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Process Evaluation of the Digital Innovation in Pandemic Control (DIPC) Initiative

Report #3: Digital Tool Roll-out

Evidence-Based Public Health| Centre for International Health Protection

Robert Koch Institute, October 2025

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OpenAI. (2025). *Image generated using ChatGPT image generator 40*. Retrieved from OpenAI.

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The content of this report expresses the opinions of its authors and does not necessarily represent the views of the Robert Koch Institute. AI was used to optimise wording and grammar.

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List of Acronyms

ANC	Antenatal Care
BMZ	Bundesministerin für Wirtschaftliche Zusammenarbeit und Entwicklung
CHIM	Centre for Health Information Management
DAK	Digital Adaptation Kit
DH	Digital Health
DIPC	Digital Innovation in Pandemic Control
DEA	Digital Ecosystem Assessment
DPPI	Department for Policy, Planning and Information
GHS	Ghana Health Service
DPPA	Digital Pandemic Preparedness Assessment Tool
EPI	Expanded Program on Immunisation
eSMT	Electronic Stock Management Tool
FHIR	Fast Healthcare Interoperability Resource
GIZ	Gesellschaft für Internationale Zusammenarbeit
HIC	High Income Country
HIS	Health Information System
HL7	Health Level Seven International
HCW	Healthcare Worker
ICT	Information and Communication Technology
IT	Information Technology
KI	Key Informant
KII	Key Informant Interview
LMICs	Low-and Middle-Income Countries
MAHIS	Malawi Healthcare Information System
M&E	Monitor & Evaluation
MoH	Ministry of Health
NDHRM	National Digital Health Roadmap
PAHO	Panamerican Health Organization
PATH	Program for Appropriate Technology in Health
PPME	Policy, Planning, Monitoring & Evaluation
SDGs	Sustainable Development Goals
SMART	Standards-based, machine-readable, adaptive, requirements-based, and testable
SURD	Systems and Users Requirements Document
UHC	Universal Health Coverage
WHO	World Health Organization

Executive Summary

Background and Purpose

Vaccine-preventable diseases claim approximately 1.5 million lives annually in Low- and Middle-Income Countries (LMICs), with 20.5 million children globally remaining unvaccinated or under-vaccinated in 2022. The COVID-19 pandemic disrupted routine immunisation services across 170 countries, highlighting the fragility of immunisation systems and the urgent need for innovative approaches to strengthen vaccine delivery mechanisms.

Digital health technologies offer substantial potential to enhance immunisation coverage through improved tracking, strengthened supply-chain management, and enhanced data accuracy. However, implementation at national scale faces substantial challenges: limited infrastructure, inadequate training, low digital literacy, and insufficient stakeholder engagement. Multiple factors impede adoption including unreliable electricity and connectivity, device shortages, workforce capacity gaps, and the persistent "know-do gap" between research-based knowledge and real-world application.

The Digital Innovation in Pandemic Control (DIPC) initiative, launched by the German Federal Ministry for Economic Cooperation and Development (BMZ) through GIZ, aimed to strengthen digital vaccine delivery systems in five partner countries. In Ghana, Malawi, and Sierra Leone, DIPC supported rollout of digital immunisation tools tailored to each country's context: Ghana's enhanced DHIS2 eTracker (electronic immunisation registry), Malawi's MAHIS Electronic Immunisation Registry integrated within the national health information system, and Sierra Leone's electronic Stock Management Tool (eSMT) extended to peripheral health units.

This report presents findings from RKI's independent process evaluation examining relevance to country contexts, implementation processes, and sustainability potential to generate actionable evidence for funders, implementers, national governments, and global health stakeholders. The component of the evaluation which is detailed in this report is concerned with the roll-out of the DIPC-supported digital tools for immunisation delivery in three of the five DIPC partner countries, namely Ghana, Malawi and Sierra Leone.

Methodology

The evaluation employed a qualitative process evaluation design grounded in the Consolidated Framework for Implementation Research (CFIR) and OECD Development Assistance Committee (DAC) criteria. Data collection comprised document reviews and for this component (“Digital Tool Roll-out”) of the evaluation, the analysis of 69 of a total of 72 semi-structured key informant interviews. These stakeholders included the funders, implementation partners (Digital Square, UNICEF), government officials, district and regional public health officials, and facility-level healthcare providers from Ghana (n=24), Malawi (n=22), Sierra Leone (n=23), and global stakeholders (n=3) who were questioned about the tool roll-out in the partner countries. The sample was weighted towards health workers at facility (30%) and district/regional levels (36%) to capture frontline implementation experiences.

Interviews lasted on average 45-90 minutes and were conducted face-to-face or via secure videoconferencing. All interviews were audio-recorded, transcribed verbatim, and analysed thematically using predominantly deductive coding. Country-specific analyses were followed by cross-country synthesis to identify common barriers and facilitators. The evaluation received ethical clearance from review boards in all participating countries.

Key Findings

Relevance

Digital immunisation tools demonstrated strong foundational relevance with high policy alignment, responsiveness to operational needs, and appropriate stakeholder engagement. DIPC's deliberate integration strategy of building within existing platforms (DHIS2/eTracker, MAHIS/EIR) or expanding tools already in use (eSMT), avoided the fragmentation, which has been repeatedly documented in the literature reporting on digital health tool implementation in sub-Saharan Africa.

Ghana's enhanced eTracker nested within DHIS2 operationalised national strategies whilst avoiding verticalisation. Sierra Leone's eSMT rollout reflected institutional learning from VaxTrac suspension in 2019, with explicit attention to sustainability through hardware provision, phased digital literacy training, and DHIS2 integration planning. Malawi's "MAHIS-first" policy requiring partners to integrate within the national platform addressed donor dependency and fragmentation.

Health workers consistently reported that the DIPC-supported tools addressed critical pain points: excessive time searching through paper registers, transcription errors, lost records, slow reporting, and limited capacity to track defaulters and vaccine stock. Defaulter tracing functionality emerged as particularly valued, transforming manual register cross-referencing into automated identification. WHO Digital Adaptation Kit (DAK)-based standards in Ghana and Malawi aligned public health requirements with frontline workflows whilst establishing technical foundations for future interoperability.

However, relevance-in-design did not automatically translate to relevance-in-use. Infrastructure deficits including device shortages, unreliable connectivity, and inadequate power emerged as the primary barrier to sustained adoption, more limiting than training inadequacy or tool design. Multi-country evidence from the existing literature shows 81-93% of African health workers possess digital literacy, but inadequate infrastructure remains the binding constraint. Sierra Leone's concurrent provision of hardware, power solutions, and connectivity facilitated adoption amongst users, whilst availability of devices was assumed in Malawi and Ghana. This resulted in reported equipment shortfalls at the pilot sites, with frequent reports of non-functioning devices and insufficient device-user ratios, which in turn dampened operational relevance despite strong design alignment.

In addition, persistent dual paper-digital workflows reportedly undermined operational value, as these parallel systems created workload burdens for frontline staff. The literature has documented that e.g., 60% of Rwandan immunisation nurses worked overtime under dual documentation and immunisation data accuracy was shown to be 60% in exclusively paper or digital systems but only 45% in dual systems. Dual systems often persist because digital tools have not achieved sufficient reliability to justify paper retirement, which creates a vicious cycle where under-resourced systems cannot demonstrate value, preventing resource commitments needed for reliability improvements.

Implementation Processes

Implementation demonstrated competent, adaptive rollout. Phased deployment reflected prudent risk management: Ghana's focused pilot during data migration, Sierra Leone's sequenced digital literacy training, and Malawi's static clinic prioritisation enabled continuous learning. Ghana's maintenance of legacy eTracker across 14 regions whilst developing the enhanced version safeguarded data continuity.

Integration, standards, and feedback loops were critical enablers. Building within existing platforms delivered concrete benefits: health workers avoided parallel system burdens, programme managers accessed near-real-time dashboards through familiar interfaces, and data quality improved through embedded validation. WHO Digital Adaptation Kit-based standards provided structured mechanisms for translating immunisation requirements whilst enabling future interoperability. Iterative feedback mechanisms, including on-screen validation, peer networks (WhatsApp), joint supervision, and actionable dashboards, reportedly helped to change data entry from an administrative burden into operationally valued processes.

Infrastructure deficits were the binding constraint. Facilities rarely possessed sufficient devices, reliable power, or stable connectivity. Persistent shortfalls resulted in partial uptake, inconsistent use, and disrupted recording. Infrastructure constraints forced teams to revert to paper systems, creating delays and requiring retrospective data entry. According to the literature, multi-country evidence confirms that whilst 77% of health workers demonstrate digital literacy, inadequate infrastructure remains the key barrier, which we also observed here.

Training was viewed as competent and appropriate but too brief to accommodate heterogeneous skill levels, high staff turnover, and low baseline digital literacy. Without funded refresher sessions, ongoing mentoring, and helpdesk support, user confidence eroded, often resulting in tools being operated by only one or two staff per facility. Recognising sustainability challenges, Digital Square developed instructional video training courses for Malawi's MAHIS EIR and Ghana's enhanced eTracker, which is an innovative response enabling self-paced learning without costly in-person refreshers.

Additional challenges included fragmented procurement limiting device availability; parallel platforms creating duplication; mandatory dual reporting adding workload pressures; inadequate fuel constraining supervision; and security and charging risks reducing system uptime.

Sustainability

The DIPC-supported tools demonstrate credible sustainability prospects attributable to integration into national platforms, established government stewardship, and demonstrated operational value. However, sustainability transitions remain incomplete, reflecting a fundamental tension: DIPC's 3-year cycle, whilst sufficient for pilot deployment and governance establishment, falls short of the 5-7 year timelines documented as necessary for achieving full sustainability.

The integration of the digital tools in partner countries' existing digital platforms provided strong institutional foundations. Ghana's enhanced eTracker is embedded within DHIS2 under GHS/PPME/CHIM/HISP Ghana ownership with established supervisory routines. Malawi's DIPC-supported and newly developed EIR functions as integrated module within the national platform MAHIS with clear stewardship (EPI as product owner, Digital Health Division as technical lead), national hosting, reverse-billing agreements, and routine feedback loops. UNICEF's approach in Sierra Leone involved the extension of the existing electronic Stock Management Tool eSMT to peripheral health units, building on established workflows and systems.

Findings highlight that country-specific pathways will require differentiated strategies going forward. Ghana requires completion of legacy system migration, resolution of parallel system challenges, and recurrent budget security for devices, data bundles, and power. Malawi faces risks in recurrent operating costs and limited in-house developer capacity, despite encouraging local vendor partnerships demonstrating capacity strengthening. Sierra Leone's emerging routines require

domestic financing transition for connectivity, power, and devices; strengthened user capacity distribution; and DHIS2 interoperability completion.

Continued multi-year financing transitions are essential. Vietnam required seven years for nationwide registry scale; Tanzania and Zambia needed extended periods. DIPC's achievements within 3 years included tool deployment, capacity building, platform integration, governance establishment and thus represent substantial progress. However, structural requirements for sustained operation, i.e., multi-year recurrent budgets, fully institutionalised support and complete technical capacity transfer, require longer timeframes than typical donor cycles. Unfunded recurrent costs for devices, connectivity, power, supervision, and technical support represent the primary sustainability threat.

Recommendations

On Relevance:

R1: Conduct infrastructure readiness assessments before deployment; deploy innovative provisioning models (Buy-Your-Own-Device programmes, reverse-billing, device-as-a-service leasing, public-private partnerships); establish government budget commitments for device replacement, connectivity, maintenance; prioritise peripheral facilities with equity-explicit provisioning.

R2: Design phased paper retirement strategies with explicit triggers (>95% uptime, >80% user confidence, >90% data concordance, >70% adoption); retire paper by function demonstrating clear digital superiority; monitor transition impacts; communicate timelines transparently.

R3: Institutionalise continuous user feedback mechanisms through multi-tiered channels (facility help desks, quarterly district forums, semi-annual national technical working groups); implement systematic feedback capture; create transparent improvement roadmaps; allocate dedicated resources for maintenance and enhancement.

On Implementation Processes:

R4: Adopt phased implementation with explicit technical readiness gates defining prerequisites per phase (minimum device ratios, connectivity reliability, user competency, system uptime thresholds); document phase learnings; implement adaptive timelines; prioritise data continuity.

R5: Establish multi-level data feedback loops through embedded technical feedback (on-screen validation, role-specific dashboards, automated alerts) and institutionalised social feedback structures (peer networks, joint supervisory protocols); build progressive data use capacity; ensure sustainability through recurrent budget allocation.

R6: Build local technical capacity through strategic vendor partnerships with knowledge transfer obligations; develop in-country technical support ecosystems (district digital health champions, regional hubs); invest in formal technical capacity; create sustainable financing for government technical positions; document and transfer knowledge systematically.

On Sustainability:

R7: Design multi-year financing transition plans aligned to realistic 5-7 year sustainability timelines through sequential phases; establish government financing commitments from outset with MoUs specifying phased budget assumption; build capacity for budget advocacy; design transparent exit strategies; acknowledge temporal mismatch explicitly.

R8: Establish dedicated government budget lines for recurrent infrastructure (device replacement, connectivity, power, supervision, technical support); conduct comprehensive costing during pilot phase; negotiate matched-funding cost-sharing during transition; link budget commitments to implementation milestones; explore innovative financing.

R9: Complete technical interoperability specifications (finalise eSMT-DHIS2 protocols in Sierra Leone, implement automated data flows); develop digital system retirement strategies with explicit triggers; consolidate support functions within integrated platforms; establish interoperability governance frameworks; build government capacity for integration management.

Conclusion

DIPC's digital immunisation tool implementation demonstrates that well-designed, government-led digital health initiatives can achieve substantial progress within 3-year cycles whilst creating credible foundations for sustained use. The initiative accomplished significant milestones: tools deployed across multiple districts, capacity built amongst hundreds of health workers, governance structures established with clear government stewardship, integration within national platforms avoiding fragmentation, and operational value demonstrated through improved defaulter tracking, stock visibility, and reporting efficiency.

The evaluation of this programme component reveals a consistent pattern: strong design quality combined with promising but incomplete implementation, creating credible but conditional sustainability prospects. Tools demonstrate strong policy alignment, respond to genuine operational needs, and were developed through appropriate multi-stakeholder engagement with national ownership at the centre. This distinguishes DIPC from the many standalone digital health tools documented across sub-Saharan Africa.

However, transitioning these foundations into durable national assets requires addressing three interrelated domains. Infrastructure gaps emerged as the primary barrier, more limiting than training or design. Persistent dual paper-digital workflows prevent efficiency gains. Sustainability requires multi-year financing transitions: whilst DIPC's 3-year cycle achieved pilot implementation and governance establishment, this falls substantially short of the 5-7 year timelines documented as necessary for full sustainability in other LMICs.

This part of the evaluation contributes important empirical evidence that digital health system transformation requires integrated approaches addressing tool design alongside infrastructure investment, phased paper retirement, continuous user feedback, local technical capacity building, and multi-year financing transitions. The DIPC experience demonstrates this integration is both feasible and essential. Feasible because documented successes prove well-designed interventions function effectively even in challenging contexts; Essential because isolated tool deployment without complementary system investments yields incomplete and potentially inequitable outcomes.

DIPC has established credible foundations. Whether these mature into sustained national digital health capacity depends on decisions and investments governments, funders, and partners make in coming years. The nine evidence-based recommendations provide actionable guidance for consolidating achievements into durable national assets. Success will ultimately be measured not by what exists when project support concludes, but by what remains functioning and valued five and ten years later.

1 Introduction

1.1 Background

Global Immunisation Landscape

Vaccine-preventable diseases remain a significant cause of mortality among children under five years of age, claiming approximately 1.5 million lives annually, predominantly in Low- and Middle-Income Countries (LMICs) (Dimitrova et al., 2023). The World Health Organisation's (WHO) Expanded Programme on Immunisation (EPI), established in 1974, marked the commencement of a coordinated international effort to utilise immunisation as a critical public health intervention (Keja et al., 1988). Over the past five decades, the EPI has been instrumental in reducing child mortality and morbidity from diseases such as measles, polio, and diphtheria, preventing an estimated 2.5 million deaths annually (Oyo-Ita et al., 2011) and modelling studies project that vaccinations against ten critical pathogens could prevent approximately 69 million deaths between 2000 and 2030 (Li et al., 2021).

Despite these achievements and ongoing global efforts to expand immunisation coverage, significant challenges persist. In 2022, approximately 20.5 million children globally remained either unvaccinated or under-vaccinated (WHO, 2020). Alarmingly, the number of children receiving no immunisation doses increased from 12.9 million to 18.2 million between 2019 and 2021, with 97% of this increase occurring in LMICs (Rachlin et al., 2022; WHO/UNICEF, 2020). These statistics underscore persistent and widening inequities in healthcare access within and between countries. For instance, vaccination coverage in Ethiopia has been documented to vary dramatically from 20.6% to 91.7% across different regions, reflecting substantial disparities in socio-economic status and healthcare accessibility (Asmare et al., 2022).

The COVID-19 pandemic further exacerbated these disparities, disrupting vaccine supply chains and intensifying the divide between high-income countries and LMICs (Basu et al., 2023; Shet et al., 2022). The pandemic's impact on routine immunisation services resulted in widespread disruptions across 170 countries and territories, setting back decades of progress in global vaccination coverage (Shet et al., 2022). This crisis highlighted the fragility of immunisation systems in resource-constrained settings and underscored the urgent need for innovative approaches to strengthen vaccine delivery mechanisms.

Digital Health Solutions for Immunisation

In response to persistent coverage gaps and emerging challenges, WHO and global partners have increasingly advocated for the integration of information and communication technologies (ICT) into immunisation programmes (WHO, 2020). During the COVID-19 pandemic, high-income countries successfully implemented various digital health solutions to monitor immunisations, create vaccination records, issue digital certificates, and report adverse effects (Mc Kenna et al., 2023). These experiences demonstrated the potential of digital technologies to enhance the efficiency, accuracy, and reach of vaccination programmes.

In LMICs, digital health technologies are expected to play a key role in reaching underserved populations, particularly through 'last mile' efforts, thereby supporting progress towards the Sustainable Development Goals and Universal Health Coverage (WHO/UNICEF, 2020). The Global Alliance for Vaccines and Immunisation (GAVI) has similarly championed the use of ICT in its Digital Health Information Strategy 2022-2025, capitalising on the widespread adoption of mobile phones in

LMICs (GAVI, 2021). Currently, 70% of the world's seven billion mobile phone users reside in LMICs (WHO, 2022), and mobile broadband connections in Sub-Saharan Africa were projected to increase from 38% to 87% by 2025 (Radcliffe, 2018), creating unprecedented opportunities for mobile health (mHealth) interventions.

The digitalisation of healthcare processes, particularly in vaccination delivery, encompasses various tools including electronic health records (EHRs), mobile health applications, and data management systems. These technologies offer numerous potential benefits: increasing immunisation coverage, addressing logistical challenges, enabling effective tracking of patients' immunisation status, improving data accuracy for public health planning, and reducing administrative burden for healthcare and public health personnel (WHO, 2019). Whilst the benefits of digital technologies in clinical medicine are well established (Nafees et al., 2023; Tanhapour et al., 2023), their application in public health programmes within LMICs, particularly for disease prevention, remains less comprehensively understood. WHO has thus called for additional research and guidance to reduce vaccine-preventable diseases and improve access to new vaccines by 2030 (WHO, 2020).

The Digital Innovation in Pandemic Control Initiative

Against this backdrop, the German Federal Ministry for Economic Cooperation and Development (BMZ), through the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), launched the Digital Innovation in Pandemic Control (DIPC) initiative. Originally positioned under a COVID-19 emergency funding stream, and nested within GIZ's Digital Cluster, this five-country programme aimed to strengthen digital vaccine delivery systems in Ghana, Sierra Leone, Malawi, Tanzania, and Peru. The initiative focused on four key implementation components: (1) Digital Ecosystem Assessments to understand existing digital health infrastructure and capacity; (2) piloting of WHO's Standards-based, Machine-readable, Adaptive, Requirements-based, and Testable (SMART) Guidelines Approach for immunisation; (3) Capacity Strengthening activities at multiple levels of the health system; and (4) integration of Gender, Equity, and Inclusion considerations into programme design and implementation.

Implementation Challenges and the Know-Do Gap

Despite the promise of digital health technologies, their implementation at national scale in LMICs entails substantial challenges. Multiple factors can impede the adoption and effective integration of digital solutions, including limited infrastructure, low levels of digital literacy, inadequate training of healthcare workers, and insufficient engagement with key stakeholders at all levels of the health system (World Bank, 2023a), to only name a few.

In implementation science, the 'know-do' gap highlights the disparity between research-based knowledge and its real-world application (Skolarus & Williams, 2024). This gap is particularly significant in digital health, which emphasises the need for identifying barriers and facilitators for effective translation of evidence into practice. Whilst numerous normative resources for digital health programming exist (Dörner et al., 2025), sharing evidence between stakeholders remains essential to inform and optimise current and future programmes. Process evaluations conducted alongside ongoing programmes can generate real-time evidence to inform programme adjustments and improvements, ensuring that digital health interventions remain relevant to country contexts, effective, and sustainable.

1.2 Rationale

Given the significant challenges and disparities highlighted in the current state of vaccination programmes in LMICs, there was a pressing need for rigorous implementation research and comprehensive process evaluations of digital health initiatives. The Robert Koch Institute (RKI) was contracted by GIZ to conduct an independent external process evaluation of the DIPC initiative in three countries: Ghana, Malawi, and Sierra Leone. Process evaluations examine the internal processes and implementation aspects of an initiative whilst placing the project into the wider context of ongoing national efforts. They focus e.g. on whether activities are being carried out as planned, the quality of work performed, and how internal management and resources impact programme execution.

The conduct of this process evaluation in accompaniment to the ongoing DIPC programme was important to generate evidence not only to inform the DIPC initiative itself, but also to contribute evidence on digital health programme implementation in Ghana, Malawi, Sierra Leone, and other LMICs more broadly. The implementation research approach adopted here, can provide important insights into the factors that facilitate or hinder the adoption and integration of digital solutions and supporting activities, allowing for refinement and optimisation of strategies to ultimately enhance vaccination coverage. Furthermore, disseminating evaluation findings is important for identifying effective practices and informing future rounds of digital health funding. Ultimately, this research aimed to bridge the 'know-do' gap, translating knowledge into actionable strategies that can be implemented in real-world settings, thereby advancing the global agenda for Universal Health Coverage and the Sustainable Development Goals.

DIPC-supported Digital Tool Roll-out in the partner countries Ghana, Malawi and Sierra Leone

As part of the DIPC Initiative Phase II in Ghana and Malawi, Digital Ecosystem Assessments (DEAs) were conducted as the first step to establish gaps in the countries' digital landscape for immunisation delivery, to then subsequently inform DIPC's programming efforts through the implementation partner Digital Square and the relevant country governments in the two partner countries.

In Ghana, Digital Square and the Ghana Health Service (GHS) partnered during this assessment process and the enhancement of the DHIS2 eTracker, also referred to as the "DHIS2 Child Health Module" was identified as a required solution to support Ghana' end-to-end immunisation workflow under the umbrella of DIPC, formulated as the following objective in the Health Data Ecosystem Mapping report: *"Enhance DHIS2 e-Tracker so it can serve as Ghana's immunisation information system for COVID-19 and routine immunisation, according to a defined and validated set of requirements prioritised by the GHS, and within the time and budget available."* (Digital Square, 2023a). Under the DIPC umbrella, this objective was operationalised through a collaborative effort between Ghana Health Service (GHS), the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), and Digital Square. The tool roll-out of the enhanced eTracker under DIPC was to be conducted in selected health facilities in Ghana's Ahafo and Volta regions.

In Malawi, Digital Square worked in close collaboration with the Ministry of Health (MoH) to identify critical gaps in the digital tools for immunisation and digital infrastructure landscape. The primary challenge identified during this process was *"The need for an electronic immunisation registry to be incorporated within the planned MaHIS. The existing paper-based immunisation registers need to be digitalised to provide improved visibility of immunisation service delivery, and this should be incorporated into the existing MOH-approved MaHIS that is being rolled out nationally."* (Digital Square, 2023b). In agreement with national stakeholders, the development of the electronic

immunisation register (EIR) within the MAHIS became one of three objectives of DIPC in Malawi. The objective was formulated as: *"Enhance the MaHIS through the addition of an electronic immunization register, ac cording to a defined and validated set of requirements as prioritized by the MOH, within the time and budget constraints. The aim is to implement this new functionality at all static immunization sites in Mchinji District and three immunization static sites in Ntcheu District."* (Digital Square, 2023b).

In Sierra Leone, a Digital Ecosystem Assessment (DEA) was conducted during Phase I of DIPC (Unicef & Ministry of Health, 2023). In Phase II, DIPC then supported the development of a National Digital Health Roadmap (NDHRM) as a natural progression from the DEA, and thereby assisted in providing a costed blueprint for Sierra Leone's strategic digital health planning between 2024 and 2026 (Republic of Sierra Leone, Ministry of Health, 2024). In addition, and in partnership with the Ministry of Health's Directorate of Policy, Planning and Information (DPPI) and the Expanded Programme on Immunisation (EPI), DIPC's implementation partner in Sierra Leone UNICEF sought to strengthen digital immunisation delivery by piloting the roll-out of the existing electronic Stock Management Tool (eSMT) for vaccine logistics management to Peripheral Health Units (PHUs). Previously, the eSMT had only been used at district health management team (DHMT) level and at national level (e.g. EPI). With DIPC support, use at PHU level was piloted in 44 health facilities across four districts (Kailahun, Bonthe, Koinadugu and Karene), accompanied by (a) provision of hardware (laptops for DHMTs and focal points, and solar panels at selected sites), and (b) digital literacy training and training on the use of the eSMT and two additional tools (Bottleneck Analysis and Scorecard), which themselves were not funded under DIPC.

1.3 Evaluation Objectives

The evaluation was designed around three primary objectives, each addressing critical dimensions of the DIPC initiative's implementation and potential for sustained impact:

1. **Relevance:** To examine the extent to which DIPC programme activities align with partner countries policies and priorities, meet target groups needs and were planned and implemented with relevant stakeholder engagement.

1. **Project Implementation:** To establish how the DIPC initiative evolved over time in each country relative to initial project plans, identifying aspects of implementation that worked well and those that did not, and identifying barriers and facilitators to implementation.

2. **Project Sustainability:** To examine the extent to which the DIPC initiative had the potential to yield sustainable results in participating countries, including an analysis of the DIPC component's integration into the national systems and the partner countries' capacity for independent continuation after the project ends.

1.4 Purpose of the Report

This report presents findings from the independent process evaluation of the roll-out of DIPC-supported digital tools for immunisation delivery in three of the five partner countries: Ghana, Malawi and Sierra Leone.

This evaluation report outlines the findings on the extent to which these tools and their implementation in pilot settings aligned with country priorities (relevance), the factors that facilitated or constrained their roll-out (implementation processes), and the potential for sustaining and scaling their contribution to digital immunisation delivery systems (sustainability). Drawing on qualitative data from key informant interviews and document review, the report synthesises empirical evidence on

tool implementation across diverse country contexts. The findings and recommendations are intended to inform future digital health planning for immunisation and other components of health systems undergoing digitisation, and to contribute to the evidence base on effective approaches for strengthening digital health systems in low- and middle-income countries (LMICs).

2 Methodology

2.1 Study Design

The evaluation employed a qualitative process evaluation design grounded in the Consolidated Framework for Implementation Research (CFIR) (Damschroder et al., 2009) to assess barriers and facilitators to the successful implementation of the Digital Innovation in Pandemic Control (DIPC) initiative across three countries: Ghana, Malawi, and Sierra Leone.

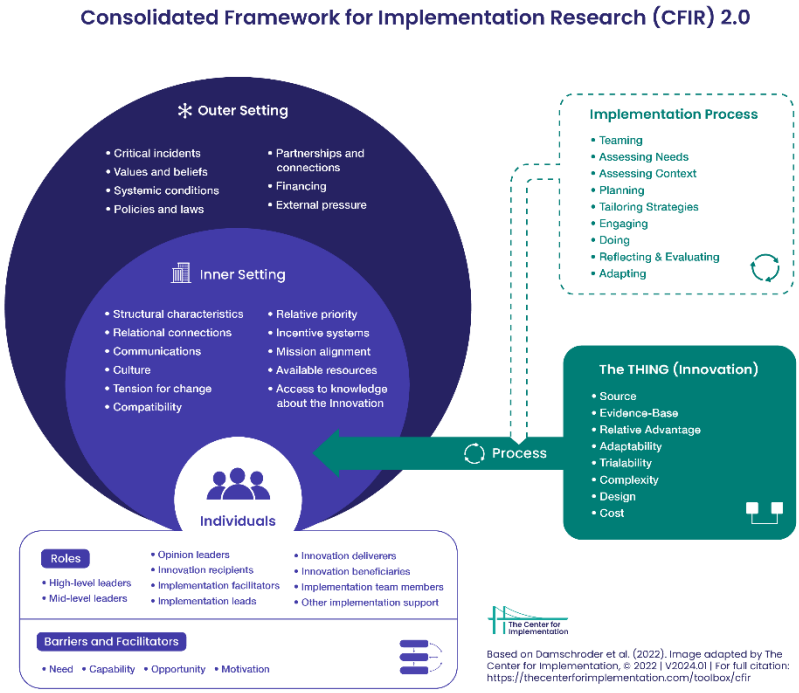

Figure 1. Consolidated Framework for Implementation Research (CFIR) 2.0 (based on Damschroder et al. (2022, adopted from The Centre for Implementation, 2022).

The evaluation framework integrated OECD Development Assistance Committee (DAC) criteria, including relevance and sustainability (OECD, 2021), to guide the formulation of evaluation questions. The focus of enquiry was structured according to the DIPC logic model, and four key implementation components were identified for detailed assessment:

1. Digital Ecosystem Assessments and the Development of a National Digital Health Road Map
2. Piloting of WHO's SMART Guidelines,
3. The implementation of DIPC-supported digital tools for immunisation,
4. Capacity Strengthening activities for digital literacy, and
5. The DIPC Initiative's Gender, Equity, and Inclusion efforts.

The evaluation utilised two primary data collection methods: comprehensive document reviews and semi-structured key informant interviews (KIIs). This mixed-method approach enabled triangulation of data sources to enhance the validity and depth of findings (Patton, 2015). Data collection was contextualised through direct observations during site visits to implementation locations.

2.2 Study Setting

We focused on three of the five DIPC partner countries, namely Ghana, Malawi and Sierra Leone. KIIs took place in the countries' capitals Accra, Freetown and Lilongwe.

2.3 Study Population and Sampling

Participants were purposively sampled to capture diverse perspectives on DIPC implementation from stakeholders at international, national, regional/provincial, district, and health facility levels. Overall, there were 4 stakeholder groups: 1) funders and implementing partners, 2) government officials, health service administrators, 3) Regional and district level public health officials and 4) healthcare providers, IT personnel at the health facility level.

Inclusion criteria required participants to: (1) occupy professional roles relevant to digital health systems, DIPC implementation, or national immunisation programmes; (2) serve as trainers, technical support staff, users, or beneficiaries of DIPC digital solutions; and (3) have been employed continuously for at least six months in their current role or facility. Persons under 18 years of age were excluded.

Sample size determination was based on the principle of data saturation, whereby interviews are to be continued until no new insights emerged and information becomes repetitive (Guest et al., 2006; Hennink & Kaiser, 2022). Based on systematic reviews demonstrating that saturation in semi-structured interviews typically occurs within 9-17 interviews in homogenous samples, and accounting for the heterogeneity of stakeholder groups in this evaluation, we anticipated conducting approximately 25 KIIs per country. The final sample sizes were 24 KIIs for Ghana, 23 KIIs for Sierra Leone and 22 KIIs for Malawi.

Participants were identified through document reviews, stakeholder lists provided by GIZ and implementing partners, health system network knowledge of the national researchers contracted to conduct the data collection and snowball sampling whereby interviewed participants referred additional relevant informants.

Health facilities included in this evaluation were selected à priori in consultation with the implementation partners and district/regional health offices and based on their involvement in DIPC activities and presence of trained staff. However, given that the process of SMART guidelines adoption in the partner countries involved mostly national level stakeholders and funders and implementers, the perspectives of regional, district and health facility staff were not obtained for this evaluation component.

2.4 Data Collection Methods

Document Review

The document review examined scientific literature, grey literature (including programme documents, and government policy papers), and project-specific materials (work plans, progress reports and stakeholder maps). This review provided contextual background on digital health landscapes, national immunisation programmes, and DIPC implementation processes in each country. Documents were obtained from publicly available sources or directly from implementing organisations and GIZ teams.

Interview Topic Guide

The overarching key informant topic guide consisted of five modules aligned with the main evaluation foci: 1. "Digital Ecosystem Assessments and National Digital Health Roadmap Development", 2.

"Piloting of WHO's SMART Guidelines", 3. "Digital Tool Development, Roll-out and Training", 4. "Digital Literacy Training and eLearning Resources", and 5. "The Women in Digital Health Event in Ghana". Each module followed a common structure and question sequence, beginning with questions on the key informant's professional background and role in relation to the DIPC initiative, followed by topic-specific questions, and sub-questions and prompts addressing the evaluation criteria of "Relevance", "Implementation Processes" and "Potential for Sustainability", adapted to the respective module. Questions were partly taken and adapted from the CFIR topic guide repositories (CFIR, 2024) to capture key CFIR domains and constructs relevant to the evaluation criteria and overarching evaluation questions.

The topic guides were further refined into four tailored versions with adapted wording for different stakeholder groups: 1. programme implementers and funders, 2. national government officials, 3. regional and district public health officials, and 4. facility-level staff. During each interview, only the modules and questions relevant to the respondent's role were used. For example, and as previously stated, the module on "Piloting WHO SMART Guidelines" was administered exclusively to implementers, funders and national-level stakeholders.

Key Informant Interviews

The semi-structured key informant interviews (KIIs) were conducted face-to-face at locations convenient to participants (offices, health facilities, or university campuses) or remotely via the RKI-approved secure videoconferencing platform (Cisco Webex) when in-person meetings were not feasible. Most interviews lasted approximately 45-90 minutes and were conducted by trained members of the evaluation team. All in-country interviews were conducted by the national researchers from Ghana, Malawi and Sierra Leone. Global level interviews were conducted by the RKI team in Germany.

Prior to each interview, participants provided written informed consent (for in-person interviews). Participants were informed of their right to withdraw at any time and to choose how they wished to be cited in reports. Demographic information collected in form of a demographic questionnaire included e.g., gender, organisational affiliation, professional role, years of experience, and geographic location.

All interviews were audio-recorded with participants' consent and supplemented with field notes. Recordings were transcribed verbatim and anonymised as possible. Transcripts and consent forms were stored separately to maintain confidentiality.

2.5 Data Analysis

Qualitative data analysis followed a thematic approach guided by the CFIR framework and OECD DAC evaluation criteria (Braun & Clarke, 2006). Transcripts were coded using predominantly deductive codes derived from the evaluation framework and a minimal level of inductive codes which emerged from the data. The analysis process involved: (1) familiarisation with data through repeated reading of transcripts, (2) generation of codebook closely aligned to the evaluation questions (3) coding of transcripts (4) data extractions and review of coded segments by evaluation topic (5) synthesis of text segments and development of themes according to evaluation questions (6) interpretation of themes in relation to evaluation objectives.

Data from document reviews were synthesised to provide context for interview findings and to triangulate information across sources. Country-specific analyses were conducted first, followed by

cross-country synthesis to identify common implementation barriers and facilitators, as well as context-specific factors influencing DIPC implementation.

Quality assurance measures included regular debriefing sessions among team members, joint codebook development with national researchers and the RKI team, peer review of coding and themes, and member checking where feasible. Reflexivity was maintained throughout the analysis process, with researchers explicitly considering how their positions and perspectives might influence interpretations.

2.6 Ethical Considerations

The evaluation received ethical clearance from the external ethics review boards in each participating country: the Ghana Health Service Ethics Review Committee (approval number GHS-ERC-025/08/24), and the Sierra Leone Ethics and Scientific Review Committee (approval number 020/10/2024). the Kamuzu University of Health Sciences - COMREC, Malawi (protocol number P.05/25-1585). Additional permissions were obtained from relevant health authorities including the Ghana Health Service Directorate, Malawi's District Health and Social Service offices, and Sierra Leone's Ministry of Health Directorate of Policy, Planning, and Information.

Informed consent was obtained from all participants prior to data collection, with comprehensive information sheets provided in advance. Participation was voluntary, and participants were informed of their right to withdraw at any time without consequences. Confidentiality was maintained through secure data storage practices, anonymisation of transcripts (as much as possible), and separation of identifying information from study data. Audio recordings and transcripts were stored on password-protected, encrypted servers compliant with European data protection regulations. Only members of the evaluation team had access to identifiable data, and findings are reported in aggregate form or with participant-chosen descriptors to prevent identification.

The evaluation adhered to principles of beneficence and non-maleficence, ensuring that data collection did not interfere with routine health service delivery and that findings would be used to improve DIPC implementation for the benefit of participating health systems.

2.7 Thematic Evaluation Focus of this Report

- The Roll-out of the DIPC-supported digital tools for immunisation in the three partner countries Ghana, Malawi and Sierra Leone

3 Sample Description

In total, we conducted 72 key informant interviews across Ghana (n=24), Malawi (n=22), Sierra Leone (n=23) and a small global cohort of funders/implementers (n=3). The overall sample was intentionally weighted towards health workers at the health facility (30%) and district and regional public health level (36%), complemented by national decision-makers and global actors to capture planning and governance perspectives.

Findings of the present evaluation component on the DIPC-supported digital tool roll-out are based on responses from 66 out of the 72 stakeholders. This includes perspectives from 21 of 24 KIs from Ghana, from 21 of 23 KIs from Sierra Leone, 22 of 22 KIs from Malawi and two of three KIs who were interviewed at the global level.

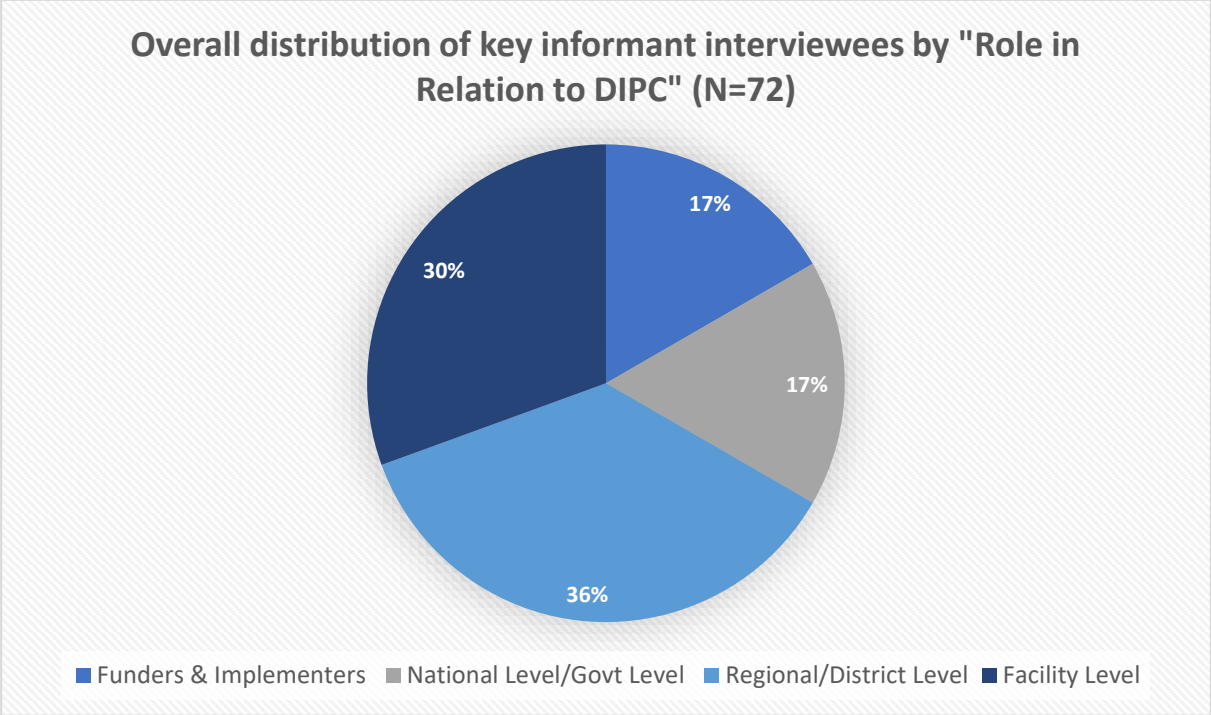

Figure 2. Proportion of Key Informants by "Role in relation to DIPC"

Overall, two-thirds of our sample were male (68%), and most were aged between 25 and 54 years, with the largest group in the 35–44-year bracket (40%). Participants were drawn from across the health system and included e.g., programme managers, public health professionals, healthcare providers, data and technical specialists, and trainers. The majority had substantial professional experience: 57% reported more than 10 years, including 36% with over 15 years in their field. Most participants reported at least moderate experience with ICT or digitalisation in healthcare (65% moderate; 24% expert) and with vaccine logistics or the Expanded Programme on Immunisation (57% moderate; 26% expert). In relation to DIPC, 38% were core team members directly involved in implementation and 32% provided technical or administrative support, with additional respondents engaged in strategic planning or occasional consultation roles. A detailed summary table of participants' background characteristics has been included in the Annex.

4 Findings

Evaluation Question

1. Relevance:
To what extent did the DIPC-supported digital tools roll-out in the partner countries respond to Target Group needs, and Align with policies, and priorities?

2. Implementation Processes:
How did the roll-out of the DIPC-supported digital tools in partner countries evolve relative to the initial project plans?

Which aspects of the implementation worked well/did not work well in partner countries, including enabling and hindering factors to the implementation?

3. Potential for Sustainability:
To what extent does the roll-out of the DIPC-supported digital tools have potential for Sustainability?
To what extent has the roll-out of the DIPC-supported digital tools been designed for continuation of efforts once assistance through the project ceases in the partner countries?

4.1 Relevance

KEY TAKE-AWAYS FOR "RELEVANCE" OF DIPC-SUPPORTED DIGITAL TOOL ROLL-OUT

- ✓ **POLICY-CONSISTENT BY DESIGN:**
  - ALL THREE TOOLS (ETRACKER, ESMT, MAHIS EIR) OPERATIONALISE EXISTING NATIONAL DIGITAL HEALTH AND IMMUNISATION STRATEGIES RATHER THAN INTRODUCING PARALLEL AGENDAS.
- ✓ **DIRECT RESPONSE TO FRONTLINE PAIN POINTS:**
  - TOOLS REPLACE BULKY PAPER REGISTERS WITH POINT-OF-SERVICE CAPTURE AND RAPID RETRIEVAL, ADDRESSING DUPLICATION, TRANSCRIPTION ERRORS, DELAYED REPORTING, AND WEAK CLIENT TRACKING.
- ✓ **SALIENT PROGRAMME FUNCTIONS:**
  - DEFAULTER TRACING, COVERAGE MONITORING AND INTEGRATED STOCK OVERSIGHT TARGET OUTREACH AND BETTER VACCINE ALLOCATION.
- ✓ **EMBEDDED IN NATIONAL STACKS:**
  - IMPLEMENTATION LEVERAGES IN-COUNTRY PLATFORMS (DHIS2/ETRACKER IN GHANA; DHIS2-CENTRED GOVERNANCE IN SIERRA LEONE; MAHIS IN MALAWI), SUPPORTING INSTITUTIONAL FIT AND LOWER SWITCHING COSTS.
- ✓ **CONTEXT-SENSITIVE DESIGN CHOICES:**
  - OFFLINE CAPABILITY, ROLE-BASED ACCESS, REVERSE-BILLING ARRANGEMENTS AND BASIC DIGITAL LITERACY TRAINING ALIGN WITH AFFORDABILITY, CONNECTIVITY AND SKILLS REALITIES.
- ✓ **OWNERSHIP WITH COMPLEMENTARY PARTNER ROLES:**
  - MINISTRIES LEAD SPECIFICATION AND SUPERVISION, WHILE DIGITAL SQUARE/UNICEF PROVIDE TARGETED TECHNICAL SUPPORT, AN ARRANGEMENT VIEWED AS APPROPRIATE TO CONTEXT.
- ✓ **RELEVANCE TEMPERED BY ENABLERS:**
  - PERCEIVED ALIGNMENT WITH PRIORITIES AND RESPONSIVENESS TO TARGET GROUP NEEDS IS REDUCED WHERE LACKING DEVICE AVAILABILITY, POWER/CONNECTIVITY AND RESIDUAL PAPER ROUTINES CONSTRAIN DAY-TO-DAY USE.

Figure 3. Key Take-Away for "Relevance" of DIPC-supported Digital Tool Roll-out

In this section, we present the findings that pertain to the evaluation criteria "Relevance" to the country context. We assessed relevance by examining it from three perspectives: 1) Alignment with national policies and priorities, 2) Response to target group needs, and 3) Stakeholder engagement during planning and implementation.

Evaluation findings indicate that the DIPC-supported digital tools implemented in the three partner countries, namely the enhanced DHIS2 eTracker in Ghana, the eSMT in Sierra Leone, and the MAHIS EIR in Malawi, were perceived as highly relevant to each country's context.

In the pilot sites in which they were rolled-out, the tools replaced fragmented, paper-based systems with platforms that enable more timely, granular and actionable immunisation data. While each context started from a different baseline and faces distinct infrastructure constraints, the tools were generally perceived as aligned with national strategies, responsive to day-to-day needs of health workers and managers, and implemented through appropriate constellations of government and partners. The identified challenges relate less to the core design of the tools and more to coverage, hardware, connectivity and long-term financing.

Alignment with national policies and priorities

Findings show that across the three countries, the DIPC-supported digital immunisation tools are operationalising existing policy directions and reflect stakeholder priorities in terms of gaps in the digital immunisation infrastructure.

> **Ghana**: Stakeholder perspectives framed the enhanced eTracker as the long-planned transactional layer within the DHIS2 ecosystem, that enables the GHS to deliver on priorities around data quality, accountability and universal health coverage (UHC). By moving from aggregate reports to named-child data, the tool reportedly supports national targets to reduce vaccine-preventable diseases and child poverty, while sitting on an established, low-cost platform consistent with the GHS digital-health policy.
>
> **Sierra Leone**: Stakeholders perceived the eSMT as a practical operationalisation of the NDHRM and immunisation strategies centred on UHC and supply-chain optimisation. Respondents indicated that the tool's deployment in PHUs represented a mechanism to advance national objectives for real-time, interoperable data systems while reducing dependence on paper-based tools and manual stock ledgers. Stakeholders further articulated that the eSMT aligned with strategic priorities necessitating low-cost digital solutions, integration with the DHIS2, and government-led capacity building. This alignment was particularly emphasised in relation to fiscal and capacity constraints in Sierra Leone that any new initiative must address, requirements which stakeholders assessed the eSMT as fulfilling.
>
> **Malawi:** The DIPC-supported MAHIS EIR is strongly linked to "Malawi 2063" (NPC, 2020), the Health Sector Strategic Plan – HSSP III 2020 – 2023 and it digitalisation pillar (Malawi Ministry of Health, 2023). KIs consistently emphasised that embedding the EIR within the broader MAHIS platform and insisting that partners "join ours" addresses past fragmentation and donor dependency. Moreover, specific tool design and roll-out choices such as reverse-billing SIMs, and role-based access and offline capability, which was introduced later, directly respond to policy concerns around affordability, data protection and equitable access.

Overall, the three roll-outs were widely perceived as "policy-consistent" investments that help the countries to move from high-level digital-health and immunisation strategies to concrete operational capability at the health facility level.

Response to target group needs

The evaluation results demonstrate that the digital tools implemented under DIPC responded to long-standing operational challenges experienced by frontline healthcare providers and programme managers across all three countries. Health workers consistently reported that eTracker, eSMT, and MAHIS EIR addressed critical pain points associated with paper-based systems, including excessive time spent searching through multiple registers, transcription errors, and limited capacity to track

individual children and stock movements. Across contexts, respondents highlighted three principal areas where target group needs were met:

1. The tools enabled faster service delivery during clinic and outreach sessions through point-of-service data entry and rapid retrieval of client histories.
2. Defaulter tracing and coverage monitoring functions, thereby allowing staff to identify children due or overdue for vaccination at the "click of a button", were particularly valued for facilitating more strategic outreach planning.
3. Integrated stock management components improved awareness of vaccine balances, expiry dates, and wastage patterns, supporting more efficient allocation and reducing both stockouts and over-stocking.

Stakeholders across all three countries assessed the digital tools as substantially better aligned with their operational information needs than previous paper-based approaches. However, common constraints diminished the extent to which target group needs were fully met.

- Persistent shortages of devices and connectivity were reported across contexts, limiting the scale and consistency of tool utilization.
- The continued requirement for parallel paper reporting in some locations, coupled with the additional workload associated with backlog data entry and dual system operation, dampened the perceived efficiency gains of the digital tools.
- In all three countries, sustainability concerns, particularly regarding hardware replacement, continuity of connectivity, and the availability of domestic funding following anticipated reductions in partner support, were emphasised as central challenges affecting long-term responsiveness to target group needs.

The country-specific reflections on the extent to which the DIPC-supported digital tool rollouts responded to target group needs were as follows:

Ghana: The eTracker system was reported to directly address frontline information needs at pilot sites. Health workers highlighted reduced time spent searching through multiple registers and faster service delivery during clinic and outreach sessions. Defaulter tracing and coverage monitoring were particularly valued; staff indicated that the ability to "click a button" to identify children due or overdue for vaccination enabled more strategic outreach planning. The integrated stock management component reportedly improved awareness of vaccine balances, expiry dates, and wastage patterns, supporting more efficient allocation and reducing both stockouts and over-stocking. Respondents further emphasised that Ghana's design features, including offline functionality, mixed-cadre training, and built-in validation rules, were well-suited to lower-capacity settings and contributed to improved data quality.

Nevertheless, persistent shortages of devices and connectivity, alongside the continued requirement for parallel paper reporting in some locations, were noted as constraints that diminished the perceived benefits of the system in Ghana. Despite these limitations, stakeholders expressed that eTracker was better aligned with their daily information and service-delivery needs than previous paper-based systems.

Sierra Leone: The eSMT was regarded as directly responding to critical operational needs at the PHU and district health level. Health workers and public health officers reported reduced time spent on manual register searches and faster service provision during both routine sessions and outreach activities. The tool's capacity to provide live visibility of service gaps,

and the stock tracking functions were cited as improving awareness of vaccine balances, expiry dates, and wastage, thereby supporting more efficient supply-chain management and reducing stockouts and over-stocking.

Capacity-building requirements were especially pronounced in Sierra Leone, where many staff were first-time computer users. Especially the phased training in basic computer literacy and troubleshooting, combined with the provision of laptops, tablets, power solutions, and connectivity infrastructure in selected sites, were repeatedly described as "really needed" to enable effective tool adoption. Respondents indicated that these capacity-building investments responded to fundamental gaps in digital literacy and infrastructure.

However, persistent device and connectivity shortages, the continued need for parallel paper reporting in some facilities, and the workload associated with backlog data entry and dual system maintenance were challenges that dampened potential utility of the introduction of the new tools. Despite these constraints, stakeholders overwhelmingly assessed the eSMT as better aligned with their operational information needs than prior paper-based approaches.

Malawi: The MAHIS EIR was reported to address key operational challenges faced by health workers at pilot sites. Respondents highlighted reduced time spent searching through multiple registers and improved service delivery speed during clinics and outreach sessions. The system's defaulter tracing and coverage monitoring functions were particularly valued; staff indicated that the ability to "click a button" to view children due or overdue for vaccination facilitated more targeted outreach planning.

Notwithstanding these benefits, several issues were raised that highlighted ways in which target group needs were not met. Persistent shortages of devices and connectivity, the ongoing requirement for parallel paper reporting in some locations, and the additional workload associated with backlog entry and dual system operation were cited as factors that diminished the perceived benefits of MAHIS EIR.

Stakeholder engagement during planning and implementation

Key informants across all three countries consistently reported that engagement of national stakeholders and users in the planning and implementation of the tools was notably high. Across countries, national stakeholder were highly engaged throughout, with the implementation partners playing a facilitating role rather than the role of planning and implementation leads. Stakeholders noted that this collaborative governance that helped ensure that tool design and roll-out remained grounded in national systems and frontline realities. Respondents commended the flexibility and responsiveness of partners, for example, expanding the roll-out of the MAHIS EIR to Ntcheu district, or UNICEF and MoH jointly adjusting eSMT training based on needs. As such, the three country experiences show broadly strong and appropriate stakeholder engagement, with national ownership at the centre and partners filling technical and financing gaps.

In **Ghana**, GHS (specifically PPME, CHIM and EPI) was described as leading the process end-to-end: defining requirements, overseeing configuration on DHIS2, guiding training content and supervising implementation. Digital Square/PATH and HISP Ghana formed the core implementation team, while GIZ provides primary funding and facilitation were needed. Regional and district officers reportedly played key roles in cascading training and supervision, and routine monitoring and help-desk arrangements reportedly created feedback loops to improve the tool.

In **Sierra Leone**, the Ministry of Health through DPPI and EPI provided technical and managerial stewardship, anchoring eSMT in existing information systems and immunisation structures. UNICEF acted as the main implementing partner, while GIZ funded the DIPC initiative and offered facilitation and technical support. A wide ecosystem of partners , including WHO, PIH, Jhpiego, CHISU, Global Fund and others, contributed equipment, training and complementary digital-health initiatives. Joint assessments, collaborative facility selection and mentorship visits illustrated an inclusive approach, though long-term reliance on external partners remains a risk.

In **Malawi**, the Ministry's Digital Health Division and EPI were regarded as the system owners. Whilst Digital Square assumed the facilitation role and provided technical and process guidance, the DHD and EPI were involved from early demos through design decisions, supervision and discussions on scale-up, and they deliberately ensured that MAHIS EIR was viewed as a government, not donor, system. PATH/Digital Square, funded primarily by GIZ, provided project management, coordination and technical support, with Luke International/PEPFAR as the local vendor for software development. Additional NGOs, ICT units and district health offices support training, infrastructure and complementary programmes.

4.2 Implementation Processes

KEY TAKE-AWAYS FOR "IMPLEMENTATION PROCESSES" OF DIPC-SUPPORTED DIGITAL TOOLS ROLL-OUT

- ✓ **IMPLEMENTATION APPROACH:**
  - PHASED ROLL-OUT STRATEGIES WITH DUAL SYSTEM OPERATION ENABLED RISK-MANAGED EXPANSION WHILE SAFEGUARDING DATA CONTINUITY
  - FIDELITY TO PLANS WAS STRONGEST WHERE TEAMS EXPANDED INCREMENTALLY WITHIN EXISTING NATIONAL PLATFORMS; DEVIATIONS REFLECTED PRUDENT ADAPTATION TO INFRASTRUCTURE CONSTRAINTS RATHER THAN EXECUTION FAILURE
- ✓ **KEY ENABLING FACTORS:**
  - TOOL ALIGNMENT WITH DAILY IMMUNISATION WORKFLOWS GROUNDED IN STANDARDISED WHO DAK-BASED SPECIFICATIONS DELIVERED IMMEDIATE, TANGIBLE BENEFITS FOR FRONTLINE STAFF IN GHANA & MALAWI
  - INTEGRATION WITHIN EXISTING PLATFORMS (DHIS2/ETRACKER, MAHIS, ESMT INTEGRATION AMBITIONS WITH DHIS2) FACILITATED ADOPTION AND REDUCED PARALLEL SYSTEM BURDEN
  - ITERATIVE FEEDBACK MECHANISMS, INCLUDING VALIDATION RULES, PEER SUPPORT NETWORKS, AND JOINT SUPERVISION, SUSTAINED IMPLEMENTATION MOMENTUM
- ✓ **KEY BARRIERS:**
  - INADEQUATE INFRASTRUCTURE (INSUFFICIENT DEVICES, UNRELIABLE POWER AND CONNECTIVITY, UNSTABLE HOSTING) RESULTED IN PARTIAL UPTAKE AND DUAL PAPER-DIGITAL ENTRY
  - TRAINING WAS COMPETENT BUT TOO BRIEF FOR HETEROGENEOUS SKILL LEVELS AND HIGH TURNOVER; ABSENCE OF ONGOING MENTORING ERODED CONFIDENCE
  - FRAGMENTED PROCUREMENT, PARALLEL EMR SYSTEMS, DONOR FUNDING VOLATILITY, AND OPERATIONAL CONSTRAINTS (FUEL, TRANSPORT) COMPOUNDED IMPLEMENTATION CHALLENGES

Figure 4. Key Take-Aways for "Implementation Processes" of DIPC-Supported Tools Roll-Out

This section describes the implementation processes observed across the three DIPC partner countries, examining the extent to which digital tool roll-out proceeded according to project plans and identifying factors that enabled or constrained effective adoption. Findings are organised around four themes: fidelity to project plans; factors that worked well and facilitated implementation; key enabling conditions that supported effective adoption; and barriers and challenges that hindered progress. The analysis draws on stakeholder perspectives at facility, district, and national levels to assess how implementation teams navigated technical, operational, and contextual constraints while pursuing phased expansion of the enhanced eTracker, eSMT, and MAHIS EIR systems within existing health information platforms.

Project implementation relative to project plans

Implementation across the three countries was characterised by phased roll-out strategies and dual system operation designed to safeguard data continuity while managing operational and technical risks.

Ghana: The roll-out of the enhanced eTracker was initially planned for broader geographical coverage, including additional regions such as Upper East, but was deliberately narrowed to a small-scale pilot in the Volta and Ahafo regions to enable completion of data migration and dashboard development. Progress was constrained by the need to maintain the legacy eTracker system across 14 regions during the transition period, which slowed the pace of scale-up.

Sierra Leone: Implementation followed a sequenced approach, prioritising digital literacy training before introducing the eSMT at district and facility levels across four pilot districts. Facility adoption commenced with 11 Primary Health Units (PHUs) per district and was reported to be expanding. However, day-to-day eSMT use remained uneven, with concurrent paper-and-digital practice common across pilot sites.

Malawi: The MAHIS EIR was deployed in phased waves, with active tool use reportedly strongest in static clinic settings, while outreach services largely continued to rely on paper-based registers. Following acceptance testing and training activities completed in October 2024, the system was formally transferred to the Ministry of Health and District Health Directorate; subsequent utilisation varied according to connectivity, hosting stability, and device availability.

Overall, findings suggest that fidelity to project plans was aided by the fact that the implementation teams moved forward incrementally and within existing national platforms as was the case for Ghana and Malawi or extended the use sites of the already existing eSMT from district to PHU-levels as was the case in Sierra Leone. Observed deviations from original timelines and coverage targets reflected in prudent adaptation to legacy system dependencies and infrastructure constraints rather than weak execution, which in our view is indicative of responsive project management aligned with operational realities. However, more thorough infrastructure assessments in roll-out regions prior to implementation would likely have identified existing constraints early and enabled more realistic planning from the outset.

What worked well during the implementation process?

Findings indicate that successful adoption of digital tools across the three countries was enabled by several interrelated aspects:

1. **Workflow integration:** The tools digitised core immunisation tasks (child registration, appointment scheduling, defaulter tracing, vaccine stock management, and report generation) that directly corresponded to frontline workers' daily routines. This functional alignment delivered immediate tangible benefits, including faster data entry and retrieval, reduced transcription errors, more timely stock ordering, and clearer visibility of coverage gaps.
2. **Data standardization and interoperability architecture:** Standardised data dictionaries and workflows based on the WHO Digital Adaptation Kit (DAK) framework, specified during earlier DIPC-supported development of System and User Requirements Documents (SURD) in Ghana and Malawi, ensured consistent data structure and quality across facilities whilst establishing technical foundations for future system interoperability and cross-platform data exchange.

3. **Continuous learning and quality assurance mechanisms:** Iterative feedback mechanisms, including on-screen validation rules, routine data quality reviews, peer support networks, and joint supervision, enabled frontline staff to engage more actively with data and sustained implementation momentum. National programme teams reportedly utilised generated data for surveillance, performance management, and supply-chain oversight, extending the perceived value of tools beyond facility-level operations.

Country-specific accounts are as follows:

Ghana: The integration of enhanced eTracker modules within the existing DHIS2/eTracker platform meant that users did not need to navigate parallel systems, facilitating adoption. Health workers highlighted specific functionalities, defaulter tracing, growth monitoring, and stock visibility, as particularly well-suited to their tasks. Routine data quality reviews, supplemented by informal problem-solving through WhatsApp groups and joint supervisory visits, reinforced consistent tool use. Programme managers reported that near-real-time dashboards enabled more responsive oversight of outreach activities and vaccine resupply.

Sierra Leone: The eSMT was designed to mirror existing vaccine logistics workflows, reducing the cognitive load associated with system adoption. Training was delivered in a stepwise manner, beginning with basic digital literacy before progressing to tool-specific instruction, and was supported by job aids and peer coaching arrangements. The provision of laptops, alongside targeted investments in solar power solutions and mobile connectivity, enabled more consistent tool use. Dashboard visibility maintained under MoH EPI stewardship facilitated timely oversight and corrective action at district and national levels.

Malawi: The MAHIS EIR digitised paper-based registers that health workers were already familiar with, which shortened client waiting times and reportedly improved retrieval of vaccination histories, appointment scheduling, and report generation. Offline data capture, which was introduced as an iteration of the initial roll-out, with subsequent synchronisation addressed connectivity limitations, while reverse billing functionality reduced administrative burdens. Local super-users, supported by WhatsApp-based peer networks, provided accessible troubleshooting support that smoothed uptake at facility level. The Ministry of Health's "MAHIS-first" policy, which prioritised the national system over parallel tools, strengthened government ownership and institutional commitment to sustained use.

Key enabling and facilitating factors

The evaluation identified several additional factors that enabled effective implementation:

1. **National anchoring and ownership:** Clear MoH custodianship, coordinated partner engagement, and integration within existing platforms (DHIS2/eTracker in Ghana, MAHIS in Malawi, and eSMT under MoH EPI stewardship in Sierra Leone) strengthened government ownership and reduced the need for parallel systems.
2. **Standardised frameworks:** Data dictionaries and health worker workflows aligned tools as specified in the WHO DAK framework-based SURD provided a common foundation for system design, documentation, and future interoperability efforts.
3. **Sequenced capacity strengthening:** Digital literacy training delivered before tool-specific instruction, reinforced through refresher sessions, mentoring, peer pairing, and simple job aids, facilitated adoption. Training of Trainers cascade approaches and prioritising training for staff who

directly handle vaccines and immunisation registers ensured capacity-building investments reached those responsible for day-to-day tool use.

4. **Foundational infrastructure:** Adequate provision of durable devices matched to workflow requirements, reliable power sources including solar solutions, and either stable connectivity or dependable offline-first data capture with robust synchronisation mechanisms constituted a minimum enabling condition for sustained implementation.
5. **Local technical capacity:** In-country software developers/vendors/partners supported responsive troubleshooting and user-acceptance testing, while detailed system specifications facilitated quality assurance.
6. **Data-use feedback loops:** On-screen validation rules, routine data quality reviews, supervisory support through WhatsApp groups, and actionable dashboards enabled frontline staff and managers to engage with data in ways that informed operational decisions.

What did not work well?

Across the three countries, implementation challenges stemmed primarily from inadequate foundational infrastructure and facility readiness rather than from tool design limitations. Health facilities rarely possessed sufficient numbers of durable devices, reliable power supplies, stable connectivity, or dependable hosting infrastructure. These deficits resulted in partial uptake, inconsistent routine use, and disrupted recording and reporting timeliness. Where reverse-billing and network signals were unreliable, teams frequently reverted to paper-based systems, creating delays, requiring retrospective data entry, and producing uneven data completeness.

Training, though not comprehensively examined in this evaluation, was consistently identified as a critical factor. Key informants regarded training as competent but insufficient in duration to ensure heterogeneous skill levels and accommodate high staff turnover rates. Respondents emphasised that without funded refresher sessions, ongoing mentoring, and functioning helpdesk support, user confidence eroded, often resulting in digital tools being operated by only one or two staff members per facility. Having recognised the challenge of conducting ongoing high-cost refresher training, Digital Square developed instructional training videos on the use of the enhanced eTracker and the MAHIS EIR for Ghana and Malawi ad-hoc. These outputs constitute training tools that remain usable beyond the project cycle of the DIPC initiative and thereby address some of the training sustainability concerns.

However, logistical and governance challenges compounded observed constraints. Fragmented procurement processes, the use of parallel platforms including overlapping electronic medical record (EMR) systems, limited district-level permissions to monitor tool use, and donor funding volatility outside of DIPC introduced friction and increased maintenance burdens. Mandatory dual reporting in both paper and digital formats added further workload pressures. Supervision and outreach activities were constrained by inadequate fuel and transport provision, while security and charging risks in remote facilities reduced system uptime.

> **Ghana:** Implementation of the enhanced eTracker in pilot sites was hindered by insufficient device availability, ageing hardware, unreliable connectivity and power supply, and server instability. These constraints reportedly necessitated dual data entry in both paper and digital formats, creating backlogs. One-off training sessions of short duration were viewed as inadequate to address varying digital skill levels and high staff attrition rates. Critical data migration from the operational legacy eTracker system slowed implementation progress, while

concurrent EMR deployment at lower health system levels created duplication and user confusion.

Sierra Leone: The eSMT's online-only design posed significant challenges in contexts characterised by weak or inadequately funded internet infrastructure and intermittent electricity supply, particularly in remote locations. The provision of a single laptop per facility constituted a critical bottleneck for consistent reporting, frequently relegating data entry to retrospective "back-entry" tasks completed by facility in-charges. The most significant barrier was reported to be low baseline digital literacy among facility staff, compounded by high turnover rates and irregular supervision visits resulting from insufficient fuel and operational funding.

Malawi: Connectivity problems and hosting reliability issues, including inconsistent reverse-billing functionality and system downtime, alongside device shortages, ageing hardware stock, and power and charging gaps, were identified as principal challenges. These constraints reportedly drove staff to revert to paper-based recording in some instances, particularly during outreach activities. Large-group training sessions with limited access to practice devices, account and login complications, and insufficient mentoring support led to workflow disruptions. In some facilities, this resulted in only one or two staff members routinely recording data in the MAHIS EIR.

Main cross-cutting barriers and challenges to implementation

1. **Inadequate foundational infrastructure:** Health facilities rarely possessed enough durable devices, and ageing or no-longer-functional hardware was common. Unreliable power supplies, unstable connectivity, undependable server hosting infrastructure, and inconsistent reverse-billing functionality resulted in partial tool uptake, inconsistent routine use, and disrupted recording and reporting timeliness. Security and charging risks in remote facilities further reduced system uptime.
2. **Design constraints and workflow disruption:** Online-only system designs posed significant challenges in contexts with weak internet infrastructure and intermittent electricity. Teams frequently reverted to paper-based recording, particularly during outreach activities, creating delays and requiring retrospective data entry. Mandatory dual reporting in both paper and digital formats added workload pressures and created backlogs.
3. **Insufficient training and support:** Training was regarded as competent but too short in duration to accommodate the heterogeneous digital skill levels, high staff turnover rates, and low baseline digital literacy in some contexts. Large-group training sessions with limited access to practice devices, combined with the absence of funded refresher sessions, ongoing mentoring, and functioning helpdesk support, eroded user confidence. In some facilities, this resulted in digital tools being operated by only one or two staff members.
4. **Logistical and governance challenges:** Fragmented procurement processes limited device availability. The use of parallel platforms and overlapping electronic medical record (EMR) systems created duplication and user confusion. Limited district-level permissions to monitor tool use and donor funding volatility outside of DIPC introduced friction and maintenance burdens. Critical data migration processes slowed implementation progress in some contexts.

5. **Operational constraints:** Supervision and outreach activities were constrained by inadequate fuel and transport provision, resulting in irregular supervision visits. Account and login complications created additional workflow disruptions.

4.3 Sustainability

KEY TAKE-AWAYS FOR "SUSTAINABILITY" OF DIPC-SUPPORTED DIGITAL TOOLS ROLL-OUT

- ✓ **SUSTAINABILITY POTENTIAL:**
  - DIPC-SUPPORTED TOOLS HAVE CREDIBLE SUSTAINABILITY PROSPECTS DUE TO INTEGRATION WITHIN NATIONAL HEALTH INFORMATION PLATFORMS AND DEMONSTRATED OPERATIONAL VALUE FOR IMMUNISATION PROGRAMME MANAGEMENT
  - REALISING THIS POTENTIAL DEPENDS ON ADDRESSING TECHNICAL INTEGRATION, RECURRENT RESOURCE AVAILABILITY, AND IN-COUNTRY CAPACITY STRENGTHENING
- ✓ **INTEGRATION INTO NATIONAL SYSTEMS:**
  - MALAWI EXHIBITS STRONG STRUCTURAL INTEGRATION WITH CLEAR GOVERNMENT OWNERSHIP, NATIONAL HOSTING, AND REVERSE-BILLING ARRANGEMENTS
  - GHANA DEMONSTRATES INSTITUTIONAL INTEGRATION WITHIN DHIS2/ETRACKER PLATFORM WITH FUNCTIONING DATA-USE ROUTINES, THOUGH OPERATIONAL RELIABILITY CONSTRAINED BY INFRASTRUCTURE GAPS
  - SIERRA LEONE SHOWS OPERATIONAL INTEGRATION BUT ARCHITECTURAL INTEROPERABILITY WITH DHIS2 WAS INCOMPLETE AT THE TIME OF EVALUATION
- ✓ **NATIONAL CAPACITY FOR INDEPENDENT CONTINUATION:**
  - ALL THREE COUNTRIES DEMONSTRATE PATHWAYS TOWARD INDEPENDENT CONTINUATION WITH ESTABLISHED GOVERNMENT STEWARDSHIP
  - CROSS-CUTTING REQUIREMENTS INCLUDE: SECURING MULTI-YEAR RECURRENT BUDGETS FOR CONNECTIVITY, POWER, DEVICES, AND SUPERVISION; INSTITUTIONALISING TIERED TRAINING AND TECHNICAL SUPPORT STRUCTURES; AND STRENGTHENING GOVERNMENT CAPACITY FOR PRODUCT MANAGEMENT, QUALITY ASSURANCE, AND IN-HOUSE ANALYTICS

Figure 5. Key Take-Aways for "Sustainability Potential" of DIPC-supported Digital Tool Roll-out

Sustainability Potential of DIPC Component

Evaluation findings suggest that the DIPC-supported digital tool roll-outs have credible sustainability prospects. The tools have been purposefully positioned within their national health information system architectures and findings indicate perceived operational value for immunisation programme management.

However, realising this potential depends on addressing three interrelated dimensions:

1. The depth of technical and governance integration into national systems;

2. The availability of recurrent resources to maintain last-mile infrastructure and user support; and
3. The strengthening of in-country capacity to utilise, manage, adapt, and extend the tools without sustained external assistance.

The following sections assess each dimension in turn.

Integration into the National System

Across countries, DIPC-supported tools are anchored in national platforms rather than operating as standalone systems, though the depth of integration varies.

Ghana demonstrates institutional integration through the enhanced eTracker's embedding within DHIS2 under GHS and PPME directorate stewardship, supported by HISP Ghana. Functioning supervisory routines, dashboard-based data review practices, and WhatsApp problem-solving channels are established, with intent to pursue national scale-up. However, operational reliability remains constrained by device shortages, connectivity limitations, and the transitional burden of maintaining dual paper and digital entry systems during the legacy eTracker phase-out.

Malawi exhibits strong structural integration. The MAHIS EIR is delivered as a module within the national MAHIS platform, with clearly defined government ownership arrangements comprising EPI as product owner and the DHD as technical lead. National hosting infrastructure and reverse-billing agreements that reduce end-user costs are in place, and routine feedback loops connect facility-level data entry to district and national programme oversight.

Sierra Leone operational integration is evident in the fact that the eSMT was already established as a stock management tool in the country and its use was extended to PHUs through the DIPC initiative. As such, it was already a firm component of the immunisation landscape. Full adoption of the eSMT, even at the pilot sites however highly contingent on continued support in terms of digital literacy, gadget provision, secured electricity and internet connectivity. Architectural integration, however, remains incomplete: interoperability pathways between eSMT and DHIS2 are under development but not yet operational, geographic coverage is limited to four pilot districts, and issue-tracking and help-desk functions sit outside the tool itself.

The evaluation documented more advanced integration in contexts where digital modules extended existing national health information architectures and aligned with established governance structures. Stakeholders across all three countries emphasised that full consolidation as routine national services will require completion of pending interoperability specifications, simplified analytics access for decision-makers at district and national levels, and sustained technical support to maintain system stability and user confidence.

National Capacity for Independent Continuation

At the time of the evaluation, all three countries demonstrated pathways toward independent continuation, supported by established government stewardship and operational routines, though each faces distinct capacity constraints.

Ghana exhibits high technical readiness, with national ownership vested in GHS, PPME, CHIM and HISP networks, and established monitoring loops that connect facility-level data entry to

programme decision-making. Sustained use at scale depends on securing predictable financing for device procurement and replacement, data bundles, and power solutions; institutionalising refresher training cycles to address staff turnover; ensuring dependable system uptime through local technical support capacity; and progressive phase-out of parallel paper-based reporting.

Malawi benefits from defined stewardship arrangements, embedded workflows that align with existing facility routines, and national enablers including reverse-billing agreements, government-managed hosting infrastructure, and routine supervisory visits. Risks to independent continuation concentrate in recurrent operating costs for device lifecycles, transport for supervision and outreach, and data connectivity, alongside limited in-house developer capacity to manage system updates, troubleshooting, and feature enhancements without external technical assistance.

Sierra Leone demonstrates emerging governance routines and staff uptake in pilot districts, indicating receptivity to sustained use. Independent continuation will require transition from donor-financed to domestically funded connectivity, power solutions, and device replacement cycles; more equitable distribution of digital skills across facility staff to reduce reliance on one or two users per site; and completion of DHIS2 interoperability specifications to eliminate parallel data entry processes and reporting burdens.

Across contexts, durable independent continuation depends on three cross-cutting capacity requirements:

1. Securing multi-year recurrent budgets for last-mile operational costs including connectivity, power, devices, and supervision;
2. Institutionalising tiered training and technical support structures including refresher cycles, peer networks, and accessible help-desk functions; and strengthening government capacity for product management, quality assurance;
3. In-house analytics, including retention and development of software developers and data analysts capable of adapting tools to evolving programme needs.

5 Discussion

5.1 Synthesis

This component of the external process evaluation of the DIPC Initiative examined the digital immunisation tool implementation across Ghana, Sierra Leone, and Malawi, assessing relevance, implementation processes, and sustainability potential. The evaluation reveals a consistent pattern: strong design quality within a 3-year implementation cycle achieved substantial progress whilst highlighting the structural challenges inherent in transitioning from donor-supported pilots to government-sustained national systems.

Strong foundational relevance with infrastructure as binding constraint. The digital tools demonstrate strong policy alignment with national strategies, respond to genuine operational needs (particularly defaulter tracing and stock visibility), and were developed through appropriate government-led multi-stakeholder engagement. This design quality distinguishes DIPC implementations from many failed digital health initiatives across sub-Saharan Africa, where donor-driven tools are imposed without national ownership. However, relevance-in-design has not

automatically translated to relevance-in-use. Infrastructure deficits, which were device shortages, unreliable connectivity and inadequate power, emerged as the primary barrier to sustained adoption, more limiting than training inadequacy or tool design. Sierra Leone's concurrent provision of hardware, power solutions, and connectivity alongside software deployment enabled adoption amongst first-time computer users, whilst Malawi and Ghana's infrastructure assumptions resulted in dampened operational relevance despite strong design alignment. Critically, persistent dual paper-digital workflows created workload burdens and undermined data quality, preventing realisation of efficiency gains that justify digital investments.

Phased implementation as prudent risk management enabled by integration and standards. Implementation fidelity was supported by incremental expansion within existing national systems: Ghana's focused pilot during data migration, Sierra Leone's sequenced digital literacy training, Malawi's static clinic prioritisation, which reflects prudent risk management. This approach contrasts with Sierra Leone's earlier VaxTrac experience, where rapid scale-up without readiness assessment contributed to system suspension. DIPC's deliberate integration strategy, building within existing platforms (DHIS2/eTracker, MAHIS/EIR) or expanding tools already in use (eSMT), avoided the fragmentation documented across 738 digital health tools in sub-Saharan Africa operating as standalone systems. Standards adoption through WHO DAK-based SURDs in Ghana and Malawi aligned public health requirements with frontline workflows, enabling technical interoperability foundations. Iterative feedback mechanisms including on-screen validation rules, peer networks (WhatsApp), joint supervision, and actionable dashboards transformed data entry from administrative burden into operational intelligence, with multi-country evidence showing 88% of facilities reporting positive feedback loop impacts.

Credible but conditional sustainability prospects requiring multi-year transitions. Integration into national platforms created institutional foundations reducing vulnerability to donor funding cycles. However, sustainability transitions remain incomplete across all countries, reflecting a fundamental tension: DIPC's 3-year cycle, whilst sufficient for pilot implementation and governance establishment, falls substantially short of the 7-year timelines documented for achieving full sustainability in Vietnam, Tanzania, and Zambia. DIPC's achievements, namely tool deployment, capacity building, national platform integration, and governance establishment, represent substantial progress given realistic constraints. Nevertheless, the pathway to independent continuation remains conditional. Ghana requires completion of legacy system migration and recurrent financing for device replacement, data bundles, and power solutions. Malawi faces concentrated risks in recurrent operating costs and limited in-house developer capacity despite encouraging local vendor partnerships (PEPFAR, Luke International). Sierra Leone's emerging institutional routines require domestic financing transition, strengthened user capacity distribution, and DHIS2 interoperability completion. Across countries, unfunded recurrent costs for devices, connectivity, power, supervision, and technical support represent the primary sustainability threat. Achieving durable sustainability requires financing commitments, phased transition plans, and capacity development extending beyond typical donor project cycles.

Nine priority recommendations address structural challenges. Recommendations organised across relevance, implementation processes, and sustainability include: conducting infrastructure readiness assessments and deploying innovative provisioning models (BYOD, reverse-billing, device-as-a-service leasing); designing phased paper retirement strategies eliminating dual workflows; institutionalising continuous user feedback mechanisms; adopting phased implementation with explicit technical readiness gates; establishing multi-level data feedback loops; building local technical capacity through

strategic vendor partnerships; designing multi-year financing transition plans aligned to realistic sustainability timelines; establishing dedicated government budget lines for recurrent digital health infrastructure; and completing technical interoperability specifications eliminating parallel systems. Success depends on sustained political commitment, adequate resource mobilisation, and patient partnership recognising that building durable national digital health systems requires extended periods of capacity building, institutional adaptation, and financing transition, not single project cycles.

5.2 Relevance

Strong Policy Alignment Across Countries

The DIPC evaluation findings demonstrate strong alignment between the digital immunisation tools and national policy frameworks across all three countries. This policy and priority, based on strong stakeholder engagement, coherence represents a critical success factor that distinguishes DIPC's approach from many failed digital health initiatives in the region. The literature on digital health implementation in sub-Saharan Africa consistently identifies policy misalignment, where donor-driven tools are imposed without regard to national strategies, as a primary cause of pilot failures and abandoned investments.

Ghana's Enhanced eTracker: Ghana exemplifies strategic digital health investment that operationalises national policies. The enhancement of the eTracker as a strategic DIPC-programme choice, is nested within the established DHIS2 ecosystem, which creates a transactional layer that extends Ghana's national health information architecture (BMZ Digital, 2024). This integration approach avoided the verticalisation challenges documented across African digital health implementations, where parallel, partner-driven systems fragment national architectures and create unsustainable dependencies (Ibeneme et al., 2022) By building inside DHIS2 rather than alongside it, Ghana protected investments in its national platform while adding required and standards-based immunisation-specific functionalities. Facilitated through Digital Square as DIPC's implementation partner, GHS maintained clear custodianship through its PPME unit, with HISP Ghana providing technical support under government direction rather than external control. This governance arrangement exemplifies the "interdisciplinary leadership team including national government staff" recommended in comparative analyses of successful EIR implementations (Carnahan et al., 2023).

Sierra Leone's eSMT: Implementation in Sierra Leone, facilitated by DIPC-partner UNICEF, demonstrates explicit attention to sustainability constraints from the design phase, perhaps a lesson drawn from the country's own experience with VaxTrac application suspension in 2019. VaxTrac was piloted in 2016-2017, expanded to 50 facilities within one year, but was suspended after three years due to sustainability concerns and inconsistent workflows for managing vaccination records especially in smaller health facilities (Jalloh et al., 2020). The evaluation of VaxTrac recommended that countries "conduct readiness assessments to determine feasibility, minimum system requirements, and sustainability" before introducing a new solution. The DIPC-supported eSMT roll-out to PHUs reflects this institutional learning and can be viewed as an exemplary form of "policy memory" from evaluation experience. The focus on provision of hardware in pilot sites (including laptops and solar panels), the selection of a low-cost digital solutions, DHIS2 integration planning for later interoperability, and a strong programmatic focus on building digital literacy skills through government-led training represents choices are closely aligned with the results of a comprehensive national digital landscape assessment (UNICEF & Ministry of Health Sierra, Leone, 2023) and the corresponding priorities scheduled into the NDHRM, which were the key programme activities implemented through DIPC in the early stages (DIPC Phase I → Landscape Assessment; DIPC Phase II → NDHRM development).

By following this path, DIPC-supported activities were arguably less innovative than in some of the other DIPC countries, but evidently foundational and designed for sustainability, which is an issue frequently reported in the literature. For example, the multi-country evaluation by Mantel et al. (2025) across Guinea, Honduras, Rwanda, and Tanzania found that sustainability concerns, including lack of targeted infrastructure investments and full government ownership were central barriers to success even in more advanced implementations (Mantel et al., 2025).

Malawi's MAHIS EIR: The Digital Square-supported implementation of the EIR in Malawi can be viewed as a strong expression of ambition for national digital sovereignty. The explicit government directive that implementing partners must "join ours" rather than introducing parallel systems addresses the donor dependency and fragmentation that has plagued immunisation data systems across the region. This "MAHIS-first" policy and approach aligns with the 2025 DHIS2 policy brief on locally-owned health data systems, which argues that "sustaining support for key digital commons" is essential for transitioning from donor-funded pilots to government-owned services (DHIS2, 2025). DIPC-supported design choices in Malawi, including the MAHIS EIR itself, reverse-billing SIM arrangements with mobile operators, role-based access controls, offline-first architecture, operationalise the World Bank's Digital Health Readiness Assessment Tool recommendations for low-resource settings (World Bank, 2023a). The clear product ownership (EPI) and technical stewardship (Digital Health Division) from early demonstration phases through design decisions exemplifies co-design approaches that literature shows predict sustained adoption.

User-Centered Design Responding to Pain Points

The evaluation's finding that digital tools respond to long-standing pain points especially of frontline health workers aligns with extensive implementation science literature showing that user-centered design which increases relevance for target groups is predictive of sustained adoption (Dolan et al., 2023). Technologies imposed without attention to workflow realities or user needs fail regardless of technical sophistication.

Across DIPC implementations in Ghana, Malawi, and Sierra Leone, health workers consistently reported that eTracker, MAHIS EIR, and eSMT addressed critical operational challenges: excessive time spent searching through paper registers, transcription errors when transferring data, lost or damaged records, slow reporting processes, weak capacity to track defaulters, and limited visibility of vaccine stock movements. These pain points are remarkably consistent with barriers documented across 20+ African EIR implementations and mirror experiences from Sierra Leone's earlier VaxTrac system, where users reported that "the EIR helped them to shorten the time to manage, summarise, and report vaccination records" and enabled quick retrieval of vaccination histories (Jalloh et al., 2020). The convergence of evidence from both DIPC countries and broader African contexts demonstrates that when digital tools directly address concrete workflow frustrations, rather than imposing externally-defined priorities, they can achieve meaningful relevance for frontline users.

DIPC implementations demonstrated notable advances in workflow integration compared to VaxTrac according to our findings, particularly through standardised WHO DAK framework-based tool design. The use of Digital Square's DAK framework-based SURDs for immunisation in Ghana and Malawi aligned public health data requirements with frontline workflow realities, enabling tools to mirror existing practices. VaxTrac, by contrast, faced inconsistent and inefficient workflows in nine of ten health facilities observed and lacked such systematic workflow alignment (Jalloh et al., 2020). However, infrastructure constraints including device shortages, connectivity limitations, and mandatory dual paper-digital reporting dampened the operational relevance gains these workflow

advances enabled. These patterns suggest that whilst DAK-aligned design represents progress in achieving relevance-in-use, realising full operational value requires concurrent investment in infrastructure readiness and operational support extending beyond initial implementation phases.

Example of High-Value Functionality - Defaulter Tracing: Defaulter tracing functionality emerged as particularly valued and relevant across all three DIPC countries. This finding resonates with Tanzania's TImR experience, where integration of the EIR with the electronic logistics management information system (eLMIS) enabled health workers to identify vaccination gaps and plan targeted outreach (Gilbert et al., 2020). A Kenya-based study found that clinical decision support features, including the ability to quickly identify children who were defaulters, were valued by users as part of the EIR's functionality (Dolan et al., 2023). Prior to digital EIR tools, defaulter identification, also in the DIPC partner countries, required manual cross-referencing of paper registers, a time-consuming process often incomplete due to workload pressures. The DIPC experience demonstrates that by addressing this specific pain point, i.e., transforming manual, time-consuming register cross-referencing into automated identification, EIR tools directly respond to front-line health worker needs while supporting programme goals of improved coverage and equity.

Infrastructure and Capacity Investments: UNICEF and GIZ's approach in Sierra Leone of providing hardware alongside software, namely laptops, tablets, power solutions, connectivity support, combined with phased training including basic computer literacy, was found to at least to some extent, address multiple dimensions of the digital divide documented in the literature. By contrast, in Malawi and Ghana, devices and solar panels were not provided, with roll-out sites expected to use existing equipment from earlier projects. In Malawi, some devices proved non-functioning or insufficient, though reportedly not as severely problematic as in Ghana, where equipment shortages emerged as the most dominant barrier to tool use in the pilot site. These implementation challenges align with findings from a 2025 multi-country evaluation across Guinea, Honduras, Rwanda, and Tanzania, which found that while 81-93% of health workers in African countries demonstrated basic digital literacy, inadequate digital infrastructure was a key barrier to tool use (Mantel et al., 2025).

Critically, infrastructure barriers extended beyond device availability. As such, while most users in the Mantel study had access to hardware, unreliable electricity and internet connectivity prevented effective tool use for real-time decision-making. The evaluation also revealed gaps in specific functional competencies. For example, only 21-66% of users could generate key reports like defaulter lists despite having basic computer skills. The differential outcomes across DIPC countries illustrate that assumptions about existing infrastructure can undermine digital tool adoption regardless of user capability. Early pre-pilot infrastructure assessments and device audits, as conducted in Sierra Leone but not systematically in Malawi or Ghana, would have provided a clear picture of actual device availability and functionality, enabling proactive provisioning rather than reactive problem-solving. The Sierra Leone model of infrastructure investment, devices, power solutions, and connectivity, alongside skills-building in the DIPC pilot sites, reflects evidence-based recognition that digital adoption requires addressing both access and enabling infrastructure, not just user training.

Gaps Between Design Relevance and Operational Reality

Despite strong design alignment, the evaluation reveals persistent gaps that dampen perceived relevance in practice. These gaps reflect the difference between "relevance-in-design" (tools theoretically suited to context) and "relevance-in-use" (tools practically valuable in daily operations), whereby the continuation of parallel paper-digital workflows represents the most significant threat to operational relevance.

Dual Systems Undermine Digital Tool Value: Persistent dual paper-digital workflows create additional workload burdens, back-entry requirements, and data quality challenges. This finding echoes extensive evidence from Rwanda's e-Tracker implementation, where dual documentation resulted in considerable dissatisfaction among health workers, with 60% of immunisation nurses working overtime to complete digital data entry (Uwera et al., 2024). The multi-country study by Mantel et al. (2025) found that immunisation data accuracy was 60% in exclusively paper or exclusively electronic systems but only 45% in dual systems, demonstrating that parallel workflows potentially undermine rather than safeguard data quality.

The persistence of dual systems may reflect that digital tools have not yet achieved sufficient reliability, in terms of uptime, ease of use, or supervisor acceptance, to justify paper retirement. In the multi-country evaluation, paper systems were still considered the most accurate sources of information for a child's immunisation history in all countries, and in Rwanda specifically, data in the e-Tracker were perceived as incomplete and unreliable (Mantel et al., 2025; Uwera et al., 2024). While some dual use during transition periods may be unavoidable from an implementer perspective, prolonged dual running prevents realisation of efficiency gains that justify digital investments. This creates a potential vicious cycle where under-resourced systems cannot demonstrate value, preventing the resource commitments needed to improve reliability and user trust that would enable paper retirement.

Infrastructure Shortfalls: Hardware and connectivity shortages reduce operational relevance despite strong design alignment. The evaluation documents that benefits are "dampened" by persistent device shortages, unreliable connectivity, and power challenges. This is consistent with infrastructure barriers documented across Tanzania (36% electric grid access, 12% solar or no power), Zambia (48% facilities with no primary power source), and Ethiopia (75.7% eLMIS functionality achieved, limited by infrastructure) (Dolan et al., 2020; Mekonen et al., 2025). The literature suggests these are not simply resource constraints but reflect deeper challenges in translating capital investments into sustained operational capacity. Initial device procurement often succeeds through donor funding, but replacement cycles, maintenance, and connectivity costs require recurrent financing that many countries struggle to provide. This gap between capital and operational financing reflects what Dolan et al. (2020) distinguished as the difference between "introduction" (facility training and sensitisation) and "adoption" (consistent, sustained use), explaining why many well-designed digital health tools fail to achieve sustained use.

5.3 Implementation Processes

Phased Roll-Out as Prudent Risk Management

The evaluation finding that fidelity to project plans was supported by incremental expansion within existing national systems aligns with implementation science principles favouring phased, adaptive deployment over simultaneous large-scale introduction. The DIPC approach, characterised by Ghana's focused pilot whilst completing data migration, Sierra Leone's sequencing of digital literacy training before tool-specific instruction, and Malawi's prioritisation of static clinic implementation before outreach services, reflects an iterative implementation model that allows for continuous learning and adaptation.

This approach contrasts with experiences documented in settings where more rapid scale-up preceded adequate preparation. Sierra Leone's earlier experience with VaxTrac provides instructive context: the system was piloted from 2016 to 2017 across 50 health facilities before being suspended in 2019. The post-implementation assessment identified several implementation challenges, including inconsistent

workflows for data entry that were rarely integrated into existing processes and data sharing restrictions that contributed to duplicate records (Jalloh et al., 2020). The assessment concluded that countries considering EIR introduction should “first consider conducting a readiness assessment to determine feasibility, minimum system requirements, and sustainability of the electronic system in the context of existing processes, workloads, and workflows in health facilities” (Jalloh et al., 2020). DIPC implementations exhibited these characteristics, incorporating infrastructure assessments and phased capacity-building prior to facility-level deployment.

As such, in Ghana, the decision by GHS, HISP Ghana and Digital Square to maintain the operational legacy eTracker system across 14 regions whilst developing and testing the enhanced version illustrates a deliberate strategy to safeguard data continuity during system transitions. This approach, though extending implementation timelines, reduces the risk of data loss or reporting gaps that can undermine stakeholder confidence in digital health investments and complicate efforts to secure sustained government commitment to system maintenance and expansion.

What Worked: Integration, Standards, and Feedback

Integration Avoided Fragmentation: DIPC's deliberate integration strategy, based on building within existing national platforms (DHIS2/eTracker, MAHIS/EIR) or expanding tools already in use at other health system levels (eSMT), directly addresses a pervasive challenge documented across African digital health initiatives. Ibeneme et al. (2022) characterise this challenge in their WHO AFRO Digital Health Platform framework, noting that "most investments are vertical, partner-driven and programme-specific with limited system-wide impacts" and that "poor linkages exist amongst different solutions as they are not designed to capture robust data across multiple programmatic areas." The DIPC approach demonstrates alignment with WHO AFRO's call for "holistic approaches when developing digital health systems" and the principle that digital tools should extend rather than replace existing information infrastructures (Ibeneme et al., 2022). This integration delivered concrete benefits beyond conceptual alignment: health workers avoided the burden of learning parallel systems, programme managers reported access to near-real-time dashboards through familiar interfaces, and data quality reportedly improved through on-screen validation embedded into routine workflows. By leveraging established platforms, DIPC avoided creating the "fragmented, inefficient vertical silos systems built with minimal involvement of end-users" that Ibeneme et al. identify as undermining digital health impact across the region. The initiative thus provides empirical evidence supporting the WHO AFRO framework's emphasis on system-wide integration as essential prerequisites for sustainable digital health scale-up in Africa, even if completed interoperability solutions were not achieved within the scope of the project.

Standards Enabled Alignment: Standards adoption in DIPC was guided by WHO DAK-framework based immunisation SURDs developed through Digital Square and national partners in Ghana and Malawi, reflecting in our view, best practice for digital health systems. In Malawi and Ghana, the localisation of DAK content, including standardised data dictionaries, clinical workflows, and decision support logic, provided a structured mechanism for translating immunisation recommendations into the MAHIS EIR and enhanced eTracker systems respectively (Mehl et al., 2021; Muliokela et al., 2025). This software-neutral approach addressed the persistent challenge of digital fragmentation documented across African health systems (Ibeneme et al., 2022), by ensuring that new digital modules were built upon rather than parallel to existing national platforms. The data dictionaries, mapped to international classification and terminology standards including ICD-11, ICHI, and LOINC (Pretty et al., 2023), created a common reference framework that aligned diverse stakeholder groups, including software developers interpreted standardised functional requirements, health workers engaged with familiar

clinical workflows digitalised consistently, and programme managers accessed data structured for meaningful aggregation and reporting. Critically, this standards-based foundation established not only immediate operational consistency but also a practical pathway towards future semantic interoperability, which will enable the MAHIS EIR and the enhanced eTracker to exchange data with other health information systems using recognised data exchange standards (Mehl et al., 2021). The Cameroon experience with BornFyne-PNMS further demonstrates how DAK-guided digitalisation can systematically integrate evidence-based content whilst maintaining fidelity to both clinical guidelines and technical interoperability requirements (Nkangu et al., 2025).

Feedback Loops Sustained Engagement: Iterative feedback mechanisms emerged as critical enablers of sustained digital tool adoption across all three DIPC partner countries. On-screen validation rules, routine data quality reviews, peer support networks through WhatsApp groups, joint supervisory visits, and actionable dashboards created rapid feedback loops that transformed data entry from administrative burden into operational intelligence. In Ghana, near-real-time dashboards enabled programme managers to conduct more responsive oversight of outreach activities and vaccine resupply decisions. Sierra Leone's dashboard visibility under MoH EPI stewardship facilitated timely corrective action at district and national levels, whilst Malawi's WhatsApp-based peer networks provided accessible troubleshooting support that smoothed facility-level uptake. Critically, these feedback mechanisms extended value beyond individual facilities as national programme teams utilised generated data for surveillance, performance management, and supply-chain oversight, demonstrating the multilevel utility of quality data systems.

This aligns with evidence that feedback loops strengthen data quality by helping users recognise the value of their data entry work (Scobie et al., 2020). The evaluation of EIRs across Guinea, Honduras, Rwanda, and Tanzania demonstrated that 88% of health facility respondents indicated the new digital processes positively impacted regional feedback loops, whilst 68% reported improvements in data quality and completeness (Mantel et al., 2025). Tanzania's experience with the Tanzania Immunisation Registry documented three distinct "waves" of data use as health workers became progressively empowered, starting with initial data collection, through quality improvement, to ultimately using data for targeted action (Werner et al., 2019). However, realising this potential requires countries to strengthen capacity for collecting, analysing, interpreting, and acting on data (Secor et al., 2022). The DIPC experience demonstrates that effective feedback loops require both technical infrastructure (validation rules, dashboards) and social infrastructure (peer networks, joint supervision), with their sustainability depending on continued investment in supervisory capacity, reliable connectivity for real-time data access, and institutional commitment to data-informed decision-making at all health system levels.

What Didn't Work: Infrastructure, Training, Governance

Infrastructure as Binding Constraint: The evaluation identified a critical finding: implementation challenges stemmed primarily from inadequate foundational infrastructure rather than tool design limitations. Health facilities rarely possessed sufficient durable devices, reliable power supplies, stable connectivity, or dependable hosting infrastructure. Persistent deficits, including too few or ageing devices, insecure charging and storage facilities, unreliable power and connectivity, and intermittent system hosting and uptime, resulted in partial tool uptake, inconsistent routine use, and disrupted recording and reporting timeliness. These infrastructure constraints frequently forced teams to revert to paper-based systems, creating delays, requiring retrospective data entry, and producing uneven data completeness.

This finding aligns with extensive evidence demonstrating that often infrastructure deficits, rather than technology deficits, constitute the primary barrier to digital health impact in LMICs. Mantel et al.'s multi-country evaluation concluded that whilst 77% of health workers demonstrated digital literacy, inadequate digital infrastructure remained a key barrier to sustained tool use (Mantel et al., 2025). Country-specific assessments reveal the scale of these constraints: in Tanzania, only 36% of health facilities had access to the electric grid, whilst in Zambia, 48% of facilities lacked any primary power source (Secor et al., 2022). Without addressing these foundational prerequisites, namely reliable electricity, consistent connectivity, adequate device provision, and secure hosting, even well-designed, standards-based digital tools cannot achieve sustained adoption or deliver their anticipated benefits for programme management and service delivery.

Training Duration and Long-term Skill Retention: Whilst a comprehensive assessment of training approaches and outcomes is presented in *Report #4* of this evaluation report series *"Capacity Strengthening for Digital Tool Use"*, some of the key findings warrant emphasis here. Training was consistently identified as competent but insufficient in duration to accommodate heterogeneous digital skill levels, high staff turnover rates, and low baseline digital literacy in some contexts. Respondents emphasised that without funded refresher sessions, ongoing mentoring, and functioning helpdesk support, user confidence eroded over time, often resulting in digital tools being operated by only one or two staff members per facility. This concentration of expertise created significant vulnerability when trained staff transferred or left positions.

These challenges are well documented across African electronic immunisation registry implementations. Rwanda's evaluation found that 60% of immunisation nurses worked overtime to complete digital data entry, partly because training was inadequate for system complexity (Uwera et al., 2024). The multi-country by Mantel and colleagues showed that limited competence in interpreting immunisation status (41-55%) and generating or interpreting defaulter reports (21-66%) persisted even after training, suggesting that whilst basic tool use was learned, advanced functionality was not internalised (Mantel et al., 2025). These findings take on particular significance given that health workforce attrition in rural African settings can exceed 30% annually (Secor et al., 2022), meaning that even excellent initial training degrades rapidly without institutionalised refresher cycles.

Cognisant of this training sustainability challenge and the often unmanageable financial burden that ongoing refresher training poses to governments beyond project cycles, Digital Square developed ad-hoc instructional video training courses for Malawi's MAHIS EIR and Ghana's enhanced eTracker. These video resources are designed to support tool users even after initial training has been provided, enabling self-paced learning and on-demand skill reinforcement without requiring costly in-person training sessions. This represents a commendable and resource-wise initiative that provides sustainable products to ensure skill upkeep, addressing one of the most persistent barriers to long-term digital health system sustainability in resource-constrained settings.

5.4 Discussion Sustainability

Integration as Foundation for Sustainability

The evaluation identified credible sustainability prospects for DIPC-supported tools, attributable primarily to their positioning within national health information system architectures rather than as standalone parallel systems. This finding aligns with extensive literature demonstrating that integration into national platforms constitutes a primary determinant of digital health sustainability in low- and middle-income countries.

The challenge of digital health sustainability in Africa is well documented. Karamagi et al.'s (2022) scoping review of 738 digital health tools across sub-Saharan Africa revealed that most solutions are standalone and deployed in response to specific programme needs rather than integrated within national systems. Critically, the review concluded that "if such interventions are not adopted by governments and funding sustained, they will close with the project cycle," and that "the sustainability of funding in digital health has given government-led interventions an advantage over private interventions." This pattern reflects the persistent challenge of verticalisation in African health systems, where investments remain "vertical, partner-driven and programme-specific with limited system-wide impacts" (Ibeneme et al., 2022). The fragmentation arising from proliferation of standalone systems has been shown to exacerbate inefficiencies. The Democratic Republic of Congo's Ebola response demonstrated how multiple vertical solutions deployed without systemic integration with national infrastructure could not share real-time data, undermining coordinated mitigation efforts (Ibeneme et al., 2022).

In contrast, Ghana's DIPC-supported enhanced eTracker is embedded within DHIS2 under GHS/PPME stewardship in collaboration with the HISP Ghana, whilst Malawi's MAHIS EIR is built as a module within the existing national MAHIS platform. Both implementations demonstrate established supervisory routines, institutionalised data-use practices, and clear government ownership arrangements, creating multiple points of organisational dependence that reduce vulnerability to donor funding cycles. This integration operates at technical, institutional, and financial levels, each contributing to long-term durability. The DIPC approach of building within rather than alongside existing national platforms positions the enhanced eTracker, MAHIS EIR, and eSMT for sustained use beyond project cycles, contingent upon continued investment in the foundational infrastructure and capacity requirements identified in this evaluation.

Differentiated Sustainability Trajectories

The three DIPC partner countries demonstrate distinct sustainability pathways shaped by their specific institutional arrangements, resource contexts, and digital health maturity, with each implementing different digital tool types tailored to their national priorities.

Ghana has positioned the enhanced eTracker (an electronic immunisation registry) within strong technical and institutional frameworks through GHS/PPME/CHIM/HISP Ghana ownership and established monitoring loops. Institutional integration is evident through dashboard-based data review practices, WhatsApp problem-solving channels, and functioning supervisory routines. Sustainability challenges stem from incomplete migration, with the enhanced eTracker remaining in pilot phase whilst the legacy system continues to operate across 14 regions, alongside operational constraints including device shortages, connectivity limitations, and the transitional burden of maintaining dual paper and digital entry systems. Sustained functionality requires completion of the migration process, resolution of parallel system challenges, and securing recurrent budgets for device provision, data costs, power supply, and institutionalised refresher training.

Malawi has established clear institutional foundations for the MAHIS EIR module through the "MAHIS-first" policy, defined stewardship arrangements (EPI as product owner, Digital Health Division as technical lead), national hosting infrastructure, reverse-billing arrangements, and routine supervision mechanisms. The tool functions as an integrated module within the national MAHIS platform, with established feedback loops connecting facility-level data entry to district and national programme oversight. Sustainability challenges centre on resource

constraints affecting recurrent operating costs (devices, transport, supervision), intermittent connectivity, and limited in-house developer posts to manage system updates and feature enhancements without external technical assistance. These constraints reflect Malawi's macroeconomic context characterised by low domestic health spending, high aid dependency, and limited fiscal space for non-salary operating costs.

Sierra Leone demonstrates emerging institutional routines for the eSMT (electronic Stock Management Tool), with governance structures and staff uptake evident in pilot districts under Ministry of Health EPI stewardship. The eSMT extended an existing stock management tool to primary health units through DIPC, building on established presence within the immunisation landscape. However, architectural integration remains incomplete: interoperability pathways between eSMT and DHIS2 are under development but not yet operational, geographic coverage is limited to four pilot districts, and issue-tracking and help-desk functions sit outside the tool itself. Full adoption at pilot sites remains highly contingent on continued support for digital literacy, gadget provision, secured electricity, and internet connectivity. The system's sustainability trajectory depends on securing domestic financing for connectivity, power, and device lifecycles; strengthening user capacity more evenly across facilities to reduce reliance on one or two users per site; and completing DHIS2 interoperability to eliminate parallel data entry processes. The transition from donor-supported pilot to government-sustained national programme represents the critical juncture for long-term viability.

Multi-country evidence from electronic immunisation registry implementations demonstrates that sustainability requires multi-year timelines, iterative development processes, and deliberate capacity-building strategies. Vietnam's achievement of nationwide EIR scale took seven years, whilst Tanzania and Zambia required extended implementation periods to establish sustainable systems (Carnahan et al., 2023). Across all three countries, national government leadership as part of interdisciplinary teams with experience in leadership, technology, and immunisation proved essential for ensuring country ownership and sustainability. A critical determinant of sustainability emerged from partnership arrangements with software developers: where international software developers were contracted, partnering with local software companies substantially improved both system responsiveness and long-term sustainability (Carnahan et al., 2023). In Zambia, the Ministry of Health deliberately worked with technical partners to build capacity for both technical implementation and governance ownership, creating institutional foundations that could persist beyond donor funding cycles.

The DIPC implementations reflect this strategic emphasis on local technical capacity. Digital Square contracted local vendors—PEPFAR and Luke International in Malawi—to build the EIR module for MAHIS, and evaluation interviews documented clear evidence of capacity strengthening and iterative learning through this partnership. Nevertheless, the pathway to independent continuation remains conditional across all three countries. A 2025 multi-country evaluation of electronic immunisation registries concluded that realising the full potential of digital immunisation tools requires full government ownership, targeted infrastructure investments, and migration to fully electronic systems (Mantel et al., 2025). This mirrors capacity constraints documented in the current evaluation, particularly Malawi's limited in-house developer capacity, Ghana's reliance on HISP networks for technical stewardship, and Sierra Leone's incomplete transition from pilot to national scale. Experience from South Africa demonstrates that inadequate and unsustained investment from donors and government, particularly in human resource capacity, continues to threaten digital health solution sustainability (Swartz et al., 2021). Durable sustainability for the DIPC implementations therefore depends on securing multi-year recurrent budgets for last-mile operational costs, institutionalising

tiered training and technical support structures, continuing to build in-house technical capacity through local partnerships, and ensuring that system ownership remains embedded within institutional arrangements rather than dependent on individual champions or external partners.

Transition Planning and Financing Arrangements

A fundamental tension emerges between pilot implementation success and the institutional mechanisms required for sustained national-scale operation. Sierra Leone's experience with VaxTrac, an electronic immunisation registry piloted from 2016 to 2019 across 50 health facilities, illustrates this challenge: the system was suspended in 2019 due to sustainability concerns and competing priorities in a resource-constrained context (Jalloh et al., 2020). The suspension occurred not because of technical failure, but because recurrent financing mechanisms for connectivity, devices, and ongoing support remained unresolved when donor funding concluded. This pattern—technically successful pilots that cannot transition to sustained national systems—reflects inadequate attention to financing arrangements during the pilot phase itself, and demonstrates risks that apply across different types of digital immunisation tools.

Achieving durable sustainability requires deliberate transition planning that addresses three critical dimensions.

1. Governments must establish clear financing commitments for recurrent costs from the project outset, integrating digital health infrastructure into national budget processes rather than treating it as a parallel, donor-dependent initiative. This requires moving beyond capital investment in initial deployment to securing predictable funding streams for device lifecycles, connectivity charges, power solutions, supervision transport, and technical support structures.
2. Implementation approaches must design phased rollouts with realistic financing timelines that extend beyond typical 3-5 year project cycles, recognising that establishing sustainable digital health systems requires extended periods of capacity building, institutional adaptation, and resource mobilisation.
3. Programmes must build in-country capacity for budget advocacy and resource mobilisation, ensuring that ministries of health can effectively negotiate for domestic resources and make the case for sustained investment in digital health infrastructure within competing budgetary priorities.

The DIPC evaluation findings indicate that whilst the supported tools demonstrate strong operational value and institutional integration, achieving the transition from donor-financed to domestically funded infrastructure remains incomplete across all three countries.

Ghana requires predictable financing for device procurement and replacement, data bundles, and power solutions to maintain system functionality at scale, alongside progressive phase-out of parallel paper-based reporting.

Malawi faces concentrated risks in recurrent operating costs for device lifecycles, connectivity, and transport for supervision and outreach, with limited in-house developer capacity to manage system updates without external assistance.

Sierra Leone's pathway to independent continuation depends on transitioning connectivity, power solutions, and device replacement cycles from external to domestic budget lines, alongside more equitable distribution of digital skills across facility staff and completion of DHIS2 interoperability specifications. Without deliberate transition planning that addresses financing arrangements, governance structures, and capacity development simultaneously,

even well-designed and operationally valuable digital health systems risk following the VaxTrac trajectory: suspension at the point when external support concludes, before domestic financing mechanisms have been established to ensure continuity.

These findings, demonstrating substantial implementation achievements within a 3-year cycle alongside persistent structural challenges in infrastructure, financing, and capacity, point toward specific strategic priorities for future digital health initiatives seeking to strengthen the pathway from pilot implementation to sustained national-scale integration.

6 Recommendations

6.1 Relevance

R1: Conduct Infrastructure Readiness Assessments and Deploy Innovative, Sustainable Infrastructure Solutions

Rationale: Infrastructure deficits, namely device shortages, unreliable connectivity, inadequate power were the primary barriers to sustained tool use, more limiting than training or tool design. Sierra Leone's hardware provision (laptops, tablets, solar panels, connectivity) enabled adoption amongst first-time computer users, whilst Malawi and Ghana's assumptions about existing infrastructure resulted in non-functioning devices and insufficient ratios. Multi-country evidence shows 81-93% of African health workers possess digital literacy, but inadequate infrastructure remains the binding constraint (Mantel et al., 2025). However, LMIC governments rarely maintain predictable device procurement and replacement through conventional public financing alone. Innovative provisioning strategies, Malawi's reverse-billing arrangements, Buy-Your-Own-Device programmes (BYOD) with data bundles, device-as-a-service leasing, and public-private partnerships, offer sustainable pathways beyond constrained central budgets (Labrique et al., 2018).

Priority Actions:

- Audit infrastructure before deployment: Document device functionality, device-to-staff ratios (minimum 1:3), power reliability, connectivity availability, workspace adequacy at facility level
- Prioritise peripheral facilities: Provide ruggedised devices, deploy solar solutions where grid power <16 hours daily, ensure robust offline functionality
- Pilot innovative provisioning models:
    - BYOD programmes with institutional data bundles and bulk tariff negotiations
    - Reverse-billing or zero-rating partnerships with telecommunications providers
    - Device-as-a-service leasing including maintenance and replacement
    - Corporate social responsibility partnerships for subsidised provision
    - Cost-sharing frameworks (central government base + district/partner co-financing)

- Establish government budget commitments: Negotiate dedicated lines for device replacement (3-5 year cycles), connectivity, maintenance, solar servicing with MoU accountability
- Create asset management systems: Equipment registries, vendor service agreements with repair response times, proactive replacement protocols
- Build government capacity: Train procurement/ICT staff in alternative models, develop BYOD security frameworks, establish public-private partnership templates

R2: Design Phased Paper Retirement Strategies with Clear Triggers Eliminating Dual Paper-Digital Workflows

Rationale: Persistent dual paper-digital workflows undermined operational relevance by creating workload burdens, back-entry requirements, and data quality challenges. Evidence shows 60% of Rwandan immunisation nurses worked overtime under dual documentation (Uwera et al., 2024), and immunisation data accuracy is 60% in exclusively paper or digital systems but only 45% in dual systems (Mantel et al., 2025). Dual systems persist because digital tools lack sufficient reliability, uptime, or supervisor acceptance to justify paper retirement—a vicious cycle where under-resourced systems cannot demonstrate value. Whilst transition-period dual operation may be unavoidable, prolonged dual running prevents efficiency gains that justify digital investments. Deliberate retirement strategies with explicit triggers are essential for transitioning from "relevance-in-design" to "relevance-in-use."

Priority Actions:

- Establish paper retirement criteria from project outset: System reliability (>95% uptime), user confidence (>80% report reliable), data quality (>90% concordance), adoption rates (>70% facilities actively using)
- Design phased retirement by function: Retire paper for specific workflows (defaulter tracking, stock monitoring) demonstrating clear digital superiority before retiring entire registers
- Monitor transition impacts: Track workload, measure dual documentation time, assess user satisfaction, monitor data quality across both systems
- Communicate transparently: Inform users of retirement timelines, celebrate milestones, provide "no-return" commitment signals once reliability thresholds met

R3: Institutionalise Continuous User Feedback Mechanisms to Maintain Operational Relevance as Contexts Evolve

Rationale: DIPC implementations achieved strong initial relevance through high stakeholder engagement during planning, with governments leading and partners facilitating. Ghana's help-desk arrangements and Malawi's collaborative governance ensured design remained grounded in frontline realities. However, operational relevance is not static—workflow needs evolve, new challenges emerge, staff turnover introduces different requirements, infrastructure changes create opportunities or constraints. Sustained relevance requires continuous user engagement with systematic mechanisms for capturing feedback, prioritising improvements, and communicating changes (Dolan et al., 2023). Without such mechanisms, initially relevant tools become misaligned with evolving realities, leading to declining satisfaction and abandonment. DIPC's strong co-design foundations create opportunity to transition from project-phase engagement to institutionalised feedback systems maintaining operational relevance over time.

Priority Actions:

- Establish multi-tiered feedback channels: Facility help desks with issue tracking, district user forums (quarterly), national technical working groups (semi-annual system reviews)
- Implement systematic feedback capture: Bi-annual user satisfaction surveys (relevance, ease of use, reliability), usage analytics (feature utilisation, declining adoption), incident reporting (technical issues, workflow barriers, training gaps)
- Create transparent improvement roadmaps: Publish annual enhancement plans based on feedback, communicate prioritisation criteria, share progress updates

- Allocate dedicated resources: Include maintenance and enhancement in recurrent budgets, retain technical capacity (in-house or contracted local vendors), ensure product owners coordinate continuous improvement
- Build government capacity: Train ministry staff in feedback methodologies, develop protocols for prioritising feature requests, establish user representative structures participating in design reviews

6.2 Implementation processes

R4: Adopt Phased Implementation with Explicit Technical Readiness Gates and Adaptive Learning

Rationale: Incremental expansion within existing national systems supported implementation fidelity—Ghana's focused pilot during migration, Sierra Leone's sequenced digital literacy training, Malawi's static clinic prioritisation reflected prudent risk management. This contrasts with Sierra Leone's VaxTrac, where rapid scale-up from pilot to 50 facilities within one year without readiness assessment contributed to 2019 suspension (Jalloh et al., 2020). Ghana's legacy eTracker maintenance across 14 regions whilst developing the enhanced version, though extending timelines, safeguarded data continuity. Evidence shows sustainable national-scale implementation requires multi-year timelines with iterative development (Carnahan et al., 2023). Phased approaches enable continuous learning, infrastructure gap identification, training refinement, and adaptive responses before full-scale deployment.

Priority Actions:

- Mandate phase-gate approaches: Define readiness prerequisites per phase (pilot, expansion, national scale)—minimum device ratios, connectivity reliability, user competency, system uptime thresholds required before progression
- Document phase learnings: Conduct structured reviews capturing successes, failures, infrastructure gaps, training effectiveness; refine subsequent strategies based on findings
- Implement adaptive timelines: Resist rapid scale-up when prerequisites unmet, communicate phase-gate criteria transparently, adjust expansion based on demonstrated readiness
- Prioritise data continuity: Maintain legacy systems until new tools demonstrate reliability (>95% uptime, >80% user confidence, >90% data concordance), implement validated migration protocols
- Build government capacity: Train ministry staff in phase-gate methodology, establish institutional memory systems

R5: Establish Multi-Level Data Feedback Loops Demonstrating Value to Sustain User Engagement and Quality

Rationale: Iterative data feedback mechanisms were critical enablers across DIPC countries. On-screen validation rules, routine data quality reviews, peer support networks (WhatsApp), joint supervision, and actionable dashboards transformed data entry from administrative burden into operational intelligence. Evidence shows 88% of health facility respondents indicated new digital processes positively impacted feedback loops, whilst 68% reported data quality improvements (Mantel et al., 2025). Tanzania documented three progressive "waves" as health workers moved from initial collection through quality improvement to targeted action (Werner et al., 2019). However, realising this requires strengthening capacity for collecting, analysing, interpreting, and acting on data (Secor et al., 2022). Effective feedback loops require both technical infrastructure (validation rules, dashboards)

and social infrastructure (peer networks, supervision), with sustainability depending on continued investment beyond initial implementation.

Priority Actions:

- Embed multi-tiered technical feedback from inception: On-screen validation for immediate quality feedback, role-specific dashboards translating data into insights, automated alerts (stock-outs, defaulters, data completeness)
- Institutionalise social feedback structures: Formalise peer networks (WhatsApp groups, monthly learning sessions), establish joint supervisory protocols including data review, create facility-district-national loops with documented response mechanisms
- Build progressive data use capacity: Design curricula moving health workers from basic entry through quality assurance to interpretation and action, develop cadre-specific data literacy resources, provide mentorship converting insights into decisions
- Ensure sustainability: Allocate recurrent budget for data-inclusive supervisory visits, negotiate connectivity enabling real-time dashboard access, train district data quality champions, document protocols in national SOPs

R6: Build Local Technical Capacity Through Strategic Vendor Partnerships and Knowledge Transfer

Rationale: In-country developers, vendors, and partners enabled responsive troubleshooting and quality assurance. Evidence shows partnering with local software companies substantially improves responsiveness and sustainability (Carnahan et al., 2023). In Zambia, the Ministry worked with technical partners to build capacity for implementation and governance ownership, creating foundations persisting beyond donor funding. DIPC's contracting of local vendors (PEPFAR and Luke International in Malawi) demonstrated this approach, with interviews documenting clear capacity strengthening. However, Malawi retains limited in-house developer capacity for system updates without external assistance, whilst Ghana relies on HISP networks. Building sustainable local technical capacity requires deliberate knowledge transfer, skills development, and institutional arrangements embedding expertise within government structures or accessible local partnerships.

Priority Actions:

- Mandate local vendor partnerships with knowledge transfer: Include capacity-building obligations in procurement (documentation standards, code repositories, government staff training), require paired programming (international alongside local developers), establish technology transfer milestones
- Develop in-country technical support ecosystems: Train district digital health champions with troubleshooting capabilities, establish regional technical support hubs, create national technical working groups (government IT staff, local vendors, academic institutions)
- Invest in formal technical capacity: Fund government staff training (software development, database management, system administration), sponsor advanced skills fellowships, establish mentorship pairing experienced vendors with government technical staff
- Create sustainable financing: Allocate recurrent budget lines for government technical positions (system administrators, database managers, digital health advisors), negotiate retainer arrangements with local vendors
- Document and transfer knowledge systematically: Require comprehensive technical documentation (system architecture, code repositories, API specifications, database schemas),

develop SOPs for common tasks, create troubleshooting guides accessible at district level, establish version control and change management protocols

6.3 Sustainability

R7: Design Multi-Year Financing Transition Plans Aligned to Realistic Sustainability Timelines

Rationale: A fundamental tension emerges between pilot success and mechanisms required for sustained national-scale operation, amplified when project cycles misalign with sustainability timelines. DIPC's 3-year cycle, whilst sufficient for pilot implementation and governance establishment, falls substantially short of multi-year periods needed for full sustainability. Vietnam required 7 years for nationwide EIR scale, whilst Tanzania and Zambia needed extended periods (Carnahan et al., 2023). DIPC's achievements within 3 years—tool deployment, capacity building, national platform integration, governance establishment—represent substantial progress. However, incompleteness at project conclusion reflects realistic constraints rather than failure: structural requirements for sustained operation—multi-year recurrent budgets, fully institutionalised support, complete technical capacity transfer—require longer timeframes than typical donor cycles provide. Sierra Leone's VaxTrac suspension in 2019 illustrates consequences: the technically successful system ended because recurrent financing mechanisms for connectivity, devices, and support remained unresolved when donor funding concluded (Jalloh et al., 2020).

Priority Actions:

- Design project cycles acknowledging sustainability timelines: Structure initiatives in sequential phases (Phase 1: pilot/proof-of-concept, 18-24 months; Phase 2: capacity strengthening/expansion, 24-36 months; Phase 3: financing transition/scale-up, 24-36 months) with explicit transition milestones
- Establish government financing commitments from outset: Negotiate MoUs specifying phased budget assumption (Year 1: 0-20% recurrent costs; Year 2: 20-40%; Year 3: 40-60%; Year 4: 60-80%; Year 5+: 80-100%) with predictable timelines enabling budget planning
- Build capacity for budget advocacy: Train ministry staff in digital health costing methodologies, develop business cases for domestic financing, support engagement with ministries of finance, document return-on-investment evidence
- Design transparent exit strategies from inception: Communicate donor withdrawal timelines clearly, identify specific financing responsibilities transitioning to government (devices, connectivity, training, support), establish contingency plans if domestic financing delays
- Acknowledge temporal mismatch explicitly: Inform funders that short-term cycles cannot achieve complete sustainability transitions, advocate for extended commitments or phased designs sequencing deployment, capacity strengthening, and financing transition across multiple cycles

R8: Establish Dedicated Government Budget Lines for Recurrent Digital Health Infrastructure and Operating Costs

Rationale: Whilst DIPC-supported tools demonstrate strong operational value and institutional integration, transition from donor-financed to domestically funded infrastructure remains incomplete across all countries. Ghana requires predictable financing for device procurement, data bundles, and power solutions. Malawi faces risks in recurrent operating costs for device lifecycles, connectivity, and supervision transport. Sierra Leone's independent continuation depends on transitioning connectivity,

power, and device replacement from external to domestic budget lines. These gaps reflect broader structural tension: initial device procurement often succeeds through donor funding, but replacement cycles, maintenance, and connectivity require recurrent financing many countries struggle to provide (Swartz et al., 2021). Karamagi et al.'s (2022) review of 738 digital health tools concluded "if interventions are not adopted by governments and funding sustained, they will close with the project cycle." Achieving durable sustainability requires moving digital health infrastructure from parallel, donor-dependent initiatives into core government budget processes with dedicated, predictable allocation mechanisms.

Priority Actions:

- Establish dedicated recurrent budget lines: Create discrete line items for device replacement (3-5 year lifecycles), connectivity/data charges, power solutions (solar servicing, generator fuel), supervision transport, technical support structures
- Conduct comprehensive costing during pilot phase: Document actual per-facility costs (devices, connectivity, power, supervision, support), project national scale-up costs, prepare detailed budget requirements for ministry of finance negotiations, update annually based on experience
- Negotiate cost-sharing during transition: Establish matched-funding where government assumes progressively larger shares whilst donors co-finance (e.g., Year 1: 80% donor/20% government; Year 3: 50%/50%; Year 5: 20%/80%; Year 7: 0%/100%)
- Link budget commitments to implementation milestones: Tie donor funding continuation to demonstrated government budget allocation progress, include budget verification in phase-gate advancement criteria, establish transparency mechanisms tracking government expenditure
- Explore innovative financing: Negotiate earmarked levies on telecommunications services, establish digital health infrastructure funds capitalised by multiple donors and government, pursue results-based financing where releases tied to system uptime and adoption metrics

R9: Complete Technical Interoperability and Eliminate Digital System Fragmentation to Consolidate Sustainability

Rationale: Whilst DIPC-supported tools are anchored in national platforms, integration depth varies significantly with direct sustainability implications. Ghana's enhanced eTracker demonstrates institutional integration through DHIS2 embedding under GHS/PPME/CHIM/HISP Ghana stewardship, yet operational reliability remains constrained by maintaining dual paper-digital entry during legacy eTracker phase-out. Sierra Leone's architectural integration remains incomplete: interoperability pathways between eSMT and DHIS2 are under development but not operational, whilst issue-tracking and help-desk functions sit outside the tool. This incomplete integration creates sustainability vulnerabilities. Karamagi et al.'s (2022) review revealed most of 738 digital health tools in sub-Saharan Africa are standalone and deployed for specific programmes rather than integrated within national systems, creating fragmentation that exacerbates inefficiencies. DRC's Ebola response demonstrated how multiple vertical solutions deployed without systemic integration could not share real-time data, undermining coordinated responses (Ibeneme et al., 2022). Complete technical integration—eliminating parallel systems, operationalising interoperability pathways, consolidating support functions—is essential for transitioning from project-phase implementations to routine national services.

Priority Actions:

- Prioritise completion of pending interoperability specifications: Allocate dedicated technical resources to finalise eSMT-DHIS2 data exchange protocols in Sierra Leone, implement automated data flows eliminating manual transcription, establish regular interoperability testing and validation cycles
- Develop and implement digital system retirement strategies with explicit triggers: Establish system reliability thresholds (>95% uptime, >80% user confidence, >90% data concordance) as prerequisites for legacy system retirement, design phased retirement by function (retire legacy for specific workflows demonstrating clear new system superiority), communicate retirement timelines transparently to prevent regression
- Consolidate support functions within integrated platforms: Embed issue-tracking, help-desk, and user feedback mechanisms within primary tools rather than maintaining parallel external systems, implement single sign-on reducing authentication complexity, standardise user interfaces across integrated modules
- Establish interoperability governance frameworks: Create national technical working groups responsible for maintaining interoperability standards, develop data exchange protocols aligned with OpenHIE specifications, require interoperability compliance for all new digital health procurements
- Build government capacity for integration management: Train ministry technical staff in health information exchange architecture, develop national interoperability roadmaps identifying priority integration pathways, establish testing environments for validating data exchange before production deployment

7 Conclusion

DIPC's Strategic Design Achievements

The DIPC Initiative represents exemplary digital health investment in three critical respects. First, the tools demonstrate strong policy alignment with national strategies, avoiding the donor-driven imposition that has caused numerous digital health failures across sub-Saharan Africa. Second, they respond directly to genuine operational needs articulated by frontline health workers particularly defaulter tracing and stock visibility rather than imposing externally defined priorities. Third, they were developed through appropriate government-led multi-stakeholder engagement, with national ownership at the centre and partners playing facilitative rather than directive roles.

Critically, DIPC's deliberate integration strategy, building within existing platforms rather than creating standalone parallel systems, represents best practice implementation. Ghana's enhanced eTracker nested within DHIS2, Malawi's MAHIS EIR as integrated module, and Sierra Leone's extension of existing eSMT to primary health units all avoided the fragmentation documented across hundreds of digital health tools operating as isolated, programme-specific solutions. This integration, combined with adoption of WHO Digital Adaptation Kit-based standards in Ghana and Malawi, created technical foundations for future interoperability whilst ensuring tools aligned with established workflows rather than disrupting care delivery.

These design achievements reflect strong foundational work. The tools are well-conceived, appropriately designed, and have demonstrated operational value to users, creating foundations for potential sustained use beyond project cycles.

Implementation Progress Through Prudent Risk Management

Within a 3-year implementation cycle, DIPC achieved impressive progress through phased, adaptive deployment. Ghana's focused pilot during legacy system migration, Sierra Leone's sequenced digital literacy training, and Malawi's static clinic prioritisation before outreach expansion all reflect implementation science principles favouring incremental learning over rapid scale-up. This prudent approach prevented implementation failures that have been observed in other digital health initiatives, maintaining data continuity whilst enabling continuous adaptation based on operational realities.

The integration strategy delivered concrete operational benefits. Health workers avoided the burden of learning parallel systems, programme managers accessed near-real-time dashboards through familiar interfaces, and data quality improved through embedded validation rules. Iterative feedback mechanisms including on-screen validation, peer support networks, joint supervision, and actionable dashboards transformed data entry from administrative burden into operational intelligence.

DIPC's deliberate sequencing and risk management enabled substantial achievements: tools deployed across multiple districts, capacity built amongst hundreds of health workers, governance structures established with clear government stewardship, and operational value demonstrated through improved defaulter tracking, stock visibility, and reporting efficiency. These represent genuine implementation successes that create credible foundations for sustained use.

Remaining Work for Sustainability Transitions

The evaluation identifies three domains where continued work is needed to consolidate DIPC's achievements into durable national systems.

Infrastructure gaps require strategic attention. Device shortages, unreliable connectivity, and inadequate power emerged as the primary barriers to sustained adoption, more limiting than training adequacy or tool design. Sierra Leone's concurrent provision of hardware, power solutions, and connectivity alongside software deployment facilitated adoption in the pilot sites, whilst Malawi and Ghana's assumptions about existing infrastructure resulted in operational constraints despite strong design alignment. Evidence shows that whilst African health workers increasingly possess digital literacy, inadequate infrastructure remains the binding constraint. Addressing this requires comprehensive readiness assessments before deployment, innovative provisioning models reducing government capital requirements (device-as-a-service leasing, reverse-billing arrangements with network providers, public-private partnerships), and dedicated budget lines for recurrent infrastructure costs.

Dual paper-digital workflows prevent efficiency gains. Persistent parallel workflows create workload burdens rather than reducing administrative time, undermining the operational value that justifies digital investments. Evidence from Rwanda and multi-country evaluations shows that dual systems actually reduce data accuracy compared to exclusive paper or exclusive digital approaches. Eliminating dual workflows requires phased paper retirement strategies with explicit triggers, system reliability thresholds, user confidence metrics and data quality benchmarks that signal readiness for full digital transition.

Sustainability requires multi-year financing transitions. DIPC's 3-year cycle, whilst sufficient for pilot implementation and governance establishment, is substantially shorter than the 5-7 year timelines documented as necessary for achieving full sustainability. Vietnam required seven years to achieve nationwide electronic immunisation registry scale, whilst Tanzania and Zambia needed extended periods to establish sustainable systems. DIPC's achievements within three years represent substantial

progress given this reality. However, completing the transition to fully government-sustained systems requires multi-year recurrent budgets for devices, connectivity, power, supervision, and technical support; continued local technical capacity building through vendor partnerships; and completion of pending interoperability specifications.

Country-Specific Pathways Forward

Each country demonstrates distinct sustainability trajectories requiring tailored strategies.

Ghana has positioned the enhanced eTracker within strong technical and institutional frameworks through government ownership and established monitoring loops. The pathway forward requires completion of legacy system migration, resolution of parallel system challenges, and recurrent budget security for device replacement, data bundles, and power solutions.

Malawi has established clear institutional foundations through the "MAHIS-first" policy, defined stewardship arrangements, national hosting infrastructure, and reverse-billing arrangements. The pathway forward centres on securing recurrent operating costs and building in-house developer capacity, despite encouraging local vendor partnerships that demonstrated substantial capacity strengthening.

Sierra Leone demonstrates emerging institutional routines with governance structures and staff uptake evident in pilot districts. The pathway forward requires domestic financing transition for connectivity, power, and devices; strengthened user capacity distribution across facilities; and DHIS2 interoperability completion to eliminate parallel data entry processes.

DIPC as Foundation for Continued Investment

The DIPC Initiative has achieved what many digital health programmes fail to accomplish: tools integrated within national platforms, genuine government ownership, demonstrated operational value, and institutional routines supporting continued use. These are not minor accomplishments, they represent the difference between abandoned pilot projects and foundations for national digital health systems.

The evaluation identifies nine evidence-based recommendations organised across relevance, implementation processes, and sustainability. These recommendations acknowledge that building sustainable national digital health systems requires timeframes and investments extending beyond what 3-year project cycles can deliver. DIPC has established credible foundations. Consolidating these into durable national assets requires continued commitment from governments, funders, and implementing partners.

Success will ultimately be measured not by what exists when project support concludes, but by what remains functioning and valued five and ten years later. The DIPC-support facilitated by implementation partners UNICEF and Digital Square has positioned Ghana, Malawi, and Sierra Leone well for this long-term success. Realising this potential requires sustained political commitment, adequate resource mobilisation, completion of pending technical and institutional transitions, and continued partnership that acknowledges building durable systems requires years of investment, not single project cycles.

The pathway exists because DIPC created it. Whether these foundations mature into sustained national digital health capacity depends on decisions and investments that governments, funders, and partners make in coming years. The evaluation evidence suggests this continued investment would

build upon a programme that has started to demonstrate its value and established the institutional, technical, and governance foundations necessary for success.

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Annex

Table 1. Demographic and Background Characteristics of Key Informants

Participant Characteristics	Country				Total
	Ghana n (%)	Malawi n (%)	Sierra Leone n (%)	Global n (%)	N (row)
Sex					
Male	15 (63%)	16 (73%)	18 (78%)	0 (0%)	49 (68%)
Female	9 (38%)	6 (27%)	5 (22%)	3 (100%)	23 (32%)
Sub-total, N (col)	24 (100%)	22 (100%)	23 (100%)	3 (100%)	72 (100%)
Age group					
18-24	0 (0%)	2 (9%)	0 (0%)	0 (0%)	2 (3%)
25-34	7 (29%)	4 (18%)	9 (39%)	0 (0%)	20 (28%)
35-44	11 (46%)	9 (41%)	9 (39%)	0 (0%)	29 (40%)
45-54	4 (17%)	6 (27%)	4 (17%)	1 (33%)	15 (21%)
55-64	2 (8%)	1 (5%)	1 (4%)	2 (67%)	6 (8%)
Sub-total	*24 (100%)*	*22 (100%)*	*23 (100%)*	*3 (100%)*	*72 (100%)*
Organisational Involvement					
Funders & Implementers	4 (17%)	1 (5%)	4 (17%)	3 (100%)	12 (17%)
National Level/Govt Level	5 (21%)	4 (18%)	3 (13%)	0 (0%)	12 (17%)
Regional/District Level	8 (33%)	8 (36%)	10 (43%)	0 (0%)	26 (36%)
Facility Level	7 (29%)	9 (41%)	6 (26%)	0 (0%)	22 (31%)
Sub-total	*24 (100%)*	*22 (100%)*	*23 (100%)*	*3 (100%)*	*72 (100%)*
Years of Professional Experience					
Less than 1 year	0 (0%)	2 (9%)	0 (0%)	0 (0%)	2 (3%)
1-5 years	4 (17%)	5 (23%)	6 (26%)	0 (0%)	15 (21%)
6-10 years	4 (17%)	2 (9%)	8 (35%)	0 (0%)	14 (19%)
11-15 years	5 (21%)	6 (27%)	4 (17%)	0 (0%)	15 (21%)
More than 15 years	11 (46%)	7 (32%)	5 (22%)	3 (100%)	26 (36%)
Sub-total	*24 (100%)*	*22 (100%)*	*23 (100%)*	*3 (100%)*	*72 (100%)*
Professional Role in relation to Digital Health					
Programme Manager/Coordinator	5 (21%)	3 (14%)	3 (13%)	1 (33%)	12 (17%)
Policy/Decision Maker	0 (0%)	3 (14%)	0 (0%)	0 (0%)	3 (4%)
Healthcare Provider/Clinician	3 (13%)	7 (32%)	4 (17%)	0 (0%)	14 (19%)
Public Health Professional	11 (46%)	3 (14%)	5 (22%)	0 (0%)	19 (26%)
Data Analyst/M&E Specialist	2 (8%)	1 (5%)	4 (17%)	0 (0%)	7 (10%)
Technical Specialist/IT Support/Developer	2 (8%)	2 (9%)	7 (30%)	0 (0%)	11 (15%)
Capacity Strengthening/Trainer	1 (4%)	1 (5%)	0 (0%)	1 (33%)	3 (4%)
Other	0 (0%)	2 (9%)	0 (0%)	1 (33%)	3 (4%)
Sub-total	*24 (100%)*	*22 (100%)*	*23 (100%)*	*3 (100%)*	*72 (100%)*
Experience with Information Communication technology (ICT) or Digitalization in Healthcare					
None	0 (0%)	1 (5%)	0 (0%)	0 (0%)	1 (1%)
Limited experience	1 (4%)	5 (23%)	1 (4%)	0 (0%)	7 (10%)
Moderate experience	16 (67%)	12 (55%)	18 (78%)	1 (33%)	47 (65%)
Expert level	7 (29%)	4 (18%)	4 (17%)	2 (67%)	17 (24%)
Sub-total	*24 (100%)*	*22 (100%)*	*23 (100%)*	*3 (100%)*	*72 (100%)*

Experience with Vaccine Logistics or the					
None	0 (0%)	3 (14%)	0 (0%)	0 (0%)	3 (4%)
Limited experience	2 (8%)	3 (14%)	3 (13%)	1 (33%)	9 (13%)
Moderate experience	12 (50%)	13 (59%)	14 (61%)	2 (67%)	41 (57%)
Expert level	10 (42%)	3 (14%)	6 (26%)	0 (0%)	19 (26%)
Sub-total	*24 (100%)*	*22 (100%)*	*23 (100%)*	*3 (100%)*	*72 (100%)*
Professional Role in DIPC					
Core team member, directly implementing	10 (42%)	8 (36%)	6 (26%)	3 (100%)	27 (38%)
Strategic decision-making/planning	1 (4%)	6 (27%)	4 (17%)	0 (0%)	11 (15%)
Technical/administrative support	7 (29%)	4 (18%)	12 (52%)	0 (0%)	23 (32%)
Occasional consultation or indirect role	2 (8%)	2 (9%)	1 (4%)	0 (0%)	5 (7%)
Not involved, but familiar with objectives	4 (17%)	2 (9%)	0 (0%)	0 (0%)	6 (8%)
Sub-total	*24 (100%)*	*22 (100%)*	*23 (100%)*	*3 (100%)*	*72 (100%)*