JSI), the Clinton Health Access Initiative (CHAI), PATH and Village Reach, in order to combine three supply chain management tools in use – the district vaccine data management tool (DVD-MT), the stock management tool (SMT), and the cold chain inventory tool (CCIT). VIMS was built based on the OpenLMIS platform and customised to accommodate the data monitoring requirements and indicators necessary for the vaccine supply chain.

In 2016, VIMS was pre-tested in seven regions (i.e., Arusha, Dar Es Salaam, Lindi, Mtwara, Mwanza, Njombe, and Tabora), followed by a phased implementation covering 15 out of 26 regions of the country, or approximately 64% of the population, the following year (Mariki, 2017; Nshunju et al., 2018). By 2018 it had been introduced in all districts and regions of the country.

Following its pilot, a cross-sectional, post-intervention study was performed on VIMS in four intervention regions (Arusha, Mtwara, Mwanza, Njombe) and four control regions (Mbeya, Dodoma, Shinyanga, Tanga). The study assessed the programmatic effectiveness of VIMS in improving immunization program-related data quality, analysis, and visualization, and the user experience of data management in three districts in each region

(Nshunju et al., 2018). The findings showed that VIMS had not improved IVDprogram data reporting (i.e., accuracy, consistency, or timeliness) nor district performance in vaccine stock management to a statistically significant level relative to the previous tripartite reporting system. Similar findings had also been reported for the Logistics Management Unit (LMU) and the eLMIS for health commodities supporting the overall public health supply chain (Rosen et al., 2015 and Mwencha et al., 2017) whereby the cost of implementing and running the eLMIS was not compensated by savings derived from better logistics management (e.g., reduction of stock-outs).

TANZANIA IMMUNIZATION REGISTRY (TIMR)

The development of the TImR was a phased process commencing in 2013. It was overseen by a partnership between the MoH and the Better Immunization Data (BID) Initiative which aimed to address challenges in the country's immunization data collection, quality and use, which included at the time: poor data quality, inaccurate denominators, inability to trace defaulters, complex data systems and data collection tools, inadequate data management and low data use capacity, and poor data visibility of vaccine consumption and supplies at facility level (Dolan, et al., 2022; Barber and Richard, 2022).

In 2014-2015, the country tested and piloted the Generic Immunization Information System (GIIS) platform, known locally as the TIIS. The TIIS was piloted in Arusha but experienced numerous challenges including problems with the synchronization of data between different devices used in the same facility, as well as with the central database; design decisions which negatively impacted the ease and cost of maintaining the source code; and high costs of extending and replicating the system. Arusha was the only region to use this system before transitioning to TImR. In its design and implementation, TImR aimed to address some of the requirements based on lessons learned during the TIIS implementation. TImR was initially introduced in three regions (Kilimanjaro, Tanga and Dodoma), and later also replaced TIIS in the Arusha region (Seymour et al., 2019).

By 2018, TImR had been deployed in these four regions covering 1,273 facilities, as depicted in *Figure 1*.

Figure 1: Timeline of implementation of TImR from 2015-2018 (based on information from Mott MacDonald, 2019)

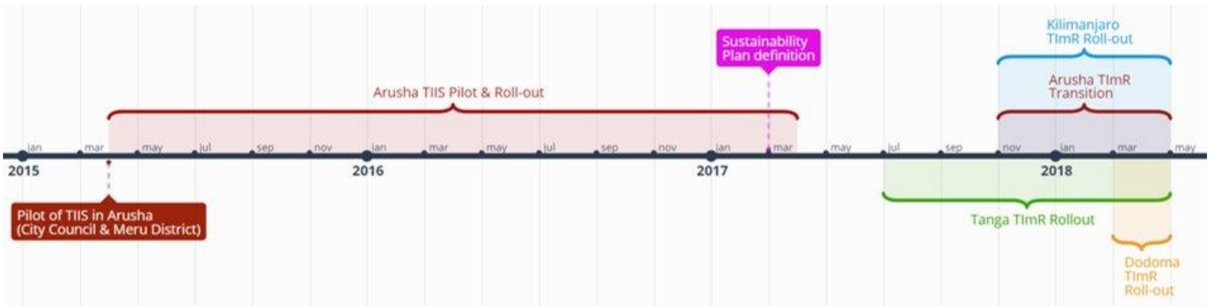
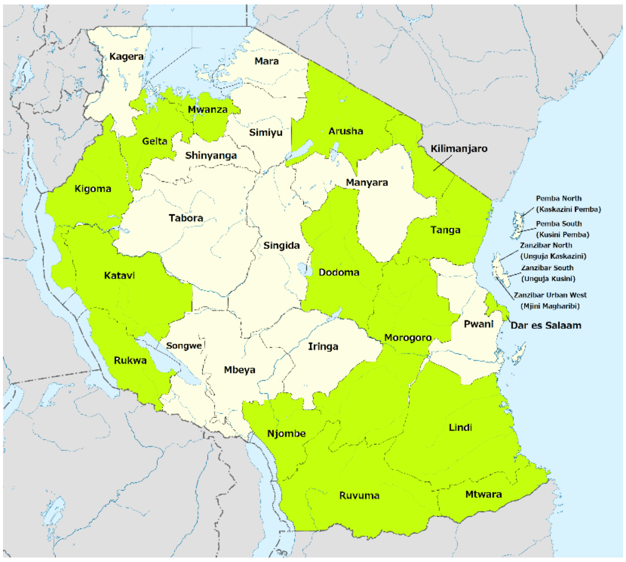


Figure 2: Regions in Tanzania with VIMS+TImR to date (green)



TImR has since been rolled out across 15 regions (Secor et al., 2022), as illustrated in *Figure 2*. The system was in use in 3,768 facilities.

TImR had been developed from an established open-source electronic medical records (EMR) platform, OpenIZ, (now known as SanteDB, SanteSuite), which allowed online and offline functionalities, scalability and customization (Gilbert, 2020; Secor et al., 2022; Mott MacDonald, 2019). The country's selection of the platform was based on a number of considerations including the national eHealth Strategy requirements; the country's existing technology landscape, technical skillset, local human resources capacity and ICT infrastructure (Barber and Richard, 2022). Through its mobile application, TImR was designed to enable frontline HWs to register, store, and track immunization information including what vaccines a child had received and when a child was due for upcoming immunizations. The tool was also designed to enable the generation of aggregate facility-level reports that feed into the health management information system (HMIS). Recognizing the value of integrating the TImR with the VIMS, several development cycles ensued to enable this function, though data synchronization challenges remain to date.

An early evaluation of the implementation of the tool in the pilot regions demonstrated little change in data quality due to inconsistent use of the TImR for data capturing, reporting or decision-making. Challenges cited in the evaluation included inadequate system updates and enhancements, poor internet connectivity, as well as additional requirements for training and supervision (Mott MacDonald, 2019).

ELECTRONIC IMMUNIZATION SYSTEM (EIS)

The integrated TImR and VIMS in Tanzania is referred to as "TImR" (at the system entry point) at HF level and as the Electronic Immunization System (eIS) at district and regional levels. **In this report, the integrated tools will be referred to as the "VIMS+TImR" across all levels.**

The integration of TImR and VIMS took place between June 2016 and January 2018. After being piloted in the Arusha region, there was a phased rollout in facilities delivering immunization across 26 districts and 924 facilities in the Tanga, Arusha and Kilimanjaro regions (Gilbert, 2020). The roll-out was done through a participatory process using district data use mentors and included support for change management and data use for decision-making (Mott Macdonald, 2019).

Using VIMS+TImR, HWs were able to register children, track, and schedule individual immunization events and vaccination sessions. The system should also be able to automatically deduct a vaccine dose from the stock available every time one is administered and registered in TImR; provide notifications on when there is low stock or a stock-out; predict vaccine stock quantities based on targeted population and the immunization schedule; provide visibility of vaccine stock levelsat the HF level, and directly exchange data with the district level. Users should also be able to receive supervisory and peer support through WhatsApp (Gilbert, 2020). While the system was designed to be able to send SMS reminders and serve as a platform for Adverse Events Following Immunization (AEFI) monitoring, these functionalities were not immediately introduced or are no longer functional (Gilbert, 2020). In addition, to date TImR has not been linked to birth registries or to the Civil Registry and Vital Statistics (CRVS) database. There are discussions to link TImR unique identifiers with national identifiers through the Registration, Insolvency and Trusteeship Agency (RITA), but definite timelines for this have not yet been established.

When the VIMS+TImR was introduced at HF level, a back-entry data process was initiated where all records included in HF paper-based registers were to be entered into the VIMS+TImR. HWs were required to register all children seen for vaccinations and to enter all vaccines the child had previously received. Unique identifiers, printed on barcode labels, were provided to caregivers to facilitate access to the child's records for future visits. Details of the immunization event were entered either at the time of vaccination or back-entered at the end of the same day (Dolan et al., 2022). The pilot implementation in Arusha however showed that the back-entry process was neither reliable nor cost-effective and a decision was made to focus on new registrations, rather than data back-entry (Mott MacDonald, 2019). The MoH, meanwhile, maintained the requirement of completing paper-based forms and reports. All facilities thus completed dual data entry from the time of VIMS+TImR introduction. While the intention was to replace the use of paper-based data collection tools (Dolan et al., 2022), this has not yet been realized in most places and a combination of different systems currently exists across the country (i.e., VIMS+TImR, VIMS+TImR+paper immunization registry (IR), and VIMS+paper IR).

Tanzania had planned to implement the integrated VIMS+TImR over four years (2016 – 2019) in 15 regions. This evaluation included six of these regions. However, use of the tools varied and no region has yet moved to a fully electronic system across all levels of the health system. This is in spite of the fact that Tanga was expected to be using the VIMS+TImR as a fully electronic system, and that both Kilimanjaro and Mwanza were expected to be in the transition phase to such a system.

D. EVALUATION RATIONALE

This evaluation consisted of a programmatic and economic assessment of the two digital tools currently supporting immunization delivery (the TImR and VIMS), as well as of the integrated system, VIMS+TImR.

Although previous operational research has been performed in Tanzania on both TImR and VIMS, earlier evaluations were limited by the absence of data from regions where the intervention was more recently rolled out thus limiting the ability to compare different geographical areas (BID, 2018). Furthermore, while evidence on the costs of the systems have been collected (Mvundura et al., 2019; Mvundura et al., 2020), a comprehensive economic evaluation of the systems had not been performed to date. There has been limited information on the full economic impact of these solutions' costs associated with the programmatic benefits incurred (Mott MacDonald, 2019).

OBJECTIVE OF THE EVALUATION

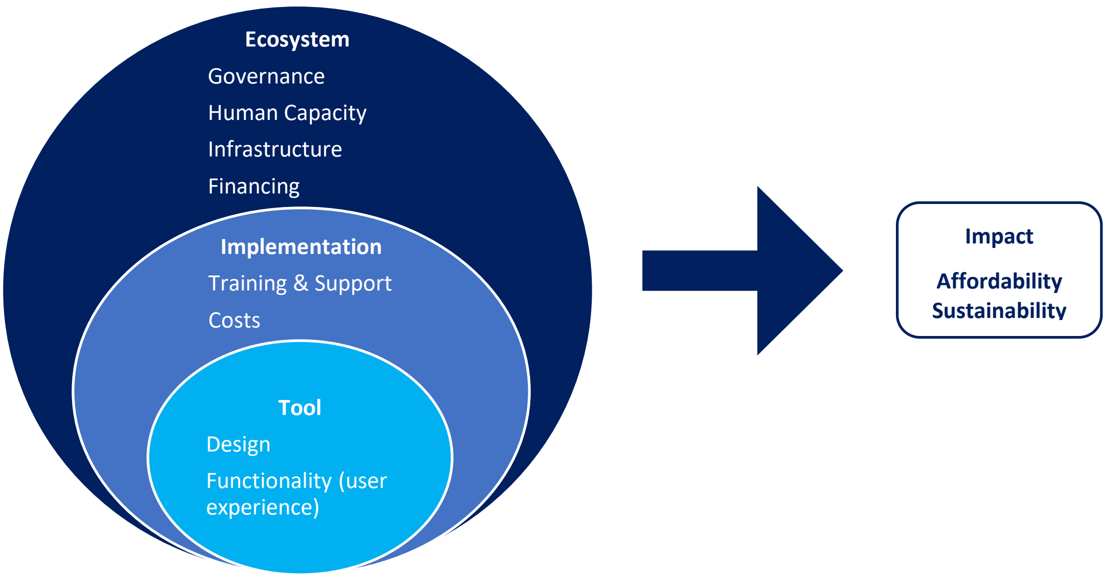
The objective of this evaluation in Tanzania was to assess the programmatic implementation, interoperability, impact, costs, affordability and sustainability of the two digital systems alone, or in combination, and to generate actionable evidence to support future decisions on the management and further development of these tools as well as of other digital technologies.

THEORY OF CHANGE

This evaluation is consistent with the wider evaluation design of the multi-country evaluation. It is based on an overarching evaluation framework supported by a Theory of Change (ToC) which is presented in **Annex 1**.Implementation and sustained use of an eIR and eLMIS at scale is envisaged in this ToC to contribute to improved immunization program performance by ensuring more equitable coverage and system efficiency and to be a good investment in the medium to long-term, with the assumption that the tools are both well-embedded into the country's processes and data architecture, and that they are affordable and financially sustainable, providing value for money.

The ToC served as the foundation for a framework used to guide the interpretation of the key findings from this evaluation. This evaluation framework focuses on the necessary ecosystem, design and functions of the tools, their implementation, impact and sustainability, as shown in *Figure 3*.

Figure 3: Evaluation Framework



RESEARCH QUESTIONS

The principal research questions for this evaluation are listed below. Each question maps to an element of the evaluation framework as indicated in parenthesis:

- Has the implementation of the TImR and VIMS improved immunization service delivery? (Impact)
    - To what extent do these systems comply with established norms and standards? (Tool)
    - What were/are the barriers and opportunities for implementing these systems? (Tool, Implementation and Ecosystem)
    - What is the impact of the TImR and VIMSon the national immunization program both in terms of process efficiencies and health outcomes (e.g., cost savings, performance, timeliness, coverage)? (Impact)
- What is the short- and medium-term economic and financial impact of implementing and scaling up these systems in the whole country? How affordable and sustainable are the systems? (Impact, Affordability & Sustainability)
- How interoperable is the TImR and VIMS with the national health management information and civil registration systems? (Tool, Ecosystem)
- How can new evidence on tools and technologies, modalities, and governance of the TImR and VIMS inform further investments from domestic sources, health financing institutions and technical partners for the sustained implementation of these systems? (Impact, Ecosystem, Affordability & Sustainability)

III. METHODOLOGY

A. PROGRAMMATIC AND ECONOMIC IMPACT EVALUATION

PROGRAMMATIC IMPACT EVALUATION

Both quantitative and qualitative methods were used to evaluate the programmatic impact of the use of the electronic systems. Impact was evaluated in terms of service delivery processes including data quality, data use for decision-making, program and process efficiencies including vaccine stock levels, as well as user experience and perception of the tools by HWs and their clients. The evaluation aimed to identify and explore factors critical for the successful implementation and further scale-up of the electronic tools.

ECONOMIC IMPACT EVALUATION

The economic impact evaluation aimed to provide an estimate of: (i) the upfront financial expenditures at national level of implementing the TImR and VIMS; (ii) the routine operating costs of managing immunization data using the VIMS+TImR; and (iii) the difference in current operating costs of the VIMS+TImR compared to the paper-based registry. An activity-based costing approach (ABC) was employed for the analysis of routine operating costs of managing immunization and stock data. The ABC approach consisted of identifying a series of activities performed by the staff of HFs (i.e., dispensaries, health centers and district hospitals), tracing direct and indirect costs to these activities and then 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 (i.e., data entry, analysis and reporting, including maintaining records of children vaccinated or vaccine stock levels, completing reports and analysis, and monitoring and evaluating immunization program data). When estimating the difference between operating costs of "users" (i.e., those using VIMS+TImR and VIMS+TImR+paper IR) and "non-users" (i.e., those using VIMS+paper IR), the analysis considered two further activities whose costs, while not directly attributable to the management of immunization data, might have been affected by the way immunization data was managed and used: the planning and delivery of outreach sessions and any emergency vaccine replacement. A rationale for the inclusion of these activities is provided in **Annex 6.1**.

Additional insights for decision-makers on the financial sustainability of maintaining the electronic systems in the long-run were provided based on Tanzania's economic outlook, current expenditures on health and dependence on external funders. Specifically, a series of indicators across three levels were reviewed : (i) macro-sustainability; (ii) activity-specific sustainability; and (iii) sustainability from the perspective of domestic funders. For the first level, an overview of the macroeconomic trends for Tanzania was provided, based on macro-economic indicators such as Gross Domestic Product (GDP), GDP per capita, share of public debt over the GDP and other indicators related to health care expenditure. The activity-specific sustainability was expressed as the percentage weight of the costs of using the VIMS+TImR over the total expenditures for immunization in Tanzania. Lastly, the sustainability of the electronic systems for domestic funders was expressed as the share of costs covered by external payers over the total cost of the systems.

B. DATA COLLECTION INSTRUMENTS

The data collection instruments are listed in *Table 2* below which summarizes the purpose of each instrument and the number of respondents. The programmatic data collection instruments were adapted from pre-existing and validated tools including: the Modular Data Quality Assessment Protocol with Electronic Immunization Registry Component (PAHO, 2017); data instruments used in the earlier evaluation of the Better Immunization Data Initiative (Mott MacDonald, 2019); and the eIR Readiness Assessment Tool, jointly developed by WHO, UNICEF, US CDC, and supported by Gavi.

Table 2: Data collection instruments

Level of use	Data collection instrument	Purpose of the data collection instrument	Number of respondents
Health Facility	Programmatic: Interview guide	To explore the use of TImR/VIMS including the infrastructure and workforce requirements and impact on data quality and data use (e.g., defaulter tracking; outreach activities; reporting; and supervision). *(Note: Interviews sometimes took place as focus group discussions.)*	61
	Economic: Interview guide	To elicit information to quantify the costs of managing immunization with and without using the tool.	60
	Programmatic: Competency assessment	To assess the competency of staff using the tool.	25
	Programmatic: On-site accuracy check	To assess the accuracy between different data sources.	62
	Programmatic: Survey	A self-administered survey designed to gather insights on HF infrastructure, staff computer literacy, IT services, information quality and user satisfaction	60
	Programmatic: Caregiver interview guide	To explore if caregivers of vaccinated children had noticed any change in service delivery since the introduction of the electronic tool	81
District	Programmatic: Interview guide	Adapted from the programmatic interview guide used at HF level.	30
	Economic: Interview guide	Adapted from the economic interview guide used at HF level.	30
Region	Programmatic: Interview guide	Adapted from the programmatic interview guide used at HF level.	10
	Economic: Interview guide	Adapted from the economic interview guide used at HF level.	10

The evaluation protocol and data collection instruments were submitted for ethical approval by NIMR-MMRC and ethical clearance was obtained on 2 September 2021 under the procedures set by the Tanzania Commission for Science and Technology (COSTECH). The data collection instruments, and ethical clearance documentation are available in **Annex 2 and Annex 3** respectively.

The field work for data collection was coordinated by NIMR-MMRC and executed over a period of 3 weeks in October and November 2021, following training of data collectors and piloting of data collection tools. Five teams of 3-4 members each visited two paired regions, one with the tools in use and the neighboring region as ‘control’. In each region all selected districts and health facilities were visited, and all interviews and observations conducted.

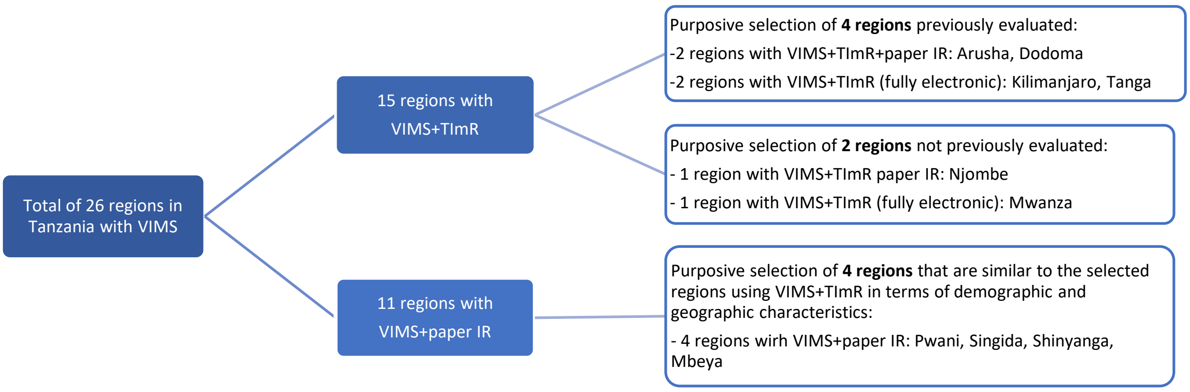
Teams were composed of an experienced MMRC team lead, a trained and competent data collector and a driver. Each team also included a senior expert from the MoH, familiar with the regional immunization system and with access to sources of relevant immunization data. All data collectors were fully trained on all aspects of the protocol and the administration of the questionnaires and data collection forms and equipped with the necessary technical evaluation tools such as electronic tablets.

Data were entered on-site using the open-source data platform Open Data Kit (ODK). Daily reports of all collected data were sent to the NIMR-MMRC headquarters in Mbeya where a senior data analyst reviewed data quality and completeness and provided immediate feedback and suggestions for improvements in case of missing or unclear data. Data were cleaned and compiled by senior NIMR-MMRC team members with remote assistance by the Bocconi/MMGH team between December 2021 and March 2022. Additional data were collected during the ensuing period, specifically related to the costs of implementation as captured by the development partners responsible for the tools' implementation (PATH and JSI), as well as on immunization-related indicators from government sources such as local and national coverage, drop-out, vaccine stock-out and wastage rates for the years before and after implementation of the tools. Data were analyzed by the Bocconi/MMGH team using Microsoft Excel, while the online Datawrapper tool (www.datawrapper.de) was used for visualization of data.

C. SAMPLING STRATEGY

A purposive sampling strategy was used to identify a quasi-representative sample of regions, districts and health facilities for inclusion in the evaluation. Ten regions were purposively selected as shown in *Figure 4.* The selection considered the following strata: regions with full electronic use of the VIMS+TImR; regions which used an VIMS+TImR together with a parallel paper-based IR; and regions which had not yet introduced TImR and were only using the VIMS. All regions where previous evaluations of the systems had taken place were included in the sample to allow for comparison of the findings and use of the systems over time.

Figure 4: Purposive sampling of regions



Regions using the VIMS+TImR were paired with regions not using the tools which were as similar as possible in their demographic and other characteristics, all of them neighboring regions, as summarized below in *Table 3*. The number of regions in each group is proportional to the number of regions with and without the intervention in the whole country (i.e., 58% with VIMS+TImR and 42% with VIMS+paper IR).

Table 3: Regional pairs included in the evaluation and comparison against country

Regions	**VIMS+TImR***	**VIMS+paper IR**
Sample	Dodoma	Singida
	Mwanza (transitioning to fully electronic)	Shinyanga
	Njombe	Mbeya
	Kilimanjaro (transitioning to fully electronic)	Pwani
	Arusha	
	Tanga (fully electronic)	
Total in sample (n=10)	**6 (60%)**	**4 (40%)**
Total in country (n=26)	**15 (58%)**	**11 (42%)**

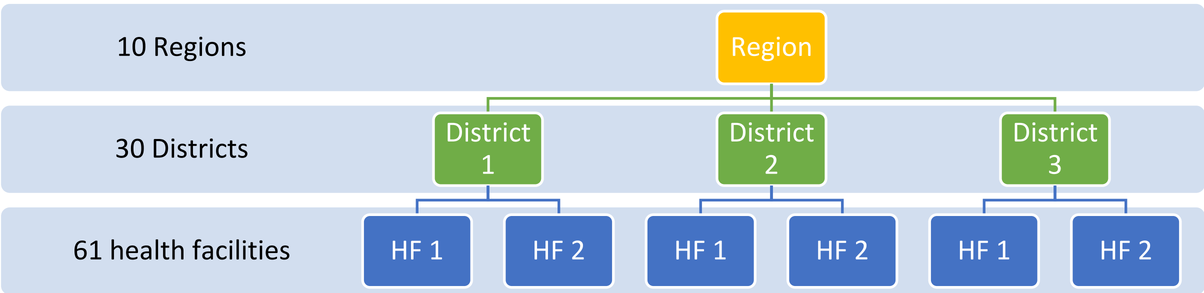
* All regions expected to operate a parallel electronic/ paper system, unless otherwise specified

Within each selected region three districts were randomly selected (see **Annex 4**), while within each selected district, two health facilities were purposively selected taking into account the distribution of the following criteria for facilities in the 10 selected regions:

- Location: Urban or rural
    - Facilities belonging to a Town Council (TC) or District Council (DC) were considered as rural, while facilities under a Municipal Council (MC) or City Council (CC) were considered as urban
- Level of HF: hospital, health center, dispensary, other (such as clinics, laboratories, etc.)
- Size of HF catchment area:
    - Based on the number of vaccine doses delivered per year of pentavalent, pneumococcal, rotavirus, measles and rubella vaccines as extracted from the District Health Information System 2 (DHIS2) for 2020.

Pragmatically, HFs delivering vaccinations were only included if immunization services took place during the two-week period of data collection. The resulting sample included ten regions, 30 districts and 61 HFs, as depicted in *Figure 5*. One additional HF was visited in Dodoma Region, a region which had stopped using the TImR, to allow for a more detailed exploration of this relatively recent discontinuation of use.

Figure 5: Sample composition depicting 3 sample selection stages from region to health facility level



The sample of HFs can be considered representative of the overall sampling frame of health facilities in the selected regions regarding the above criteria, as shown in *Table 4*. A slightly larger proportion of hospitals was sampled as at least one hospital per pair of regions was to be included. As 80% of the sites delivering vaccination services in the regions were dispensaries, the final sample included 46 dispensaries (representing 75% of the sites), 10 health centres and 5 hospitals. Other types of health facilities were excluded due to the small number of vaccinations delivered , such as other clinics, maternity homes, laboratories, etc. A list of the sampled facilities, mapped to their respective districts and regions is available in **Annex 4**.

Table 4: Representativeness of sample against selection characteristics of facilities in the 10 regions

	Description	Distribution across selected regions			Distribution in sample		
		VIMS+TImR	VIMS+paper IR	**Total**	VIMS+TImR	VIMS+paper IR	**Total**
Location / District type	Rural: Town Council (TC) or District Council (DC)	73%	77%	**74%**	70%	75%	**72%**
	Urban: Municipal Council (MC) or City Council (CC)	27%	23%	**26%**	30%	25%	**28%**
HF Type	Dispensary	80%	80%	**80%**	76%	75%	**76%**
	Health Center	14%	12%	**13%**	16%	17%	**16%**
	Hospital	4%	5%	**5%**	8%	8%	**8%**
	Other privately owned facilities (clinics, maternity homes, laboratories, etc.)	2%	3%	**2%**	0%	0%	**0%**

D. DATA ANALYSIS

PROGRAMMATIC ANALYSIS

The programmatic data analysis adopted a mixed methods approach. A descriptive analysis of primary data collected during the field visits from interviews and observations was performed by generating uni- and bivariate frequency distributions and summary measures.

The multi-country study compares input, process and output parameters between those health facilities who actually use the tools and those who do not ("users" vs. "non-users"). "Users" include those using exclusively an electronic tool (VIMS+TImR only) and those using a dual system (VIMS+TImR+paper IR). "Non-users" refer to those HFs which had never introduced the VIMS+TImR and those which had historically introduced the VIMS+TImR but were no longer using it.

A qualitative review of open-ended questions contained in the data collection instruments was done which focused particularly on the challenges and enabling factors of the use of the tools. Results were stratified by urban/rural location as a potential confounding variable. Simple statistical tests were performed to allow for the generation of hypotheses for further research. These included z- and t-tests for the comparison of continuous variables, and Chi-square and Fisher's exact tests for the assessment of associations between categorical variables.

ECONOMIC ANALYSIS

The economic analysis used a mix of primary and secondary data sources and methodological approaches, as summarized in *Table 5* and explained in more detail below.

Table 5: Summary of costing analysis

	Implementation costs of the VIMS+TImR	**Routine operating costs of using the VIMS+TImR**	**Cost impact of using the VIMS+TImR (as opposed to using VIMS + paper IR)**	**Financial affordability and sustainability**
Scope of the analysis	Costs of the VIMS and TImR for: (i) Design & Development (ii) Initial roll-out (iii) Scale-up (iv) Continuous improvement	Routine economic costs related to the management of immunization and vaccine stock data using the VIMS+TImR	Difference in the operating costs of managing immunization data with the VIMS+TImR as compared to the use of VIMS + paper IR; broader impact of using VIMS+TImR on pre-specified costs related to immunization service delivery	Financial sustainability of maintaining the continuous operations of the VIMS+TImR, using domestic resources. Return on investment (ROI) analysis
Type of analysis	Descriptive analysis	Activity Based Costing (ABC) analysis of users	ABC analysis comparing users and non-users – subgroup analysis by user groups and rural vs urban facilities	Descriptive and comparative analysis. Analysis of the total cost of the system based on the ABC analysis
Output of analysis	Total cost of implementation and roll-out of the systems	Cost per dose Cost per facility	Net cost of VIMS+TImR, including any avoided cost to the immunization program	Macroeconomic and health care sustainability indicators. Percentage of financial resources required for the VIMS+TImR / total EPI costs. Percentage of costs covered by domestic payers
Source of data	IVD department MoH, PATH, JSI	Questionnaires, Health Facility Registry (HFR) data	Questionnaires, HFR data	International Monetary Fund (IMF), WHO, Immunization Costing Action Network (ICAN) estimates
Cost inputs	Personnel, durable goods, consumable goods, services			

FINANCIAL EXPENDITURES OF IMPLEMENTING THE VIMS+TIMR

The perspective used for the analysis of financial expenditures was that of a "third-party payer." This perspective included the expenditures from both external funders (e.g., international organizations and/or private funders) and domestic funders (e.g., national or subnational authorities).

The costs incurred to implement the VIMS and TImR were mainly based on data obtained from the following sources: the IVD program of Tanzania which owns both systems; PATH and JSI (i.e., the organizations which supported the development and implementation of the systems); and Santé Suite Inc. which provided technical assistance in the development of the TImR. No expenditures were directly available concerning BID staff during the initial roll-out of the system in Arusha, Tanga and Kilimanjaro, and for the TImR implementation in the Dodoma region in the year 2018. As such, this information was taken from published literature. Specifically, Mvundura et al. (2019) estimated BID staff cost at USD 1.6 million for the three regions, whereas the costs for the TImR implementation in Dodoma were reported to be USD 89,795 in a costing study by Mott MacDonald (2019).

A descriptive analysis of the financial expenditures was performed categorizing them into: (i) system design and development (i.e., software development and customization of the system to the country needs and context) and (ii) implementation (i.e., purchasing of hardware, such as tablets, desktops and modems; training and supervision). A similar approach had been followed by Mvundura et al. (2019) who provided evidence on the costing of the BID initiative in Tanzania and Zambia. Two additional categories of expenditures were included in for (iii) scale-up and (iv) continuous improvement activities. The former category included financial expenditures for the roll-out of the TImR in additional regions beyond the initial implementation in the regions reported by Mvundura et al. (2019) and Mott MacDonald (2019), including the same cost items. The latter category included expenditures for new additions to and refinements of the systems, either in terms of technology or human capacity, as these evolved from their original design. It must be noted that detailed accounting information and expenditure reports were not able to be obtained during data collection. As such the analysis of financial expenditures is based on available budgets, assuming that these were consumed entirely for the budgeted purposes and thus the budgets reflect the actual expenditures incurred. In addition, no information on in-kind contributions from the local government were available (e.g., in terms of government staff time spent for management, coordination and operational activities, as well as goods and infrastructure made available to the implementation team) and, therefore, were not considered in this analysis.

All cost estimates were adjusted to 2021 real values using the World Bank GDP deflator index and converted to USD using the World Bank's average exchange rate in 2021 (1 USD = 2,297.76 TZS). The average costs in the economic analysis are reported along with the 95% confidence intervals.

ROUTINE OPERATING COSTS

The routine operating costs of managing immunization and vaccine stock data using VIMS+TImR were investigated. These costs are different from the costs for continuous improvement specified above. While continuous improvements costs refer to further developments of the digital tools, routine operating costs relate to the performance of routine activities by healthcare staff that involve the use of immunization and stock management data. These activities were pre-defined based on a literature review and an iterative consultation process with experts in electronic immunization systems and represent areas within immunization service delivery and vaccine stock management that are impacted the most by the implementation of the electronic systems, as shown below in *Table 6*.

Table 6: Description of activities related to the management of immunization and vaccine stock data

Activity	Description
Vaccination session execution: Child registration	Time spent on entering details and data regarding a new child registration (including service provision and data management, finding client folder and event recording).
Defaulter identification	Reviewing registry to identify children who missed appointments, making list of defaulters
Defaulter contacting	Contacting defaulters to remind caregivers of missed vaccinations
Organizing outreach sessions	Preparation for the delivery of immunizations in outreach settings

Identifying performance gaps	Reviewing data to find performance gaps (such as HFs not being on track for coverage goals)
Report generation	Time taken to search for and record data that will be included in the regular reports on immunization services and stock management.
Report transportation	Physical transport of weekly/monthly reports to higher administrative level for submission
Vaccine quality control/ monitoring	Physical counting, recording, and checking of closed vaccine vials for expiry dates or temperature excursions; Physical counting, recording, and checking of any open vials
Cold Chain monitoring	Data entry of records of the refrigerator or freezer temperatures
Determining quantities of vaccine to order	Data mining and information extraction from dispensing/vaccine use and storage system and processing it to prepare the next order
Refresher trainings	Recurrent trainings provided to HF staff on recording and reporting of immunization data, whether on paper or electronically
Technical and/or administrative support visits	Recurring visits from higher health system levels for supportive supervision and technical assistance in immunization service delivery

The analysis of the routine operating costs of using the VIMS+TImR was based on primary data collected at regional, district and HF level on costing information for the identified activities. During the data collection effort respondents were asked to provide estimates of the number of staff and the amount of time spent on each of the defined activities, as well as of other costs incurred on average for equipment, consumables and services that were directly attributable to that activity. Information was also collected on the average frequency at which each activity was performed, and on printing and maintenance costs that were directly attributable to the management of immunization data (e.g., printing costs of reports and maintenance of IT equipment). Identical questions were asked at regional, district and health facility levels in settings with the VIMS+TImR (users) and in those using the VIMS + paper IR (non-users), with the possibility for the respondent to indicate whether the activity is or is not performed at that administrative level and be subsequently asked detailed questions for data on the activities which are performed.

Staff time was converted to a monetary value using national reference salaries for healthcare staff (Ofisi ya rais, 2015). **Annex 6.3** provides further details on the approach used to map the staff profiles reported during primary data collection to the staff titles and salary levels published in the Official Gazette. The cost per minute of staff was then calculated considering a monthly practical capacity equal to 20 days per month and 8 hours a day, and assuming a 20% reduction in capacity to account for sick leave, trainings and breaks/leave.

Data on shared cost pertaining to recurrent services, consumable and durable goods were directly elicited from the questionnaires or derived from the 2021 immunization budget of the IVD Program. These costs were then allocated across all activities using staff time as a cost driver and included printing and maintenance costs as well as costs of internet, and of distributing paper registries from central to lower administrative levels. Each facility was also assumed to be endowed with an electronic tablet, whose cost was apportioned across all reported activities using the same cost-driver. The cost of each tablet was assumed to be approximately USD 522 annuitized over 5 years. Other indirect and overhead costs (e.g., those related to facility costs on electricity or other maintenance costs) were not able to be obtained due to lack of reliable data sources and, thus, were excluded from the analysis.

The costs of performing immunization and vaccine stock management activities were reported as the total average annual immunization services cost per HF, as well as the cost per dose delivered. In both estimates, the costs at district and regional levels were apportioned to each HF in the sample based on the total number of HFs delivering immunization services under the administration of the respective districts or regions, as obtained from the Health Facility Registry (HFR) portal of the MoH (HFR portal, 2022). The number of doses delivered were calculated based on the 2,235,407 surviving infants in Tanzania in 2021 (UNPOP, 2021) and on the WUENIC national immunization coverage estimates for the first dose of BCG, the third dose of Pentavalent vaccine, the third dose of oral Polio vaccine and at least one dose of Measles containing vaccine. The total number of doses represented the sum of the number of infants multiplied by the % coverage for each antigen times the number of doses for that antigen in order for a child to be considered fully immunized against it. Coverage rates were taken from 2019 to avoid incorporating the effect of the COVID-19 pandemic on immunization services. The cost per dose was then obtained by dividing the total annual cost per HC by the calculated number of doses delivered.

COST IMPACT

A cross-sectional approach was used to estimate the difference in costs of immunization and vaccine stock data management with and without the VIMS+TImR between health facilities using and not using the tool. To account for potential effects of the implementation of the system on the broader costs of the immunization program, the cost impact analysis explored whether using the VIMS+TImR would also affect the costs of delivering outreach sessions and the costs of emergency vaccine replenishment due to unforeseen stock-outs. For these two activities, it was explored whether the implementation of the system was associated with any difference in costs, for example, through a reduction in stock-out events or through improvement in the efficiency of outreach sessions (i.e., if the number of children vaccinated per session was increased or if the number of annual outreach sessions was reduced as a result of better planning).

The total annual cost for the entire country was then estimated based on the mean costs per HF using VIMS+TImR or using VIMS+paper IR. For each region, the cost for immunization data management was calculated by multiplying the mean cost per HF in each region with the total number of HFs delivering immunization services in that region. Then the cost for the other regions was extrapolated assuming that: i) the mean cost of the 6 regions with VIMS+TImR was generalizable to the total of 15 regions that have implemented the system so far and ii) the mean cost for the 4 regions that still rely on paper for immunization data management but have the VIMS installed was generalizable to the 11 regions in which the TImR is yet to be introduced.

FINANCIAL AFFORDABILITY AND SUSTAINABILITY

Time series data for the sustainability analysis were derived from the International Monetary Fund (IMF) for macro-economic indicators. For expenditure on immunization, multiple sources were considered. According to the WHO Joint Reporting Form (JRF) for 2018 and 2019, Tanzania's total expenditure from all sources for routine immunization, including vaccines, averaged USD 60M over the two years and was financed at an average rate of 16% by government funds (WHO, n.d.). However, JRF estimates on immunization expenditures have been shown to underestimate immunization expenditures compared to other sources. For example, in a multi-country analysis, Ikilezi et al. showed that JRF expenditure captured only about half of expenditures reported in the comprehensive multi-year plans (cMYP) using the WHO-UNICEF cMYP costing tool. In Tanzania, the cMYP 2016-2020 estimated the future resource requirements for the immunization program at USD 151,301,084 and USD 184,384,572 in 2019 and 2020, respectively. Of these requirements, 56% and 50%, respectively, were secured by government funds, whereas the rest were dependent on external funding. These figures are consistent with more recent estimates provided by the ICAN for 2019 which estimated the total costs of the immunization program to be USD 2.4 per capita. Based on this, the total immunization program costs for the 63.6M population of Tanzania in 2021 were estimated at approximately USD 154M. Using the average between the ICAN estimate and cMYP estimates, the activity-specific sustainability, expressed as the percentage weight of the costs of using the electronic systems over the total budget for immunization in Tanzania, was calculated using a range for the total immunization budget between USD 154M and 168M.

Finally, a simple Return on Investment (ROI) analysis was done comparing the cumulative savings from using the system with the initial investment at year t_0 required for its implementation. The ROI at year t after implementation was calculated using the formula:

$$ROI_t = \frac{Savings_t - initial\ investment_{t_0}}{initial\ investment_{t_0}} * 100$$

Future savings were discounted at a discount rate of 3.5%.

IV. FINDINGS

The findings of this evaluation provide programmatic data on the implementation status of the electronic tools as of November 2021, as well as financial data on their implementation and routine operating costs. Programmatic findings are reported based on the analysis of data from questionnaires during the primary data collection effort and secondary data from a desk review and largely reflect interview responses related to the use of the tools and their perceived benefits and challenges. Economic findings are reported from the ABC analysis, as well as from a sustainability and affordability analysis. Below is a synthesis of the key findings with additional details on the programmatic and economic findings provided in **Annex 5** and **Annex 6**, respectively.

A. IMPLEMENTATION STATUS: DESCRIPTION OF USE OF THE TOOLS

The evaluation revealed that contrary to the predicted status of system use in 10 regions, only three regions (Kilimanjaro, Mwanza and Tanga) were actually using the VIMS+TImR, mostly parallel with a paper IR; only two HFs in Kilimanjaro and three HFs in Mwanza region were using the tool in fully electronic mode while implementation was variable in the remaining HFs. While the district level in Tanga was using the VIMS+TImR, no HFs were fully electronic there (four HFs used the VIMS+TImR+paper IR and two were no longer using the VIMS+TImR). In Arusha, while the region maintained the VIMS+TImR and a parallel paper IR process, no districts nor HFs had actually used the VIMS+TImR (rather only VIMS + paper IR). In Njombe, only one district was found to be using VIMS+TImR, while the regional level and the remaining HFs relied on VIMS + paper IR. Finally, in Dodoma no use of the VIMS+TImR was witnessed at regional, district or HF level.

Data were collected from 61 HFs, 30 district and 10 regional immunization offices. The way in which the tools wereused is described in *Table 7* with further details provided in **Annex 4**. Overall, one third (34%) of HFs visited, anticipated to be using the VIMS+TImR, were no longer using the tool. This was largely due to IT problems with accessing the tool, ecosystem challenges, and the failure of HWs to continue to use the system (rather than due to a policy decision to slow down implementation). Notably, at the national level, senior staff were unable (during the evaluation period) to export system data for further analysis directly from the TImR and VIMS due to a continued failure of the system, which could not be rectified for several months.

Table 7: Use of the digital tools for immunization in sites visited

Level	Users		Non-users	
	VIMS+TImR	**VIMS+TImR + parallel paper IR**	**VIMS + paper IR (no longer using VIMS+TImR)**	**VIMS + paper IR (never used VIMS+TImR)**
RIVO (n= 10)	3	1	4	2
DIVO (n= 30)	7	1	10	12
HF (n=61)	5	10	21	25
Total	15	12	35	39

Table 8 describes characteristics of the different user groups. Respondents were split between rural and urban locations, and HF respondents were primarily clinicians. When comparing users and those no longer using the tool, users were more likely to consider themselves adequately trained and to have access to support from the district (or elsewhere). Users also received more frequent supportive supervision and reported having a clearer understanding of their roles and responsibilities than those no longer using the tool. The VIMS+TImR was designed for use by HF staff including heads of clinics and vaccinators, and for use by DIVOs and RIVOs at the district and regional offices. DIVOs and RIVOs reported having a clear understanding of their roles and responsibilities related to the use of the electronic tools.

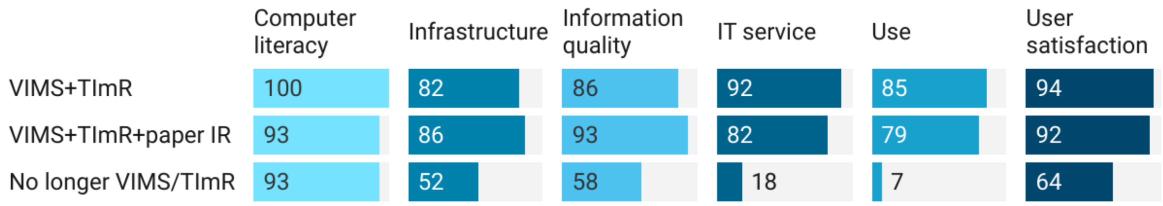
Table 8: Characteristics of respondents

		Users		Non-users	
		VIMS+TImR-only	**VIMS+TImR + paper IR**	**No longer VIMS+TImR**	**Never VIMS+TImR**
Location of HF	*Rural (n = 34)*	40%	50%	57%	60%
	Urban (n = 27)	60%	50%	43%	40%
Role within immunization services (at HF)[1]	*Data manager (n=1)*			5%	
	Clinical staff (n=60)	100%	100%	95%	100%
Access to support from the district or elsewhere	*HF (n=61)*	100%	90%	20%	
Frequency of immunization supervision activities	*Once a month*	40%	10%	19%	4%
	Once a quarter	40%	80%	33%	76%
	At least once a year	20%		33%	16%
	None		10%	14%	4%
Use of VIMS/VIMS+TImR to inform supervision	*HF (n=61)*	100%	70%	76%	64%
	District (n=30)	71%	100%	70%	67%
	Region (n=10)	67%	100%	50%	100%
Clear understanding of roles & responsibilities in using the VIMS+TImR/VIMS	*HF (n=61)*	60%	100%	20%	NA
	District (n=30)	100%	100%	100%	100%
	Region (n=10)	100%	100%	100%	100%
Adequately trained on VIMS+TImR/VIMS	*HF (n=61)*	60%	40%	20%	NA
	District (n=30)	100%	100%	50%	50%
	Region (n=10)	67%	0%	50%	75%

Figure 6 presents the results of the HW survey indicating that computer literacy was not perceived as a barrier to implementation, and that access to infrastructure facilitated more frequent use (as evidenced by those no longer using the tool). Whilst those using both the VIMS+TImR together with a parallel paper IR had the highest perception of immunization information quality, unsurprisingly those no longer using the tool did not perceive well the quality of information from use of the tool. Those no longer using the tool also thought that the quality of the IT service received was insufficient, while more frequent users, particularly those using exclusively the electronic tool, reported better access to quality IT services. Overall, user satisfaction increased with increased use.

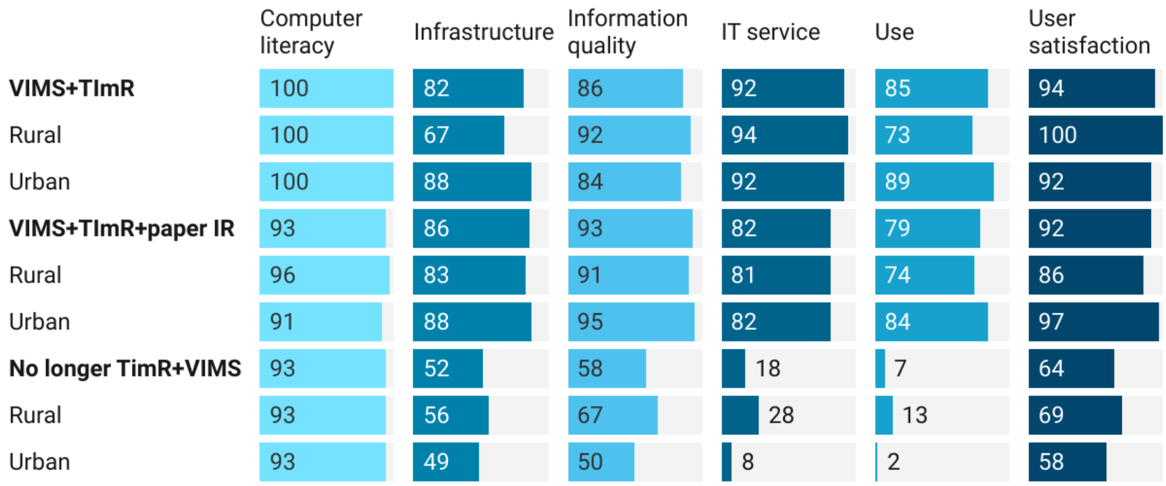
[1] At district level, respondents included DIVOs, Assistant DIVOs, previous DIVOs and environmental health officers. At the regional level, respondents were RIVOs except for one environmental health officer. There was no relationship between role of respondent and categorization of region or district in terms of use of an electronic tool.

Figure 6: HW perception based on use (HF %)



Further, *Figure 7* describes the differences between rural and urban use. Whilst there was no consistent difference between rural and urban users, rural users no longer using the tool perceived the experience of using the tool as better compared to no longer urban users. Overall, urban users had better access to infrastructure, and used the tool more regularly.

Figure 7: HW perception based on location of use (HF %)

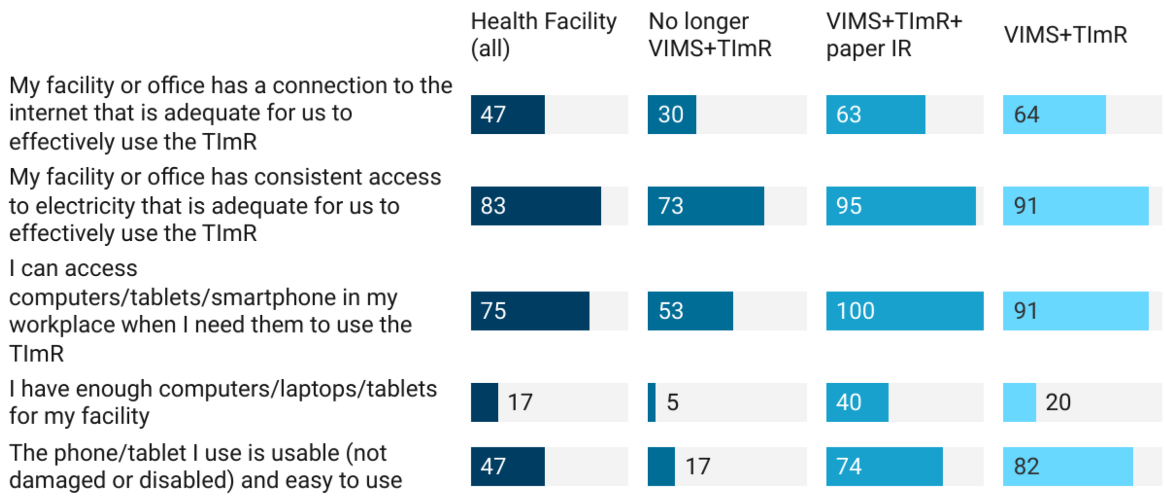


B. PROGRAMMATIC FINDINGS

ECOSYSTEM (INFRASTRUCTURE)

The biggest infrastructure challenge experienced by HFs was access to the **internet and data bundles.** The majority of users were able access hardware (e.g., computers, tablets, smartphones) in their workplace when required, however many still considered their availability as insufficient. The majority (95%) of HF staff no longer using the tool stated that they did not have enough working computers, laptops or tablets at their HFs. Similarly, amongst users, VIMS+TImR-only users (80%) and VIMS+TImR+parallel IR (50%) users complained about insufficient hardware. VIMS+TImR users were more likely than non-users to state that their internet connectivity was adequate (*p=0.04*). Access to the internet was frequently mentioned as enhancing the benefits of the tool (e.g., "*when Internet is working, I do my work faster and more efficiently"; "When the Internet connection is good using tablet is quicker than paper").* Users also reported that they had better access to electricity than non-users (n.s.) and thought that they could more easily access hardware if needed (*p<0.01*). Their hardware was perceived as more 'usable' (i.e., not damaged) (*p<0.01*) *(Figure 8).*

Figure 8: Access to infrastructure at HF level (%)

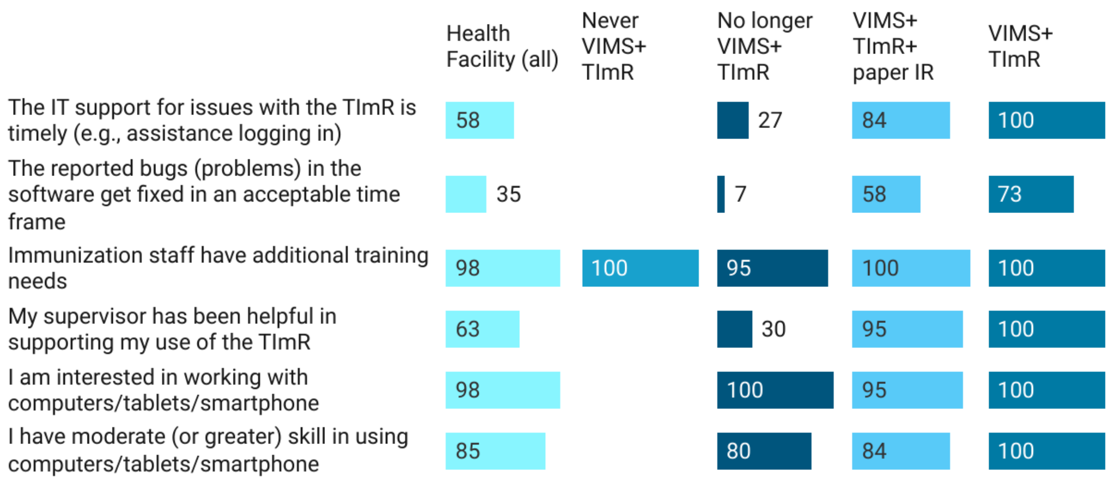


The biggest infrastructure challenge experienced by DIVOs (50%) and RIVOs (40%) was again poor internet connectivity. Some DIVOs (13%) and RIVOs (10%) also reported challenges with electricity. Respondents acknowledged having to use personal funds for purchasing data bundles, particularly during outreach services. The vast majority of DIVOs (93%) and RIVOs (80%) did not think they had enough computers, laptops or tablets. Almost two-thirds (63%) of DIVOs and 90% of RIVOs described personal experience with unusable hardware.

TOOL IMPLEMENTATION (TRAINING AND SUPPORT)

As presented in *Figure 9*, users i.e., those using the VIMS+TImR exclusively or in combination with a parallel paper IR were much more likely than those no longer using the tool (27%) to state that **IT support** for the tool was timely (*$p<0.01$)*. Two-thirds of users thought that reported IT problems were fixed in the appropriate time with decisive differences between user groups (73% VIMS+TImR only, 58% VIMS+TImR+paper IR) and 7% of those no longer using the VIMS+TImR. Two-thirds (63%) of HF respondents - the majority of whom were users - thought their **supervisors had been helpful** in supporting the use of the tool. Those no longer using the tool were much less likely to think their supervisors had been helpful with supporting theirthe use of the tool. HF respondents acknowledged that DIVOs tried to assist where possible (e.g., replacing broken chargers or with non-technical challenges) but oftentimes were unable to do so (e.g., if there were software challenges). The majority (98%) of all HF respondents were overall **interested in working with** computers, 85% thought they had **moderate or greater IT skills** and all respondents thought that IT hardware would **support them to be more efficient at work**.

Figure 9: HW perception of training and support (%)

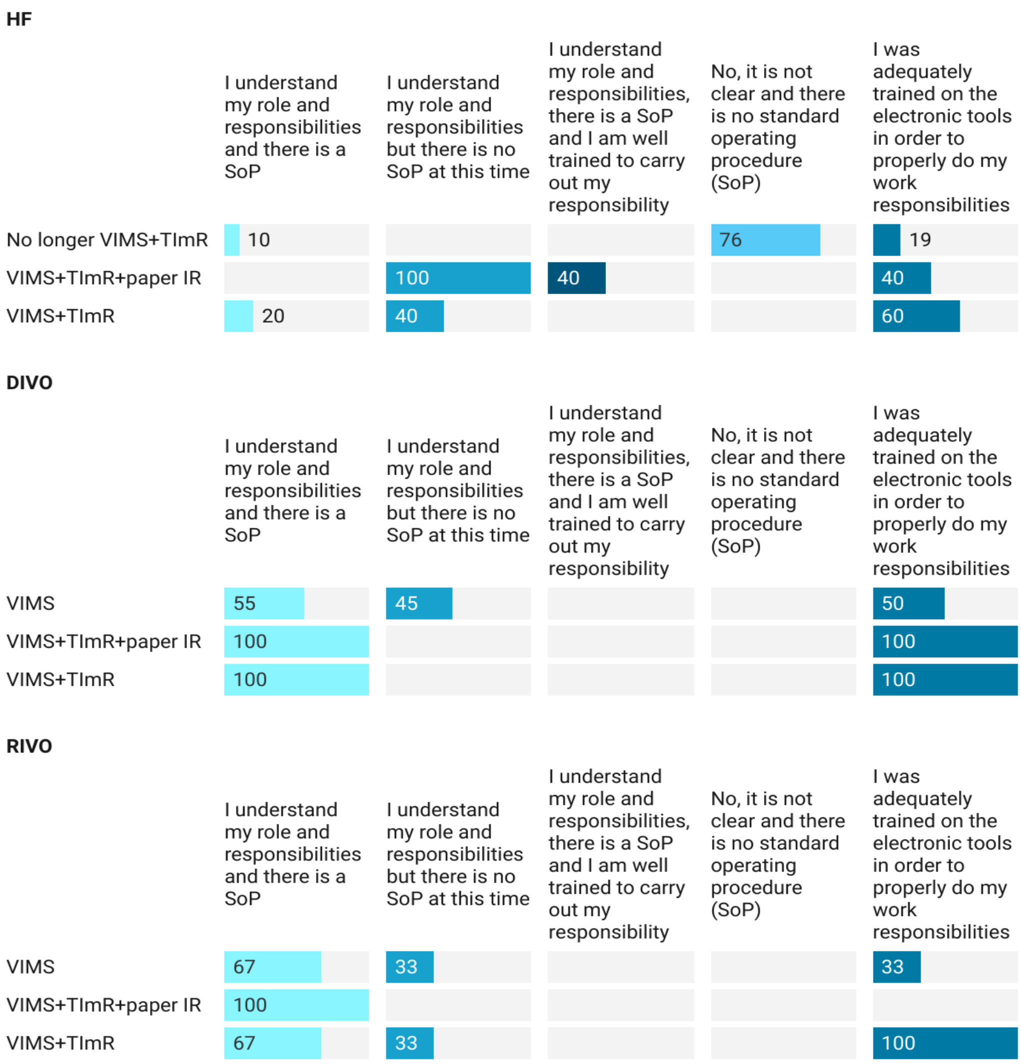


Most district level respondents acknowledged that additional staff were required, or a reorganization of staff had become necessary for the operation of the electronic tools.Most regional respondents acknowledged the requirement to reorganize and train staff, but that work was "*simplified*" and workload "*decreased significantly*" when using the tools.

More than half (54%) of HF users, and all district and regional respondents understood well their **roles and responsibilities**. However, SOPs were said not to be routinely available. Available training materials at HFs included job aids and instruction manuals. DIVOs and RIVOS largely had access to instruction manuals which, according to the DIVOs, needed to be updated. The majority (90%) of VIMS+TImR users at the HF level thought that the user guides/help functions in the VIMS+TImR were helpful to them; those no longer using the tool were less likely to think so.

In terms of training, 60% of VIMS+TImR users and 40% of those using VIMS+TImR+paper IR compared to only 19% of those no longer using the VIMS+TImR thought they had been adequately trained. Nonetheless, almost all HF (98%) respondents reported **additional training needs**, most commonly in data analysis (89%), data recording (87%), data reporting (82%), and data collection (54%). By contrast, all district level VIMS+TImR users thought they had been adequately trained on the electronic tools while only 50% of the district level VIMS-only users reported having received adequate training. At regional level, VIMS+TImR users considered themselves as Being more adequately trained than VIMS-only users *(Figure 10).*

Figure 10: Roles, responsibilities, SoPs and training at health facility, district and regional levels (%)



The standard competency assessment was intended to be used at all facilities where the VIMS+TImR had been introduced (n = 36). A total of 25 responses were able to be assessed i.e., 9 responses from 5 HF exclusively using the VIMS+TImR, and 16 responses from the 10 HF using a parallel system, VIMS+TImR+paper IR.

Overall, VIMS+TImR+paper IR users appeared to be slightly more competent than users with an exclusively electronic VIMS+TImR as shown in *Figure 11*. Users were more comfortable in generating reports, than interpreting them, as summarized in *Figure 12* below. HWs noted concerns about missing orientation after new updates were done to the tool, and the challenge of not being able to enter data instantly due to poor internet connection. Some HWs acknowledged that they were capable of using the tool, but that there were challenges which prevented them from using it: *"The vaccinator is capable of using the system very well, despite the challenges related to the systems, bugs and loading"*. The DIVOs were acknowledged as supporting tool implementation: *"… users are competent in using the system, however they were unable to generate the defaulter report, so we asked the DIVO to retrain them"*.

Figure 11: Competency of HF users using the tool (%)

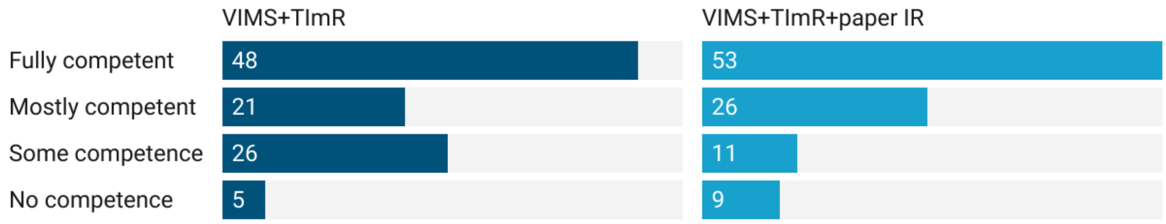
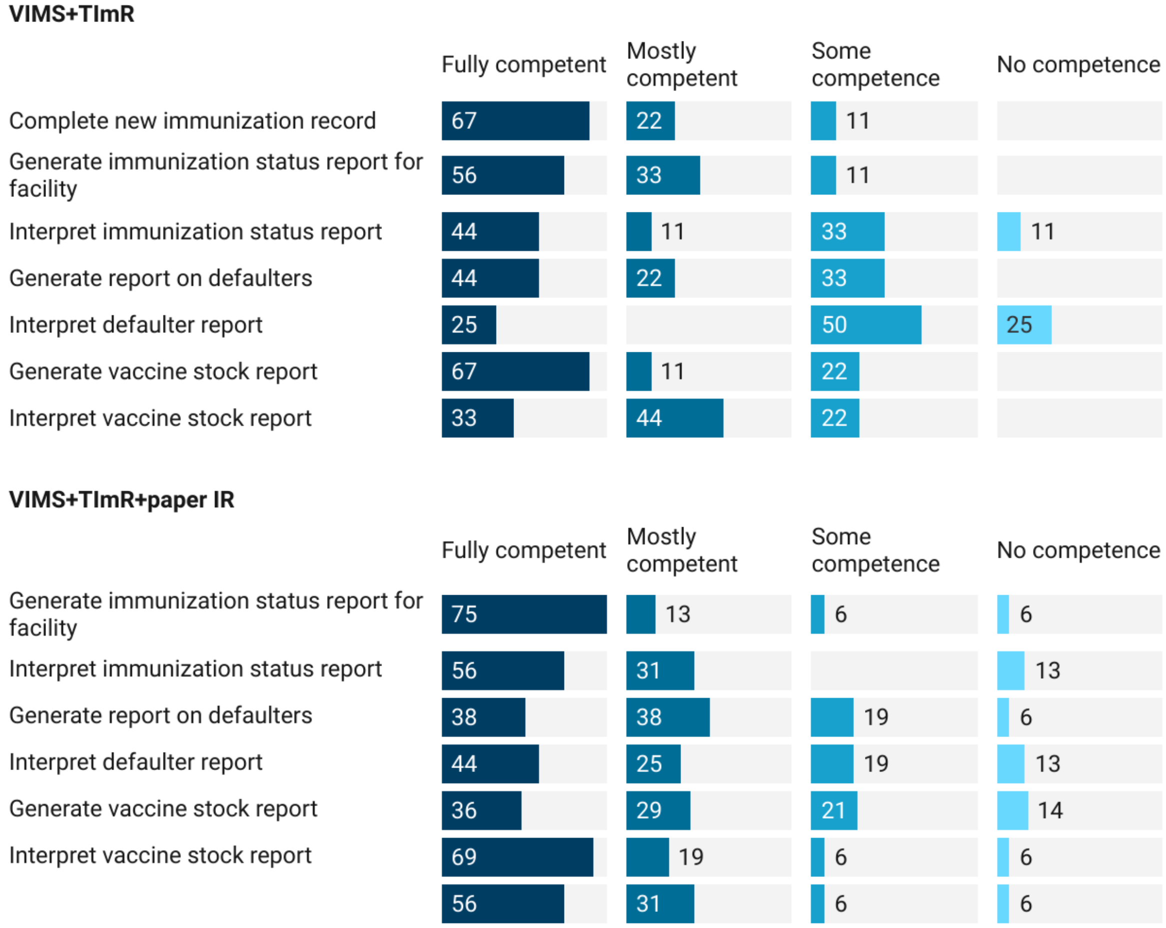


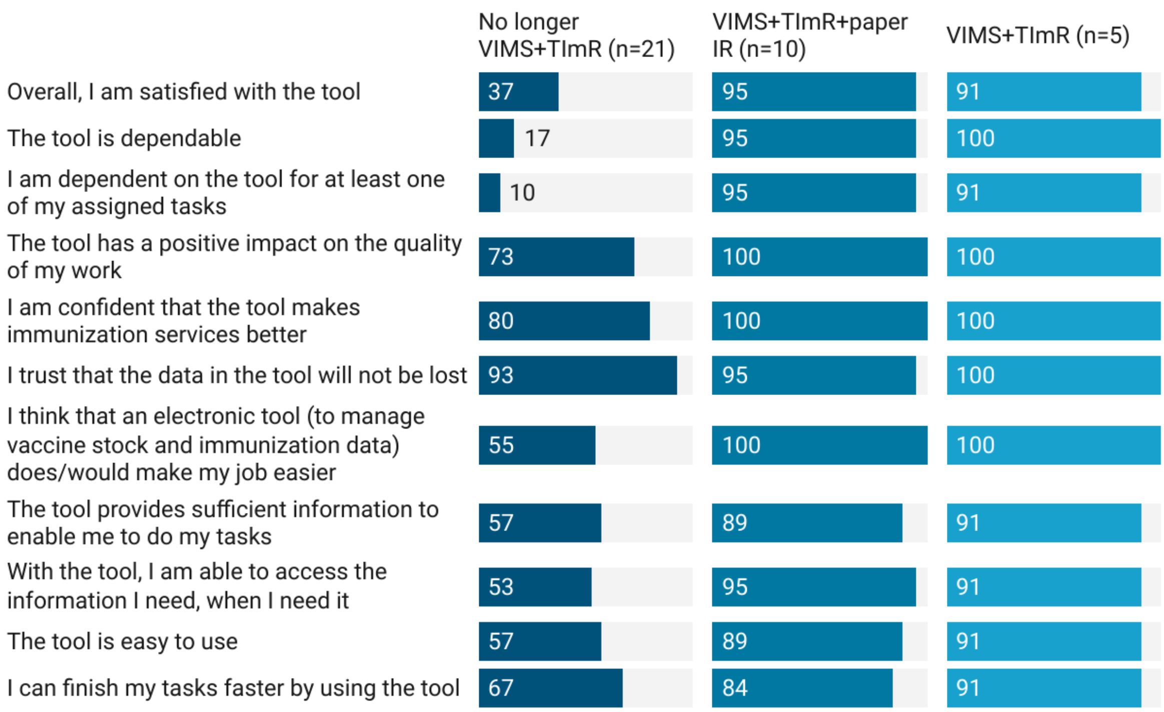
Figure 12: Competency of VIMS+TImR (n=10) and VIMS+TImR+paper IR users for identified activities (%)



TOOL FUNCTIONALITY (USER EXPERIENCE)

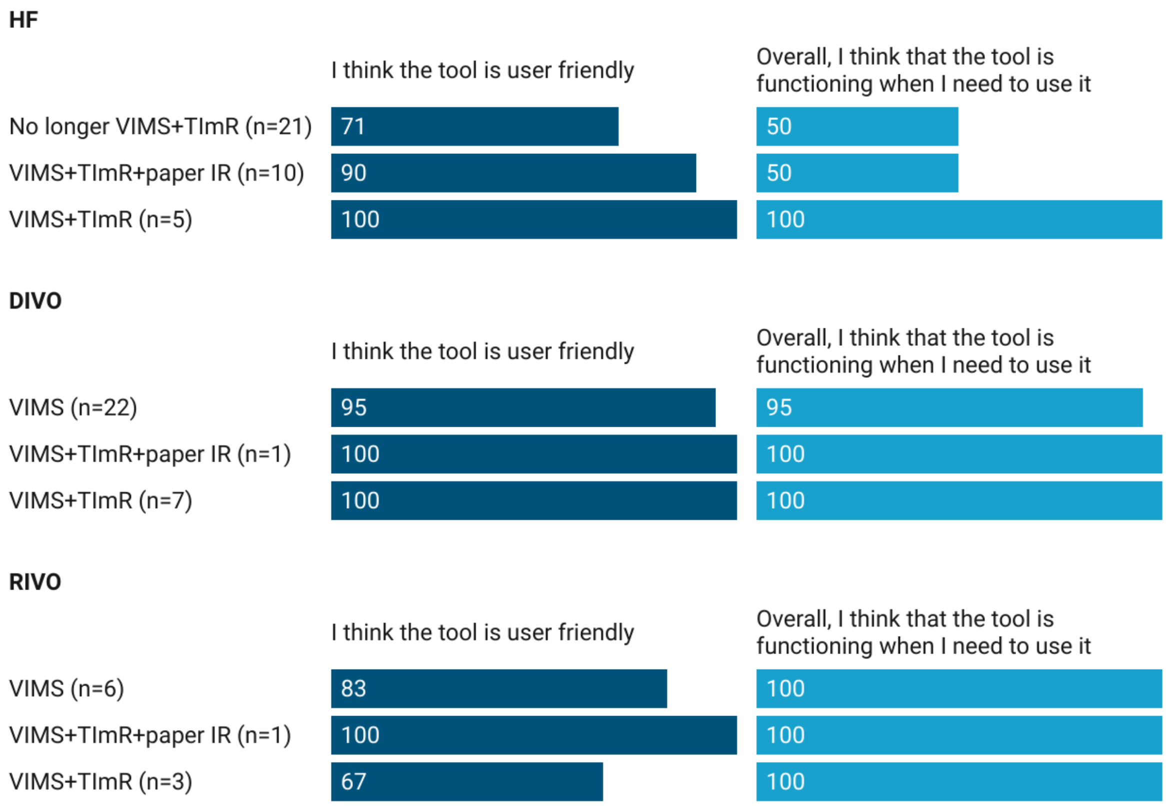
As shown in *Figure 13,* users (both exclusively electronic and those in parallel with a paper IR) were more likely than those no longer using the tool to be satisfied with the tool (*p=<0.01)* and considered the tool to be dependable (*p= < 0.01).* Users thought that the tool had a positive impact on the quality of their work whilst improving immunization services. They further trusted that the data in the tool would not be lost. Similarly, three-quarters (74%) of users felt that an electronic tool did/or would (for those not using the tool) **make their job easier**, with users being more convinced of this than those no longer using the tool. One HW commented: *"Because it is easy to use and simple it takes only a short time for lots of tasks."*HF users were more likely than those no longer using the VIMS+TImR to think that the tool **provided sufficient information** to enable them to perform their tasks (p=0.01) and access the information required (p=0.002). They also were more likely to state that the VIMS+TImR **was easy to use** *(p=0.01).* In addition, users were slightly more prone to think that they could finish their tasks faster by using the tool (n.s.).

Figure 13: HW user satisfaction (%)



All VIMS+TImR-only users (100%) and 90% of VIMS+TImR+paper IR users felt that the tool was **user-friendly** compared to only 71% of those no longer using the VIMS+TImR. The majority of district (97%) and regional (80%) users agreed with this statement. Despite this, one RIVO reported, "*The system is user friendly as every responsible person with a password can easily access the system."* The majority of district level users (93%) and all regional users thought that the tools were functioning when required, however only 57% of HF users thought so: this included 100% of VIMS+TImR-only users; 50% of VIMS+TImR+paper IR users and 50% of those no longer using the VIMS+TImR *(Figure 14).*

Figure 14: User experience across all levels (%)

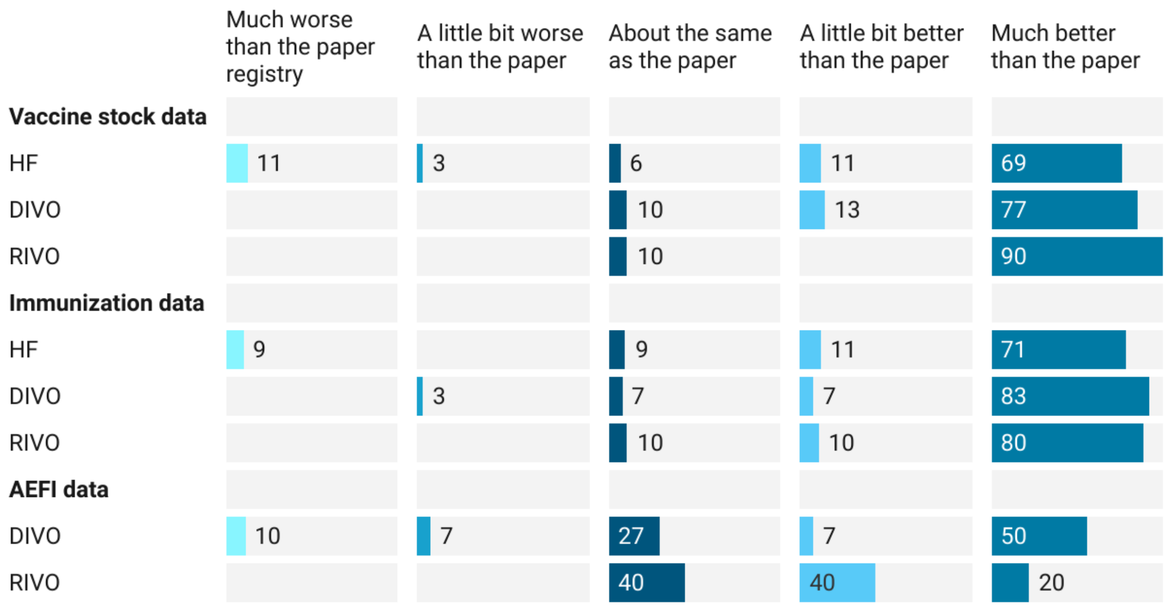


Users of the tools at all levels reported consistent challenges, notably tablets "sticking" (i.e., not progressing in the software program) and poor interoperability between the TImR and the VIMS. Respondents noted that IT challenges were significant and were impacting on the sustainable adoption of the tools, as evidenced by the following experience at district level: "The d*istrict is using the VIMS+TImR in immunizations services but the system is not stable so they have introduced data sets in excel format to avoid losing data".*

IMPACT: DATA QUALITY

The vast majority of HF respondents agreed that **both vaccine stock data and immunization data quality had improved** since the introduction of the VIMS+TImR as below in *Figure 15*. It is to be noted that it was only through the introduction of TImR that HF staff gained access to VIMS.HF users were more satisfied with the accuracy and completeness of vaccine stock and immunization records in the VIMS+TImR than those no longer using the tool (n.s.). There was no difference between rural users (77%) and urban users (71%) (n.s.). Any potential change in quality of AEFI data could not be assessed as the VIMS+TImR was only rarely used for reporting AEFI.

Figure 15: Quality of vaccine stock, immunization, and AEFI data since the introduction of the VIMS+TImR (%)

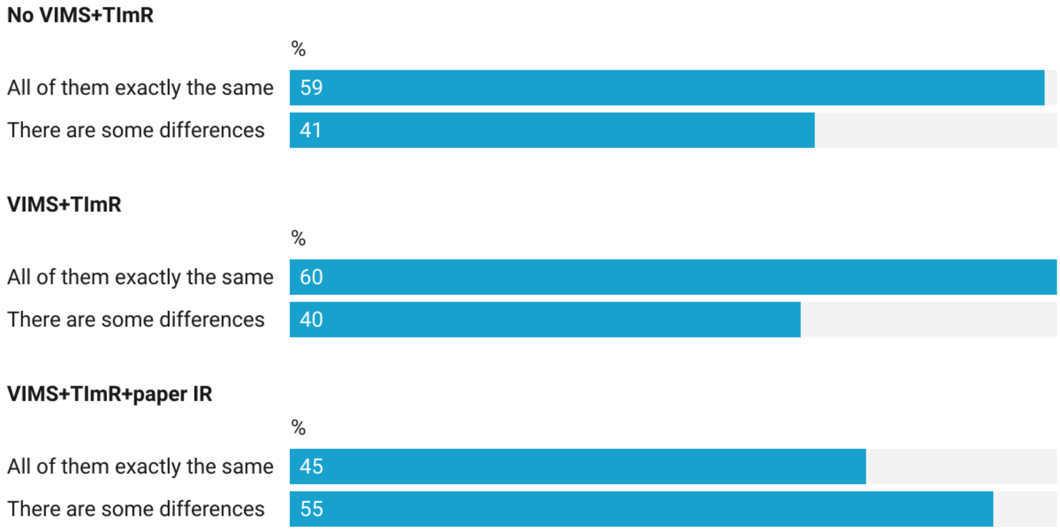


HF users were more likely to think that the VIMS+TImR provided the information needed compared to those no longer using the tool (p=0.03). More than half of regional (60%) and district (53%) but only 20% of HF respondents acknowledged challenges in their immunization and vaccine stock data which they wanted to address. At HF level, challenges reported included the VIMS+TImR failing to work properly, , and inaccurate denominators. At the district level, reported challenges related to poor data quality, limited or no interoperability between the VIMS and TImR, and challenges with the VIMS in retrieving and displaying data. Data quality challenges at the regional level included poor interoperability between the TImR and VIMS, and the need for continued use of paper tools.

Overall, the majority of HF respondents considered the **paper registry and Child Health Card to be the most accurate source of data**. District and regional respondents were largely split between the perception of accuracy across the three different data sources.

Results from the on-site data accuracy check demonstrated that when comparing data entries for selected children in the paper registry, the child health card and the electronic database (where the electronic tool was in use), more than half (56%) of entries matched. The highest accuracy between records was seen in either VIMS+TImR-only or exclusively paper IR settings where 60% and 59% (respectively) of entries fully matched. In contrast, in settings with a dual system (VIMS+TImR+paper IR), only 45% of entries matched exactly (difference n.s) *(Figure 16).*

Figure 16: Results of on-site accuracy assessment (%)



There was an association between perception of accuracy stated by respondents and accuracy confirmed during the on-site accuracy check: 60% of HF respondents who were satisfied with the accuracy and completeness of the VIMS+TImR data had data entries from different sources which matched exactly; while only 33% of respondents who were unsatisfied with their data quality had such matching entries. The documented discrepancies in data entries were explained by HF staff by a number of factors including: children vaccinated at other HFs and thus, whilst documented on the child health card, data not entered into the paper registry; child registration often done by community health workers (CHWs) who were not skilled in capturing data properly; delayed data entry due to staff shortages or poor internet connectivity resulting in staff forgetting to enter all/some details; and errors with the electronic system in accepting historical data.

Slightly more than half (56%) of HF staff thought that the **estimate of their HF target population was accurate**, with VIMS+TImR-only users more likely to think that this was the case. Even fewer district (50%) and regional respondents (30%) perceived their target population to be accurate and tended towards thinking that their true catchment populations were larger. Paper IR users were more likely to think that their target population was accurate both at the district (73%) and at the regional level (67%).

IMPACT: DATA USE

PROGRAM MANAGEMENT

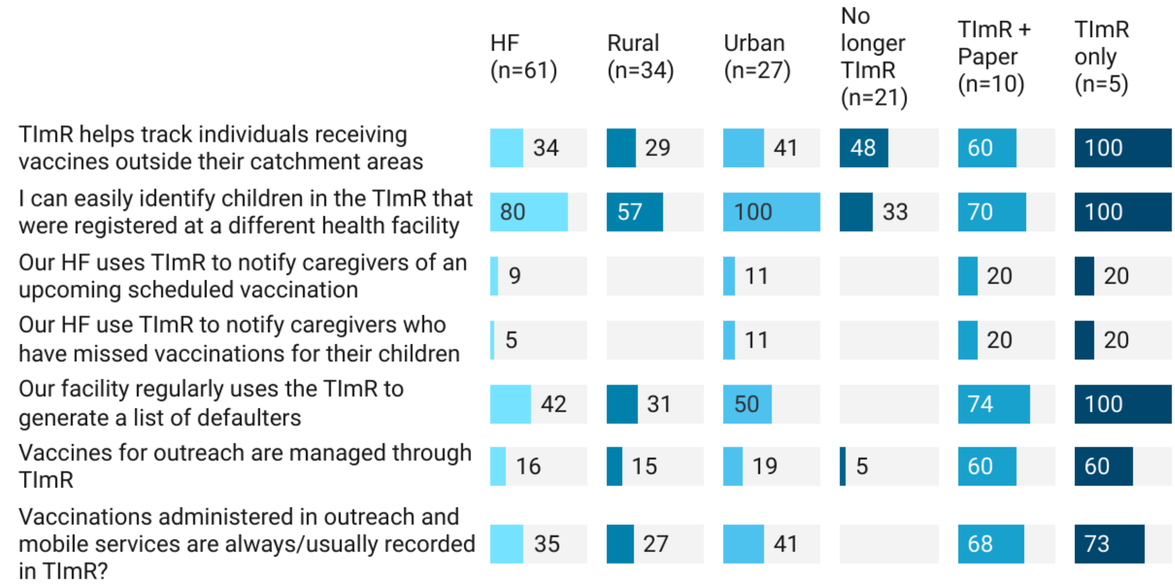
Program management was mostly impacted by improvements in supervisory activities facilitated by use of the tool, including providing and receiving feedback, and improving the quality of decisions made by DIVOs and RIVOs. Users also perceived the tool to assist in tracking individuals outside of their catchment areas or registered at a different facility. Whilst users were more likely to use the tool to assist with outreach sessions and defaulter tracking, the tool was not routinely used for these tasks.

At the HF level, most VIMS+TImR users thought that the system helped to **track individuals outside of their catchment** area. The vast majority of users, but less than a third of HF staff no longer using the VIMS+TImR, were easily able to identify children that were **registered at a different facility**. Urban VIMS+TImR users were more likely to be able to identify children registered at a different health facility *(p=0.05)* than rural users. Less than a quarter of HF users (n=15) used the VIMS+TImR to **notify caregivers** of upcoming or missed vaccinations; all of these respondents thought these reminders were effective. The possibility to send SMS's via TImR, however, is no longer functional *(Figure 17).*

Similarly, most HFs had a **defaulter tracking** mechanism in place. The majority of HF users regularly used the VIMS+TImR to generate a list of defaulters. Urban users were slightly more likely than rural users to use the VIMS+TImR to generate such a list (n.s.). The majority of users thought their defaulter tracking process was effective, but there was no difference in perceived effectiveness between users (67%) and non- users (61%). Qualitative insights refer to the tool being *"accurate and fast"*, and "*quick and easier"* thus improving effectiveness and efficiency; however this was only when the tool was functioning well: "*If the system has no problem and there is stable internet it is faster and it is better to use it, but when it has bugs it is better to use paper*"; *"When we started using it, it worked perfectly, however it suddenly stopped itself".* Whilst most HFs conducted **outreach sessions** for vaccination, most (70%) managed outreach immunization data by using paper-based forms; 60% of VIMS+TImR and VIMS+TImR+paper IR users used the TImR to manage vaccines for outreach, and most of these users also recorded vaccinations administered in outreach and mobile services in TImR *(Figure 17).*

At HFs, immunization data were largely used for forecasting vaccine needs and planning and budgeting. **Examples of how VIMS+TImR data were used to inform decisions** included: informing actions based on coverage levels; defaulter identification and tracking; stock management and vaccine ordering; workload assessment, planning of human resource requirements; and planning for outreach sessions (e.g., one HF: *"In the past the outreach session was done only once but by using electronic data the sessions were now increased to three";* different HF: *"The data was used to increase the outreach sessions from 2 to 4 per month"*).

Figure 17: Impact of tool on HF program management (%)

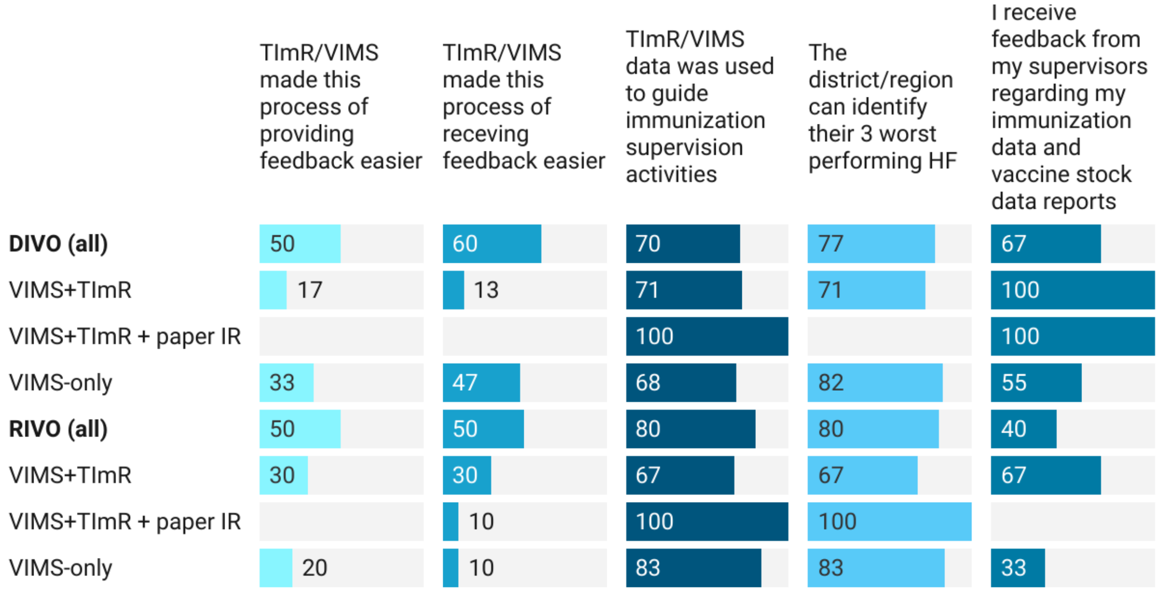


The majority (90%) of HFs received feedback from the district on their immunization and vaccine stock data. Half (50%) of DIVOs thought that the tool had made the **process of *providing* feedback** easier and more than half (60%) of DIVO users thought that the electronic tools had made the process of ***receiving* feedback** easier. Similarly, half of RIVOs thought that these tools had made these processes easier. It was noted that: "*The electronic tool simplifies work, as there is currently no need to prepare reports because the data can be accessed through the system" [RIVO] (Figure 18).*

The vast majority of DIVOs (77%) and RIVOs (80%) could easily **identify their three worst performing HFs**. Those who were not able to do so cited challenges with the TImR/VIMS not being able to provide a comprehensive picture of their district/region (due to use of paper tools in some HFs i.e., inconsistent use of VIMS+TImR), and the poor interoperability between the VIMS and TImR. Most DIVOs (77%) and RIVOs (90%) had district/regional immunization microplans and most DIVOs (93%) and all RIVOs prioritized the needs of HFs based on available performance data. Notably, the VIMS was used as the primary source for this performance data by most DIVOs (70%) and RIVOs (70%); only 20% of RIVOs used the VIMS+TImR, and the remaining 10% of RIVOs and 30% of DIVOs used paper-based systems *(Figure 18).*

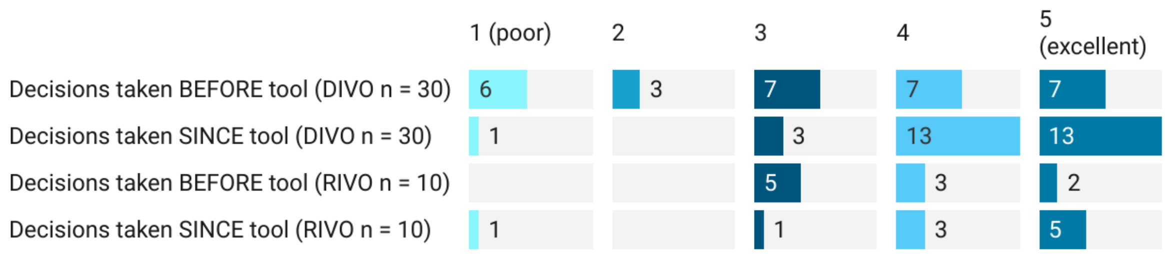
At the district and regional levels, immunization data were mostly used for **supervisory activities, and for planning and forecasting vaccine needs.** Data were used to **inform decisions** on the initiation of outreach services; requesting new staff; and for vaccine stock management. The majority of DIVOs (84%) and RIVOs (70%) held regular meetings to review and discuss their immunization, vaccine stock and cold chain data.

Figure 18: Impact of tools on DIVO/RIVO program management (%)



The majority of HF users (67%), DIVOs (70%) and RIVOs (80%) used data from the VIMS+TImR to guide their **supervisory activities.** Users at the HF level (80%) were slightly more likely to have their supervisors (DIVOS) use data from the tool to guide them than non-users (70%). DIVOs and RIVOs **perceived an improvement in the quality of decisions made since the implementation of the electronic tools** (DIVO score 96 before vs. 127 after implementation; RIVO score 37 before vs. 41 after implementation; difference n.s.) with 1 being poor and 5 being excellent, as below in *Figure 19*.

Figure 19: Quality of immunization services and vaccine management decisions taken pre- and post- implementation of the tools

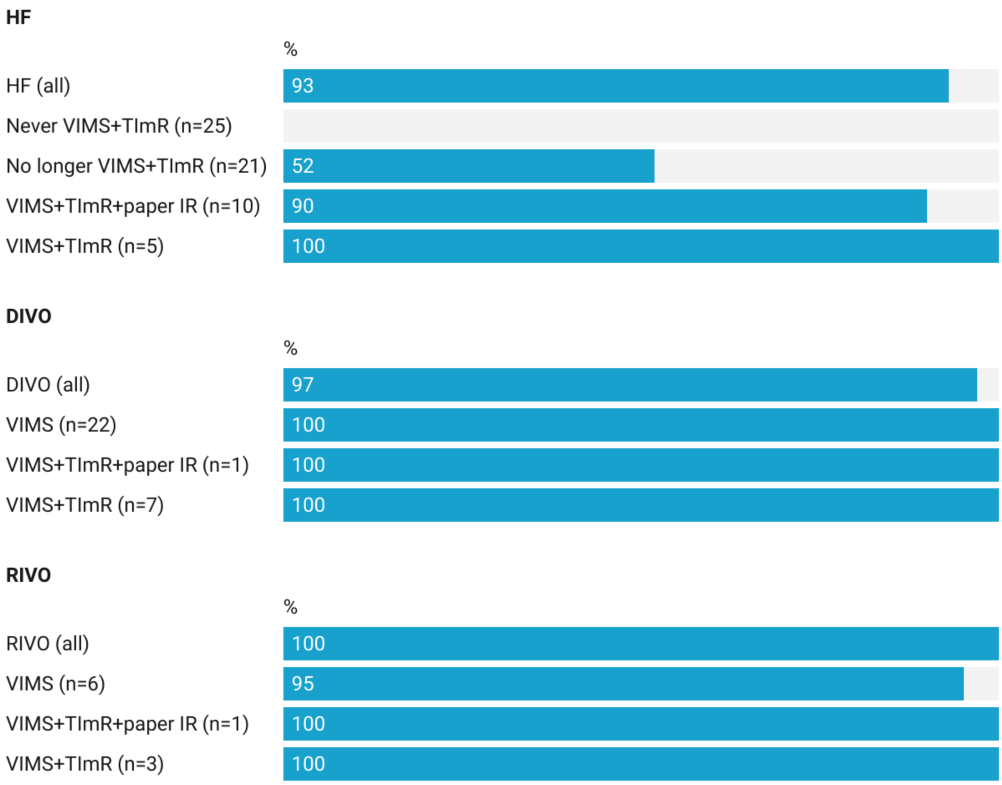


STOCK MANAGEMENT

Almost all users, across all levels, thought that the tool assisted them in better managing vaccine stock. The tool had also positively impacted on the receiving and putting-away of vaccines with the majority of respondents (including those no longer using the tool) perceiving this activity to be faster using the tool. Users of the fully electronic systems, across all levels, were less likely to experience stock-outs than users using the parallel system or those with only the VIMS in place.

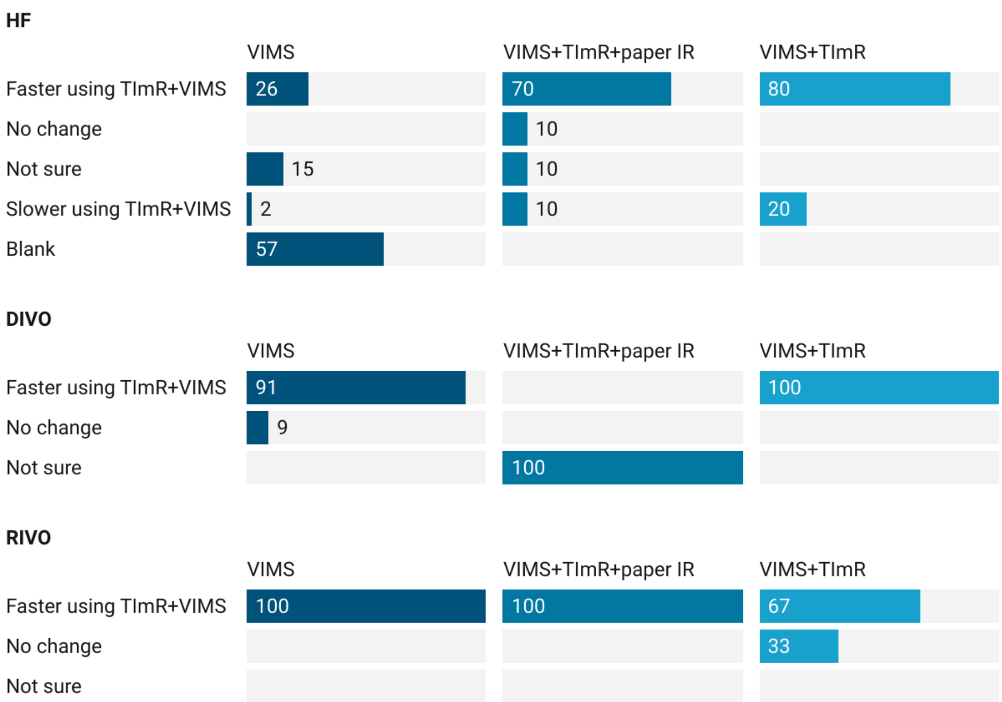
Almost all users at all levels thought that the tools assisted them in better managing stock, although only half of HF users no longer using the tool agreed with this. Further, urban HF users (100%) were more likely than rural HF users (86%) at the HF level to think that the tool improved their management of vaccine stock. HF staff stated that the VIMS+TImR assisted them in direct communications with the DIVOs by automatically calculating stock balances *(Figure 20)*. However, there were concerns about the unsatisfactory speed and reliability of the tool, and the need for additional training. The majority of HF users regularly used the VIMS+TImR to generate monthly reports (87%) and to order new supplies (80%).

Figure 20: % of users at different levels who think that the tool allow for more effective stock management



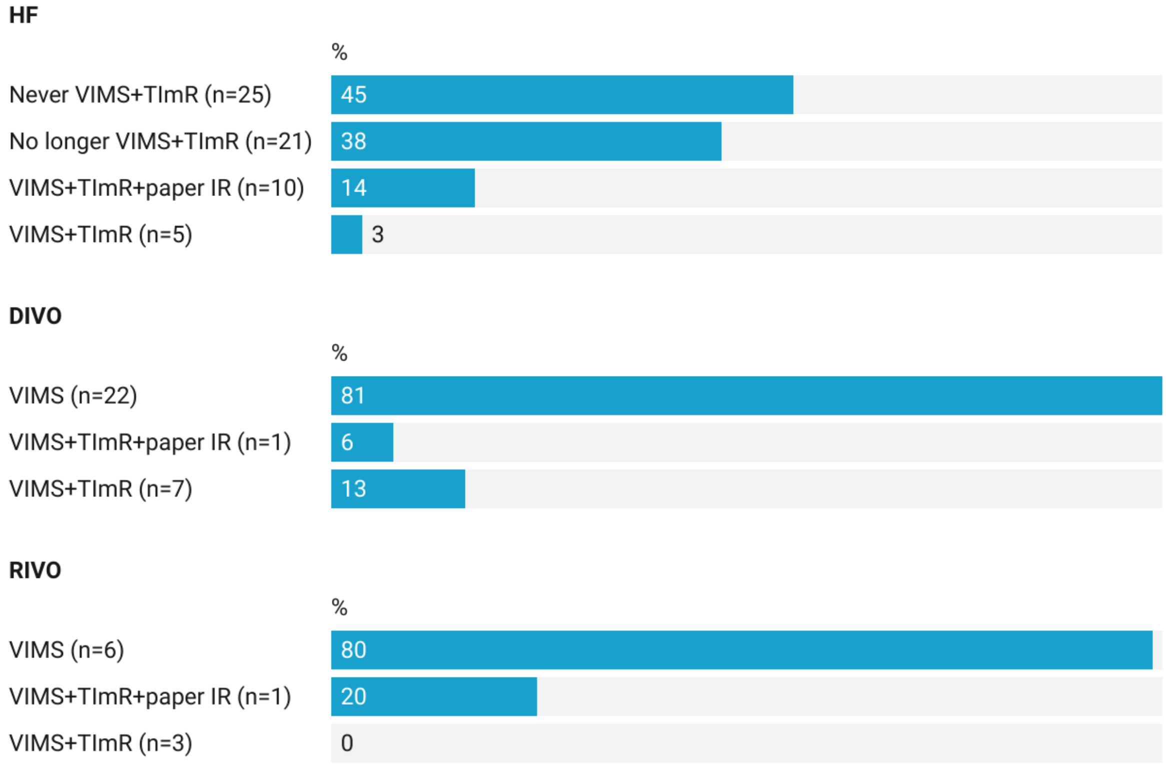
The majority of all respondents (including those no longer using the tool) thought that the **receiving and putting-away of vaccine supplies** was *"faster using the VIMS+TImR"* as summarized in *Figure 21*. At HFs, it was noted that: *"It is easy and fast, but the speed depends on the internet connection."* DIVOs acknowledged that it saved time, was simple, and user-friendly: "*Everything is simple in the VIMS and all the required reports are generated automatically"*.

Figure 21: Impact of VIMS on receiving and putting away of vaccines (%)



Approximately half of HFs (48%), district (53%), and regional (50%) offices had experienced **a vaccine stock-out** in the three months prior to the evaluation. At HF level, 83% (24) of these stock-outs occurred in HFs not using the VIMS+TImR (i.e., those who never introduced VIMS+TImR and those no longer using VIMS+TImR), while only five (17%) occurred in those HFs using the VIMS+TImR. Overall, users of the fully electronic system at all levels were substantially less likely to have experienced stock-outs than users of the VIMS+TImR+paper IR and non-users as shown below in *Figure 22*.

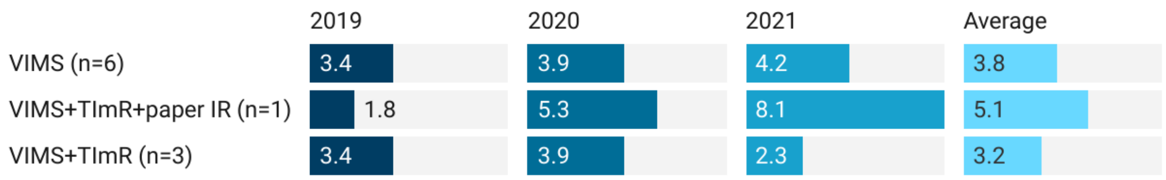
Figure 22: Experience of stock-outs in the prior 3 months



Reasons for stock-outs, according to respondents, included delayed delivery from regional/national level; and COVID-19 impacting the supply of certain EPI vaccines. The most common vaccine found out of stock was that against measles and rubella, followed by human papilloma virus, pentavalent and pneumococcal vaccines. There were also less frequent and shorter stock-outs of BCG, oral polio, rotavirus and diphtheria/tetanus vaccines. The longest amount of time a vaccine was out of stock at the HF level was reported as one month or more (80% HFs; with no difference between users and non-users).

The primary data collected during the evaluation in the 10 regions was compared to data extracted from the VIMS for the years 2019 – 2021[2] and the total number of stock-out events per region was reviewed. Over the three-year period, regions using the VIMS+TImR experienced the least number of stock outs with an average of 3.2 events, compared to 5.1 events in those regions with (VIMS+TImR+paper IR) and 3.8 events (in those with VIMS only) (see *Figure 23* below).

Figure 23: Average number of stock out events per region (2019 – 2021)

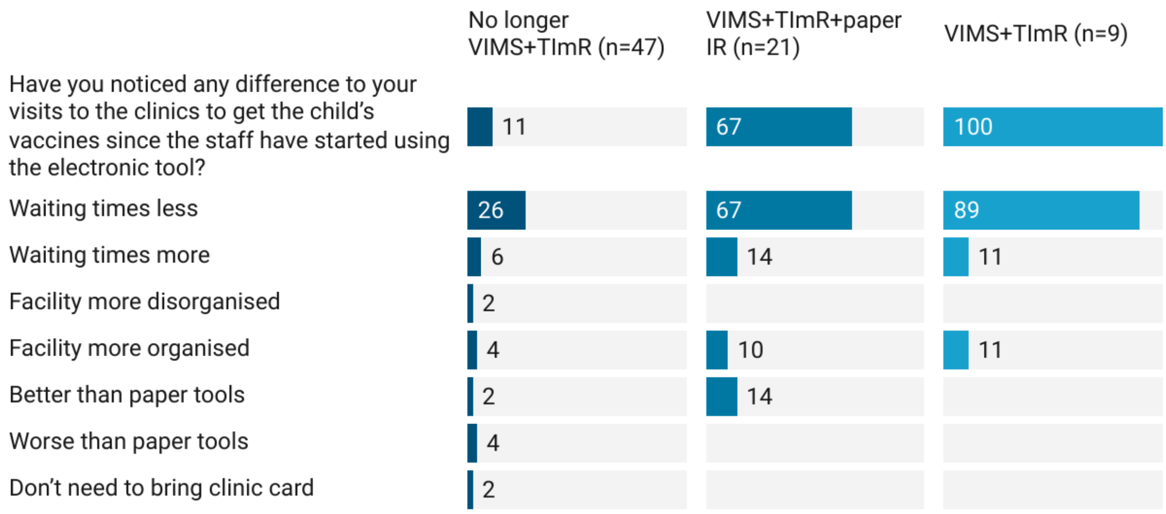


[2] Data were available for four antigens: PCV-13, HPV, MR and DTP-HepB-Hib

IMPACT: CAREGIVER SATISFACTION

VIMS+TImR-only users were more likely than VIMS+TImR+paper IR and non-users to state that **caregiver satisfaction had improved since the introduction of the tool** *(p=0.01),* while caregivers themselves felt that they had experienced **shorter waiting times** in HFs with VIMS+TImR-only (89%) and VIMS+TImR+paper IR (67%) than in those without the tool. However, caregivers did not think that tool had contributed to the HF being more organized.

Figure 24: Caregiver satisfaction with the tool (%)



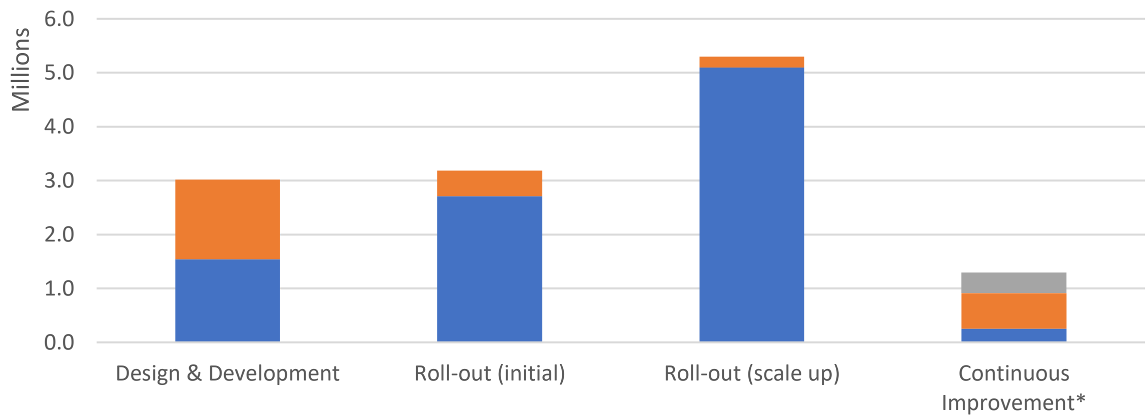
VIMS+TImR-only users were more likely than VIMS+TImR+paper IR users and non-users to regularly **use the tool to generate new records of immunization for children that had lost their child health card** (100% of VIMS+TImR-only users; 68% of VIMS+TImR+paper IR), 7% of those no longer using the tool (*p<0.01).*

C. ECONOMIC FINDINGS

FINANCIAL EXPENDITURES

Between 2015 and 2021, a combined total expenditure of USD 12.8M was estimated for the implementation of both systems, VIMS and TImR. *Figure 25* below illustrates this sum across four categories: (i) design and development; (ii) initial roll-out; (iii) scale-up; and (iv) continuous improvement. Expenditures were distinguished between those for VIMS only, those for TImR only, and those for the integrated system VIMS+TImR once implemented. A further break-down of the expenditures by funding entity and cost item is provided in **Annex 6.2**. Most of these costs have been financed by external donors such as the BMGF, USAID and Gavi.

Figure 25: Financial expenditures in 2021 USD for VIMS (orange), TImR (blue), and VIMS+TImR (grey) to date.



**Forecast based on 2021 IVD budget plan*

Design and development costs as well as costs for the initial roll-out of the systems are listed in *Table 9*. The former includes activities such as software development, including the project management costs incurred by PATH and JSI, security licenses and system hosting costs. Notably, the expenditures for the TImR of approximately USD 0.5M also included learning costs sustained from developing and piloting Tanzania's first eIR, TIIS, which was since shelved and substituted by TImR.

The initial roll-out consisted of the implementation of the VIMS and TImR by multiple partners between 2015-2018, which cost approximately USD 475,700 and USD 2.7M respectively. These expenditures were predominantly accounted for by the execution of trainings and supervision activities across administrative levels for the regions of Arusha, Tanga, Dodoma and Kilimanjaro for the TImR and for the national deployment of the VIMS. The trainings and supervision costs as reported by Mott MacDonald (2019) for Dodoma region were comparatively lower than the USD 135,000 per region spent for the first three regions due to a more efficient roll-out strategy. For the roll-out of the TImR in the 4 regions, USD 572,486 were spent on the procurement of electronic tablets for a total of 1,308 health facilities at a unit cost of 1,050,000 TZS or USD 457 in 2017.

Table 9: Overall costs for design and development and initial roll-out of the TImR and VIMS, in 2021 USD (NA = Not Applicable)

Category	Cost item	TImR	VIMS	Total
Design & Development	Software development	971,511	1,483,226	2,454,737
	Learning costs (previous eIR)	506,593	NA	506,593
	System hosting	33,583	-	33,583
	Software security certificates	26,637	-	26,637
	Total	1,538,324	1,483,226	3,021,550
Roll-out (initial)	BID staff costs	1,582,716	NA	1,582,716
	Tablets	651,616	NA	651,616
	Trainings (per-diem, transportation, conference package, venue, training materials, etc)	473,617	475,700	949,317
	Total	2,707,949	475,700	3,183,649
Total		4,246,273	1,958,925	6,205,199

Further roll-out expenditures were incurred in 2018 for the scale up of both systems by the MoH IVD Program, primarily through utilisation of Gavi funding. In more detail, USD 2.37M was allocated for the implementation of the TImR in 6 additional regions as listed in *Table 10*. The expenditures refer to the execution of trainings across administrative levels in these regions. As illustrated, more than half (54%) of the expenditures for these regions were for per-diems for staff across administrative levels for participation in trainings, as well as for facilitators to deliver the trainings. In addition, training materials were printed at the national level at a cost of USD 62,362. Conference packages and venue costs accounted for 29% of the expenditure. Finally, internet bundles that were given to the regions, districts and HFs to be used for several months following trainings accounted for 10%, while transportation of participants (e.g., bus fares, air tickets, fuel and driver costs) accounted for 7% of expenditures.

The overall investment in tablets by the government for the scale-up of TImR in the 6 regions amounted to USD 1.86M, equivalent to 3,325 new tablets. It must be noted that, compared to the tablets purchased for the initial roll-out, the tablets for the scale-up were characterized by a tailored and highly specified design to ensure their durability, and had a slightly higher unit cost of TZS 1,200,000, or USD 522. These tablets represent a substantial cost for the scale-up of the TImR reported in *Table 10*, as they account for 44% of the total expenditure incurred between 2018 and 2021.

Table 101: Total expenditure in 2021 USD for the expansion of the TImR in 6 additional regions.

Cost Item	Mtwara	Mwanza	Morogoro	Dar Es Salaam	Njombe	Geita	Total per item
Conference package	18,613	19,117	19,468	16,678	14,044	9,881	97,800
Internet bundles	5,550	9,713	9,713	8,535	6,622	3,856	43,989
Per-diem	61,061	43,822	43,654	33,376	32,722	21,621	236,255
Transportation	5,145	7,709	6,974	3,577	5,505	3,880	32,789
Venue	3,294	5,887	6,447	4,905	4,765	4,765	30,063
Total per region	93,587	86,322	86,255	67,072	63,658	44,003	440,897
Training materials							62,362
Tablets							1,864,066
Total							**2,367,325**

The roll-out costs for the remaining 5 regions where the TImR was implemented after 2018 were estimated based on the Health System Strengthening (HSS) Gavi multi-stakeholder dialogue for the strategic period 2019-2023 (Gavi, 2020). Based on the expenditures incurred in 2020 for tablets of approximately USD 2.2M for the VIMS+TImR (Gavi, 2020), and the average expenditure per region reported in Table 10 including training materials (USD 83,877), the roll-out costs for the remaining 5 regions were estimated at USD 523,877 per region in 2020. Additional USD 2.7M in 2021 value were thus added to the overall financial costs of implementing the electronic systems, assuming that the Government financed this scale-up through Gavi funding as for the 6 regions reported in *Table 10*.

Furthermore, trainings at regional and district levels conducted by government officials continued during 2018 also for the VIMS in 10 regions, as shown in *Table 11*. These trainings were grouped according to geographical location. The average expenditure per district for the VIMS roll-out was USD 3,209.

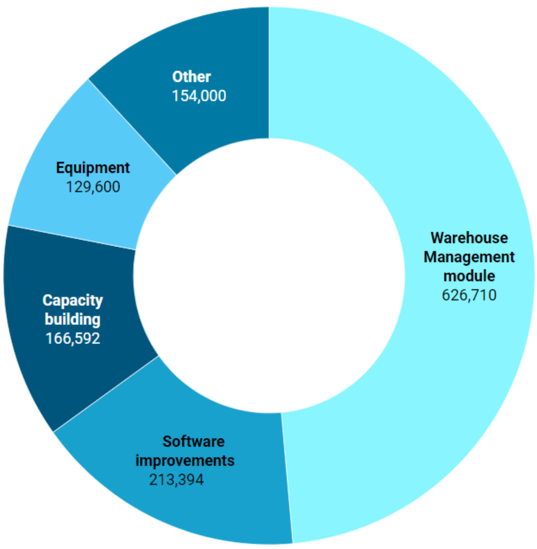
Table 112: Total expenditure in 2021 USD for the expansion of the VIMS in 10 regions based on the grouped trainings organized. The number of districts per region is indicated in parentheses.

Cost item	Mbeya (7), Songwe (5), Rukwa (4)	Mara (9), Simiyu (6)	Iringa (5), Pwani (9)	Katavi (5), Kigoma (8)	Manyara (7)	Total per item
Per diem	46,896	28,386	27,601	25,770	8,176	136,829
Conference Package	13,455	8,409	7,849	7,849	2,943	40,505
Transportation	7,372	4,616	2,971	4,317	1,785	21,061
Venue	1,402	934	934	934	234	4,438
Total per region	**69,125**	**42,346**	**39,356**	**38,870**	**13,137**	**202,833**

The overall roll-out expenditures for TImR were higher than those for VIMS as the former was implemented down to health facility level, whereas the latter only down to district level. The TImR user base was, therefore, much larger, as was the number of trainings required and the amount of hardware and internet bundles provided.

Finally, *Figure 26* illustrates the distribution of the planned expenditures for continuous improvement activities, obtained from the 2021 IVD budget plan, amounting to USD 1.3M. While these figures are accounted for in the estimation of the financial expenditures for the implementation of the systems, as of this moment, many of the activities and thus their associated expenditures are not yet realized. The addition of the Warehouse Management (WH) module to the VIMS, has an estimated budget for USD 0.63M (49% of the expenditures). This includes the procurement and installation as well as the recurrent costs for Remote Temperature Monitoring (RTM) devices at an annualized cost per HF of USD 46 (JSI, 2020), as well as specific training and supervision of users on the additional functionalities of the system. Furthermore, 47% of the planned expenditures for continuous improvement regarded the enhancement of the combined VIMS+TImR which specifically included: software improvements of USD 0.29M to resolve technical issues, interoperability efforts with the Civil Registration and Vital Statistics (CRVS) system, and the introduction of equity indicators into the TImR.

Figure 26: Proportion of continuous improvement expenditures per cost item group

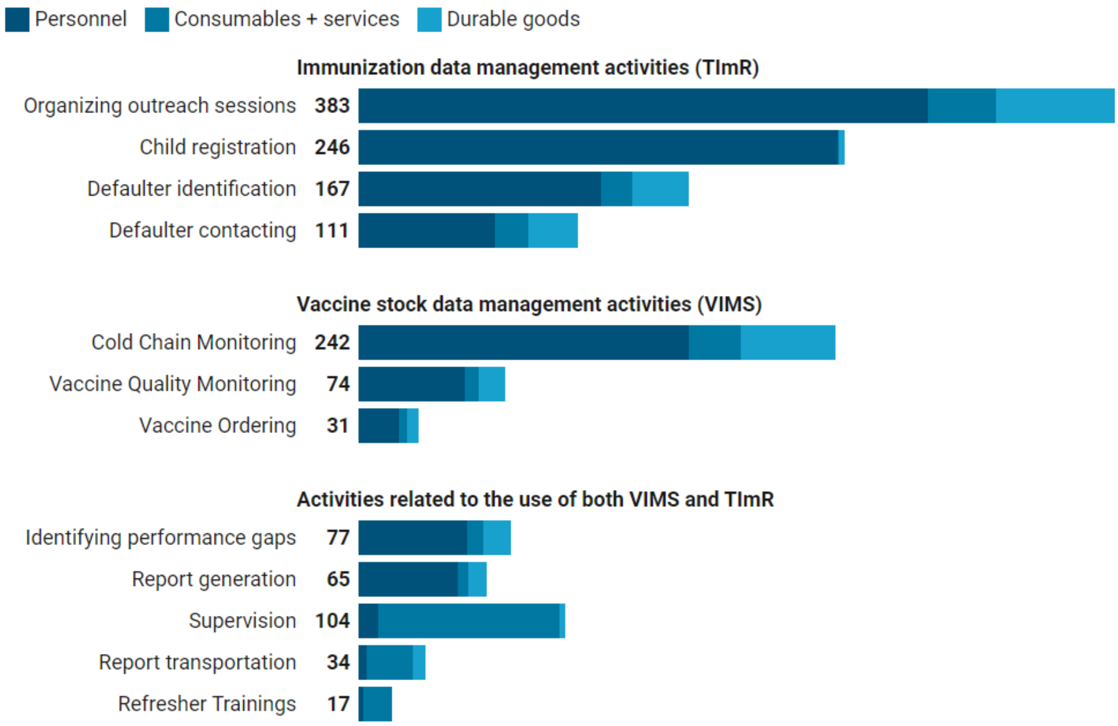


To enhance the usage of VIMS+TImR across administrative levels, USD 0.16M were budgeted in 2021 for capacity building and mentorship activities aimed at instigating leadership and ownership of the system with local authorities, as well as supporting mentors for regions, districts and HF levels with low usage of the VIMS+TImR. The planned expenditure for the procurement of tablets considered both the need for replacing old or broken equipment, as well as the purchase of new ones for the expansion of the VIMS+TImR in the rest of the country and accounted for 10% of the total continuous improvement expenditures. The amount of approximately USD 0.1M for scalability and sustainability relates to maintenance of the system to respond to user needs, further integration between the VIMS, TImR and DHIS2, and support for transitioning to a paperless system. Finally, to accommodate the increasing number of users and the subsequent need for storage of data, including online storage of the VIMS data, additional servers were procured for USD 55,000 in total. Overall, the continuous improvement activities were driven by investments in durable goods at 53%.

ROUTINE OPERATING COSTS OF VIMS+TIMR

The analysis of costs for VIMS+TImR users was based on the subsample of 15 facilities across 12 districts and 6 regions that were using the systems at the time of the data collection. The average cost of performing immunization data management activities using the VIMS+TImR is estimated at USD 1,550.8 (95% Confidence Interval: 1,227.4, 1,874.2) per health facility, or 0.54 per dose. This cost is entirely borne by the Government of Tanzania. A breakdown of the costs per facility is provided in Annex 6.4 and illustrated below in *Figure 27*, summarized per group of activities linked to the scope of use of TImR for immunization data management, of VIMS for vaccine stock data management, and to both.

Figure 27: Mean cost (USD) incurred by users of VIMS+TImR for performing activities related to immunization data management (TImR), vaccine stock management (VIMS) as well as for reporting, performance management and supervision and training activities related to both TImR and VIMS.



As shown**,** the largest cost input was personnel, accounting for 59% (USD 1,085) of the total cost per HF using the combined VIMS+TImR. Direct shared costs in consumables and services as well as durable goods accounted for 29% and 12% of the total costs reported, respectively. These costs pertained to maintenance, printing and internet, apportioned to each activity reported, as well as fuel costs and per-diems specifically for report transportation and supervision activities.

The highest operating costs were observed for organization of outreach sessions, cold chain monitoring and child registration. The cost of organizing outreach sessions accounted for 24% of the total cost per HF (USD 383.4, 95% CI: 189.7, 577.1), with sessions organized on average 17 times a year by users of the system, who spent an average of 5 hours for preparing them. The second most costly activity was reported to be cold chain monitoring, again driven by personnel costs, accounting for 17% of the total costs. This was mostly due to the necessity of performing this activity very frequently, on many occasions twice a day. Finally, child registration cost USD 246.3 (95% CI: 158.3, 334.4) per HF, with an average time per child registered estimated at 11 minutes at the HF level. Notably, survey respondents reported that before the system's implementation, registration took a long time; however, even after implementation of the VIMS+TImR, delays were still observed due to problems with synchronizing or updating data and/or because of the use of a parallel system with registrations also performed in the paper registries.

Among VIMS+TImR users at the HF level, most (75%) still operated parallel paper registries, which were contributing to some printing costs reported. HFs reported printing of an average of 1,491 pages per year per HF at an average annual cost of USD 26, which reflected the cost of printing reports and registries.

COST IMPACT OF USING VIMS+TIMR COMPARED TO THE USE OF VIMS + PAPER IR

The findings presented below are based on a cross-sectional analysis of 15 VIMS+TImR users at HF level compared to 46 non-users, who rely only on VIMS+paper IRs. The reported costs include the apportioned costs of the respective DIVOs and RIVOs, with the distinction of users vs. non-users drawn at the HF level, i.e., the point of service delivery. The analytical operating costs of the facilities using VIMS + paper IRs for immunization and vaccine stock data management activities by cost input are reported in **Annex 6.5**.

Figure 28: Comparison of mean annual costs (USD) per activity per health facility between health facilities using VIMS + TImR (blue) and those using VIMS+ paper IR (grey).

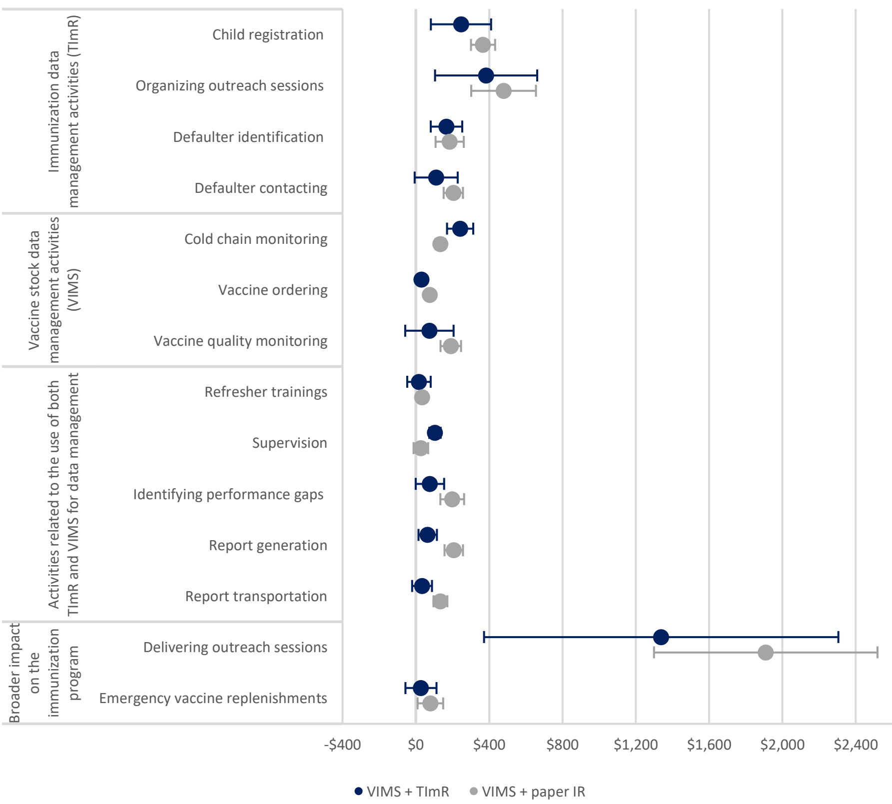


Figure 28 illustrates the mean costs per activity for the two groups of health facilities, while *Table 12* outlines the mean difference in costs per health facility between users and non-users. Overall, a health facility using VIMS + TImR benefited from a cost reduction of USD -686 (95% CI: -1159.1, -212.8) for data management activities. This reduction in costs was due to decreases in costs per health facility for all activities except cold chain monitoring and supervision.

Table 12: Mean cost difference between health facilities using VIMS+paper IR (n=46) and facilities using VIMS+TImR (n=15) in USD (95% CI).

Activity	Mean costs of VIMS+paper IR in USD (95% CI)	Mean costs of VIMS+TImR in USD (95% CI)	Mean cost difference in USD (95% CI)
Immunization data management activities (TImR)			
Child registration	366.7 (287.9, 445.4)	246.3 (158.3, 334.4)	-120.3 (-297.4, 56.7)
Organizing outreach sessions	478.8 (291.2, 666.4)	383.4 (189.7, 577.1)	-95.4 (-425.3, 234.5)
Defaulter identification	184.5 (111.3, 257.8)	167.2 (53.5, 280.9)	-17.3 (-132.7, 98)
Defaulter contacting	204.4 (143.6, 265.3)	111 (54.4, 167.6)	-93.5 (-222.1, 35.2)
Vaccine stock data management activities (VIMS)			
Cold chain monitoring	133.8 (108.8, 158.8)	241.7 (169.8, 313.5)	107.9 (31.6, 184.1)
Vaccine ordering	76.1 (57.6, 94.5)	30.5 (18.5, 42.5)	-45.6 (-69.3, -21.9)
Vaccine quality monitoring	190.7 (121.6, 259.7)	74 (52.1, 95.8)	-116.7 (-260, 26.6)
Activities related to the use of both TImR and VIMS for data management			
Refresher trainings	34.9 (2.8, 67.1)	17.1 (1.8, 32.3)	-17.9 (-86.8, 51)
Supervision	27.4 (-1.1, 55.9)	104.3 (17.8, 190.9)	76.9 (26.4, 127.4)
Identifying performance gaps	198.5 (131.6, 265.5)	76.8 (40.8, 112.7)	-121.8 (-222.8, -20.7)
Report generation	206.9 (157.3, 256.5)	64.7 (30.5, 98.9)	-142.2 (-213.3, -71.1)
Report transportation	134.1 (95, 173.2)	33.9 (5, 62.9)	-100.1 (-166.1, -34.1)
Total	**2,236.8 (987.6, 3,485.9)**	**1,550.8 (1,227.4, 1,874.2)**	**-685.9 (-1159.1, -212.8)**
Cost per dose	**0.77**	**0.54**	**-0.23**
Broader impact on the immunization program			
Delivering outreach sessions	1,909.2 (1,299.6, 2,518.8)	1,338.7 (372.1, 2,305.4)	-570.5 (-1,713.3, 572.3)
Emergency vaccine replenishments	79.4 (9.6, 149.1)	28 (-46.9, 135.4)	-51.3 (-161, 58.4)
Total	**4,225.3 (3,565.6, 4,885.1)**	**2,917.6 (1,865.6, 3,969.6)**	**-1,307.8 (-2,549.5, -66)**
Cost per dose	**1.46**	**1.01**	**-0.45**

The activities for which the largest cost decreases were observed were **report generation** (USD 142.2 per health facility) and **report transportation** (USD 100.1 per health facility*).* For the former activity, 87% of users reported using the VIMS+TImR for the generation of reports or stated that with the VIMS+TImR there was no need to prepare reports as the data was directly accessible by higher administrative levels through the system. As a consequence, the time employed for the activity was reported to be less for users, who quoted up to 30 minutes per report. On the other hand, non-users stated that they could sometimes spend a whole working day to prepare one report using the paper IR, while others reported that multiple staff were needed to perform the activity concurrently. Accordingly, when submitting reports to higher administrative levels, users reported that doing so through the VIMS+TImR took only 10 minutes. Users were found to incur less costs for report transportation, with users spending on average USD 20 per year for report transportation as some users were also still using paper IRs in parallel, while non-users reported a cost more than four times higher at approximately USD 90 per year. These costs were the result of two trends: on the one hand, the frequency with which reports were transported to the higher administrative level was once every two months for users and once per month for non-users; on the other hand, the average cost per trip was lower for VIMS+TImR users compared to non-users.

For **child registration**, a cost impact of USD -120.3 per HF was observed. Contrary to the user group, where this activity was the third most important driver of costs, in the non-user group, child registration was the biggest cost driver for data management. The cost impact between the two groups was influenced by a lower number of staff and less time dedicated to the activity, with users spending on average 11 minutes to register one new child, compared to 14 minutes spent by non-users. In addition, in the user group the majority of personnel performing the activity were reported to be vaccinators and enrolled nurses, who had a lower pay grade compared to the clinical officers and registered nurses in the non-user group. As per qualitative comments received, both groups mentioned the limited number of staff and the difficult division of tasks as a challenge in performing the activity efficiently. It was reported in several cases that one nurse was responsible both for delivering the vaccination and registering the data. Moreover, users of the VIMS+TImR at HF level provided mixed comments on the reported time spent for child registration. Some alluded to the ease of use of the system as contributing to less time spent per child, down to 5 minutes, while others quoted challenges such as internet stability and system bugs, all of which could explain the greater variability in times and costs for child registration observed among users compared to non-users.

For **outreach sessions organization**, an annual cost reduction of USD 95.4 per health facility was observed. This was driven by a difference in the number and time of staff involved in the activity (i.e., one person employing 3 hours organizing outreach sessions in VIMS+TImR-user facilities versus 1-2 staff employing approximately 4 hours in non-user facilities).

Defaulter identification and **defaulter contacting** were two additional activities where cost reductions were observed for VIMS+TImR users, experiencing savings of USD 17.3 and USD 93.5 per health facility, respectively. For defaulter identification, this was driven by a reduction in the time taken to perform the activity. Facilities that explicitly reported generating defaulter lists using the VIMS+TImR (83%) noted employing less than an hour to do so, with some quoting only a few minutes. On the other hand, those who still used the paper-based IR overall spent up to 4 hours on average to generate a defaulter list, while noting challenges such as missing documentation due to shortage of staff, or staff not documenting their work properly. For contacting defaulters, users employed less time and performed the activity more than once a month, compared to non-users who contacted defaulters less frequently. HFs which performed defaulter contacting (77%) referred to a multitude of ways in which defaulter contacting was done: utilizing community health workers (n=35), directly by healthcare staff calling the caregivers on mobile phones (n=5), through SMS notifications from the VIMS+TImR,(n=3) as well as by engaging village leaders in the process (n=4).

Cost reductions for VIMS+TImR users were observed also for the **identification of performance gaps**, with reductions of USD 121.8 per health facility. The cost reduction was due to less time taken to perform the activity by users, however it must be noted that a quarter of the interviewed HFs (15/61) reported that they did not usually attempt to identify performance gaps. Of those, 5 were users of the VIMS+TImR.

Additional cost reductions for users of the VIMS+TImR of USD 45.6 per HF were seen for **vaccine ordering**. This activity took less than an hour for VIMS+TImR users to perform, and almost 2 hours for those who maintained a paper-based system. Overall, one third of users who reported using the VIMS+TImR to verify the quantity of vaccines to be ordered noted that it took only a few minutes to perform the activity.

With regards to **vaccine quality monitoring**, a cost reduction of USD 116.7 per health facility was captured for VIMS+TImR users. The lower costs were driven by the frequency with which the activity was performed, monthly by VIMS+TImR users and weekly by the VIMS+paper IR group, as both groups employed on average between 1.5-2 hours to check for vaccine quality.

For the rest of the activities, a cost increase was observed for users of the VIMS+TImR. Such increases were reported for cold chain monitoring, and supervision. Higher costs for **cold chain monitoring** of USD 107.9 per HF for users were due to the variation in frequency and time dedicated to performing the activity, which were comparatively higher for users. Users performed the task on average 13 times a week and employed 6 minutes to check and record fridge temperatures, while non-users monitored the cold chain 11 times a week for 4.5 minutes each time.

Higher costs for users were also observed for **supervision** (USD 76.9 per HF). High variability across the data for this activity suggests that supervision was not conducted in a standard way across regions and districts. While at the regional level, supervision was performed by the RIVOs themselves, at the district level, visits were executed by a variety of personnel whose salary ranged from low to high, such as clinical officers, nurses or the DIVO. Variability was observed also within user groups. For example, in two intervention regions, supervision by districts to HFs is conducted by clinical officers in Tanga and the DIVO/CIVO in Dodoma. Overall, users employed 4.5 FTEs to conduct a supervisory visit, while non-users 2.5 FTEs. Notably, in Arusha and Njombe, two VIMS+TImR regions, 2/3 of the visited district offices in each region declared not to conduct supervisory visits.

Regarding the broader impact of the electronic tools on the immunization program, cost reductions for VIMS+TImR users were observed also in **emergency vaccine replenishments** and the **delivery of outreach sessions**. For the former, the lower costs may have been attributable to lower vaccine stock-out rates which were associated with the use of the VIMS+TImR and the visibility that it offered on stock levels. The annual cost of delivering outreach sessions was significantly lower in VIMS+TImR users by a difference of USD 570.5 per health facility. VIMS+TImR users employed less staff for delivering outreach sessions with a maximum of 2 people, whereas non-users reported more, and multiple staff involved in the activity, driving the cost of human resources up. Variations were seen also in the size and frequency of outreach sessions between the two groups. More specifically, users reported vaccinating an average of 32 children per outreach session, performing 17 sessions per year (thus reaching 544 children), while non-users vaccinated an average of 21 children per session and executed 20 sessions per year reaching 420 children (i.e., 23% less). The cost driver for this activity however were costs for consumables and services, such as for fuel and per-diems. While the former were lower for the VIMS+TImR group, who spent an average USD 14 per trip on fuel compared to USD 24 by the VIMS+paper IR group, per diem costs were double for the former group at USD 32.4.

Finally, a summary of the mean cost difference between urban and rural facilities are presented in **Annex 6.6**. For data management activities, urban facilities incurred USD 763.9 (-1,160.3, -367.4) less than rural facilities. Notably, urban facilities incurred less costs overall for all activities except for delivering outreach, report generation and child registration.

Total costs

The average cost of the immunization data management including for managing vaccine stock for each 100 children registered per HF in each region were estimated as shown in *Table 13* below. These estimates showed considerable variability across regions. In the VIMS+TImR user group, part of the variability observed may be explained by a different rate of adherence to the system, as certain HFs in regions where the VIMS+TImR had long been implemented were found not to be using the system anymore. Overall, the annual cost of immunization and vaccine stock data management per facility averaged USD 1,476.7 and USD 2,989.4 in VIMS+TImR and VIMS+paper IR regions, respectively.

Table 13: Mean annual cost of immunization and vaccine stock data management per HF in USD (95% CI) by system use and Region.

System	Region	Mean cost per health facility in USD (95% CI)
VIMS+TImR	Arusha	1,743.8 (1,162.3, 2,325.3)
	Dodoma	1,249.7 (513.9, 1,985.5)
	Kilimanjaro	494.1 (20.6, 967.5)
	Tanga	1,483.5 (729.9, 2,237.1)
	Mwanza	2,457.2 (1,961.7, 2,952.8)
	Njombe	1,431.6 (285.6, 2,577.6)
	Mean	**1,476.7 (-320.7, 3,274)**
VIMS+paper IR	Mbeya	1,328.6 (779.9, 1,877.2)
	Pwani	2,573.7 (2,020.8, 3,126.7)
	Shinyanga	6,065 (5,758.6, 6,371.5)
	Singida	1,990.1 (1,445.7, 2,534.6)
	Mean	**2,989.4 (1,990.8, 3,987.9)**

The total annual cost for the entire country was then estimated based on the mean costs per HF calculated in *Table 13.* The cost of managing immunization and stock data for all regions was estimated at USD 11.7M per year, with the total cost of the VIMS+TImR in all 15 regions totalling USD 4.62M. Nonetheless, because using VIMS+TImR was also associated with cost savings for the immunization program beyond data management (Table 12), the net cost of managing immunization and vaccine stock data with VIMS+TImR was lower and estimated at USD 9.76M.

Finally, additional USD 0.7M were considered to account for the costs incurred by the central level such as costs for electricity, internet, technical assistance and system improvements, replacement of hardware, and servers. This estimate was based on the expenditures reported for the continuous improvement and maintenance in the financial expenditures section. Overall, the total cost for immunization and stock data management for the whole country at all administrative levels was estimated at USD 10.46M. Compared to the scenario where VIMS + paper IR was used in all regions, the associated annual savings of using the electronic tools was estimated at approximately USD 6.2M per year, under the assumption that all observed differences in costs between users and non-users were attributable to the electronic tools.

SUSTAINABILITY AND AFFORDABILITY

The net cost of operating the VIMS+TImR was considered within the general macro-economic context of Tanzania. Trends were estimated from data obtained from the IMF and are presented in **Annex 6.7**.

Over the past 20 years, Tanzania has experienced a phase of steady economic growth with 5-year annual compound growth rates (CAGR) remaining stable between 6% and 7% from 2000 and 2021. Similarly, the growth rate of GDP per capita increased from 3% in the early 2000s up to 7% in the period between 2015-2021. Public debt over GDP constantly increased from 2010 until 2018, from 28% to 41%. From 2015 to date, it has remained stable between 39-41%; however, it is expected to gradually decrease to 34% by 2027. Public expenditure on health from domestic sources as a share of total public expenditure has increased steadily from 2010 until 2016 reaching 13.5%. Fluctuations were observed from then until 2019, when this share was estimated at 7.5%, indicating a decreasing trend. As Tanzania's economy and domestic health expenditures are experiencing a slowdown, the country is still dependent to a large extent on external sources to finance current health expenditures. In the past decade, the percentage of current expenditures on health financed by external funders has ranged between 25-45%.

It is against this backdrop of macro-economic and immunization-specific financing elements that the Government of Tanzania is called to finance the annual cost for immunization and vaccine stock data management. Table 14 summarizes the costs and likely affordability of these activities for the IVD program based on three scenarios: 1) only on VIMS + paper IR, 2) the current situation where 11 regions use VIMS+paper IR and 15 regions use VIMS+TImR, and 3) a future scenario where the VIMS+TImR is scaled-up nationwide.

The total net cost in the third scenario was estimated assuming that all HFs across the country were VIMS+TImR users, thus incurring an average annual cost per HF for data management activities of USD 1,476.7. The costs at central level were assumed to be proportional to the number of regions with the VIMS+TImR implemented and, therefore, were doubled in the scenario with the VIMS+TImR implemented nationwide compared to the actual scenario. With VIMS+TImR implemented nationwide, it was estimated that further savings of USD 4.36M per year would be generated with respect to the cost currently incurred for immunization and vaccine stock data management in the country.

Table 14: Affordability of immunization and vaccine stock data management activities in Tanzania according to three scenarios of use of the electronic systems.

	VIMS + paper IR nationwide	**Current situation[a]**	**VIMS+TImR nationwide**
Annual costs for system maintenance at the central level	250,000	700,000	1,400,000
Annual operational costs for immunization and vaccine stock data management (USD)	16,688,512	11,708,284	8,120,148
Avoided costs to immunization service delivery (USD)	NA	-1,944,401	-3,419,336
Net cost (USD)	16,688,512	10,463,883	6,100,813
% of total IVD expenditures*	9.9-10.8%	6.2-6.8%	3.6-4%
% of domestic IVD expenditures**	18.8-20.5%	11.8-12.8%	6.9-7.5%

*[a]Current situation: 11 regions with VIMS + paper IR and 15 regions with VIMS+TImR; *based on a range for the IVD budget between USD 154 and 168 million; **assuming domestic expenditures equal to 53% of the total IVD expenditures.*

Compared to the considered budget range for immunization between USD 154-168M per year, in the current scenario, the net operating cost of managing immunization and stock data of USD 10.46M would be between 6.2% and 6.8% of the total immunization budget, or between 12% and 13% of the domestic budget in immunization, assuming a rate of 53% of the IVD budget financed domestically (Table 14). When considering the scenario with VIMS+TImR implemented nationwide, however, the percentage of the total immunization budget would be reduced due to the lower operating costs when using the electronic tools, and approximately equal to 3.6%-4% of the total immunization budget, or 6.9%-7.5% of the country's domestic budget on immunization.

Finally, considering the initial investment of 12.8M for implementing the system in 15 regions and assuming constant yearly net savings starting arbitrarily after 1 year since the implementation in each region, it is estimated that the return on investment (with the actual scenario) would turn positive after approximately 8 years of implementation, meaning that after this period the use of VIMS+TImR would generate cost savings to the IVD budget.

V. DISCUSSION

This evaluation complements earlier assessments of eIR and eLMIS tools in LMICs, including Tanzania, with the aim to generate evidence for the Government of Tanzania to support future decisions on the management of these tools and other digital technologies, as well as to provide further evidence on the governance, design and implementation of these electronic tools to inform future investments in other countries.

The following discussion is structured around the overarching evaluation framework which includes: the ecosystem; tool design and functionality; implementation experience and costs; and impact and sustainability. Some of the limitations of this evaluation are noted and recommendations provided on the way forward to support a national scale-up of the VIMS and TImR in Tanzania.

A. ECOSYSTEM

Despite a clear commitment to digitalization as outlined in Tanzania's National Digital Health Strategy 2019-2024, this evaluation revealed that the combined use of the VIMS+TImR was limited across the country. Given a number of technical challenges with the use of the electronic systems, the VIMS+TImR have been abandoned to a large extent with more than a third of HFs which had initially been identified as implementors no longer using the tools.

Findings suggest that the decline in use of the tools was partly due to inadequate access to hardware and inadequate access to internet and data bundles across all levels of the health system. This is consistent with findings from previous evaluations that also underscore the continuous challenges around internet access (Dolan et al., 2020; Mott MacDonald, 2019; Nshunju et al., 2018).

The heavy reliance on external partners and limited internal capacity to manage, maintain, and enhance the current electronic systems remains a significant change; this includes supporting the interoperability between the two tools. While HWs at the service delivery level, DIVOs and RIVOs acknowledged the availability of IT support and assistance from higher levels, often government staff were not able to respond to actual software issues experienced by the users, and there was no longer external support available to assist. While there were substantial training efforts, it appears that many staff who were trained at the central level have since taken on new roles, transitioned out of government services or could no longer recall the training content received. The scarcity of skilled ICT personnel was acknowledged, and the Government of Tanzania has attempted to address this shortfall with the creation of a community of practice (COP) bringing together technical talent across the country. Presently, there are renewed efforts to address this challenge through workshops attempting to rebuild the capacity of government staff, as well as by including private sector staff in the provision of ICT support. In addition, data storage needs are being addressed more locally, as the current server capacity hosting VIMS+TImR data is no longer able to serve the country's needs.

From the economic lens, while the macroeconomic context appears to be favourable for the continued investment in the VIMS+TImR, Tanzania still relies on external funds with about 50% of its immunization budget covered by external sources. Expenditures for the development, roll-out (including initial and scale-up) and continuous improvement of both the VIMS and TImR were almost entirely covered by external funds from BMGF, USAID and Gavi. Further external support has also been provided to scale up the VIMS+TImR in the remaining 16 regions. Given the necessary investment for the continuity of operations of the system and its scale up to other regions, the heavy reliance on external sources could threaten the continued running and maintenance of the VIMS+TImR.

B. TOOL DESIGN AND FUNCTIONALITY

Both the VIMS and the TImR satisfy the functional requirements of an "ideal" eIR and 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. With support of partners, the Government of Tanzania has been continuously refining both systems, including developing the capacity for interoperability between the two tools, as well as the procurement of local servers with the capacity to host the entire data from both systems.

While this evaluation suggests that the VIMS+TImR was perceived as user-friendly, dependable and that data in the system would not be lost, only half of the staff reported that the tool was actually functioning at the HF level when required. Software issues were said to be abundant including the system being slow and unstable, and challenges with synchronization and interoperability between the tools were mentioned. Similar challenges have been described in previous evaluations (Mott MacDonald, 2019; Nshunju et al., 2018). These issues appear to have impacted uptake of the VIMS+TImR in the country, particularly as TImR was the interface at HF level and thus HWs were unable to access VIMS at the HF level without TImR being available.

Despite such challenges, most staff expressed an interest in continuing to work with both tools. VIMS+TImR users were more likely than those who no longer used the tool to think that the system provided access to sufficient information to enable them to do their work. Staff emphasized their desire to be to re-trained in the use of the tools, as well as to be provided with updated SOPs to allow their full use. Other user requests included improving data visualization and building in checks to improve data quality, suggestions which would need to be taken up in the further development of the tools.

C. IMPLEMENTATION

IMPLEMENTATION EXPERIENCE

At the time of this evaluation, the VIMS+TImR was in use in only three of the six regions anticipated to be exclusively transitioning to fully electronic use of the VIMS+TImR (i.e., Kilimanjaro, Mwanza and Tanga). However, only two of the six sampled HFs in Kilimanjaro and three of the six sampled HFs in Mwanza were found to be in fully electronic mode. System implementation was variable in the remaining districts and HFs in these regions, with some using VIMS+TImR + paper IR and others using only the VIMS + paper IR (see **Annex 4**). In Arusha, the VIMS+TImR was used in parallel with a paper IR. The regions of Dodoma and Njombe which had introduced VIMS+TImR earlier had since abandoned the use of VIMS+TImR and reverted back to only using the VIMS together with a paper IR.An earlier assessment had been similarly sobering with Dolan et al. (2020) reporting inconsistent data entry following the implementation of the TImR attributable to the highly variable use of the tool, coupled with other implementation challenges such as those related to workflow and training.

The implementation experience highlights the need for adequate supervisory support. It was encouraging to note that district and regional immunization staff were using the VIMS+TImR data for supervisory activities. Facilities which had initially introduced TImR but then discontinued its use stated that they did so due to insufficient infrastructure (e.g., hardware, electricity and internet access), technical issues interfering with the functioning of the tool, and inadequate training. Timely high-quality IT support and continuous training for frontline HWs appears to be one of the important factors allowing for the sustained implementation of electronic tool. Carnahan et al. (2020) previously demonstrated that the actual use of the TImR in Tanzania was associated with organizational factors, including the number of staff trained. Dolan et al. (2020) also suggested that on-the-job trainings were an important strategy for the introduction of eIRs.

IMPLEMENTATION COSTS

The total expenditures to date for implementing the VIMS+TImR, including the nation-wide use of the VIMS, the design and roll-out of TImR in 15 regions and further developments and improvements have been estimated at about USD 12.8M. Estimates of the expenditures for the design and development and initial roll-out of the TImR component amount to approximately USD 4.25M and compare with the USD 4.2M reported by Mvundura et al., noting that this analysis considered the costs of 5 regions for the initial roll-out compared to 4 in Mvundura et al. (2019).

Hardware costs, specifically tablets and computers, accounted for 42% of the funds used for the roll-out of both systems. Despite this major initial investment, 53% of the continuous improvement funds budgeted in 2021 were still devoted to the procurement and distribution of hardware. This expenditure was likely necessary to address the reported challenges of broken and/or missing hardware. Financial planning for the availability and maintenance of hardware must be in place to ensure the sustainability of the tools.

With respect to the roll-out of the system, USD 2.14M (24%) of the total expenditures for both systems were spent on trainings. However, based on the data collected, this amount appeared to be insufficient to meet the reported needs of users. This may be due to fact that the necessary trainings had not been adequately planned, trainings were partly ineffective in transferring the necessary skills or competencies had waned given the high turnover of staff. As competencies in using digital tools for health are a decisive factor for their adoption and continued use, sufficient funds based on an assessment of current training needs should be earmarked for training and retraining on the VIMS+TImR.

D. IMPACT

Despite implementation challenges, the limited use of the electronic tools may still have had a positive impact on immunization program management in the areas of data quality, supervisory activities and stock management. The evaluation was unable to assess the impact of the use of the tools on immunization outcome indicators (e.g., immunization coverage or dropout-rates), partly due to the COVID-19 pandemic and its repercussions on the routine immunization system. The evaluation, thus, used more proximal process and output indicators, in line with earlier recommendations for the assessment of digital health interventions (Dolan et al. 2022).

USER SATISFACTION

When the tools were working with stable IT infrastructure in place, users were generally satisfied with their use. Users at the HF level considered the tool to be dependable. Users also reported that the VIMS+TImR had positively influenced the quality of their work, improved the services delivered and made their jobs easier overall. Caregivers also appeared to be more satisfied with the immunization services after the implementation of the VIMS+TImR, with some reportedly experiencing shorter waiting times in HFs using the tool and finding it easier to retrieve child records if their child health card was not available. However, only a small proportion of caregivers had actually noticed that the tool was in use. Other qualitative insights acknowledged, in some instances, that using the tool may actually have extended waiting times as its use by inexperienced HWs was more time consuming.

DATA QUALITY

Overall, there were perceived improvements in both **vaccine stock data and immunization data** since the introduction of the VIMS+TImR at HF level. Users of the VIMS+TImR were assessed to be competent in adequately completing new immunization records and in generating reports at the HF level. HWs reported some improvement in the accuracy and completeness of immunization data at the HF level with use of the VIMS+TImR. There was, however, a discordance between HW perceptions of data accuracy and the assessed accuracy of data across various sources, with most HWs being overly optimistic about the accuracy of their own data precision.

Data quality was challenged by the apparently poor synchronisation of the systems (VIMS and TImR) and limited internet access. Synchronization issues may have led to limited data quality and duplication of work as HWs resorted to paper, similar to the earlier findings of Dolan et al. (2020). In addition, insufficient capacity of staff in data collection, recording and analysis may have further negatively impacted on data quality. Similar challenges around data quality, including those related to inconsistent data entry in view of the parallel use of paper records were also acknowledged in earlier reviews of the Tanzania immunization data system (Nshunju, 2018; Mott MacDonald, 2019; Dolan et al, 2020; Nsaghurwe et al, 2021).

PROGRAM MANAGEMENT

The use of the VIMS+TImR appears to have aided decision-making for program management across health system levels. This included improvements in the quality of decisions made in critical areas such as supportive supervision, vaccine stock management, defaulter tracing, the preparation and conduct of immunization sessions including outreach, the identification of performance gaps, and resource planning. At district and regional levels, the tools were perceived as having simplified work and decreasing overall workload.

Efforts to estimate the size of target populations for vaccination, on the other hand, appear not to have improved with use of the VIMS+TImR, although the tool may have been helpful in tracking individuals outside these target populations. Users of the legacy paper IR at district and regional levels were more likely to think that their target population was accurate than VIMS+TImR users, preferring the paper registries over the electronic data base, which they considered to be incomplete and, thus, inaccurate.

At the HF level, the VIMS+TImR was reportedly used in some places for defaulter identification and tracking (i.e., to generate a list of defaulters), but no difference was seen in the perceived effectiveness of the electronic versus paper system for this activity. It was noted that when the tool was functioning, the process was easier, more accurate, and faster; however, when the tool was available inconsistently, it was no longer perceived to improve efficiency and effectiveness. The automated SMS functionality for the notification of caregivers of upcoming or missed vaccinations was no longer operational at the time of the evaluation. Interestingly, VIMS+TImR use for establishing defaulter lists was higher in urban than in rural areas. This could be due to the fact that in rural areas there were more established parallel means of tracking children with missed doses, such as through village health workers and other community support structures.

From a costing perspective, reductions were seen in the cost per facility for identifying and contacting defaulters. Users of the VIMS+TImR reported to have spent less time to identify defaulters and generate a defaulter list, explicitly attributing this to the use of the system. The respective cost impact remained, however, limited at USD 11 per facility per year. Users stated they were employing less time to contact defaulters, but the link with the use of the system was difficult to ascertain as only few users reported using it to remind caregivers. The reported difference of costs for defaulter contacting of USD 103 per facility per year may be attributed to other differences between TImR users and those using a paper-IR system besides the mere use of the electronic system.

The VIMS+TImR was also considered by HWs a good tool for effectively managing outreach sessions. Those HFs not using the VIMS+TImR reported the need for involving more and multiple staff in delivering outreach than those who did use the tool. This could be due to HFs using the VIMS+TImR being better managed, with better trained, more competent staff using the tool more effectively.

STOCK MANAGEMENT

At the HF level, stock management was performed either using VIMS+TImR, for those facilities with TImR through its interface with VIMS, or on paper, given that VIMS alone is only implemented down to the district level. Users of the fully electronic systems, across all levels, were less likely to experience vaccine stock-outs than users using the parallel paper system or those with only the VIMS in place. Similarly, regions with the fully electronic system experienced fewer stock-outs during the period 2019 -2021. The VIMS+TImR was reportedly useful for receiving and putting away vaccine supplies, as well as for generating monthly reports, for identifying vaccine doses close to expiry, for ordering new supplies and for performing stock management activities faster. These findings are similar to those of Nshunju et al. (2018) who found that users benefited from the more streamlined data collection and reporting functions of the VIMS, easing the stock status management process and improving the necessary decision-making. Also, in the present evaluation use of the VIMS+TImR may have enabled HWs to more regularly and timely review their vaccine stock, establish appropriate supply balances and to perform improved vaccine forecasting and ordering. In addition, the VIMS+TImR may have enabled better quality remote supervision with data being available at the higher levels, including dashboards for easier assessment of trends to inform decision-making. The positive impact on stock levels seen is consistent with the results of Gilbert et al. (2020) who observed an overall decline in monthly stock-outs with VIMS+TImR use, associated with avoided annual costs of USD 50.7 per HF from reduced emergency vaccine replenishments. Mvundura et al. (2020) also estimated annual cost-savings for emergency vaccine replenishment of USD 14 per facility in the Arusha region.

More than half of district and regional health staff reported some challenges with vaccine stock data, but only one fifth of HF respondents. This difference might be due to the more complex vaccine management functions at the higher levels, as well as the variable usage of paper or electronic tools at the HF level impacting the ability of the higher levels to see and interpret the necessary data. Stock management at the HF level was challenged by the fact that the review of stock status of non-users of the VIMS+TImR was usually only done at the end of each month.

From an economic perspective, improved stock management with use of the VIMS+TImR may also be reflected in an observed reduction in annual costs for vaccine ordering and for monitoring vaccine quality of USD 50.1 and USD 132.9 per facility, respectively. This was driven by efficiency gains from reduced staff time. Notably, cold chain monitoring represented the second most costly activity for VIMS+TImR users, who apparently performed the activity more often than non-users, thus experiencing higher costs. Further investigation into cold chain monitoring activities and impact of RTM devices is recommended to provide more insights in view of these findings.

Overall, the findings of this evaluation suggest that use of the VIMS+TImR may have contributed to improved stock management and to savings in terms of time and costs. However, given the multitude of external and domestic factors influencing vaccine stock levels, any such associations will warrant further exploration. Other vaccine management areas, including cold chain monitoring, can be targeted through regular investments for the maintenance of infrastructure, which may further lower HW workload and thus generate cost-savings.

COST SAVINGS

The average cost of performing immunization data management activities using the VIMS+TImR was estimated at USD 1,551 (95% CI = 1,227, 1,874) per HF. Most of this cost was absorbed by human resources, which accounted for 59% of the total cost. This reinforces the critical role of HWs in the process of data generation and use for decision-making and underscores the importance of training and routine supervision of HWs to ensure that use of the electronic tools is maintained over time. Given the relative weight of staff costs on the total cost, improving the competence of staff in the use of the tool may contribute to further reductions in the costs of managing immunization and stock data.

Findings from this evaluation suggest that implementing the VIMS+TImR could have generated annual savings of USD 686 per HF through improvements in the efficiency of managing vaccine stock and immunization data. Such savings may have resulted from the decreased time required to perform activities, as well as from the reduced frequency with which the activities were performed, the profile and salary of the health personnel involved, as well as the lower additional costs for consumables, services and durables. Nonetheless, attribution of the effect to the use of the electronic systems was not always clear. In some activities, users clearly mentioned that the tools contributed to reducing their workload; whereas in other activities, a qualitative explanation of the observed reduction in costs based on the comments by the respondents was not possible. For example, HFs using VIMS+TImR had lower costs for transporting paper reports to the DIVOs and RIVOs, but the use of the electronic tools was never mentioned as a factor that may have affected such costs. Similarly, for the activity of organizing outreach sessions, the observed savings was driven by a difference in the number and time of staff involved in the activity, though it was unclear whether this difference was attributable to the system (i.e., by having better data availability on target population).

Process efficiency gains by using TImR for the registration of new children were expected to be observed; however, only small-scale gains were captured. This could possibly be attributed to the fact that the majority of respondents had not been continuously using the system and/or challenges such as internet instability and system bugs resulted in a higher variability in the observed costs for this activity among users and a more skewed distribution compared to non-users. The reported challenges may have increased the average cost for users and, therefore, reduced the difference with non-users.

Efforts to address the technology and process-related barriers that contributed to the lower use of the system (i.e., through capacity building or system fixes) should commence with initiation of the process of child registration. Solving potential implementation issues at the point of data entry may present the largest opportunity where gains in data quality and further cost savings could be achieved.

Overall, savings per HF in the users group amounted to more than USD 1,000 per year for all the activities investigated. These savings are lower than the ones reported in Mvundura et al. (2020) in a survey-based, micro-costing study in Arusha. They reported cost-savings of USD 10,236 per facility/year (95% CI USD 7,606-14,123), and USD 6,542 per district. As in this evaluation, savings were driven by reduced staff time for providing fixed and outreach immunization services, for logistics and stock management, as well as for data reporting. The previous study, however, did not clarify which activity weighed highest in the reported cost savings, making a more detailed comparison difficult.

Finally, this evaluation also saw the discontinuation of TImR in many HFs, most notably in all HFs visited in the Arusha region, from where higher cost-savings had been reported earlier. While Mvundura et al. (2020) hypothesized that cost savings and benefits from using the TImR increased with increased usage of the tool with time, this was not confirmed by Carnahan et al. (2020) who showed that tool use at HF level in Tanzania decreased with time, anticipating findings of this evaluation. Implementation and uptake of eLMIS and eIR are complex interventions with many interacting components. Assessments should, therefore, be performed iteratively to better understand how changes in use and in the broader health system context may affect the impact of the interventions.

IMMUNIZATION OUTCOME INDICATORS

Given the interference of the COVID-19 pandemic, it was not expected that this evaluation would be able to demonstrate an impact of the VIMS+TImR use on immunization outcome indicators such as immunization coverage, timeliness or drop-out rates. Nevertheless, a national DHIS2 extract of these indicators was reviewed for the pre-intervention period (2015 and 2016) and compared to the post-intervention period (2020 and 2021). No consistent associations were found between the use of the VIMS+TImR and any change in first or third dose pentavalent vaccine coverage (PCV), in Measles Rubella (MR) first dose and MR second dose coverage, or in PCV1 to PCV3, MR1 to MR2, or PCV1 to MR drop-out rates. Immunization coverage rates in the country had started to decline in 2016, and the introduction of the VIMS+TImR had not visibly impacted this trend. It was also noted that, as expected, the mean administrative coverage rates from the DHIS2 data base were higher than the WUENIC estimates, thus further questioning the validity of these data and limiting their use for such comparisons. The multitude of additional political, social and program management factors, including the substantial impact of COVID-19, therefore did not allow to determine associations between the use of the electronic tools and administrative coverage data. Dolan et al. (2022) was similarly unable to relate use of the TImR to another immunization outcome indicator, vaccination timeliness. They did, however, describe an overall decrease in vaccination timeliness following the introduction of the TImR, while acknowledging the poor quality of data used for their assessment.

E. AFFORDABILITY AND SUSTAINABILITY

This evaluation provided some evidence that the implementation of the VIMS+TImR may be associated with operational savings as a result of lower costs of immunization and stock data management and fewer costs for the delivery of outreach sessions. In the present scenario with 15 out of 26 regions using VIMS+TImR, approximately USD 6.2M were expected to be saved annually compared to a simulated scenario in which VIMS+TImR were not used at all. Consequently, the proportion of the total IVD budget attributable to the cost of managing immunization and stock data was expected to decrease in a range between 3.7% and 4% per year. When extrapolating the estimated difference between VIMS+TImR users and VIMS+paper IR users to the whole country, this proportion was predicted to further reduce to approximately 3.8% of the IVD budget due to the more generalized savings. Importantly, the reported savings may have been partially offset by the fact that most users of the VIMS+TImR maintained the parallel paper system for many of the activities considered in this evaluation. Removal of the paper registries would reduce task duplication for HWs and further reduce costs. Nonetheless, a clear quantification of the avoided costs that could be generated by removing paper was not possible due to the limited number of HFs in the sample using the fully electronic system.

These findings are somewhat unexpected given the reported challenges in using the tool observed at all levels of the health system, which were expected to hamper, at least in part, the capability of the tools to generate savings. These findings, however, should be interpreted with caution. The difference in costs observed between users and non-users were assumed to be entirely attributable to the electronic tools. The observational and retrospective nature of this evaluation make this assumption difficult to validate against potential unobserved confounders. In addition, the extrapolation of the costs to the national scale was done by linearly projecting the average cost per HF observed in each region to all other HFs in the same region and by assuming that the average savings generated in the regions where VIMS+TImR was implemented would also apply to all other regions, not directly observed in the sample. The simple extrapolation of the study results to all HFs and regions in the country is challenged by the inherent complexity of implementing, maintaining and operating an electronic information systems. In fact, several factors, including political, human, infrastructural and organizational factors may differ both across HFs in the same regions and across regions, limiting generalizability of findings. Thus, while providing an indication towards a potential cost-saving effect of using the tools compared to the paper-based registries, the reported evidence should be considered exploratory. Further studies are recommended to validate these findings.

The implementation of the system required large upfront investment cost mainly associated with the development of the software, capital purchase of equipment, and training which was estimated at USD 12.8M. In addition, the routine maintenance of the electronic tools, as well as any further development and scale up to other regions would require additional annual investments which were estimated at approximately USD 0.7M per year. Decisions on whether to use external or domestic immunization funds to implement, maintain or scale up tools such VIMS and TImR should be based on whether these tools have the capacity to improve immunization outcomes more efficiently than any other potential interventions that could be funded with the same limited resources.

This evaluation suggested that the savings generated over time would recover the initial investment after a relatively short amount of time, after which using the tools would start to free IVD resources, with a positive indirect effect on immunization outcomes. Further investments on the maintenance and expansion of the system would be recommended in parallel to resolving challenges related to the enabling environment.

Even if the tools were not to generate the aforementioned saving, there may still be a case for investing in the VIMS+TImR provided that the use of the tools directly contributes to the achievement of the goals of the immunization program in Tanzania. Benefits on immunization outcomes would be expected through improved vaccine management and availability of vaccines at the point of service, as well as through enhanced management of vaccination services, including more effective outreach and better follow up of defaulters, potentially leading to reduced numbers of zero-dose children (if linked to the CRVS or birth registries), reduced dropouts, and improved vaccination coverage and timeliness. Should this be the case, investment decisions would require a full economic evaluation providing a measure of cost-effectiveness such as the incremental cost per unit of benefit expressed, for example, as a cost per disability-adjusted life years. To date, the available evidence on the programmatic effectiveness of VIMS and TImR is still sparse and poorly generalizable given that the effectiveness of such interventions is typically very context specific. In Tanzania, Dolan et al. (2022) used a quasi-experimental design to estimate the effect of the TImR in the first four years after implementation of TImR in the Arusha region. They found no significant impact on timeliness of vaccination and argued that this was likely attributable to implementation issues resulting in inconsistent data entry and problems with data quality. No other studies have attempted to estimate the direct impact of the VIMS+TImR on outcomes relevant to the immunization program in Tanzania. In the absence of such studies, it will not be possible to reliably estimate a measure of cost-effectiveness, so that these types of studies should be prioritized over other types of research in the future.

Finally, the sustainability of the VIMS+TImR was called into question by key national stakeholders who expressed concerns about the overreliance on external developers. The Government of Tanzania is called upon to consider developing the internal capacity to implement, adapt, upgrade and maintain the TImR and VIMS, whilst responding to the software and system challenges currently experienced by users. Further domestic funding will need to be made available to respond to the infrastructure requirements, including access to internet and hardware and capacity building.

F. LIMITATIONS

This evaluation has several limitations. The sample size of 61 health facilities in 10 regions was somewhat limited. Nonetheless, it was comparable to those of similar recent studies in Tanzania, such as the ICAN study which was based on data from 51 facilities (ICAN, 2019). In addition, the use of purposive sampling may have led to imbalances in the sample and introduced biases in the results, though care was taken to select the HFs to be representative of the entirety of HFs offering immunization in the respective regions with regards to their type and level (hospital, health center, dispensary), the size of their catchment area and their urban or rural location. Additionally, potential information bias may have influenced the findings. The data collected and reported consist primarily of perceptions reported by healthcare staff during interviews, both for the programmatic data, as well as for many of the economic components. To reduce the resulting recall bias triangulation of primary data sources was done across levels of the health system when possible. In addition, alternative secondary sources were explored to increase the validity and reliability of estimates obtained from primary data.

While a classification was introduced to distinguish the types of VIMS+TImR users, there may be variations in its actual use. For example, while a HF was classified overall as using VIMS+TImR only, there might have been instances where paper was also used for specific activities, and vice-versa, leading to possible misclassifications. For what concerns the estimation of the implementation costs, when expenditures data was not available, the analysis was based on on available budgets, assuming that these were consumed entirely for the budgeted purposes. This is an important limitation since expenditures may deviate from the original budgets in several ways and to an extent that it is difficult to quantify. However, the observed close match with the estimates from Mvundura et al. (2019) for the initial roll-out costs seems to suggest that differences between budgets and expenditures were not too relevant in this case. Also, the analysis of the implementation costs for the VIMS+TImR did not include in-kind contributions from the local government (i.e., in terms of government staff time spent for management, coordination and operational activities, as well as goods and infrastructure made available to the implementation team). While these local contributions did not require additional financial disbursement, they do have an opportunity cost that should be considered in the full cost of implementation. Nonetheless, estimating these costs ex-post was deemed too prone to bias and therefore, the analysis was limited to the available data on financial expenditures. Lastly, the average cost per facility in the regions where VIMS+TImR was implemented was affected by the numbers of facilities that were no-longer users in each region and whose costs were higher compared to users. While these estimates likely reflect the reality of implementation and usage of the electronic system within each region, they may represent an overestimation of the cost of using VIMS+TImR should the usage rate increase in the future.

G. INFLUENCE OF THE COVID-19 PANDEMIC

The COVID-19 pandemic was a notable confounder in this evaluation. Although the Government of Tanzania initiated COVID-19 vaccination only in August 2021, later than in neighbouring countries, shifting government priorities may have influenced and delayed the country’s VIMS+TImR scale-up plan, including the necessary support for the transition to fully electronic use, enhancements to the tools and interoperability between tools and other HIS functions. The set-up of a parallel DHIS2-based system for COVID-19 vaccine recording and reporting may have also reduced the availability of hardware and human resources necessary for the further uptake and maintenance of the VIMS+TImR. At the same time, COVID-19 lockdowns and related accessibility factors have impacted routine immunization services and reduced vaccination coverage. Together with other influencing factors this situation made it difficult to demonstrate an impact of the tools on primary immunization outcomes, including vaccination coverage, timeliness of vaccination and drop-out rates. This evaluation, as a result, focused on the more proximal process and output measures to ascertain directional progress in the implementation and impact of the tools.

VI. CONCLUSION

The findings of this evaluation confirm that the TImR, VIMS and VIMS+TImR were perceived by HWs at all levels to be a valuable contribution to the management of immunization data. In particular, there were perceived improvements in both vaccine stock and immunization data quality since the introduction of the tools, including improved access to real-time information. Supervisory activities were positively impacted by the use of the tools including improvements in the quality of decisions made by the district and regional levels (DIVOs and RIVOs) and enhanced processes of providing and receiving feedback. Users perceived the TImR as providing assistance in the tracking of individuals outside of their catchment areas or registered at a different facility. In some instances, the TImR was reportedly helpful in defaulter identification and tracking, as well as positively impacting the management of outreach services. Use of the tools was associated with improved vaccine stock management and made the processes of receiving and putting-away of vaccines more efficient. Users of the fully electronic systems were less likely to experience stock-outs than users using the parallel system or those with only the VIMS in place. When the tools were working, and in the context of a stable infrastructure (electricity, IT, hardware), users were generally satisfied and considered the tools to have positively influenced the quality of their work, improved the services delivered and, overall, made their jobs easier.

From an economic perspective, the use of the electronic tools was associated with substantial cost-savings to the immunization program. However, the programmatic and economic benefits of the tools are unlikely to be realized without addressing challenges related to the adoption and use of the tools.

The often-difficult ecosystem (e.g., internet and electricity), coupled with repeated hardware and software problems led many users to abandon the use of the tools. Local capacity and country ownership will need to be strengthened to sustainably resolve these challenges, including those related to the further synchronization and interoperability of the tools with the existing HMIS and the CRVS. Ensuring adequate access to stable internet, sufficient and robust hardware and high-quality, regular training will be critical for enhancing the continued use of the tools. This will necessitate further prioritized investments. Improved local management and continued monitoring of the systems by the MoH of Tanzania may ensure their long-term programmatic and financial sustainability.

The Government of Tanzania is called upon to consider developing the internal capacity to implement, adapt, upgrade and maintain the TImR and VIMS, whilst responding to the software and system challenges currently experienced by their users. Further domestic funding will need to be made available to respond to the prevailing infrastructure requirements.

Once a platform which enables the successful implementation of the tools (i.e., with sufficient internal capacity and IT infrastructure) has been established, the MoH should plan for the elimination of paper registries. This will significantly reduce HW workload and enhance data quality by focusing on a single electronic process of recording and reporting immunization data. The existing monitoring framework will need to be further enhanced to continuously assess tool adoption and its impact on HW activities, as well as any potential cost savings. Defaulter tracking mechanisms and SMS reminders for caregiver notification should be activated and a feasibility assessment done to further explore potential interoperability between the eIR and the national CRVS or local birth registries.

Despite the reported challenges, the continued use of these electronic tools could well be associated with cost-savings to the immunization program after a relatively short period required to recover the initial investments. Further investments are encouraged to resolve such challenges, specifically including those related to the enabling environment, and support the further introduction and sustained use of electronic tools.

VII. ANNEXES

ANNEX 1A: THEORY OF CHANGE (EIR)

Vision	Reduce morbidity and mortality from VPDs by enhancing equitable access to vaccines and strengthening immunization delivery within PHC (IA 2030)				
Mission	Improve immunization program performance (equitable coverage and system efficiency) by sustained use of eIR				
Strategic Outcome	1. Functioning eIR as part of a broader health information system	2. Improved immunization data quality	3. Increased use of immunization data for decision-making	4. More efficient, affordable, and sustainable eIR use	5. Increased stakeholder satisfaction and engagement
Output	a) eIR is functional and interoperable with other health information systems. b) Data flow and feedback mechanisms between administrative levels is improved. c) Linkages between data systems enable estimation of vaccine effectiveness, impact and causality assessment of serious AEFI.	a) Data are complete, sufficiently granular, accurate and timely. b) HWs at all levels understand data quality dimensions and are motivated to improve it. c) More updated and precise information is available on size of target populations for different vaccines. d) Data facilitate the identification of un- and under-immunized individuals and communities.	a) HWs at all levels are capable, empowered and motivated to make data-enabled decisions to improve planning (e.g. analyze data by geography, SES, gender, etc.). b) The ability to uniquely identify individuals targeted by immunization services is improved.	a) Country ownership of the eIR is enhanced with adequate system governance. b) All levels of the health system have access and the capacity to use the eIR. c) Time required to organize vaccination sessions, record vaccine events, establish defaulter lists and generate monthly reports is reduced. d) Financial resources allocated are adequate to sustain and periodically update the eIR.	a) Time savings and knowledge gains increase HW motivation to use the system. b) User confidence in eIR data quality is enhanced. c) Caregiver satisfaction with immunization services is increased, e.g., by benefitting from receiving notifications
Input & Process **External environment; Human Resources; Systems & tools**	d) Appropriate IT and facility infrastructure (security, integrity, electricity, internet) is in place. e) Data recording and reporting is user-	e) Competency and proficiency of eIR users at all levels is ensured. f) Data quality and consistency checks are in-built.	c) Reporting flow of case-based data from vaccination sites to national level is seamless. d) Interactive data dashboards are	e) An e-health policy environment is in place. f) Sufficient technical and governance capacity is generated. g) The eIR is continuously maintained and updated	d) Feedback from stakeholders (government, funders, users, clients) is used to continuously improve the system.

	friendly and efficient (including revised paper-based forms). f) Interoperability is established with HMIS, civil registration (CRVS), surveillance, pharmacovigilance and logistics management systems, including in the private sector.	g) Periodic data quality audits are performed. h) SOPs, job aids, training and supportive supervision tools for eIR use are available.	available that enable data visualization. e) HW capacity to use immunization data is strengthened at all levels. f) HWs have the ability to identify zero-dose children and to track defaulters. g) Data can be generated to monitor performance indicators at all levels. h) Client usage patterns reveal HF management issues and help reduce unnecessary supervisory visits.	(e.g., help desk available) h) Costs of implementation of the eIR and costs avoided are well known. i) A budget line exists for maintaining and updating the eIR.	e) HWs are empowered to use saved time to improve the quality of service delivery.

ANNEX 1B : THEORY OF CHANGE (ELMIS)

Vision	Reduce morbidity and mortality from VPDs by enhancing equitable access to vaccines and strengthening immunization delivery within PHC (IA2030)				
Mission	Improve immunization program performance (vaccine availability and equitable access; logistics management efficiency) by sustained use of eLMIS				
Strategic Outcome	1. Improved eLMIS functionality	2. Improved vaccine forecast accuracy	3. Improved inventory and stock levels (data use for decision making)	4. More efficient, affordable, and sustainable eLMIS use	5. Increased stakeholder satisfaction and engagement
Output	a) eLMIS is functional and interoperable with other HMIS. b) Data flow and feedback mechanisms between administrative levels is improved.	a) Vaccine stock data are complete, sufficiently granular, accurate and timely. b) eLMIS stock balances match physical count. c) The need for ad-hoc (emergency) transports to replenish vaccine stocks is reduced.	a) Stock levels of vaccines are adequate at all times and all health system levels. b) Stockouts leading to interruption of vaccination services are reduced. c) Closed vial wastage (due to temperature excursions or expiry) is minimized. d) Open vial wastage is minimized.	a) Country ownership of the eLMIS is increased with adequate system governance. b) HWs at all levels are empowered to make data-based decisions to improve vaccine management. c) Financial resources are adequate to sustain the eLMIS. d) Time required to perform cold chain equipment temperature monitoring and generate monthly reports is reduced.	a) Time savings and knowledge gains increase HW motivation to use the system. b) User perception on eLMIS data quality is enhanced. c) Caregiver satisfaction with availability of vaccines has increased, e.g., by not having to return in case of stockout.
Input & Process **External environment; Human Resources; Systems & tools**	c) Timely tracking of vaccines from arrival in country to service delivery point is possible. d) Appropriate IT and facility infrastructure (security, integrity) is in place. e) Data recording and reporting functions are user-friendly and efficient.	d) Good-quality data to monitor eLMIS performance are generated at all levels. e) Forecasting competency and proficiency of eLMIS users at all levels is ensured. f) Data quality and consistency checks and	e) Near-time data are available at all levels on inventory and stock levels. f) HR capacity to utilize data for decision making is strengthened (e.g., for early stock replenishment). g) Interactive data dashboards are	e) An e-health policy environment is in place. f) Sufficient technical and governance capacity is generated. g) The eLMIS is continuously maintained and updated (e.g., help desk available for	d) Feedback from stakeholders (government, funders, users, clients) is used to continuously improve the system. e) HWs are empowered to use saved time more effectively.

	f) Interoperability or integration with eIR and other health sector LMIS is enabled. g) Integration with other electronic health management systems is possible. h) (Remote) temperature monitoring systems are in place.	periodic data quality audits are performed. g) SOPs, job aids, training and supportive supervision tools for eLMIS use are available.	accessible that enable data visualization. h) Improved inventory data use leads to increased size of vaccination sessions.	timely correction of problems). h) Costs of implementation of the eLMIS and costs avoided by its use are known. i) A budget line exists for maintaining and updating the eLMIS.	

ANNEX 2: DATA COLLECTION TOOLS

Attached

ANNEX 3: ETHICAL APPROVAL

THE UNITED REPUBLIC OF TANZANIA

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3 Barack Obama Drive
P.O. Box 9653
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Ministry of Health, Community Development, Gender, Elderly & Children
Government City Mtumba, Health Road
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NIMR/HQ/R.8a/Vol. IX/3770

02nd September 2021

Dr. Nyanda Elias Ntinginya
Centre Director
NIMR-Mbeya Medical Research Centre
P O Box 2410
Mbeya

RE: ETHICAL CLEARANCE CERTIFICATE FOR CONDUCTING MEDICAL RESEARCH IN TANZANIA

This is to certify that the research entitled: **Evaluating the impact of electronic logistics management information systems (eLMIS) and electronic immunization registries (eIR) (Nyanda N. E. et al.)**, has been granted ethical clearance to be conducted in Tanzania.

The Principal Investigator of the study must ensure that the following conditions are fulfilled:

1. Progress report is submitted to the Ministry of Health, Community Development, Gender, Elderly & Children and the National Institute for Medical Research, Regional and District Medical Officers after every six months.
2. Permission to publish the results is obtained from National Institute for Medical Research.
3. Copies of final publications are made available to the Ministry of Health, Community Development, Gender, Elderly & Children and the National Institute for Medical Research.
4. Any researcher, who contravenes or fails to comply with these conditions, shall be guilty of an offence and shall be liable on conviction to a fine as per NIMR Act No. 23 of 1979, PART III Section 10(2).
5. Sites: Arusha, Dodoma, Kilimanjaro, Mbeya, Mwanza, Njombe, Pwani, Shinyanga, Singida and Tanga regions.

Approval is valid for one year: 02nd September 2021 to 01st September 2022.

Name: Prof. Yunus Daud Mgaya

Signature
CHAIR PERSON
MEDICAL RESEARCH COORDINATING COMMITTEE

Name: Dr. Aifello Wedson Sichalwe

Signature
CHIEF MEDICAL OFFICER
MINISTRY OF HEALTH, COMMUNITY DEVELOPMENT, GENDER, ELDERLY & CHILDREN

CC: Director, Health Services-TAMISEMI, Dodoma.
RMO of Arusha, Dodoma, Kilimanjaro, Mbeya, Mwanza, Njombe, Pwani, Shinyanga, Singida and Tanga regions.
DMO/DED of respective districts.

ANNEX 4: SAMPLING

Table 1: List of districts selected per region*

Dodoma (VIMS+TImR)	Mwanza (VIMS+TImR)	Njombe (VIMS+TImR)	Arusha (VIMS+TImR)	Kilimanjaro (VIMS+TImR)
Bahi **Chawino** Kongwa **Mpwapwa** Kondoa **Dodoma** Chemba	**Ilemela** Nyamagana **Magu** **Misungwi** Kwimba Sengerema Ukerewe Buchosa	**Njombe TC** Njombe DC Makete Ludewa **Wangingombe** **Makambako**	**Arusha CC** Arusha DC **Monduli** Karatu **Longido** Ngorongoro Meru	Hai **Mwanga** Moshi DC **Moshi MC** Same **Rombo** Siha
Tanga (VIMS+TImR)	**Singida (VIMS)**	**Shinyinga (VIMS)**	**Mbeya (VIMS)**	**Pwani (VIMS)**
Handeni **Korogwe** Lushoto Muheza Pangani **Tanga** Mkinga **Kilindi** Bumbuli	Ikungi **Iramba** Manyoni **Mkalama** Singida DC **Singida MC** Itigi	Shinyanga DC **Shinyanga MC** **Ushetu** Kishapu **Kahama** Msalala	**Mbeya CC** Mbeya DC **Busekelo** **Chunya** Mbarali Kyela Rungwe	**Kibaha** Bagamoyo Mafia Kisarawe **Mkuranga** Rufiji Kibiti **Chalinze**

* Districts randomly selected for inclusion in the evaluation are highlighted in bold.

Table 2: List of regions, districts and health facilities interviewed

Region	District	HF Name	Location	Ownership
Arusha (VIMS+TImR)	Arusha CC	Elerai Dispensary	Urban	Public
		Levolosi Health Centre	Urban	Public
	Longido DC	Kimokouwa Dispensary	Rural	Public
		Namanga Dispensary	Rural	Public
	Monduli DC	Mtimmoja Dispensary	Rural	Public
		Olarashi Dispensary	Rural	Public
Dodoma (VIMS+TImR)	Chawino DC	Bwigiri Dispensary	Urban	Public
		Machali Dispensary	Rural	Public
	Dodoma MC	Makole Dispensary	Urban	Public
		Makole Health Centre	Urban	Public
		Nala Dispensary	Urban	Public
	Mpwapwa DC	Iyenge Dispensary	Rural	Public
		Lukole Dispensary	Rural	Public
Kilimanjaro (VIMS+TImR)	Moshi MC	Bondeni Dispensary	Urban	Public
		Shirimatunda Dispensary	Urban	Public
	Mwanga DC	Mwanga District Hospital Usangi	Urban	Public
		Mwanga Health Centre	Urban	Public
	Rombo DC	Kahe Dispensary	Rural	Public
		Mkuu Rc Dispensary	Rural	Private
Mbeya	Busokelo DC	Ikama Dispensary	Rural	Public

		Mpanda Dispensary	Rural	Public
	Chunya DC	Matundasi Dispensary	Rural	Public
		Sangambi Dispensary	Rural	Public
	Mbeya CC	Iganzo Dispensary	Urban	Public
		Kiwanjampaka Health Centre	Urban	Public
Mwanza (VIMS+TImR)	Ilemela MC	Kahamadispensary	Urban	Public
		Kirumba Dispensary	Urban	Public
	Magu DC	Kahangalahealthcentre	Rural	Public
		Mwashepi Dispensary	Rural	Public
	Misungwi DC	Igokelo Dispensary	Rural	Public
		Misungwi District Hospital	Urban	Public
Njombe (VIMS+TImR)	Makambako TC	Kifumbe Dispensary	Rural	Public
		Makambako Health Centre	Urban	Public
	Njombe TC	Mjimwema Dispensary	Rural	Public
		Njombe District Hospital	Urban	Public
	Wanging'ombe DC	Dulamu Dispensary	Rural	Public
		Luduga Dispensary	Rural	Public
Pwani	Chalinze DC	Ruvu Darajani Dispensary	Rural	Public
		Vigwaza Dispensary	Rural	Public
	Kibaha DC	Kwala Dispensary	Rural	Public
		Mlandizi Health Centre	Urban	Public
	Mkuranga DC	Mkuranga District Hospital	Urban	Public
		Mwanambaya Dispensary	Rural	Public
Shinyanga	Kahama TC	Busoka Dispensary	Rural	Public
		Sangilwa Dispensary	Rural	Public
	Shinyanga MC	Kambarage Health Centre	Urban	Public
		Kizumbi Dispensary	Urban	Public
	Ushetu DC	Igunda Dispensary	Rural	Public
		Uyogo Dispensary	Rural	Public
Singida	Iramba DC	Bomani Dispensary	Rural	Private
		Kiomboi District Hospital	Urban	Public
	Mkalama DC	Ishenga Dispensary	Rural	Public
		Nkalakala Dispensary	Rural	Public
	Singida MC	Soloing Health Centre	Urban	Public
		Uhasibu Dispensary	Urban	Public
Tanga (VIMS+TImR)	Kilindi DC	Kibirashi Dispensary	Rural	Public
		Mafisa Dispensary	Rural	Public
	Korogwe DC	Kwakombo Dispensary	Urban	Private
		Majengo Health Centre	Urban	Public
	Tanga CC	Mwanzange Dispensary	Urban	Public
		Nguvumali Dispensary	Urban	Public

Table 3: Use of electronic tools in sites visited by region

Region	Use of tool	VIMS+TImR only		VIMS+TImR+paper IR		VIMS + paper IR	
		HF	DIVO	HF	DIVO	HF	DIVO
Arusha	VIMS+TImR+paper IR					6	3
Dodoma	VIMS+paper IR					7	3
Kilimanjaro	VIMS+TImR	2		3	1	1	2
Mbeya	VIMS+paper IR					6	3
Mwanza	VIMS+TImR	3	3	3			
Njombe	VIMS		1			6	2
Pwani	VIMS					6	3
Shinyanga	VIMS					6	3
Singida	VIMS					6	3
Tanga	VIMS+TImR		3	4		2	
Total		5	7	10	1	46	22

ANNEX 5: COMPLETE PROGRAMMATIC FINDINGS AS MAPPED AGAINST TOC STRATEGIC OBJECTIVES

The programmatic analysis was conducted against the four strategic outcomes of the Theory of Change (ToC). Each question of the various data collection forms was mapped against the ToC in order to provide a detailed and holistic appreciation for the complexity of the tools, its implementation, and its expected outputs; as well as the enabling environment required for its successful adoption. This analysis explored input, process and output areas related to each strategic outcome. This report is intended to support program managers, providing detailed insights into the use of the tools, as well as the challenges and successes of its implementation. As Tanzania transitions away from a dual system, abandoning paper-based tools, these insights can assist program managers in their planning and monitoring of successful scale-up to full electronic use of the VIMS+TImR. Further, these insights may be particularly helpful in exploring why those HFs who had introduced the VIMS+TImR but are no longer using the tool.

Overall, computer literacy did not hinder implementation, but availability to infrastructure (including the internet) and IT support (including challenges with the tool that local IT support and supervisors could not assist with) were considerable barriers to adoption and scale-up. The perception of the quality of information and overall user satisfaction was similar between rural and urban users whilst urban users were more likely to use the tool than rural users *(Table 1).*

Table 1 Assessment of domains of the health facility survey

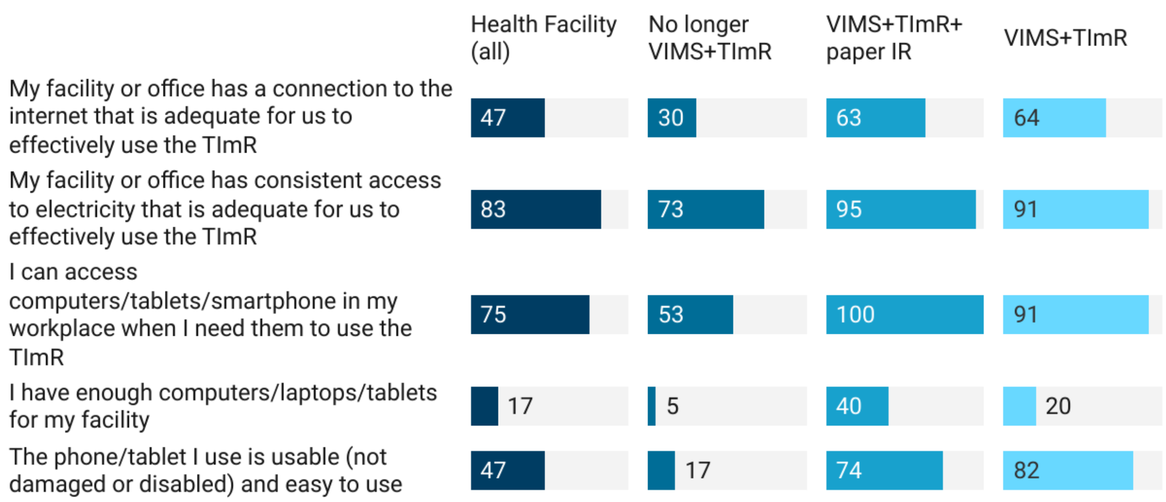
	Computer literacy	Infrastructure	Information quality	IT service	Use	User satisfaction
TImR+VIMS	100	82	86	92	85	94
Rural	100	67	92	94	73	100
Urban	100	88	84	92	89	92
TImR+VIMS+paper IR	93	86	93	82	79	92
Rural	96	83	91	81	74	86
Urban	91	88	95	82	84	97
No longer TimR+VIMS	93	52	58	18	7	64
Rural	93	56	67	28	13	69
Urban	93	49	50	8	2	58

STRATEGIC OUTCOME 1: FUNCTIONING EIR AS PART OF A BROADER HEALTH INFORMATION SYSTEM | IMPROVED ELMIS FUNCTIONALITY

INPUT/PROCESS

The biggest infrastructure challenge experienced by HFs was access to the **internet and data bundles.** The majority of users were able access hardware (e.g., computers, tablets, smartphones) in their workplace when required, however many still considered their availability as insufficient. The majority (95%) of HF staff no longer using the tool stated that they did not have enough working computers, laptops or tablets at their HFs. Similarly, amongst users, VIMS+TImR-only users (80%) and VIMS+TImR + parallel IR (50%) users complained about insufficient hardware. VIMS+TImR users were more likely than non-users to state that their internet connectivity was adequate (*p=0.04*). Access to the internet was frequently mentioned as enhancing the benefits of the tool (e.g., "*when Internet is working, I do my work faster and more efficiently*"; *"When the Internet connection is good using tablet is quicker than paper").* Users also reported that they had better access to electricity than non-users (n.s.) and thought that they could more easily access hardware if needed (*p<0.01*). Their hardware was perceived as more 'usable' (i.e., not damaged) (*p<0.01*) *(Figure 1).*

Figure 1: Access to infrastructure at HW level (%)



The biggest infrastructure challenge experienced by DIVOs (50%) and RIVOs (40%) was again poor internet connectivity. Some DIVOs (13%) and RIVOs (10%) also reported challenges with electricity. Respondents acknowledged having to use personal funds for purchasing data bundles, particularly during outreach services. The vast majority of DIVOs (93%) and RIVOs (80%) did not think they had enough computers, laptops or tablets. Almost two-thirds (63%) of DIVOs and 90% of RIVOs described personal experience with unusable hardware.

All VIMS+TImR-only users (100%), 90% of VIMS+TImR+paper IR and 71% of those no longer using VIMS+TImR agreed that the tool was user-friendly. The majority of DIVO (97%) and RIVO (80%) users agreed with this statement. RIVOs acknowledged: "*The system is user friendly as every responsible person with passwords can access the system".*

Users (90%) were much more likely than non-users (27%) to state that IT support for the tool was timely (*p<.001)*. Two-thirds of users (63%) thought that the reported problems were fixed in the appropriate time with decisive differences between user groups (73% VIMS+TImR only, 58% VIMS+TImR+paper IR) and 7% of those no longer using the VIMS+TImR. Two-thirds (63%) of HF respondents - the majority of whom were users (76%) -thought their **supervisors had been helpful** in supporting the use of the tool. Those no longer using the tool were much less likely to think their supervisors had been helpful in the use of the tool. HFs acknowledged that DIVOs tried to assist where possible (e.g., replacing broken chargers or with non-technical challenges) but oftentimes were unable to do so (e.g., if there were software challenges).

Users were more likely than those no longer using the tool to think that VIMS+TImR provided sufficient information to enable them to perform their tasks (p=0.01); that, with VIMS+TImR, they were able to access the information required (p=0.002); and that VIMS+TImR was easy to use (p=0.01). In addition, Users were slightly more likely to think that they could finish their tasks faster by using the VIMS+TImR (n.s.).

OUTPUT

All HF staff that used VIMS+TImR exclusively thought the tool was functioning when required; 50% of VIMS+TImR + paper IR and 50% of those no longer using VIMS+TImR agreed with this statement. The majority of district users (93%) and all regional users thought the VIMS+TImR was functioning when required.

The majority (87% of users; 91% of non-users) of HF received feedback from the district on their immunization and vaccine stock data and most (97%) of DIVOs provided feedback to HFs regarding their immunization and vaccine stock data. Half (50%) of DIVOs thought that the tool had made the process of *providing* feedback easier and more than half (60%) of DIVO users thought that electronic tools had made the process of *receiving* feedback easier. Similarly, 50% of RIVOs thought that the electronic tools had made the process of *providing and receiving* feedback easier. It was noted that: *"[The tool] simplified work, currently no need to prepare reports because data can be accessed through the system" [RIVO].*

STRATEGIC OUTCOME 2: IMPROVED IMMUNIZATION DATA QUALITY | IMPROVED VACCINE FORECAST ACCURACY

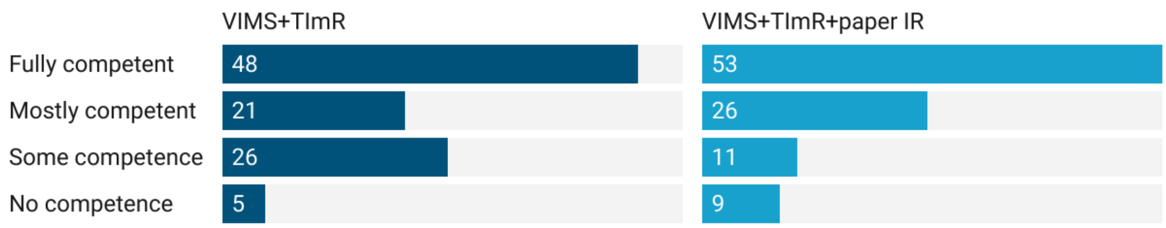
INPUT/PROCESS

The majority (98%) of HF respondents were interested in working with computers/tablets/smartphones; 85% thought they had moderate or greater skills in using computers/tablets/smartphones and all respondents thought that computers/tablets/smartphones would support them to be more efficient at work. Two-thirds (63%) of HF respondents thought their supervisors had been helpful in supporting his/her use VIMS+TImR use.

The majority of all DIVO respondents acknowledged that additional staff were required, or there was a reorganization of staff for the implementation of the VIMS or the VIMS+TImR. However, one DIVO respondent did comment that the VIMS+TImR "*help(s) to fasten work and reduce the number of staff needed*". Conversely, whilst one RIVO respondent mentioned that additional staff were required, the remaining nine respondents acknowledged the requirement to reorganize and train staff, but that the work has "*simplified",* and the workload "*decreased significantly".*

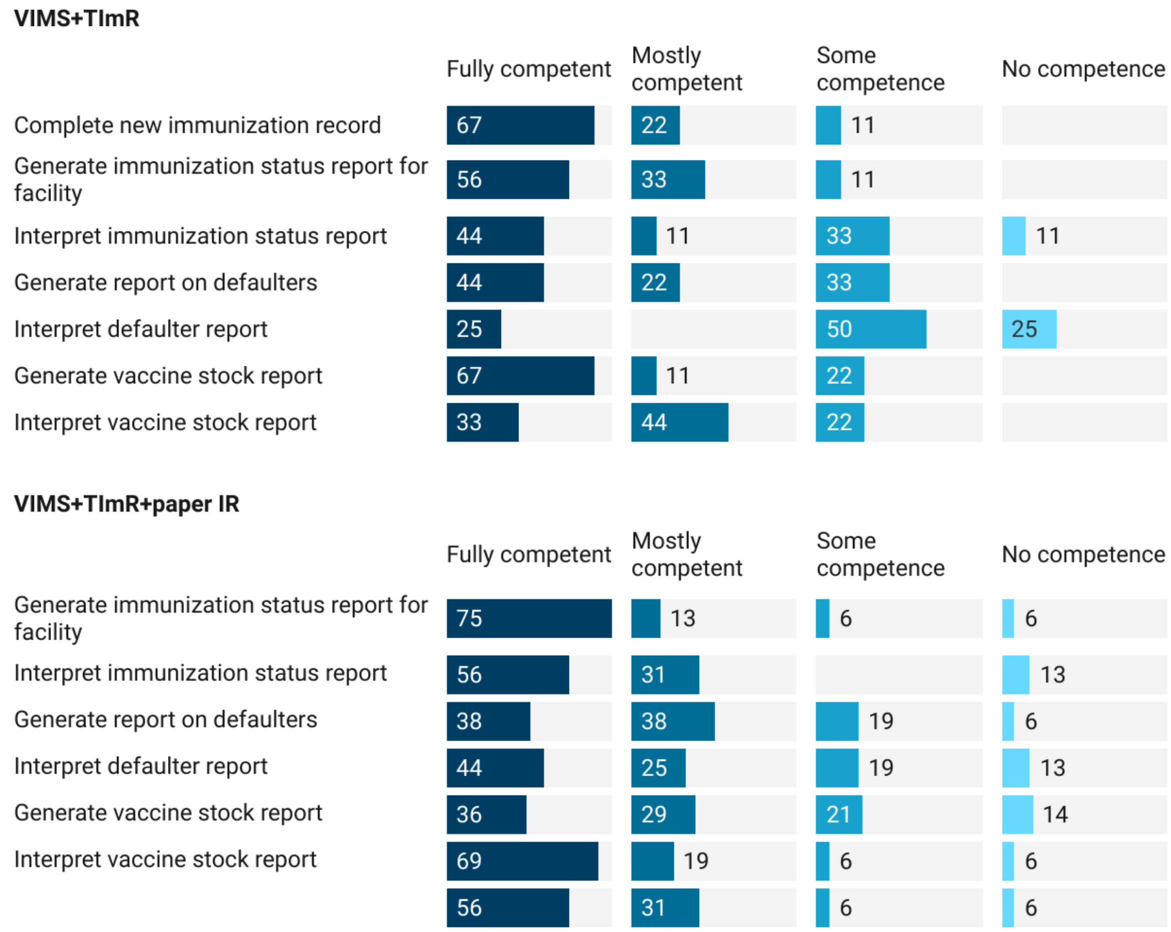
The competency of 42 respondents (at 26 HFs[3]) was assessed. Overall, VIMS+TImR users with a parallel paper IR were more competent than users with an exclusively electronic VIMS+TImR as shown in *Figure 2*. Users were more comfortable in generating reports, than interpreting them and most users have at least some competences in all activities, as summarized in *Figure 3* below.

Figure 2: Competency of VIMS+TImR and VIMS+TImR + paper IR users in using the tool



[3] The competency assessment was intended to be used at all facilities where the VIMS+TImR had been introduced (n = 36). Competency assessments were in some cases attempted in those facilities where the tool was no longer in use (n = 21). However, 10 competency assessments were not possible due to a complete inability to assess competency based on non-existence of the tool.

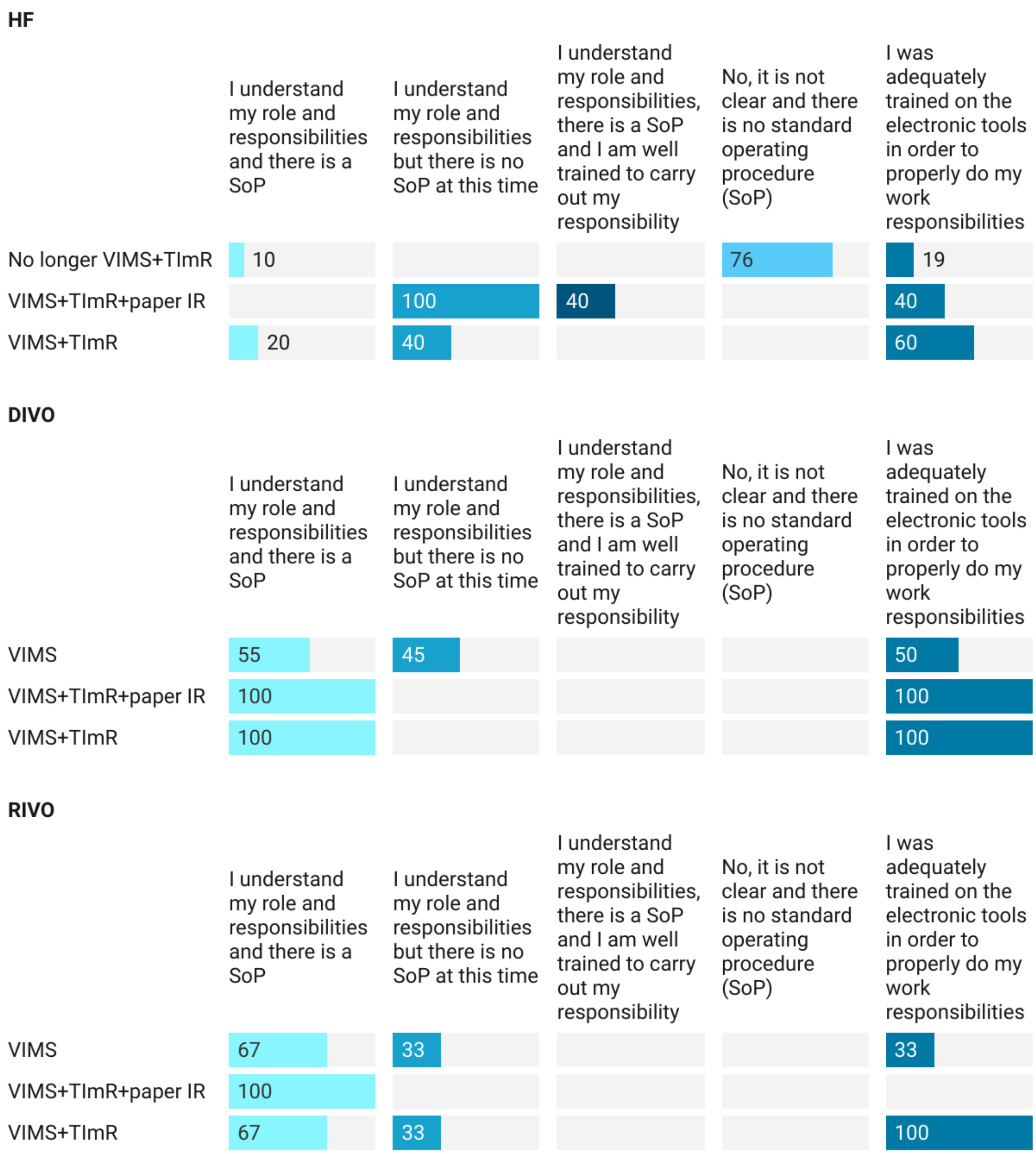
Figure 3: Competency of VIMS+TImR users for identified activities



In terms of training, 60% of VIMS+TImR users and 40% of those using VIMS+TImR+paper IR compared to only 19% of those no longer using the VIMS+TImR thought they had been adequately trained. Nonetheless, almost all HF (98%) respondents reported **additional training needs**, most commonly in data analysis (89%), data recording (87%), data reporting (82%), and data collection (54%). By contrast, all district level VIMS+TImR thought they had been adequately trained on the electronic tools while only 50% of the district level VIMS-only users reported having received adequate training. At regional level, VIMS+TImR users were more adequately trained than VIMS-only users.

More than half (54%) of HF users, and all DIVO and RIVO respondents understood their roles and responsibilities, but SOPs were not standardly available. Available training materials at HFs for VIMS+TImR and paper-based tools included job aids, instruction manuals. DIVOs and RIVOS largely had access to instruction manuals, which (according to the DIVOs) needed to be updated. The majority (90%) of HF users thought that the user guides/help functions in the VIMS+TImR were useful; those no longer using the tool were less likely to think so *(Figure 4).*

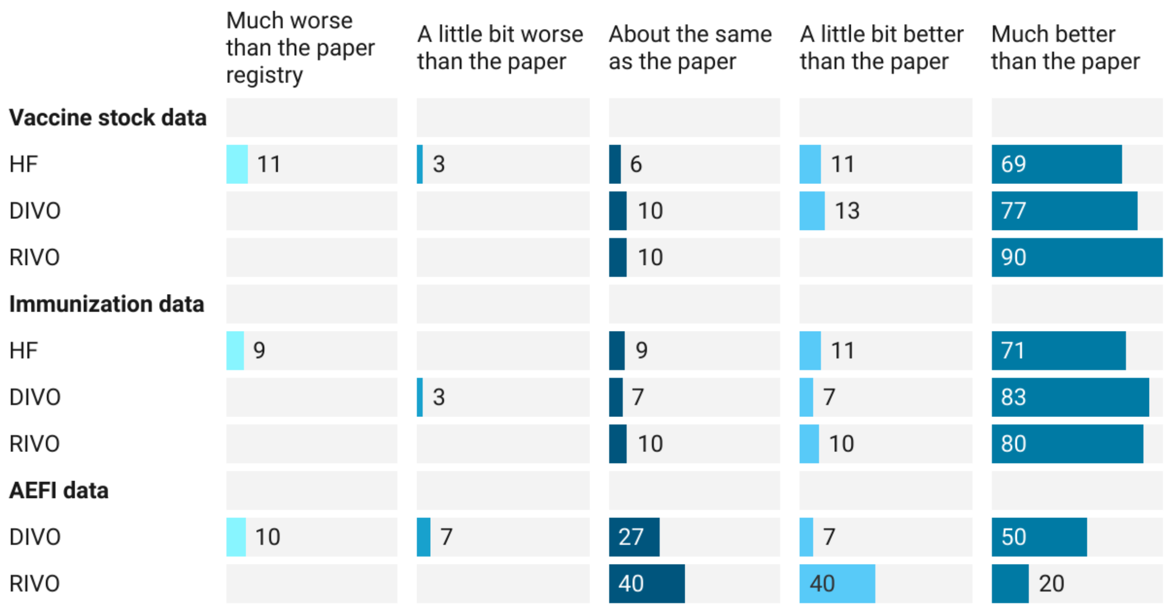
Figure 4: Roles, responsibilities, SoPs and training at health facility, district and regional levels (%)



OUTPUT

The vast majority of respondents agreed that both vaccine stock data and immunization data quality had improved since the introduction of VIMS+TImR *(Figure 5).* Users were somewhat more satisfied with the accuracy and completeness of vaccine stock and immunization records in the VIMS+TImR than those no longer using the tool. VIMS+TImR users were more likely to think that the VIMS+TImR gives users the information needed than those no longer using VIMS+TImR ($p=0.03$). More than half of RIVOs (60%) and DIVOs (53%) and 20% of HF respondents acknowledged challenges in their vaccine and stock data which they wanted to address. At HF level these challenges included the VIMS+TImR failing to work properly, poor data collection and data recording due to insufficient training on the tool, inaccurate denominators and vaccine shortages. DIVOs refer to challenges regarding poor data quality, limited/no interoperability between the VIMS and VIMS+TImR, and challenges with the VIMS in retrieving and displaying data. Data quality challenges experienced by RIVOs include poor interoperability between the VIMS+TImR and VIMS, the continued use of paper tools (i.e., inconsistent use of the VIMS+TImR) and a shortage of funds.

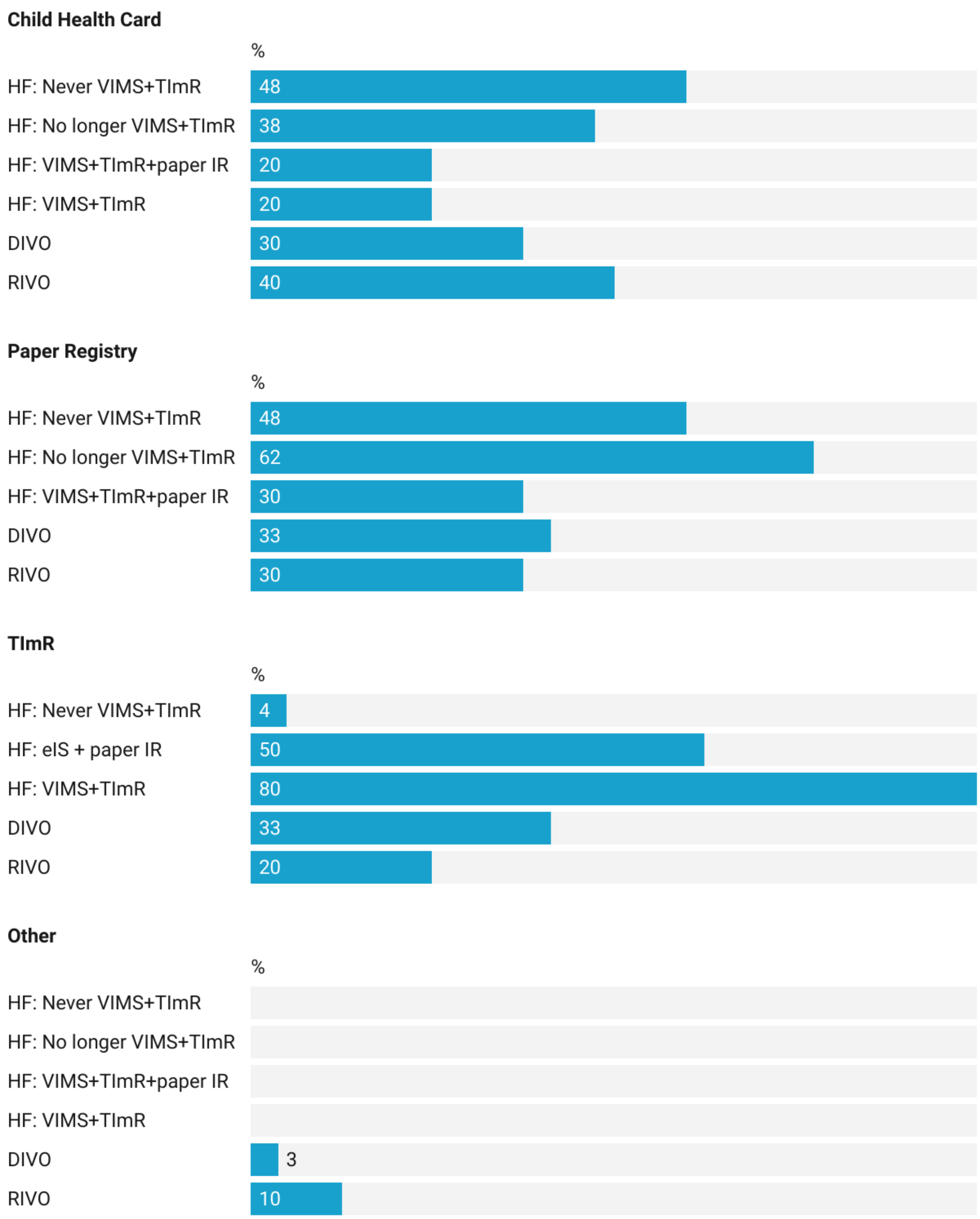
Figure 5: Quality of vaccine stock, immunization, and AEFI data since the introduction of VIMS+TImR (%)



There was an association between perceptions of accuracy stated by respondents and accuracy confirmed during the on-site accuracy check: 60% of HFs of respondents who were satisfied with the accuracy and completeness of the VIMS+TImR data had data entries from different sources which matched exactly; while only 30% of respondents who were unsatisfied with their data quality had matching entries . The documented discrepancies in data entries were explained by HF staff by a number of factors including: children vaccinated at other HFs and thus, whilst documented on the Child Card, data not entered into the paper registry; child registration often done by community health workers (CHWs) who were not skilled in capturing data properly; delayed data entry due to staff shortages or poor internet connectivity resulting in staff forgetting to enter all/some details; and errors with the electronic system in accepting historical data.

Overall, the majority of respondents at all levels considered the paper registry and Child Health Card to be the most accurate source of data. However, amongst the respondents (16%) who thought the VIMS+TImR was the most accurate, the majority (90%) were VIMS+TImR users. District and regional respondents were largely split between the perception of accuracy across the three different data sources *(Figure 6).*

Figure 6: Perception of most accurate data source by user type



Slightly more than half (56%) of HF staff thought that the estimate of their HF target population was accurate, with VIMS+TImR-only users more likely to think that this was the case. Even fewer district (50%) and regional respondents (30%) perceived their target population to be accurate and tended towards thinking that their true catchment populations were larger. Paper IR users were more likely to think that their target population was accurate both at the district (73%) and at the regional level (67%).

The majority (73%) of users thought that the system helped track individuals outside of their catchment area, by using the unique identifier and barcode which is created when a child is registered into the system.

The vast majority (82%) of HFs conducted outreach sessions for vaccination. Most of these HFs (70%) managed outreach immunization data through paper-based forms; only 7% of HFs used VIMS+TImR + paper IR and another 7% used the VIMS+TImR exclusively to record outreach immunization data. The majority (60%) of users managed vaccines for outreach through the VIMS+TImR.

Similarly, the vast majority of DIVOs (77%) and RIVOs (80%) could easily identify their three worst performing HFs. Those who were not able to do so cited challenges with the VIMS+TImR not being able to provide a comprehensive picture of their district/region (due to use of paper tools in some HFs i.e., inconsistent use of VIMS+TImR), and poor interoperability between the VIMS and TImR.

SO 3: INCREASED USE OF IMMUNIZATION DATA FOR DECISION-MAKING | IMPROVED INVENTORY AND STOCK LEVELS

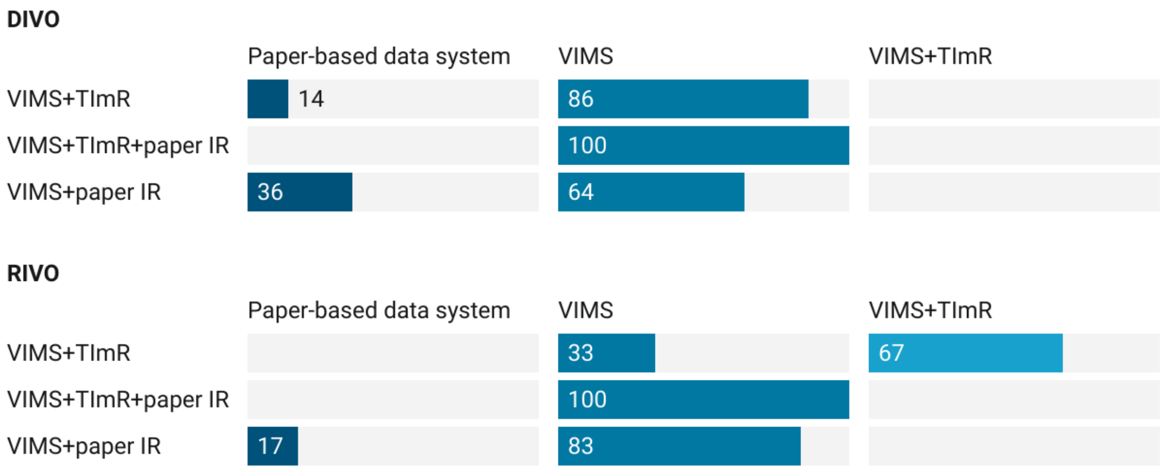
INPUT/PROCESS

At HFs, immunization data were largely used for forecasting vaccine needs, adjusting plans for outreach sessions, and planning and budgeting. Examples of how VIMS+TImR data were used to inform decisions included: defaulter identification and tracking; informing actions based on low coverage; stock management and vaccine ordering; workload assessment and human resource requirement planning; and planning for outreach sessions (e.g., one HF: *"In the past the outreach session was done only once but by using (electronic) data the sessions are [now] increased to three";* different HF: *"The data was used to increase the outreach sessions from 2 to 4 per month"*).

At the district and region levels, immunization data were mostly used for supervisory activities, and for planning and forecasting vaccine needs. Data were used to inform decisions on the initiation of outreach services; planning for supervisory activities; requesting new staff; and for stock management. The majority of DIVOs (84%) and RIVOs (70%) held regular meetings to review and discuss their immunization, vaccine stock and cold chain data.

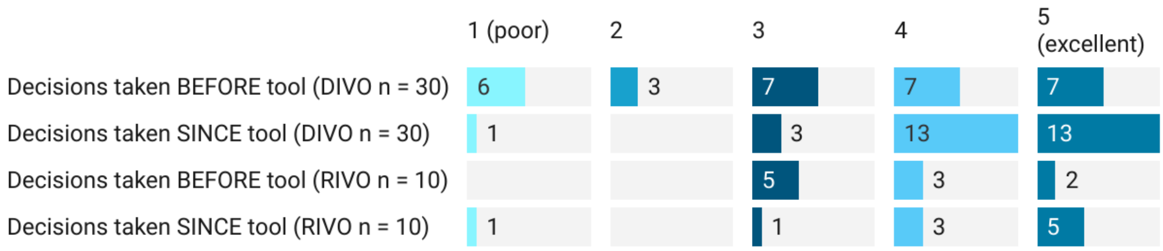
Most DIVOs (77%) and RIVOs (90%) had district/regional immunization microplans and most DIVOs (93%) and all RIVOs prioritized the needs of HFs based on available performance data. Notably, the VIMS was used as the primary source for this performance data by most DIVOs (70%) and RIVOs (70%); only 20% of RIVOs used the VIMS+TImR, and the remaining 10% of RIVOs and 30% of DIVOs used paper-based systems *(Figure 7).*

Figure 7: Perception of most accurate performance data by DIVOs and RIVOs



DIVOs and RIVOs perceived an improvement in the quality of decisions made since the implementation of the VIMS+TImR (DIVO score 96 vs. 127; RIVO score 37 vs. 41; n.s.) *(Figure 8).*

Figure 8: Quality of decisions made pre- and post- implementation of the tools



All HF VIMS+TImR-only users, 90% of VIMS+TImR+paper IR, 97% DIVOs and 100% RIVOs thought that VIMS+TImR assisted them in better managing stock; 52% of HF no-longer using the VIMS+TImR agreed. Further, urban HF users (100%) were more likely than rural HF users (86%) to think that VIMS+TImR improved stock management. HFs stated that the VIMS+TImR assisted in direct communication with the DIVO and automatically calculated balances, however there were concerns on the speed and reliability of the tools, and the need for additional training.

Less than a quarter of HF users (n=15) used the VIMS+TImR to **notify caregivers (n=3)** of upcoming or missed vaccinations; all of these respondents. thought these reminders were effective. The possibility to send SMS's via TImR is no longer functional.

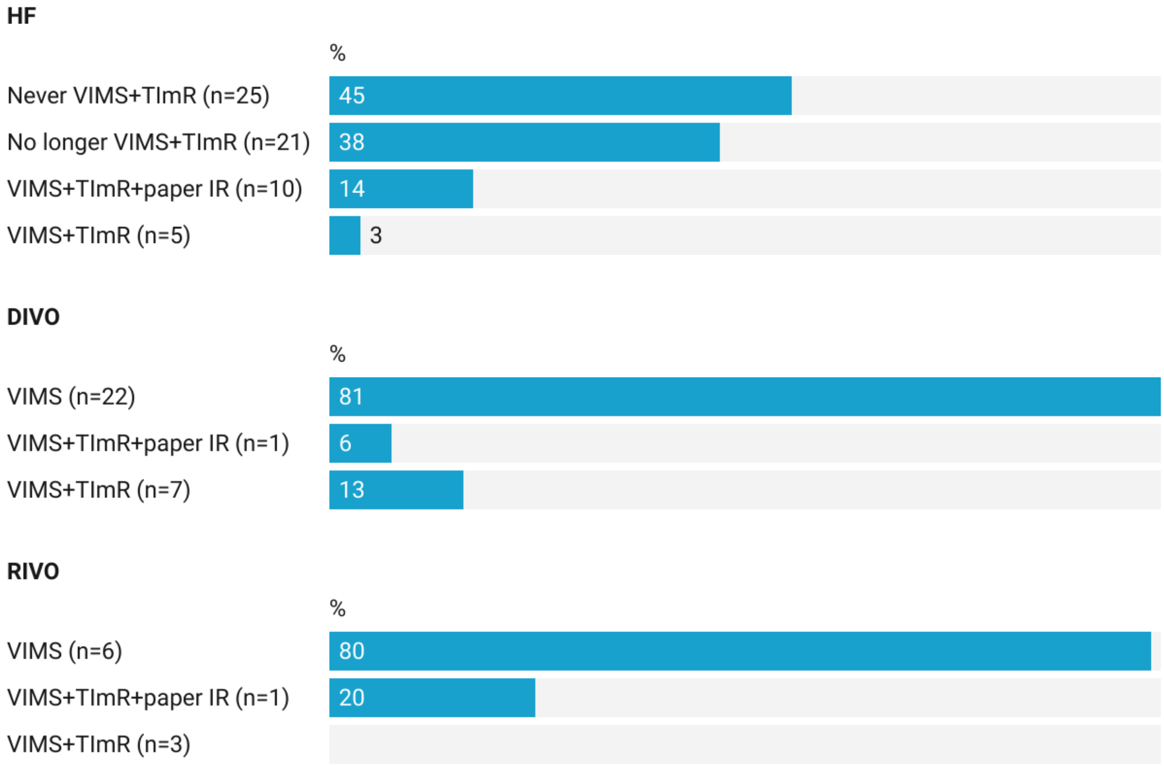
OUTPUT

The majority of HF users regularly used the VIMS+TImR to generate monthly reports (87%) and to order new supplies (80%).

Users were less likely to have an immunization performance monitoring chart, dashboard or other data visualisation at HFs (92% of these were in paper format). More than half (60%) of these HF monitoring charts were up to date. All RIVOs and DIVOs have a performance monitoring chart available, 80% of RIVOs and 70% of DIVOs have this performance chart available in electronic format (exclusively electronic, or in both paper and electronic format). The majority (79%) of HFs had a defaulter tracking mechanism in place. The majority (83%) of HF users regularly used the VIMS+TImR to generate a list of defaulters; this includes all VIMS+TImR-only users and 74% of VIMS+TImR+paper IR users. Urban users were slightly more likely than rural users to use the VIMS+TImR to generate a list of defaulters (n.s.). The majority of users thought their defaulter tracking process was effective; with similar findings amongst users (67%) and non-users (61%). The majority (80%) of VIMS+TImR users (including 100% of VIMS+TImR-only users) and 33% of those no longer using the tool were easily able to identify children in the VIMS+TImR that were registered at a different facility, all or most of the time. Urban users were more likely to be able to identify children in the VIMS+TImR registered at a different health facility (p=0.05) than rural users.

Approximately half of HFs (48%), district (53%), and regional (50%) offices had experienced **a vaccine stock-out** in the last three months. At HF level, 83% (24) of these stock outs occurred in HFs not using the VIMS+TImR, while only five (17%) occurred in those HFs with VIMS+TImR . Overall, users of the fully electronic system at all levels were substantially less likely to have experienced stock-outs than users of the VIMS+TImR plus paper and non-users as shown below in *Figure 9*.

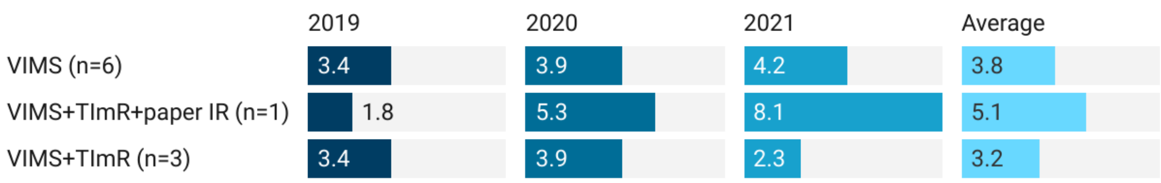
Figure 9: Experience of stock-outs by different user types



Reasons for stock-outs, according to respondents, included delayed delivery from regional/national level; lack of availability of syringes; and COVID-19 impacting the supply of certain EPI vaccines. The most common vaccine found out of stock was MR followed by HPV, Pentavalent and PCV. There were also less frequent and shorter stock-outs of BCG OPV, Rotavirus and TD vaccines. The longest amount of time a vaccine was out of stock at the HF level was reported as one month or more (80% HFs; with no difference between users and non-users).

The primary data collected during the evaluation in the 10 regions was compared to data extracted from the VIMS for the years 2019 – 2021[4]. The total number of stock-out events per region was reviewed.Over the three-year period, regions using the VIMS+TImR experienced the least number of stock outs with an average of 3.2 events, compared to 5.1 events in those regions with (VIMS+TImR+paper IR) and 3.8 events (in those with an VIMS + paper IR). This regional data is presented in *Figure 10* below.

Figure 10: Average number of stock out events per region (2019 - 2021)



STRATEGIC OUTCOME 4: MORE EFFICIENT, AFFORDABLE, AND SUSTAINABLE EIR USE

Refer to economic analysis

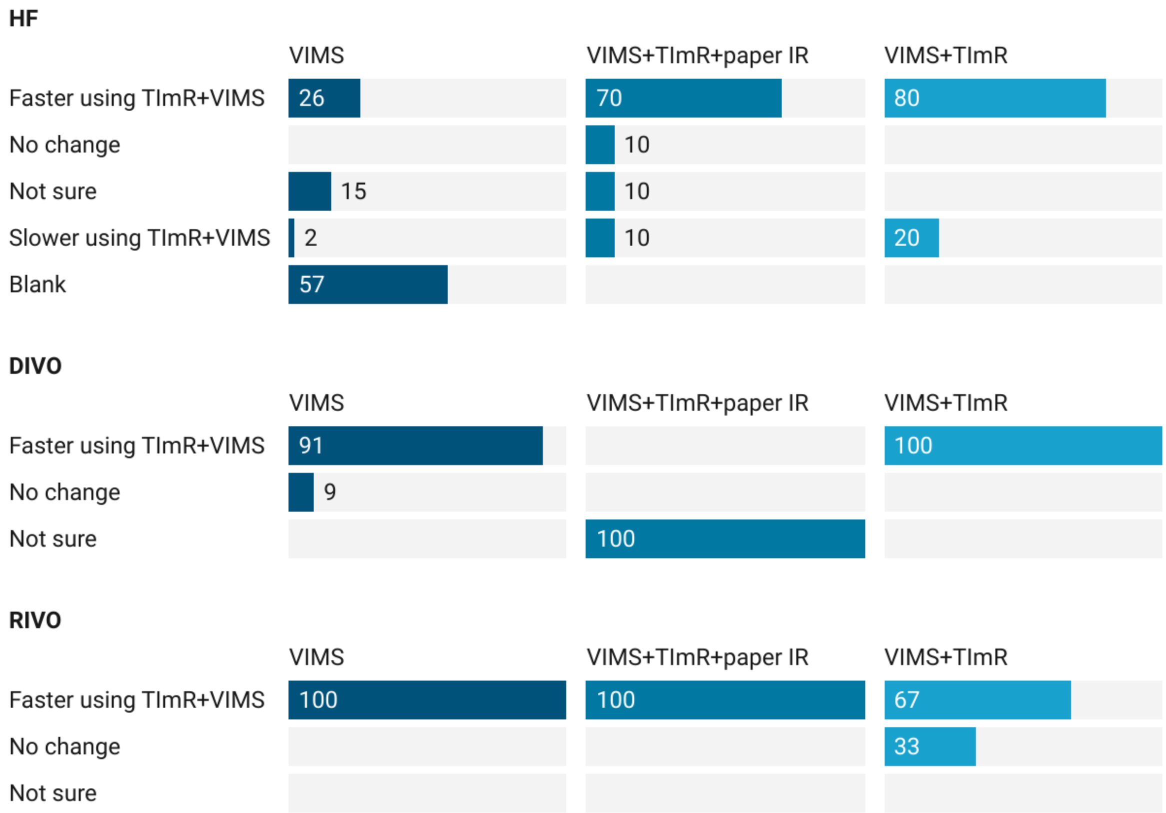
[4] Data were available for four antigens: PCV-13, HPV, MR and DTP-HepB-Hib

STRATEGIC OUTCOME 5: INCREASED STAKEHOLDER SATISFACTION AND ENGAGEMENT

INPUT/PROCESS

The majority of all respondents thought that the receiving and putting-away of vaccine supplies was 'faster using VIMS+TImR' (including 60% of HFs no-longer using the VIMS+TImR) *(Figure 11).* At HFs, it is noted that: *"It is easy and fast, but the speed depends on the Internet connection"*; DIVOs acknowledged that it saved time, was simple, and user-friendly: "*Everything is simple in [VIMS] and all the required report are generated automatically"*.

Figure 11: Impact of VIMS on the receiving and putting-away of vaccine supplies (%)



Users were more likely than non-users to be satisfied with the tool (*p=<.001)* and considered the tool to be dependable (*p= < 0.001).* Respondents thought that the tool had a positive impact on the quality of their work whilst improving immunization services. Further they trusted that the data in TImR would not be lost and were overall satisfied with the tool as shown below in *Figure 12*. Similarly, three-quarters (74%) of users felt that an electronic tool did/or would (for those not using the tool) **make their job easier**, with users being clearly more convinced of this those no longer using the tool: *"Because it is easy to use and simple it takes only a short time for a lots of tasks".* Access to the internet was however frequently mentioned as inhibiting benefits e.g., "w*hen Internet is working I do my work faster and [more] efficiently"; "When the Internet connection is good using tablet is quicker than paper".* Rural users were slightly more satisfied than urban users with the tool (n.s.) *(Figure 13).*

Figure 12: User satisfaction between different HF users (%)

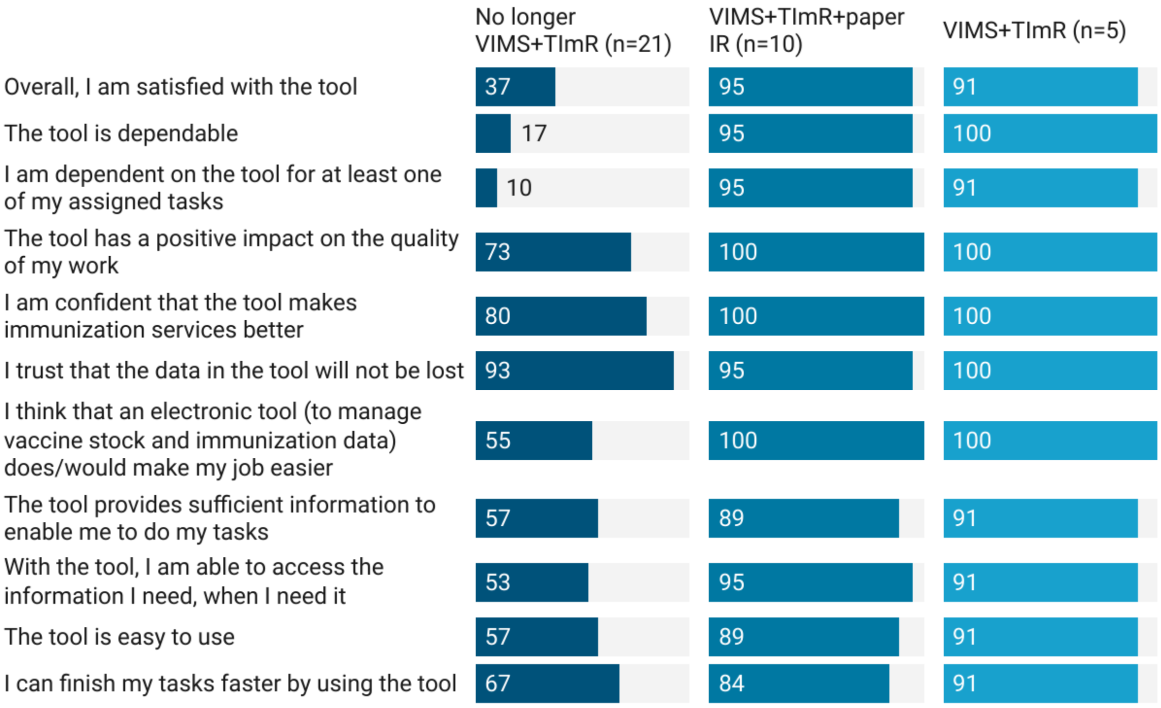
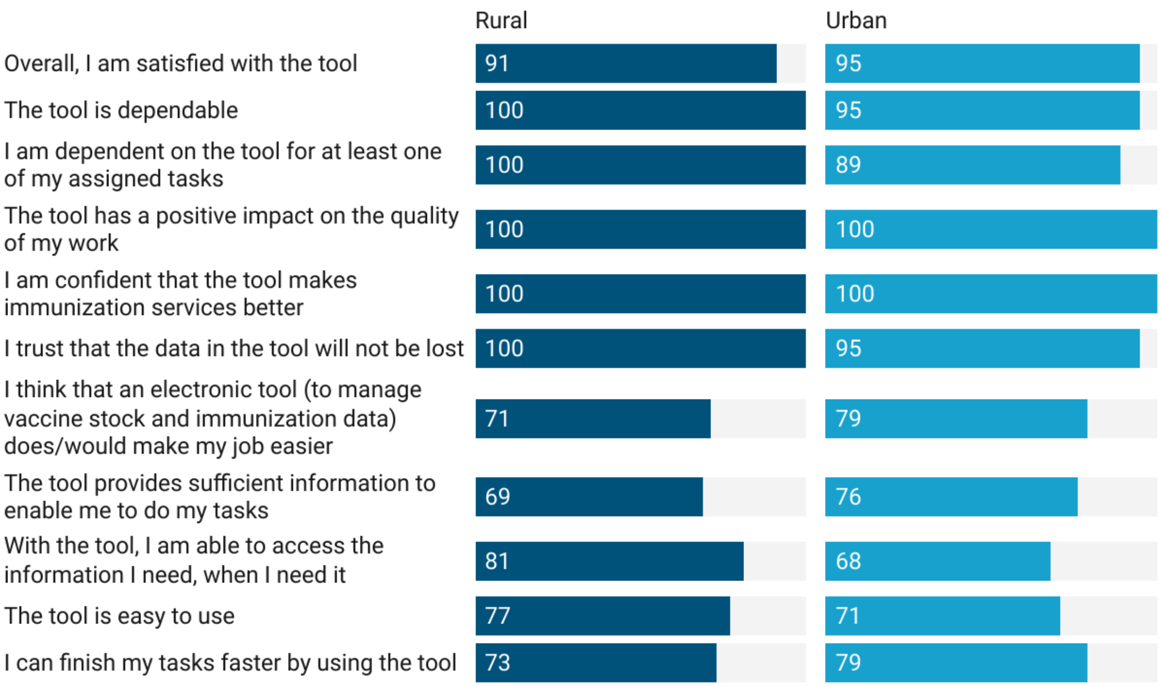


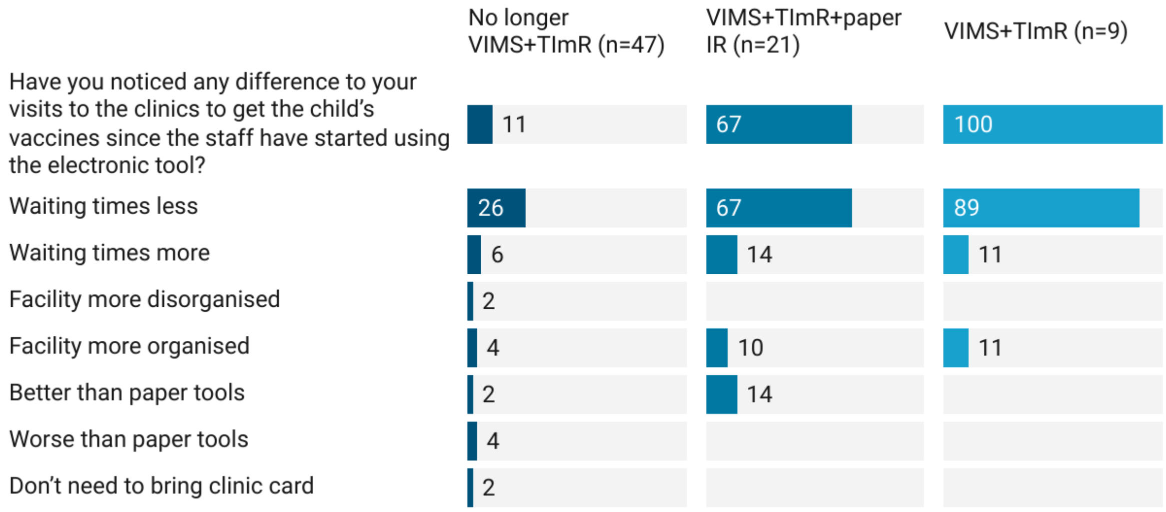
Figure 13: User satisfaction between location of users (%)



VIMS+TImR-only users were more likely than VIMS+TImR+paper IR and non-users to state that caregiver satisfaction had improved since the introduction of the VIMS+TImR *(p=0.01)* while caregivers themselves stated that they had experienced shorter waiting times in HFs with VIMS+TImR-only (89%) and VIMS+TImR + parallel paper IR (67%) than in those without the tool *(Figure 14).* Qualitative insights did however report some increased waiting times for parents e.g., *"… system is good but sometimes it takes us longer time to complete our work and that makes parents unhappy with the service, as they wait so long…".*

However, caregivers did not feel that tool had contributed to the HF being more organized. VIMS+TImR-only users were more likely than VIMS+TImR+paper IR users and non-users to regularly use the tool to generate new records of immunization for children that had lost their child health card (100% of VIMS+TImR-only users; 68% of VIMS+TImR+paper IR), 7% of those no longer using the tool (*$p<0.001$*).

Figure 14: Caregiver satisfaction with the tool (%)



6.1 BROADER IMPACT OF THE VIMS+TIMR ON IMMUNIZATION SERVICE DELIVERY

The focus of the economic analysis was primarily on the costs of immunization and vaccine stock data management, as the impact of implementing the electronic system on immunization costs are to be expected mainly in this area. Nonetheless, we assumed that using the VIMS+TImR may also have a broader impact on other costs of the immunization program. For this reason, with the objective of estimating the net cost of using the VIMS+TImR compared to the paper-based registry, the incremental analysis considered two further activities. These activities refer to the cost of delivering outreach sessions and the cost of emergency vaccine replacement. In the former, it was theorized that better data on defaulters through the use of the VIMS+TImR at facility level might contribute to the more efficient delivery of outreach activities, by potentially leading to a reduction in their frequency or an increase in their size. Along the same line of thought, 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. While at HF level, the VIMS+TImR may not be directly used to perform these activities, the information and benefits of the use of the VIMS+TImR can inform these activities and indirectly lead to reduced costs for the immunization program, and thus they were included in a broader analysis for the cost impact of the system.

6.2 FINANCIAL EXPENDITURES

Total upfront expenditure in 2021 USD for the implementation of TImR and VIMS, per system and funding entity.

Phase	System	Implementor / Funder	Expenditure (USD)
Design & Development			**3,021,550**
	TImR	PATH / BMGF	1,538,324
	VIMS	JSI and CHAI/ Multiple	1,483,226
Roll-out (initial)			**3,183,649**
	TImR	PATH / BMGF	2,707,949
	VIMS	JSI / USAID	475,700
Roll-out (scale up)			**5,298,388**
	TImR	Government / GAVI	5,095,555
	VIMS	Government / BMGF	202,833
Continuous Improvement			**1,290,297**
	VIMS	GAVI	501,710
		Government	30,000
		JSI	125,000
	VIMS+TImR	GAVI	349,192
		JSI	14,000
		PATH	16,000
	TImR	Government	204,394
		PATH	50,000
Grand Total			**12,793,883**

6.3 COST INPUTS

Profile	Comment	Lower Limit (TZS)	Upper Limit (TZS)	Mean (TZS)
Assistant clinical officer		432,000	980,000	706,000
Assistant DIVO / CIVO/ RIVO				1,610,000
Assistant medical officer		980,000	2,240,000	1,610,000
Clinical officer	CHMT members	680,000	1,820,000	1,250,000
Community Health Worker	Community health worker have the same scale as nurses attendant	320,000	655,000	487,500
Cost of paper	One packet that contains 500 sheets it costs 20,000 TZS			40
DIVO / RIVO / CIVO / TIVO / MIVO				2,280,000
Driver		430,000	1,175,000	802,500
Enrolled nurse	Enrolled nurses with Certificates	432,000	1,480,000	956,000
Environmental health officer				487,500
Exchange rate 2021	1 USD = 2,297.76 TZS			2297.76
Facility in-charge	Facility in charge is the person in charge of the hospital or health center and in the Hospitals and Health Centres they are Medical Doctor but at dispensary level we have Medical Doctor and Clinical officer as facility in charge	1,080,000	2,450,000	1,765,000
Medical Doctor	This salary can also be used for DIVO/RIVO/MIVO/TIVO/CIVO	1,480,000	3,080,000	2,280,000
Nurse	Average of all nurse profiles	603,000	1,548,750	1,075,875
Nurse attendant	Medical attendant	320,000	655,000	487,500
Other	Average of all profiles	700,364	1,643,182	1,171,773
Public health nurse	To be considered as nurse profiles above: They use the system as other nurses it depend on their level of education(certificates, Diploma, Degree) as mentioned above.	603,000	1,548,750	1,075,875
Registered nurse		830,000	2,030,000	1,430,000
Registered nurses with Degree		980,000	2,240,000	1,610,000
Registered nurses with Diploma		680,000	1,820,000	1,250,000
Surveillance coordinator				706,000
Tablet	1 tablet = 1,200,000 TZS (annuitized over 5 years)			104.45
Technician	District level	700,000	900,000	800,000
Vaccinator		320,000	655,000	487,500

6.4 ROUTINE OPERATING COSTS OF VIMS+TIMR

Mean cost of immunization and vaccine stock data management activities for VIMS+TImR users (n=15) in USD (95% CI) based on the annual direct costs at HF, district and regional levels.

		Activities												
		Child registration	Organizing outreach sessions	Defaulter identification	Defaulter contacting	Cold Chain Monitoring	Vaccine Ordering	Vaccine Quality Monitoring	Refresher Trainings	Supervision	Identifying performance gaps	Report generation	Report transportation	Total
Inputs	Personnel	242.7 (154.7, 330.7)	288.6 (104.7, 472.4)	122.7 (13, 232.5)	68.8 (19.1, 118.5)	167.3 (103.8, 230.8)	20.5 (10.2, 30.9)	53.5 (33.5, 73.6)	2.1 (1, 3.2)	9.7 (7.3, 12.1)	54.9 (20.9, 88.9)	50.1 (16.6, 83.5)	3.9 (1, 6.8)	**1,084.7 (833.9, 1335.5)**
	Consumables + services	0.8 (-0.2, 1.7)	34.4 (1.4, 67.4)	15.7 (-1, 32.4)	17 (-3, 36.9)	26.4 (0.4, 52.4)	3.8 (-1, 8.5)	7.1 (0.5, 13.6)	14.9 (-0.3, 30.2)	91.8 (5.3, 178.3)	8.3 (0.2, 16.5)	5.2 (0.2, 10.2)	23.7 (-4.5, 51.9)	**249 (143.7, 354.4)**
	Durable goods	2.9 (0, 4.8)	60.4 (0, 111.8)	28.8 (0, 53.4)	25.2 (0, 43.6)	47.9 (0, 69.2)	6.2 (0, 10)	13.4 (0, 19.2)	0 (0, 0)	2.9 (0, 4.4)	13.6 (0, 22.1)	9.4 (0, 14.3)	6.3 (0, 11.9)	**217 (42.1, 392)**
	Total costs	**246.3 (158.3, 334.4)**	**383.4 (189.7, 577.1)**	**167.2 (53.5, 280.9)**	**111 (54.4, 167.6)**	**241.7 (169.8, 313.5)**	**30.5 (18.5, 42.5)**	**74 (52.1, 95.8)**	**17.1 (1.8, 32.3)**	**104.3 (17.8, 190.9)**	**76.8 (40.8, 112.7)**	**64.7 (30.5, 98.9)**	**33.9 (5, 62.9)**	**1,550.8 (1,227.4, 1,874.2)**

6.5 ROUTINE OPERATING COSTS OF VIMS+PAPER IR

Mean cost of immunization and vaccine stock data management activities for health facilities using VIMS+paper IR (n=46) in USD (95% CI) based on the annual direct costs at HF, district and regional levels.

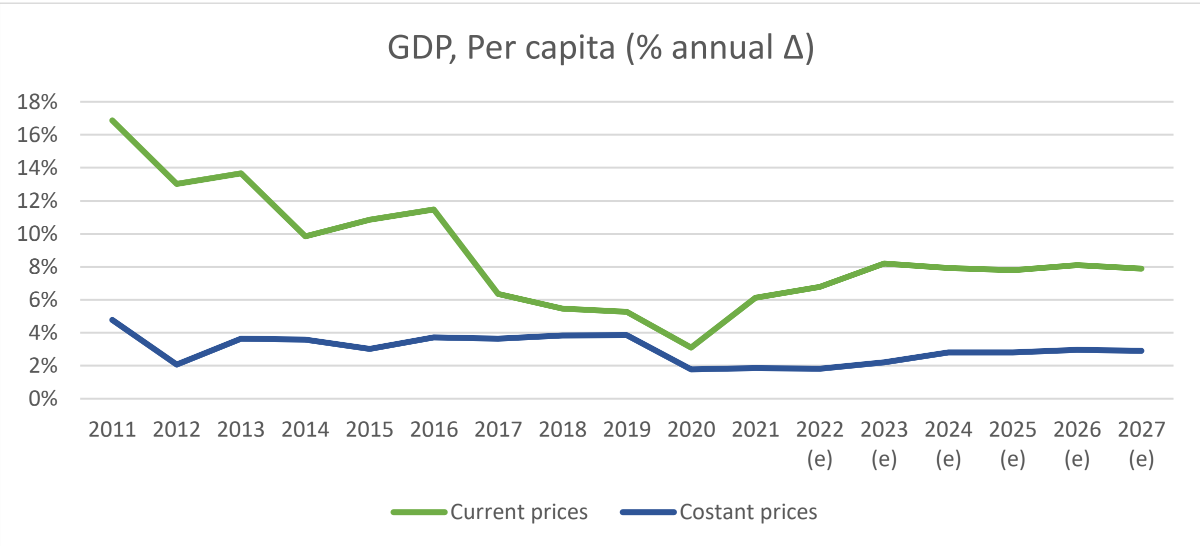
		Activities												
		Child registration	Organizing outreach sessions	Defaulter identification	Defaulter contacting	Cold Chain Monitoring	Vaccine Ordering	Vaccine Quality Monitoring	Refresher Trainings	Supervision	Identifying performance gaps	Report generation	Report transportation	Total
Inputs	Personnel	353.3 (275.4, 431.2)	373.7 (200.8, 546.6)	129.9 (75.4, 184.5)	156.4 (99.8, 213)	106.4 (84.8, 128)	56.6 (42.1, 71.1)	141 (83.8, 198.2)	0.8 (0.5, 1.1)	7.1 (2.4, 11.9)	163.7 (100, 227.4)	162.9 (119.9, 205.8)	18.4 (2.3, 34.6)	**1,670.3 (440.1, 2,900.4)**
	Consumables + services	5.3 (-0.8, 11.5)	32.8 (7.2, 58.4)	15.3 (-0.5, 31.1)	19.7 (2.1, 37.4)	7.9 (2.2, 13.6)	9 (-0.3, 18.4)	12.9 (0.6, 25.1)	34.2 (2, 66.3)	19.7 (-8.4, 47.8)	9.8 (1.1, 18.5)	18.6 (-1.9, 39)	101.7 (68, 135.4)	**286.7 (216.2, 357.3)**
	Durable goods	8 (0, 17.8)	72.3 (0, 140.6)	39.3 (0, 85.6)	28.3 (0, 42)	19.5 (0, 30.6)	10.5 (0, 16.8)	36.8 (0, 73.5)	0 (0, 0)	0.6 (0, 1.2)	25.1 (0, 43.9)	25.4 (0, 39.5)	14 (0, 25.4)	**279.8 (74.6, 485)**
	Total costs	**366.7 (287.9, 445.4)**	**478.8 (291.2, 666.4)**	**184.5 (111.3, 257.8)**	**204.4 (143.6, 265.3)**	**133.8 (108.8, 158.8)**	**76.1 (57.6, 94.5)**	**190.7 (121.6, 259.7)**	**34.9 (2.8, 67.1)**	**27.4 (-1.1, 55.9)**	**198.5 (131.6, 265.5)**	**206.9 (157.3, 256.5)**	**134.1 (95, 173.2)**	**2,236.8 (987.6, 3,485.9)**

6.6 COST IMPACT: URBAN VS. RURAL ANALYSIS

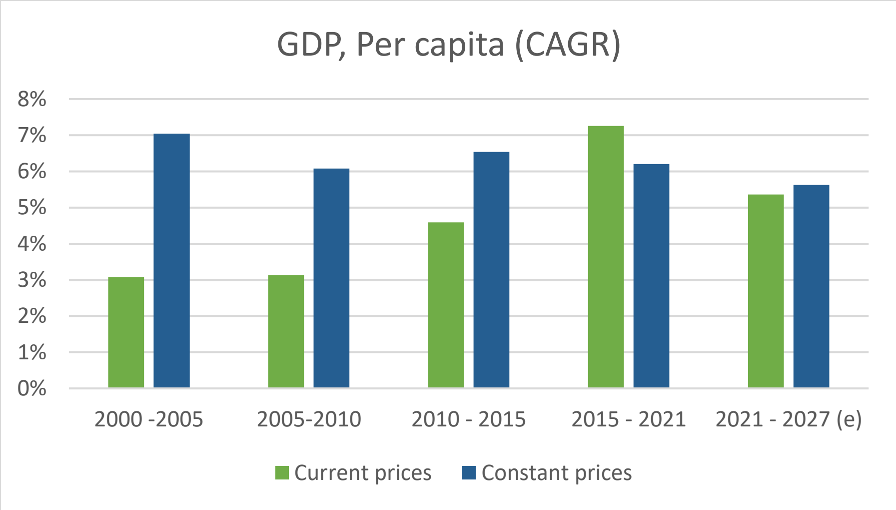
Mean cost difference for data management activities and the broader impact of the tools on immunization between urban (n=28) and rural (n=33) facilities in USD (95% CI).

Activity	Urban	Rural	Mean cost difference in USD (95% CI)
Immunization data management activities (TImR)			
Child registration	356.6 (259.8, 453.5)	320.4 (234.3, 406.6)	36.2 (-93.4, 165.8)
Organizing outreach sessions	258 (144.3, 371.7)	622.8 (371.2, 874.3)	-364.8 (-640.8, -88.7)
Defaulter identification	131.8 (67.3, 196.3)	221.4 (121.8, 321.1)	-89.6 (-208.3, 29)
Defaulter contacting	151.7 (98.9, 204.6)	206.7 (129.1, 284.3)	-55 (-148.9, 38.9)
Vaccine stock data management activities (VIMS)			
Cold chain monitoring	150.7 (114.7, 186.7)	168.5 (129.7, 207.3)	-17.8 (-70.7, 35.2)
Vaccine ordering	55.9 (37.3, 74.5)	72.4 (50.3, 94.6)	-16.5 (-45.4, 12.4)
Vaccine quality monitoring	98.7 (65.7, 131.6)	215.7 (122.7, 308.6)	-117 (-215.6, -18.4)
Activities related to the use of both TImR and VIMS for data management			
Refresher trainings	21.5 (-3.1, 46.2)	38.2 (-2.3, 78.7)	-16.6 (-64, 30.8)
Supervision	35.3 (13.7, 56.9)	55.7 (1.5, 110)	-20.4 (-78.8, 38)
Identifying performance gaps	150.9 (60.7, 241.1)	183.6 (122.9, 244.4)	-32.7 (-141.5, 76)
Report generation	192.8 (121.6, 263.9)	154.2 (110.3, 198.1)	38.6 (-45.1, 122.2)
Report transportation	50.9 (16.6, 85.2)	159.1 (111.9, 206.3)	-108.2 (-166.5, -49.8)
Total	**1,654.9 (1,437.1, 1872.7)**	**2,418.7 (2,087.5, 2750)**	**-763.9 (-1,160.3, -367.4)**
Broader impact on the immunization program			
Delivering outreach sessions	1,922.1 (980, 2,864.1)	1,639 (1,125.5, 2,152.4)	283.1 (-789.8, 1,356)
Emergency vaccine replenishments	21.7 (10.9, 32.5)	104.9 (2.1, 207.8)	-83.2 (-186.7, 20.2)
Total	**3,598.7 (2,631.7, 4,565.6)**	**4,162.6 (3,543, 4,782.3)**	**-564 (-1,712.4, 584.5)**

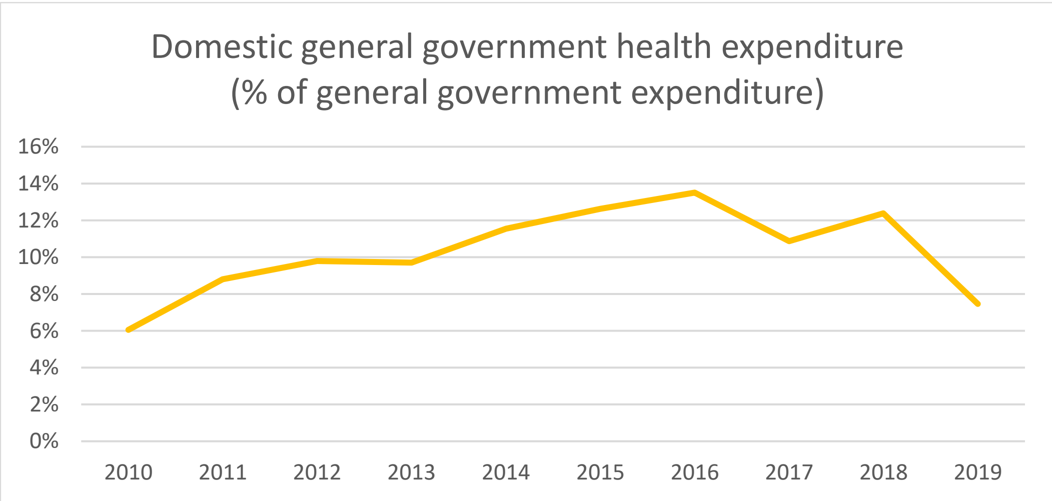
6.7 MACROECONOMIC INDICATORS

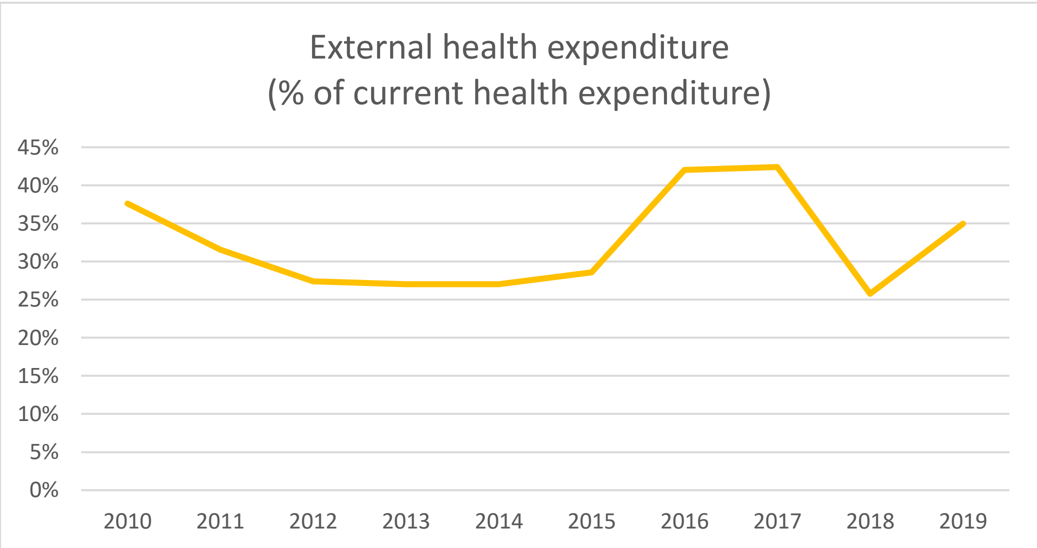


* (e) stands for expected



* (e) stands for expected





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