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

Report #4: Capacity Strengthening for Digital Tool Use

Evidence-Based Public Health| Centre for International Health Protection

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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

The integration of digital health technologies into health systems in Low- and Middle-Income Countries (LMICs) faces substantial workforce capacity challenges. WHO projects a global shortage of 10 million health workers by 2030, predominantly affecting LMICs, whilst simultaneously health systems must navigate digital transformation requiring new competencies and skills. Digital health literacy, encompassing information and data literacy, content creation, communication, problem-solving, and safety, has emerged as a foundational competency for health workforce effectiveness. However, studies document that only 43.6-67.4% of healthcare professionals in settings such as Ethiopia possess adequate digital health literacy, whilst research on digital literacy in healthcare remains substantially underrepresented in Africa, South America, and Asia, which are the regions most affected by digital literacy gaps.

Capacity strengthening interventions in LMICs have employed diverse training modalities with variable effectiveness. Cascade Training of Trainers (ToT) models represent a predominant approach for achieving scale with contained resource requirements, yet face inherent depth-reach trade-offs with concerns regarding skill dilution across training tiers. Systematic reviews document training effectiveness ranging from -19.9 to 60.8 percentage points (median 10.3), with single-occasion training without systematic follow-up yielding limited sustained impact. A critical challenge concerns sustainability beyond pilot phases, with most successful interventions remaining externally funded pilots with limited evidence of domestically-financed long-term implementations at scale.

The Digital Innovation in Pandemic Control (DIPC) initiative, launched by the German Federal Ministry for Economic Cooperation and Development (BMZ) through the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), implemented comprehensive capacity strengthening interventions across its partner countries as a foundational component enabling digital health system integration. In Ghana, Malawi and Sierra Leone, which are the partner countries in focus of this evaluation, the interventions employed cascade ToT models to achieve scale, combined practical hands-on training with workflow-oriented pedagogy, established district-level training capacity, and engaged stakeholders at multiple health system levels. Training focused on digital literacy, and digital immunisation platforms including DHIS2, MAHIS Electronic Immunisation Registry (EIR), and the enhanced DHIS2 eTracker, emphasising technical operation, data quality, reporting workflows, and problem-solving under resource constraints.

This report presents findings from RKI's independent process evaluation of DIPC's capacity strengthening interventions, examining relevance, implementation processes, and sustainability potential to generate actionable evidence for funders, implementers, national governments, and WHO as digital health initiatives expand globally.

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 comprehensive document reviews and 69 semi-structured key informant interviews with funders, implementation partners, government officials, district and regional public health officials, and facility-level healthcare providers and IT personnel from Ghana (n=24), Malawi (n=22), Sierra Leone (n=23), complemented by global-level stakeholders (n=3). The

sample was intentionally weighted towards health workers at facility (30%) and district/regional levels (36%) to capture implementation experiences.

Participants were purposively sampled to capture diverse perspectives across health system levels. Interviews lasted 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 aligned with the evaluation framework. The evaluation received ethical clearance from review boards in all participating countries.

Key Findings

Relevance

Capacity strengthening interventions demonstrated high relevance across all three contexts, with training content effectively addressing documented workforce development needs. Cascade ToT models successfully achieved rapid geographic coverage: Ghana trained approximately 1,400 staff from over 700 facilities within five weeks; Malawi covered 47-48 facilities with 1,200 health workers; Sierra Leone reached 44 peripheral health units across four districts. This efficiency demonstrates cascade training's capacity for large-scale workforce development with contained resource requirements, representing a significant accomplishment for resource-constrained health systems.

Curriculum design demonstrated strong alignment with operational requirements. The emphasis on hands-on, workflow-oriented pedagogy using authentic facility registers, live demonstrations, and practical drills reportedly built health worker confidence and initial competency. Stakeholder reports of immediate applicability to daily tasks confirmed that training content successfully addressed real workflow challenges rather than theoretical abstractions. Sierra Leone's evidence-informed sequencing of foundational digital literacy preceding technical tool training exemplified appropriate baseline needs assessment and context-responsive design, addressing documented minimal digital maturity through targeted foundational instruction.

However, evaluation findings revealed a significant limitation: two to three-day training durations achieved only activation-level competency, with health workers unable to perform tasks independently without ongoing support. This inadequacy is compounded for peripheral health workers who receive equivalent initial training but have substantially fewer opportunities for post-training practice due to infrastructure constraints, creating a self-reinforcing cycle of skill gaps. The training duration was consistently deemed insufficient for the complexity of competencies required. Subsequent to the evaluation, and in response to the remaining training needs, Digital Square developed instructional videos for MAHIS EIR and enhanced eTracker operations in Malawi and Ghana, which in our view is an innovative, resource-conscious response acknowledging that in-person refresher trainings are highly resource-intensive and often financially unsustainable for national governments.

Implementation Processes

Implementation processes revealed both significant achievements and valuable lessons for optimisation. The cascade ToT model functioned successfully across diverse contexts, demonstrating model adaptability and implementer accomplishment in contextual tailoring of capacity strengthening activities. The creation of district-level training capacity represents a particularly important accomplishment, establishing local technical expertise positioned for ongoing workforce support. Malawi's evidence of autonomous training expansion, wherein district trainers independently

onboarded additional facilities beyond initial implementation plans, illustrates successful capacity transfer and emerging local ownership.

Digital tool adoption patterns demonstrated encouraging progress alongside opportunities for enhancement. District-level adoption emerged as substantive across settings, with routine electronic Stock Management Tool and enhanced eTracker utilisation generating faster reporting cycles and earlier stock alerts, which are tangible operational improvements supporting programme management. This district-level success provides proof-of-concept that trained health workers can effectively integrate digital tools into routine workflows when enabling conditions exist.

However, findings revealed significant spatial heterogeneity in tool adoption, with peripheral facilities showing markedly more limited uptake than district-level counterparts. This pattern reflects well-documented dynamics wherein infrastructure availability mediates technology adoption. The infrastructure-adoption relationship creates a compounding disadvantage for peripheral health workers: inadequate equipment not only directly limits digital tool utilisation but also restricts opportunities for hands-on practice and skill consolidation. Consequently, health workers in remote, poorly-equipped facilities receive equivalent initial training yet have substantially fewer opportunities to apply and reinforce newly acquired competencies through routine use.

Infrastructure constraints, including unreliable devices, intermittent power, limited connectivity, emerged as primary implementation barriers for training delivery and skills adoption, necessitating hybrid paper-digital workflows. Documented district-level success that in some settings were under more favourable infrastructure conditions demonstrates training's potential effectiveness; peripheral constraints highlight infrastructure as the limiting factor requiring attention. Additional implementation barriers included: non-institutionalised refresher mechanisms; thin irregular supervision often terminating at facility in-charge level; skill concentration among limited facility staff creating vulnerability during staff turnover; and partner-funding dependency threatening continuity.

Stakeholder-articulated recommendations converged on actionable improvements: scheduled refreshers, district-anchored peer coaching, comprehensive facility coverage, curriculum expansion to encompass data quality and analytics, and infrastructure assurance. The specificity and consistency of these recommendations across contexts provide valuable guidance for intervention enhancement. Notably, stakeholders advocated strengthening rather than redesigning the cascade model, suggesting core approach validity with opportunities for optimisation.

Sustainability

Sustainability assessments revealed promising foundations alongside clear requirements for consolidation. The evaluation identified several positive sustainability indicators: functioning cascade training mechanisms, established district-level technical capacity, evidence of local ownership and autonomous expansion (particularly in Malawi), and documented operational improvements motivating continued use. Malawi's Ministry of Health stewardship model with reverse-billing innovation and district-managed onboarding exemplified promising governance approaches demonstrating local ownership principles. Ghana's Ghana Health Service digital health leadership structures and Sierra Leone's Ministry of Health hands-on engagement similarly indicated government commitment, essential prerequisites for sustained implementation.

Sustainability prospects assessed across contexts reflect realistic acknowledgement that consolidating initial achievements requires transitioning from episodic partner-supported implementation of training activities to institutionalised government-owned systems. This transition challenge is well-

documented in LMIC digital health literature, where externally-funded pilot programmes frequently struggle to achieve sustained domestic financing and scale. The evaluation's documentation of this challenge provides important evidence for funders and policymakers regarding investment requirements beyond initial implementation. Findings indicate that successful initial capacity building requires complementary governance institutionalisation, financing transitions, and innovative solutions for capacity strengthening scale-up and refreshers to consolidate gains.

Stakeholder recommendations regarding governance and financing clarity converged on government assumption of core operational costs whilst partners support acceleration and infrastructure investment, reflecting established public-private collaboration frameworks. Ghana's recommendation for diversified financing with Ghana Health Service assuming core costs, Malawi's emphasis on embedding training within routine structures, and Sierra Leone's call for Ministry of Health-led training cycles all articulated similar governance principles: institutional ownership, predictable financing, and clear accountability mechanisms.

Recommendations

On Relevance:

R1: Implement Multi-Tiered Training Duration Based on Role Complexity and Infrastructure Context

- Differentiate training duration by role: 5-7 days for district super-users and facility champions; 3-4 days for frontline staff with mandatory follow-up within 2-4 weeks
- Design extended training for peripheral facility staff to compensate for limited practice opportunities
- Conduct pre-training digital literacy assessments to identify workers requiring foundational skills training

R2: Establish Institutionalised Continuous Learning Systems with Multi-Modal Delivery

- Institutionalise mandatory quarterly refresher cycles with government ownership, incorporating progressive curriculum
- Deploy multi-modal resources: instructional videos, visual job aids, WhatsApp/SMS micro-learning, offline-accessible materials
- Expand curriculum to include data quality principles, dashboard interpretation, and statistical literacy

On Implementation Processes:

R3: Adopt Integrated Socio-Technical Investment with Concurrent Infrastructure and Training Deployment

- Mandate infrastructure readiness before training: functional devices (minimum 1:3 staff ratio), reliable power with backup, connectivity or demonstrated offline functionality
- Implement equity-focused distribution prioritising peripheral facilities: solar solutions, ruggedised devices, robust offline systems
- Establish predictable maintenance, repair, and replacement protocols with government ownership

R4: Establish District-Level Technical Support Hubs with Formalised Super-User Networks

- Formalise district digital health technical support roles with clear terms of reference and dedicated time allocation (minimum 25% workload)
- Establish peer coaching systems: scheduled monthly site visits, virtual check-ins, responsive technical assistance
- Develop district dashboards to monitor facility adoption, identify declining usage, and track technical issues

R5: Implement Equity-Focused Strategies Ensuring Inclusive Reach

- Adopt equity-explicit planning: geographic targeting prioritising remote facilities, transparent quarterly equity indicators, remediation protocols
- Design peripheral-specific interventions: more intensive initial training, more frequent supervision, prioritised offline-accessible resources
- Ensure inclusive participation: gender-balanced cohorts, local language materials, visual-heavy pedagogy

On Sustainability:

R6: Institutionalise Government-Led Governance and Sustainable Financing Frameworks

- Formalise ownership through Memoranda of Understanding defining operational responsibilities: Ministries assume recurrent training costs, infrastructure maintenance, connectivity, and supervision integration
- Embed digital health training in pre-service curricula and routine in-service structures
- Establish dedicated government budget lines with transparent allocation processes and accountability mechanisms

R7: Deploy Scalable Digital Learning Resources and Institutionalise Quality Assurance

- Develop comprehensive digital resource libraries: instructional videos in local languages, visual job aids, FAQ databases, self-assessment quizzes—all offline-accessible
- Implement quality assurance: standardised trainer competency assessments, structured observation, post-training assessments, six-month follow-up evaluations
- Establish national training registries documenting coverage, enabling identification of gaps and quality variations

Conclusion

DIPC's capacity strengthening interventions demonstrate that well-designed cascade training can successfully achieve substantial geographic reach and catalyse initial digital health system adoption in resource-constrained LMIC settings. The interventions accomplished significant milestones: training approximately 3,600 health workers across more than 800 facilities within compressed timeframes, developing contextually-relevant curricula addressing authentic operational workflows, establishing district-level technical capacity, and generating documented operational improvements including faster reporting cycles and earlier stock alerts.

The remarkable convergence of stakeholder recommendations across three diverse contexts—continuous learning systems, district-anchored technical support, concurrent infrastructure investment, comprehensive facility coverage, and governance-financing clarity—provides strong evidence that these represent fundamental rather than context-specific requirements for digital health workforce development in LMICs. The consistency of findings with published implementation science literature strengthens confidence in the generalisability of evaluation insights beyond the three countries assessed.

However, progression to sustained, equitable adoption requires addressing systemic gaps: abbreviated training duration insufficient for skill consolidation, infrastructure deficits limiting practice opportunities, non-institutionalised refresher mechanisms, and unclear governance-financing transitions. These findings reflect implementation realities in diverse LMIC contexts, illuminating enabling conditions required for success.

The evaluation contributes important empirical evidence that digital health workforce development requires integrated approaches addressing training alongside infrastructure investment, supervision strengthening, governance institutionalisation, and sustainable financing. The DIPC experience demonstrates that achieving this integration is both feasible and essential—feasible because documented successes prove that well-designed interventions can function effectively even in challenging contexts; essential because isolated capacity building without complementary system investments yields incomplete and potentially inequitable outcomes. The foundation has been established; sustained commitment addressing the identified gaps will determine the ultimate contribution to digital health transformation in LMICs.

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).

Digital Health Workforce Development Imperatives in LMICs

DIPC's capacity strengthening interventions across partner countries represented a critical programme component recognising that successful digital health implementation fundamentally depends on workforce readiness and institutional capacity. This component forms the focus of this evaluation report.

The integration of digital technologies into health systems in LMICs faces substantial human resource challenges. WHO projects a global shortage of 10 million health workers by 2030, predominantly affecting LMICs (Long et al., 2018), whilst simultaneously, health systems must navigate the complexity of digital transformation requiring new competencies and skills. Digital health literacy, which encompasses information and data literacy, content creation, communication, problem-solving, and safety, has emerged as a foundational competency for health workforce effectiveness in the digital age (Arias López et al., 2023). However, studies from Ethiopia document that only 43.6-67.4% of healthcare professionals possess adequate digital health literacy (Kasaye et al., 2024; Moges et al., 2024), whilst research on digital literacy in healthcare remains substantially underrepresented in Africa, South America, and Asia, the regions that are likely most affected by digital literacy gaps.

The imperative to strengthen digital health capacity is amplified by persistent infrastructure constraints and resource limitations characteristic of LMIC health systems. Systematic reviews document that infrastructure deficits including unreliable devices, intermittent power supply, and limited connectivity represent primary barriers to digital health implementation (Yew et al., 2025; Qureshi et al., 2013; Adeloye et al., 2017). Inadequate infrastructure forces health workers to maintain parallel paper-digital workflows, negating efficiency gains and increasing workload burden. Moreover, competition for resources between information technology equipment and other healthcare priorities creates tension in resource allocation decisions (Qureshi et al., 2013). In this context, capacity strengthening interventions must address not only technical skill development but also adaptive problem-solving competencies enabling health workers to function effectively under resource-constrained conditions.

Training Approaches and Effectiveness Evidence

Capacity strengthening interventions in LMICs have employed diverse training modalities with variable effectiveness. Cascade Training of Trainers (ToT) models, wherein a core group receives intensive

training and subsequently trains others, represent a predominant approach for achieving scale with contained resource requirements (Crisp & Raven, 2016). Evidence from LMIC settings demonstrates that cascade models can achieve substantial geographic coverage: for instance, mass training interventions in Pakistan trained over 15,000 community healthcare workers within three months using hierarchical trainer networks (Muhammad et al., 2024). However, cascade models face inherent depth-reach trade-offs, with concerns regarding skill dilution across training tiers and quality inconsistencies as training cascades to peripheral levels (Crisp & Raven, 2016).

Systematic reviews of training effectiveness in LMICs reveal highly variable impact. A comprehensive review of 101 studies documented training effectiveness ranging from -19.9 to 60.8 percentage points, with a median of 10.3 percentage points (Rowe et al., 2021). Training modalities demonstrate differential effectiveness: educational outreach visits outperform in-service training, which in turn exceeds peer-to-peer training and self-study approaches (Rowe et al., 2021). Importantly, training effectiveness increases substantially when incorporating clinical practice opportunities, delivering training at work sites, and combining training with supportive supervision (Rowe et al., 2021; Botha et al., 2025). Single-occasion training without systematic follow-up yields limited sustained impact, with evidence documenting skill degradation within months absent reinforcement mechanisms (Karvande et al., 2024; Abdel-All et al., 2017).

Sustainability and Scale-Up Challenges

A critical challenge for digital health capacity strengthening in LMICs concerns sustainability beyond pilot phases. Systematic reviews identify that most successful digital health interventions remain externally funded pilots, with limited evidence of domestically-financed long-term implementations at scale (Campbell et al., 2025; Verhey et al., 2020). The phenomenon of "pilotitis", wherein promising pilot projects fail to transition to sustained national programmes, reflects broader challenges of governance institutionalisation, sustainable financing, and transition from partner-dependency to government ownership. Sustainability requires not only initial capacity building but also institutionalised continuous learning mechanisms, supportive supervision systems, and predictable financing for refresher training and ongoing technical support (Witter et al., 2022).

Evidence suggests that sustainable capacity strengthening requires multi-component strategies combining initial training with continuous on-the-job support, regular supervision, and quality assurance mechanisms (Upadhyay et al., 2023; Udeh et al., 2022). A proposed six-step approach for sustainable capacity includes: pre-training screening to assess baseline competencies, ToT with rigorous assessment, staggered induction allowing mentorship, continuous support through district-level resources, quality assessment identifying training needs, and virtual refreshers reducing resource intensity (Karvande et al., 2024). Positioning district health management teams as accessible first-line technical support has proven effective in reducing perceived effort and increasing technology acceptance whilst ensuring locally-contextualised assistance (Longhini et al., 2022; Borges do Nascimento et al., 2023).

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.

DIPC's Capacity Strengthening Approach

Recognising these imperatives and challenges, DIPC implemented comprehensive capacity strengthening interventions across Ghana, Malawi, and Sierra Leone as a foundational component enabling digital health system integration. The interventions employed cascade ToT models to achieve scale, combined practical hands-on training with workflow-oriented pedagogy, established district-level training capacity for ongoing support, and engaged stakeholders at multiple health system levels—from national programme managers to facility-level health workers. Training focused on digital immunisation platforms including DHIS2, MAHIS Electronic Immunisation Registry (EIR), and enhanced eTracker, emphasising not only technical operation but also data quality, reporting workflows, and problem-solving under resource constraints.

The capacity strengthening interventions were implemented in partnership with Digital Square and UNICEF, adapting training approaches to country-specific contexts whilst maintaining core design principles. Ghana and Malawi focused on MAHIS EIR and enhanced eTracker respectively, whilst Sierra Leone integrated foundational digital literacy training preceding technical tool instruction—an evidence-informed sequencing responding to documented minimal baseline digital maturity. Training durations ranged from 2-3 days in Ghana to 3-5 days in Sierra Leone and Malawi, with cascade models progressing from national-level master trainers through district trainers to facility-level health workers. The interventions aimed not only to build individual competencies but also to establish sustainable training systems with local ownership positioned for ongoing workforce development beyond external partner support.

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, 2023), 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

Overall Process Evaluation

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.

Evaluation of DIPC's Capacity Strengthening Interventions

Within the broader DIPC evaluation, assessing capacity strengthening interventions holds particular significance for understanding digital health implementation feasibility in resource-constrained settings. Whilst normative guidance on digital health workforce development exists (Long et al., 2018; WHO, 2021), empirical evidence on training effectiveness, optimal implementation modalities, and realistic sustainability pathways in diverse LMIC contexts remains limited. Systematic reviews document highly variable training effectiveness and identify that most successful interventions remain externally-funded pilots with uncertain long-term sustainability (Rowe et al., 2021; Campbell et al., 2025; Verhey et al., 2020). Critical evidence gaps persist regarding: optimal training duration and pedagogy for complex digital health competencies, effectiveness of cascade models across diverse infrastructure contexts, requirements for transitioning from partner-supported implementation to government-owned sustainable systems, and strategies for ensuring equitable capacity development reaching peripheral facilities alongside district-level tiers.

DIPC's capacity strengthening interventions provide an important opportunity to generate empirical evidence addressing these gaps. The multi-country implementation across Ghana, Malawi, and Sierra Leone—contexts with substantial variation in digital health maturity, infrastructure availability, and health system organisation—enables assessment of how training approaches perform under diverse conditions and what contextual factors mediate effectiveness. The cascade ToT model employed represents one of the most common approaches for achieving scale in LMICs, yet concerns regarding quality dilution and sustainability persist (Crisp & Raven, 2016; Muhammad et al., 2024). Rigorous evaluation documenting implementation processes, immediate outcomes, barriers, facilitators, and stakeholder perspectives can inform both DIPC programme refinement and broader understanding of digital health capacity strengthening best practices.

This evaluation addresses crucial questions: Are cascade training models effective for building complex digital health competencies, or do depth-reach trade-offs compromise skill consolidation? What

training durations and pedagogical approaches prove sufficient for independent operational competency versus requiring ongoing support? How does infrastructure availability mediate training effectiveness and adoption patterns? What mechanisms enable transition from partner-dependent episodic training to government-owned continuous learning systems? How can capacity strengthening interventions ensure equitable reach to peripheral facilities facing resource constraints? By systematically examining these questions through multi-level stakeholder engagement, this evaluation generates actionable evidence for funders, implementers, national governments, and WHO as digital health initiatives expand globally. The findings contribute important empirical data to implementation science whilst providing practical guidance for strengthening workforce development strategies in diverse resource-constrained settings.

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 DIPC's capacity strengthening interventions for digital tool use in three of the five partner countries: Ghana, Malawi, and Sierra Leone.

The evaluation examines the extent to which training and capacity development approaches aligned with country contexts, workforce needs, and digital literacy levels (relevance); the factors that facilitated or constrained effective skill transfer and sustained competency development (implementation processes); and the potential for institutionalising continuous learning systems supporting autonomous workforce development (sustainability). Drawing on qualitative data from key informant interviews with health workers, trainers, supervisors, and programme managers, alongside document review of training materials and implementation reports, the report synthesises empirical evidence on capacity strengthening approaches across diverse country contexts. The findings and recommendations are intended to inform future digital health workforce development strategies, contributing to the evidence base on effective approaches for building sustainable digital health capacity 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.

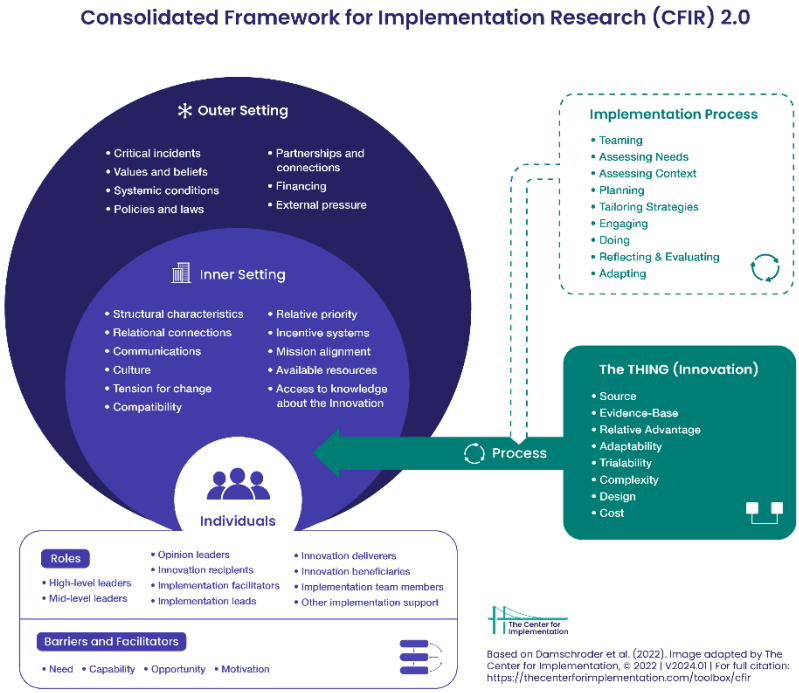

Figure 1. Consolidated Framework for Implementation Research (CFIR) 2.0 (based on Damschroder et al. (2022, adopted from The Centre for Implementation, 2022).

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 (DEAs) and National Digital Health Roadmap (NDHRM)

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) familiarization 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

- Digital Literacy and Digital Tool Use Capacity Strengthening Activities provided 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.

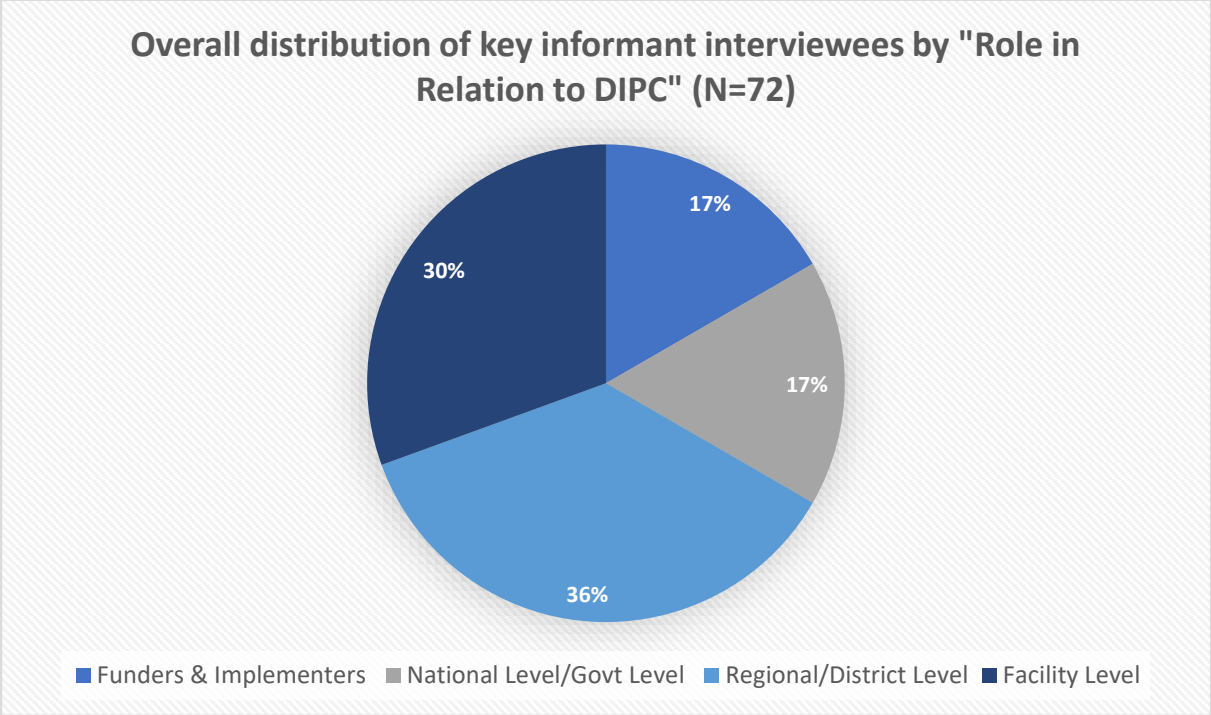

Figure 2. Proportion of Key Informants by "Role in relation to DIPC"

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 LITERACY AND DIGITAL TOOLS TRAINING RESPOND TO TARGET GROUP NEEDS, AND ALIGN WITH POLICIES, AND PRIORITIES?

2. IMPLEMENTATION PROCESSES:
HOW DID THE DIGITAL LITERACY AND DIGITAL TOOLS TRAINING 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 DIGITAL LITERACY AND DIGITAL TOOLS TRAINING HAVE POTENTIAL FOR SUSTAINABILITY?

TO WHAT EXTENT HAS THE DIGITAL LITERACY AND DIGITAL TOOLS TRAINING BEEN DESIGNED FOR CONTINUATION OF EFFORTS ONCE ASSISTANCE THROUGH THE PROJECT CEASES IN THE PARTNER

4.1 Ghana

4.1.1 Situation Before DIPC

Prior to DIPC, Ghana's immunisation data systems operated predominantly through paper-based workflows at all administrative levels. Health workers maintained multiple bulky age-segmented registers, conducting manual tallies at month-end that generated delayed, error-prone data. Early digital platforms (eTracker, GHLIMS) existed but had significant weaknesses: frequent downtime, outdated devices, connectivity failures, and data loss necessitated parallel paper-digital systems. Single shared tablets per facility were common.

According to stakeholder reports, data quality challenges were pervasive, which was apparent in form of inconsistencies, duplication, and unverified figures, which in turn undermined accountability. Weak feedback loops between levels and limited supervisory capacity meant discrepancies often went unaddressed. Front-line health workers explained that operational burdens included substantial time expenditures locating register entries, transporting ledgers to outreach sites, and reconciling discrepancies, with minimal analytical data utilisation for programme decisions.

4.1.2 Structure of Training

Training Model: Ghana implemented a cascade approach commencing with national Training of Trainers (ToT) in Kumasi, engaging Ghana Health Service (GHS) units (EPI, PPME, CHIM), regional focal persons, and the DIPC technical implementation partners (PATH, HISP Ghana). Training cascaded through regional, district, and facility levels.

Curriculum: Two to three-day sessions combined brief theoretical content (rationale for digitisation, data quality principles) with intensive hands-on practice using laptops and tablets. The training content addressed authentication, password management, synchronisation, offline-online transitions, and first-line troubleshooting. Pedagogy emphasised live demonstrations and practical drills with authentic facility registers, including role-play of client enrolment, dose recording, stock verification, and dashboard navigation.

Participants: Training encompassed community/public health nurses, enrolled nurses, midwives, physician assistants, disease control officers, health information officers, district teams, and selected community volunteers. In Volta Region alone, approximately 1,400 staff from over 700 facilities were trained within five weeks through small classes and rotating district sessions.

Post-Training Support: On-site mentoring and small-group coaching were provided, though application instability required some sessions to utilize web-based platforms. Delays between training completion and system activation due to data migration and device procurement underscored the need for periodic refreshers.

4.1.3 Relevance

Alignment with Priorities and Policies

Training interventions demonstrated strong operational alignment with GHS priorities. The cascade model mirrored GHS governance structures and integrated with established supervision, monitoring and evaluation, and DHIS2 routines, directly supporting core priorities of service delivery improvement, reporting accuracy, and data availability for decision-making. Facility and district-level respondents characterised alignment in practical terms, making work easier, recording correctly,

delivering digital services, which indicates that convergence occurred through existing supervisory channels rather than explicit policy reference. National and implementer stakeholders framed priorities as system strengthening and scale-up, with DIPC resources bridging identified funding and technical gaps through pragmatic cost-sharing arrangements.

However, the findings indicate that the alignment was only partially perceived especially regarding longer-term priorities: substantial dependence on external resources for refreshers and mentoring constrained sustainability prospects; equity and digital inclusion received limited explicit priority-setting, with participation patterns largely reflecting existing workforce distributions rather than deliberate targeting of underserved groups or facilities. Interview evidence indicates solid operational alignment facilitating implementation feasibility, whilst strategic alignment with equity, inclusion, and sustained domestic capacity objectives remained underdeveloped and requires deliberate attention in future programming.

Response to Target Group Needs

Training interventions demonstrated high responsiveness to operational needs, with curriculum directly addressing essential daily tasks including client enrolment, dose recording, stock verification, and synchronisation. The hands-on, workflow-based pedagogical approach using authentic facility registers within small group settings effectively built confidence and initial competency, with respondents identifying practical demonstrations and immediate application as particularly valuable. Post-training support mechanisms**,** namely on-site mentoring, peer learning networks, and accessible troubleshooting, were identified as critical enablers for immediate uptake.

However, the cascade model's two to three-day format achieved geographic reach at the cost of skill consolidation, with insufficient depth for independent mastery absent scheduled refreshers. Critically, training value proved substantially mediated by enabling environment factors: inadequate device-to-staff ratios, unreliable connectivity, delays between training completion and system activation, and staff turnover prevented routine skill application essential for competency retention. Whilst training design intentionally engaged diverse cadres, existing workforce imbalances resulted in uneven participation despite inclusive intent. Interview evidence indicates that curriculum quality alone proved insufficient; realised responsiveness required concurrent infrastructure readiness and institutionalised continuous learning mechanisms sustaining competencies beyond initial activation.

Stakeholder Engagement in planning and implementation

Stakeholder engagement demonstrated appropriate institutional configuration at system level, with GHS units (EPI, PPME/CHIM) providing strategic direction alongside regional focal persons and district teams, supported by implementing partners (PATH/Digital Square, HISP Ghana, GIZ) during planning and initial delivery phases. The selection of frontline trainees composition was reportedly broadly operationally appropriate, encompassing community and public health nurses, disease control officers, nutrition staff, and health information officers, all of which are cadres directly engaged in immunisation workflows.

At the same time, the actual engagement depth within facilities revealed limitations: facility-level respondents reported that typically only two to three staff per site received comprehensive training and remained actively engaged, with colleagues acquiring competencies informally through peer "brush-throughs" rather than structured instruction. Inclusion efforts incorporated mixed-cadre groups and gender balance considerations, yet respondents identified uneven digital confidence at baseline, particularly among some female health workers. Critically, supervision continuity and

refresher provision remained substantially dependent on external partner presence and funding rather than institutionalised GHS mechanisms. Evidence indicates that whilst system-level stakeholder architecture was perceived as sound, facility-level engagement depth, practical inclusion equity, and autonomous capability maintenance require strengthening to enable sustainable knowledge acquisition and retainment.

4.1.4 Implementation Processes

Perceived Value

Respondents consistently attributed enhanced eTracker operationalisation to training interventions, with stakeholders across health system levels linking sessions directly to operational improvements including accelerated client processing, reduced transcription errors, improved defaulter tracing, and enhanced dashboard utility. Interviewees described observable behavioural shifts wherein health workers demonstrated increased digital confidence and adopted more data-driven workflow practices following training. Notably, training value extended beyond formal participants through peer coaching mechanisms and informal knowledge transfer, which enabled skill dissemination to colleagues not attending structured sessions.

Having said that, the value that respondents assigned to the training activities was at the same time also constrained by certain system-level factors external to training quality. As such, mandatory parallel paper-digital workflows, that were required to ensure limited data loss during the transition period, was perceived as negating efficiency gains. Moreover, inadequate device availability and unreliable connectivity limited routine practice opportunities and frequent staff turnover reportedly poses a high risk for eroding facility-level competency. Respondents emphasised that sustained value required light but regular refreshers, accessible on-site mentoring, and first-line troubleshooting support to consolidate skills and address degradation over time.

Enablers and Facilitating Factors

Multiple enabling conditions facilitated training uptake and early consolidation:

Institutional Architecture: The cascade model demonstrated coherent coordination from national through regional, district, to facility levels, mirroring established GHS governance structures. GHS units led delivery logistics whilst regions and districts organised sessions and co-facilitated instruction, establishing clear institutional ownership.

Pedagogical Approach: Hands-on, small-group practice helped to build confidence and operational competence. Training integrated digital skills with familiar EPI and stock management concepts, improving data utilisation rather than imposing disconnected technical content. Adaptive support mechanisms, including on-site coaching, virtual refreshers via WhatsApp, accessible troubleshooting sustained skills between formal sessions, with peer learning extending coverage beyond formal trainees.

Motivation and Resourcing: Visible operational utility (e.g., faster reporting and improved stock visibility) reinforced health workers' motivation by demonstrating tangible workflow improvements. Partner financing through DIPC/GIZ bridged critical resource and logistics gaps.

Evidence indicates that national stewardship, local institutional ownership, adaptive ongoing support, and partner resource bridging enabled rapid uptake, contingent on continuation of these enabling conditions.

Challenges and Barriers to Implementation

A key finding was that health workers were reportedly frequently limited by external system-level constraints rather than training related factors, when trying to apply their acquired skills into routine practice. We were able to decipher the following specific barriers and challenges from key informant accounts:

Infrastructure Deficits: Many facilities operated with single, faulty, or outdated tablets. Data bundles were not guaranteed, with staff reported using personal airtime to cover costs. Connectivity was another unreliable factor, forcing offline data entry and delayed synchronisation. Technical limitations including offline/web client issues required workarounds undermining efficiency.

Implementation Process Barriers: Extended delays between training completion and system activation caused skill degradation. Mandatory parallel paper-digital workflows persisted, which often negating efficiency gains despite the training.

Governance and Support Limitations: User permissions were reportedly unclear, which limited functionality. Inadequate first-line help-desk capacity at district level constrained troubleshooting access. In some cases, curtailed regional monitoring rights prevented supervisors from viewing facility-level performance. DHIS2 interoperability remained incomplete, perpetuating data duplication despite specifications having been developed under the DIPC initiative.

Sustainability Constraints: Funding for refresher training or structured induction cycles was not (sufficiently) allocated to address skill drop-off or staff turnover. Training remained episodic and partner-funded rather than continuous and government-financed.

Stakeholder-Proposed Solutions: Interviewees raised recommendations to address the identified challenges. Those included to guarantee device and data packages at training; institutionalise scheduled refreshers with domestic financing; restore monitoring rights and strengthen help-desk capacity; reduce intervals between training and deployment;

Remaining Gaps

Training design exhibited specific limitations requiring attention in future implementations. The two to three-day duration was perceived as not sufficient for skill consolidation, achieving activation-level competency but not independent mastery. The training curriculum did not adequately differentiate instruction based on baseline digital literacy variations, with uneven digital confidence among health workers and this persisted post-training. Interviewees raised that the training content focused primarily on technical operation rather than expanding to data quality verification, basic analytics, or advanced troubleshooting, all of which were competencies stakeholders identified as necessary for sustainable use. Training coverage was perceived as narrow within facilities, whilst national stakeholders and implementers suggested that budget constraints limited attendance. District and facility level stakeholders in turn noticed that many sites were left with only two to three trained staff and key cadres were reportedly sometimes entirely missed. This reportedly creates vulnerability, when trained staff are absent or turnover of staff leaves facilities without personnel skilled at using the enhanced eTracker.

4.1.5 Sustainability

Evidence of Adoption

Adoption evidence reflects primarily a small number of active pilot sites. Within these pilots, respondents reported routine enhanced eTracker utilisation for immunisation data entry, dashboard monitoring, and defaulter tracing, with skills progressively strengthening through cascade training and informal on-the-job coaching. GHS quickly assumed ownership of training delivery, logistics, and first-line troubleshooting support. Stakeholders documented operational benefits including accelerated reporting cycles, improved data timeliness and quality, and actionable insights for stock management and defaulter follow-up. However, adoption beyond pilot sites remained incomplete and uneven: some regions had not commenced implementation; parallel paper-based workflows persisted; device and data availability gaps constrained consistent use; staff turnover eroded facility-level capacity. Evidence indicates that adoption proved genuine where enabling conditions existed, specifically predictable refresher training and on-boarding for new staff, assured device and data packages at point of use, and sustained supervisory and peer support. Scaling adoption beyond pilot sites requires systematically establishing these enabling conditions across all implementation settings rather than maintaining dependence on partner-intensive pilot support models.

Potential for Sustainability

The findings suggest that the sustainability of capacity strengthening efforts is certainly achievable but conditional on institutionalising key mechanisms. The cascade training model demonstrates clear viability: GHS possesses capacity to deliver training independently through existing structures. Cross-cadre coverage created some redundancy that could buffer against some level of staff turnover, and peer support networks reportedly already function informally at district level. National respondents identified a credible pathway to embed content within Mid-Level Management training curricula, though integration remains emergent.

However, durability depends less on initial training expansion than on routine operational mechanisms. These include calendared refresher cycles aligned with deployment timelines, structured on-boarding for new staff, designated peer trainers with protected time, and regular supervision incorporating digital health monitoring. Stakeholders emphasised that sustainability requires a basic "facility package": functional tablets, assured data connectivity, and stable application performance. Single-entry workflows must replace parallel paper systems to prevent duplication burden.

Financing sustainability requires progressive cost transfer. Core operational expenses including device replacement, data bundles, and technical support must shift into routine GHS budgets. Partner resources should accelerate scale-up rather than subsidise essentials. Primary risks include device procurement delays, staff turnover, external funding discontinuities, and uneven peripheral coverage.

If these practical enablers are institutionalised, the foundation exists for sustained implementation. Without such mechanisms, acquired skills and adoption patterns will likely erode over time.

Stakeholder Recommendations

Stakeholders across all health system levels converged on consistent recommendations for strengthening capacity building interventions. Their recommendations articulate a coherent vision: a continuous, practice-centred, district-anchored capacity building model, adequately resourced to translate training into routine, resilient digital health system use.

Institutionalise Continuous Learning: Replacing one-off courses with scheduled refresher cycles and rapid on-boarding mechanisms to offset staff turnover.

Enhance Practical Content: Extend hands-on practice time and incorporate explicit troubleshooting modules addressing everyday technical issues that currently stall system use. Training should equip users to resolve common problems independently rather than requiring external support for routine challenges.

Position Support Proximal to Users: Districts should function as first-line help desks, providing brief, frequent coaching rather than episodic facility visits. This positioning reduces access barriers and ensures contextually informed, timely assistance.

Ensure Comprehensive Coverage and Infrastructure Readiness: Train all facility cadres rather than relying on limited "champions" vulnerable to turnover. Concurrently guarantee basic enablers at point of training: functioning tablets, reliable connectivity, and small data budgets enabling immediate practice and routine use.

Clarify Financing and Scale-Up Planning: Core operational costs including refreshers, device replacement, and data bundles should shift progressively into GHS budgets, with partner resources accelerating scale-up rather than subsidising essentials. Regional monitoring access should be restored, and national modular training packages integrated within existing structures such as Mid-Level Management curricula to ensure predictable, domestically financed delivery.

4.2 SIERRA LEONE

4.2.1 Situation Before DIPC

Pre-DIPC, Sierra Leone's immunisation data infrastructure exhibited extreme fragmentation and minimal digital maturity across all health system levels. At facility level, vaccine data remained almost entirely paper based. Staff maintained multiple ledgers and couriered forms to districts, with frequent data loss, delays, and discrepancies. Most peripheral health unit (PHU) staff possessed little or no computer experience. Data entry and analysis occurred at district level rather than point of care, limiting facility ownership and real-time data utilisation. Devices, electricity, and connectivity were scarce or non-functional, with negligible maintenance capacity.

District operations involved heavy manual aggregation from PHUs using outdated or broken computers with unreliable electricity. Earlier digital tools including DVDMT, DHIS2, and Excel existed, but usage proved inconsistent and difficult to sustain beyond project funding cycles. Digital skills varied substantially, with marked gaps between district offices and peripheral facilities.

Nationally, governance and infrastructure remained fragmented. Multiple parallel partner-driven tools operated without interoperability. Procurement systems were donor dependent and often not locally maintainable. Reporting logistics proved costly and slow. Even where DHIS2 existed, weak interoperability and limited technical capacity constrained data quality and utilisation.

The system functioned as fragmented, manual, and under-resourced, with isolated pockets of readiness but low overall digital maturity. This context established clear rationale for DIPC's foundational approach: basic digital literacy training, infrastructure stabilisation, and alignment with a more coherent DHIS2-anchored governance model.

4.2.2 Structure of Training

Dual-Strand Approach: Training comprised two sequential strands: foundational digital literacy (computer basics, troubleshooting) followed by electronic Stock Management Tool (eSMT) implementation with light Bottleneck Analysis (BNA) and scorecard orientation. This sequencing addressed documented baseline digital literacy deficits.

Delivery Model: Cascade progression from national ToT to District Health Management Teams (DHMT), then district-led sessions for selected PHUs, combining regional workshops with on-site coaching. Curriculum emphasized practical competencies: account management, stock receipts/issues, physical counts, vaccine vial monitor/temperature logging, basic DHIS2 reporting, and simple technical fixes.

Methods and Participants: Three to five-day sessions employed hands-on practice, pre/post assessments, live demonstrations, job aids, and WhatsApp/peer follow-up. Primary learners were PHU in-charges and EPI focal persons (approximately two per site) plus DHMT supervisors, prioritising foundational digital threshold attainment for lower-cadre staff.

Reach: Phase one covered 44 PHUs across four districts with concurrent device provision. Additional procurement (56 laptops) supported 2025 scale-up. Coaching visits triggered initial routine eSMT utilisation in several facilities.

4.2.3 Relevance

Alignment with National Priorities

The evaluation findings suggest that the training interventions in Sierra Leone aligned clearly with national priorities. The capacity strengthening package, comprising basic digital literacy, troubleshooting, and eSMT implementation, directly supports Government of Sierra Leone's paper-to-digital transformation agenda. The cascade model from national trainers through districts to facilities matches the health system's decentralisation framework.

At operational levels, alignment appeared in practice rather than policy language. Facility and district respondents described concrete improvements: better data quality, faster vaccine reporting, and increased DHMT supervision. These outcomes reflect national digital health strategy objectives translated into daily work.

However, two gaps emerged. First, output coverage was strong, with user accounts created, devices issued to target facilities and district health management teams, and staff were trained. However, independent, consistent tool use remained reportedly uneven. District and facility respondents indicated that sustained use required periodic refreshers and mentoring beyond initial training. Second, frontline staff experienced practical benefits but rarely connected them to formal national strategies. Equity objectives prominent at national level proved less visible in routine facility monitoring.

As such, findings suggest that alignment is strong in intent and in early results. However, consolidation requires shifting from coverage metrics to measuring actual competency and routine use. Structured refreshers must be embedded within district supervision cycles. This ensures that initial alignment translates into sustained practice through government systems rather than continued partner support.

Responsiveness to Target Group Needs

Training interventions demonstrated high relevance to documented digital literacy deficits. A national landscape assessment identified 11 priority competency areas, with basic computer literacy and basic troubleshooting flagged as critical gaps among frontline workers. DIPC's sequential approach, foundational digital literacy preceding technical eSMT training, proved appropriate for baseline conditions. Facility-level respondents reported immediate practical gains: enhanced confidence, reduced errors, and smoother vaccine stock workflows. This alignment between training content and operational requirements confirms strong responsiveness to documented beneficiary needs.

However, relevance proved partial regarding depth and skill differentiation. Short-duration courses provided solid introductions for most participants but achieved only surface-level learning for some cadres, particularly lower-cadre or less digitally experienced staff. Higher-order competencies including advanced troubleshooting and basic data analysis remained largely unmet. Training design intentionally included older and lower-cadre staff to ensure foundational threshold attainment. Gender-responsive claims emerged primarily from national and implementer respondents, with less evidence in trainee accounts.

Evidence indicates that training effectively addressed foundational digital literacy needs for users with minimal baseline competencies. Conversely, users with greater baseline digital literacy or requiring advanced analytical skills found content only partially responsive. The intervention successfully lifted lower-cadre staff over initial digital thresholds whilst leaving capacity gaps at intermediate and advanced competency levels requiring subsequent curriculum expansion.

Stakeholder Engagement

The observed stakeholder configuration was appropriate for the implementation objectives and the government's ownership was evident: Ministry of Health DPPI and EPI provided strategic direction, supplied master trainers, and mandated the cascade through DHMTs. District teams comprising M&E officers, District Oversight Officers, and cold-room officers delivered training and supervised uptake. At facility level, in-charges and EPI focal staff constituted primary trainees and first-line users.

Partner roles were clearly delineated. UNICEF coordinated operations and logistics whilst supporting eSMT roll-out. GIZ provided funding and technical assistance were needed. This division of labour was widely recognised across stakeholders and facilitated implementation progress.

The digital competency framework development also involved multi-stakeholder collaboration. MoH DPPI and UNICEF convened contributions from WHO, CDC, CHISU, Jhpiego, and PIH. From an 11-area competency framework, two priority areas were implemented: basic computer literacy and troubleshooting. This prioritisation reflected evidence-based assessment of very low baseline skills.

Strengths included clear government stewardship, a practical cascade embedding district-level capacity, and inclusion of cadres most relevant to vaccine stock management. However, gaps emerged in breadth and coordination. Participation often concentrated on in-charges and EPI focals, leaving within-facility coverage partial. Coordination relied heavily on UNICEF in some districts. Attribution blurred where multiple tools and partners operated concurrently. Equity tracking, including gender and rural reach monitoring, was not systematic.

Conclusion: Relevance

DIPC capacity strengthening in Sierra Leone demonstrated high relevance in design and early effects. The intervention followed an evidence-based sequence: national landscape assessment identified very low digital skills, eleven competency areas were defined, and two foundational courses, basic

computer literacy and basic troubleshooting, were developed and delivered before eSMT implementation. This sequencing appropriately addressed documented baseline deficits.

Beneficiary accounts confirm tangible operational gains: increased confidence, reduced errors, and smoother vaccine stock workflows. The cascade model from national trainers through districts to facilities aligns with government decentralisation frameworks. Policy intent manifested in practice through improved reporting and DHMT supervision utilisation. Stakeholder configuration proved appropriate: MoH DPPI and EPI provided leadership and master trainers, DHMTs supervised implementation, UNICEF coordinated delivery, GIZ funded, and technical partners contributed to competency framework development.

However, relevance proved partial regarding depth and continuity. Single-occasion courses did not achieve independent use for all participants. Within-facility coverage often concentrated on in-charges and EPI focals. Sustained performance depended on refreshers and mentoring not yet systematically embedded. Policy literacy and equity tracking remained limited.

Sustaining relevance requires widening trainee participation within facilities, embedding structured refresher and mentorship cycles in DHMT routines, and tracking competence, routine use, and equity rather than coverage alone. This ensures initial relevance translates into sustained, independent practice.

4.2.4 Implementation Processes

Perceived Value

Interview evidence indicates that capacity strengthening delivered clear practical value at point of care. Respondents emphasised that foundational digital upskilling, including powering on devices, saving files, typing, and basic troubleshooting, directly enabled routine eSMT use at PHUs. Facility staff consistently reported faster workflows: regular stock and temperature entries, easier data retrieval, and timelier reporting. Several noted that tasks previously requiring paper handling and travel now completed within minutes with immediate visibility.

District teams described how real-time visibility improved stock management and supervision. DHMTs could monitor facility activity, identify issues earlier, and intervene to prevent stock-outs. Participants attributed increased confidence and motivation to hands-on practice with equipment, including laptops, log-ins, and basic connectivity support. This practical approach strengthened willingness to continue practising beyond formal training.

The cascade model, progressing from national trainers through districts to facilities, established local training capacity. Where refreshers occurred, respondents linked them to steadier performance. Evidence indicates spill-over benefits beyond eSMT: smoother DHIS2 reporting, use of bottleneck analysis and scorecards for problem-solving, and quicker preparation of briefs and presentations.

Stakeholder accounts converge on a coherent narrative: pairing basic digital literacy with practical eSMT training and minimal equipment enabled frontline staff to work faster, feel more capable, and produce more reliable, visible data.

Enablers and Facilitating Factors

Pedagogical Approach: The training method employed short, hands-on, high-frequency sessions beginning with digital literacy and basic troubleshooting before progressing to job-relevant eSMT

workflows including stock receipt, VVM and temperature logging, and month-end counts. Respondents emphasised practice on real tasks within small cohorts. Peer mechanisms, pairing stronger with weaker users and brief trainee showcases, built confidence quickly.

Cascade with Follow-Up: The training model progressed from national trainers to DHMTs, then district delivery to facilities, followed by refreshers and on-site mentoring. DHMT and UNICEF presence, clear job aids, and visible quick wins reinforced routine use.

Practical Enablers:

- Laptop provision and account set-up at point of training
- Job aids supporting independent task completion
- Protected time for practice during and immediately following training
- Connectivity and power supply where available
- Supportive supervision incorporating digital health monitoring

Targeting: Focusing on frontline EPI staff, including many women MCH Aides, kept training closely tied to daily vaccine work. Respondents linked this targeting to faster reporting and smoother stock control.

Evidence indicates that practical, bite-sized training combined with equipment provision and scheduled coaching enabled rapid transition to routine eSMT use at facility level.

Remaining Gaps

Training design exhibited specific limitations requiring attention. The abbreviated one-off workshop format proved insufficient for skill consolidation. Competencies solidified where follow-up occurred but degraded without structured reinforcement mechanisms. Coverage remained narrow, concentrated on in-charges whilst excluding lower cadres and peripheral facilities. This created vulnerability during staff absences or turnover.

Curriculum gaps persisted. Foundational capabilities including typing speed, basic IT navigation, and troubleshooting require further strengthening. Content focused primarily on technical operation without adequately developing data use habits, particularly reviewing outputs and acting on insights. Training did not sufficiently differentiate instruction based on baseline digital literacy variations, leaving some participants with only surface-level learning.

Post-training support mechanisms remained underdeveloped. Structured refresher schedules, competency tracking, and mentorship systems were not systematically embedded within routine district supervision, limiting capacity to sustain and deepen initial gains.

Challenges and Barriers to Implementation

External system-level constraints substantially impeded translation of acquired skills into routine practice.

Infrastructure Deficits: Many sites operated with insufficient devices, unreliable power, and poor connectivity. Single-device arrangements restricted practice opportunities. Staff reverted to paper-first workflows, digitising retrospectively and stalling skill development.

Supervision and Governance Limitations: Supervision proved thin and irregular. Device ownership and stewardship arrangements remained unclear, hampering accountability. Trainee selection sometimes missed appropriate candidates. Logistics and approval processes moved slowly.

Equity Barriers: PHUs and lower cadres exhibited lowest baseline competencies yet received least intensive support. Language and usability issues impeded uptake among these groups, whilst remote facilities faced compounded disadvantages.

Tool Constraints: Absent offline functionality and weak DHIS2 interoperability created duplicate workflows, undermining user confidence and negating efficiency gains.

Funding Fragility: Partner dependence for data bundles, equipment replacement, and supervision travel made continuity unsustainable beyond project funding cycles.

Evidence indicates that whilst training built foundational competencies, routine adoption requires addressing these systemic barriers through district-led mentoring cycles, protected infrastructure budgets, clearer governance arrangements, and offline-capable interoperable systems.

4.2.5 Sustainability

Evidence of Adoption

Adoption evidence indicates substantive yet spatially uneven uptake. District teams reported routine eSMT and DHIS2 utilisation with documented operational benefits: accelerated reporting cycles, earlier stock alerts, and improved supervisory oversight. However, PHU-level adoption remained patchy, often concentrated among one or two motivated staff per facility rather than representing facility-wide practice.

Skills demonstrably improved through hands-on practice and periodic refreshers. Yet many staff requested continued on-site coaching to operate confidently and independently. Hybrid paper-digital workflows persisted: staff captured data on paper first, digitising when power, connectivity, or shared device access became available. These infrastructure constraints functioned as practical brakes on consistent digital-first workflows.

Stakeholder testimonies across health system levels provided consistent accounts of these adoption patterns. However, systematic usage analytics remained limited. Current monitoring systems do not yet verify adoption scale or routine use frequency through objective metrics, constraining definitive adoption quantification.

Evidence indicates that the capacity strengthening package achieved traction and perceived value, particularly at district level. Converting partial uptake into routine PHU practice requires reliable devices, power, and connectivity at point of care, combined with regular district-led mentoring and verification of real-world use and data quality. Where these complementary conditions existed, adoption sustained. Where absent, staff reverted to paper-based workflows.

Potential for Sustainability

The capacity strengthening approach demonstrates functional delivery mechanisms that could support long-term implementation. National-to-district-to-facility cascade structures operate successfully, DHMT coaching reaches facilities, and initial refresher sessions have occurred through UNICEF-GIZ partnership. Close alignment with daily stock management workflows strengthens practical relevance and encourages continued application.

Several factors constrain long-term viability. Facility-level participation remains limited, often involving only one or two staff members whilst excluding broader cadres. This concentration creates significant risk when trained individuals depart or transfer. Essential infrastructure supporting digital work, including devices, electricity, and internet access, depends heavily on external financing rather than government operational budgets. Supervision and skills reinforcement occur episodically through partner initiatives rather than through permanent district health management structures. Existing monitoring captures training completion and test performance but does not systematically verify whether systems are used routinely or whether data quality improves over time.

Long-term success depends on specific institutional changes: expanding trained staff numbers within each facility to create backup capacity, transitioning infrastructure costs into regular government budget allocations, integrating refresher training into standard district supervision schedules, and establishing monitoring approaches that measure actual system utilisation and output quality. Without these shifts from project-based support to government-owned systems, current achievements risk erosion through normal attrition, equipment failure, or funding changes. Working foundations exist but require deliberate conversion into permanent institutional arrangements rather than time-limited programme activities.

Stakeholder Recommendations

Stakeholders articulated a coherent vision for evolving capacity strengthening from project-driven interventions into institutionalised systems. Their recommendations emphasise continuous learning, proximity of support to users, comprehensive coverage, and practical resourcing.

Continuous Learning Architecture: Replace episodic training with scheduled refresher cycles and rapid onboarding protocols addressing staff turnover. Structure initial training as longer, comprehensive induction whilst keeping refreshers brief and targeted to emerging needs.

Proximal Support Systems: Formalise district super-users providing first-line assistance through routine facility follow-ups. Establish peer coaching networks resolving practical issues quickly rather than requiring external intervention. Integrate mentoring into regular supervision visits rather than maintaining as separate activity.

Comprehensive and Equitable Coverage: Train all relevant cadres at every facility rather than concentrating on selected individuals. Deliberately include remote chiefdoms and ensure gender-inclusive participation to prevent digital divides reinforcing existing inequities.

Enhanced Content Depth: Extend curriculum beyond basic data entry to encompass typing proficiency, email communication, connectivity troubleshooting, DHIS2 navigation, and eSMT workflows. Incorporate data quality verification, basic statistics, and simple analytical interpretation enabling facility-level decision-making.

Operational Enablers: Guarantee sufficient devices per facility, reliable power solutions, and assured data connectivity. Establish clear repair and replacement protocols preventing prolonged equipment downtime. Cultivate routine data use culture through weekly bulletins, accessible dashboards, and feedback loops demonstrating value.

Governance and Financing Clarity: Transition leadership to Ministry of Health-directed training cycles embedded within routine health system structures. Partner support should accelerate expansion and finance infrastructure whilst government assumes recurrent operational responsibilities.

Stakeholder recommendations collectively describe a district-anchored, equity-focused model integrating digital capacity building into permanent health system functions rather than maintaining dependency on time-limited external programmes.

4.3 MALAWI

4.3.1 Situation Before DIPC

Pre-DIPC, Malawi's immunisation data systems exhibited fragmentation across all administrative levels. Facilities managed multiple overlapping paper registers prone to loss and physical damage. Staff described frequent mismatches between tally sheets, registers, and monthly reports that undermined child follow-up and vaccine stock control. Slow data retrieval hampered timely decision-making.

Digital tools existed in isolated pockets. Various systems including ODK, CONCARE, ICIS, and facility e-registers operated without integration or standardisation. Most were externally hosted and donor-cycle dependent. When funding concluded, programmes typically reverted to paper-based workflows. Limited device availability and scarce data clerk positions forced administrative burdens onto clinical staff including nurses and Health Surveillance Assistants.

District teams navigated parallel unlinked platforms: DHIS2 for routine reporting, NHEN for health information exchange, and IKIS for immunisation-specific data. This fragmentation required manual reconciliation across systems. National-level actors primarily accessed aggregate HMIS data or Excel compilations lacking individual-level trajectories necessary for granular programme monitoring.

Substantial resource constraints compounded these challenges. Staff shortages, manual reporting requirements, stationery gaps, and unreliable connectivity created heavy workloads whilst limiting data quality and utilisation. Digital capacity varied considerably, with notable gaps between district offices and peripheral facilities.

This fragmented, under-resourced landscape established the rationale for DIPC intervention: consolidate disparate tools into a unified, locally owned Electronic Immunisation Registry within the Malawi Health Information System (MAHIS), thereby improving data traceability, quality, and timely utilisation for programme decision-making.

4.3.2 Structure of Training

Cascade Model: National/district Training of Trainers progressed to cluster classes, then facility-based coaching upon device arrival. Dual delivery modes: central/cluster sessions and on-site hands-on mentoring.

Curriculum: Three to five-day courses anchored to MAHIS Electronic Immunisation Registry (EIR) workflows: registration, consultation, defaulter tracing, stock management, device setup, account security, and basic troubleshooting. Pedagogical emphasis on practice: live demonstrations, step-by-step tasks, real patient data entry during facility sessions.

Participants: Mixed-cadre, mixed-gender cohorts with HSAs as primary audience, also encompassing facility in-charges/clinicians, HSA/cluster supervisors, HMIS/data clerks, environmental health officers, and DHMT members. Slower adopters paired with technology-confident peers. Requests emerged for extended time and advanced analytics content.

Reach: October-December implementation reportedly covered 47-48 facilities and approximately 1,200 health workers, though coverage remained uneven with some districts untrained. District

officers positioned as first-line support; WhatsApp groups enabled peer problem-solving. Formal refreshers were limited.

4.3.3 Relevance

Alignment with National Priorities

Training interventions demonstrated strong structural coherence with national health system priorities encompassing digitalisation, decentralisation, and capacity building. National-level actors established strategic digitalisation direction, districts enacted implementation through the ToT cascade, and facilities applied digital workflows within daily service delivery. This vertical alignment translated policy objectives into operational practice.

Facility-level respondents characterised the transition from paper to electronic records as practical and transformative, supporting standardisation and accountability within routine EPI, MCH, and stock management tasks. District testimonies confirmed local ownership through autonomous trainee selection and facility mentoring, aligning with decentralisation frameworks that position districts as primary implementation units. Mixed-cadre participation strengthened coverage and stakeholder buy-in across the health workforce.

However, observed alignment operated primarily at structural and early implementation levels. Brief training duration and inconsistent follow-up resulted in variable user mastery across facilities and cadres. Sustaining policy-practice alignment requires institutionalising mechanisms that deepen and maintain competencies over time: scheduled refresher training cycles, embedded on-site coaching within routine supervision, and predictable resource allocation for devices and connectivity ensuring equitable readiness. Without these consolidation mechanisms, structural alignment risks remaining superficial rather than translating into sustained, independent digital health system functionality across all facility types and workforce cadres.

Responsiveness to Target Group Needs

Training interventions largely addressed immediate operational requirements at point of care. Facility and district respondents valued hands-on, task-centred practice directly linked to routine workflows including data entry, client registration, and stock verification. Learning through practical application proved effective for building initial confidence and basic competency. Local trainers demonstrated adaptive capacity, addressing mixed digital literacy levels through peer pairing strategies that matched less experienced staff with confident users. District autonomy in participant selection strengthened local ownership and improved trainee-role alignment.

However, the cascade model prioritised geographic reach over skill depth. Brief training focused on system activation rather than comprehensive mastery. Users reported readiness for basic operations but identified significant gaps in troubleshooting beyond simple errors, data quality verification, and basic analytical interpretation. Post-training support proved inconsistent, with structured refresher mechanisms and embedded mentorship largely absent.

Responsiveness proved strong for initial system adoption and confidence building. Yet beneficiaries' evolving needs indicate requirements for continuous support architectures: scheduled refresher cycles, accessible district-level coaching addressing emerging challenges, and curriculum expansion beyond data entry to encompass quality assurance and analytical competencies enabling facility-level decision-making rather than solely data capture functions.

Stakeholder Engagement

Governance arrangements positioned Ministry of Health units, specifically Digital Health Division and EPI, as primary leaders directing the Training of Trainers cascade. Districts subsequently managed cluster training sessions and facility-based coaching. Implementation partners operated through MoH channels: PATH and Digital Square provided technical support whilst GIZ supplied financing. This configuration established clear government ownership rather than partner-led delivery.

Participant composition reflected operational requirements for immunisation registry implementation. Health Surveillance Assistants constituted the primary user group, complemented by HSA and cluster supervisors, facility in-charges and clinicians, HMIS and data clerks, environmental health officers, and selected DHMT members. Districts nominated facility-level "super users" responsible for peer training. Cohorts incorporated mixed-gender participation, with less experienced staff paired alongside technology-confident colleagues to accelerate learning. WhatsApp groups facilitated ongoing problem-solving beyond formal training sessions.

4.3.4 Implementation Processes

Perceived Value

The training interventions in Malawi functioned as essential catalysts for transitioning from paper-based to MAHIS-EIR-based workflows. Respondents reported sufficient confidence to perform core tasks: logging into systems, registering clients, and navigating key interface screens. These basic competencies enabled routine digital work at facility level.

Staff linked training to tangible operational improvements in daily workflows. Benefits included accelerated client record retrieval, clearer defaulter identification, simplified immunisation session planning, basic stock control functionality, and faster routine reporting completion. These practical gains reinforced continued system engagement by demonstrating concrete efficiency improvements over paper-based predecessors.

Critically, sustained value derived substantially from post-training support mechanisms operating outside formal classroom settings. Peer WhatsApp groups provided rapid troubleshooting for common technical issues. Supervisors reviewing facility data entries offered informal quality feedback. Brief coaching visits addressed emerging operational challenges. This proximal, responsive support proved essential for consolidating initial competencies into routine practice.

Training clarified fundamental operational parameters including user roles and permissions, basic data hygiene protocols, device care requirements, and strategies for maintaining functionality during connectivity interruptions such as offline operation and reverse-billed data arrangements.

Evidence limitations warrant acknowledgement. Interview data provided limited detail regarding skill depth, facility coverage breadth, or systematic competency assessment. Respondents explicitly requested short refresher training cycles and accessible first-line troubleshooting support, indicating that initial training achieved activation but not comprehensive independent mastery.

Training established foundational capacity enabling routine system use. However, translation into sustained facility-level practice depended substantially on continuous, accessible, work-integrated support rather than formal instruction alone.

Enablers and Facilitating Factors

Implementation success reflected multiple reinforcing conditions operating across health system levels.

Layered Delivery Architecture: The cascade model progressed through distinct phases: national and district Training of Trainers, cluster-based group sessions, then individualised facility coaching. This layering provided both scale and proximity, enabling standardised content delivery whilst allowing local adaptation to facility-specific contexts.

District Ownership and Governance: Local teams exercised autonomy in trainee selection, identifying appropriate candidates based on role requirements and aptitude. Districts nominated facility-level super users responsible for peer support and nominated slower learners for pairing with technology-confident colleagues, accelerating skill transfer. Ministry of Health EPI stewardship, technical working groups, and district coordination teams provided problem-solving mechanisms and maintained strategic direction.

Practical Operational Enablers: Reverse-billing arrangements for mobile data reduced connectivity costs and administrative friction. Prompt technical operator response addressed implementation challenges quickly. National hosting within MAHIS infrastructure and prior workforce exposure to familiar digital tools reduced learning burden. Additional staff deployment and visible leadership attention sustained implementation momentum.

Feedback and Motivation Systems: Performance dashboards and progress visualisations made improvements tangible, reinforcing continued engagement and demonstrating practical value of digital workflows.

These convergent factors explain translation of initial training into routine facility-level practice. Early uptake momentum derived from this enabling environment. Long-term sustainability depends on maintaining these support conditions through government systems rather than time-limited project arrangements.

Remaining Gaps

Training design exhibited specific limitations requiring attention. Initial instruction achieved activation-level competency but not independent mastery. Skills degraded without regular practice and reinforcement mechanisms. Brief training duration focused on basic system navigation whilst leaving deeper competencies unaddressed, including advanced troubleshooting, data quality verification procedures, comprehensive stock management functions, and analytical interpretation enabling facility-level decision-making.

Post-training support architecture remained underdeveloped. Structured refresher schedules, on-site mentoring protocols, and accessible first-line technical assistance were not systematically embedded within district supervision routines. This gap constrained ability to consolidate initial competencies through work-integrated coaching.

Coverage proved incomplete. Large group sizes during training limited individual hands-on practice time. New staff recruits and some facility cadres missed initial training cohorts, creating uneven facility-level capacity. Within-facility participation often concentrated on selected individuals rather than ensuring comprehensive team coverage providing backup capacity during absences or turnover.

Technical content gaps persisted. Online-offline functionality guidance and synchronisation protocols were not sufficiently internalised. Device stewardship procedures including account handover during staff transitions and asset management remained unclear. Standard operating procedures for routine system administration tasks required strengthening.

Challenges and Barriers to Implementation

External system-level constraints substantially impeded translation of acquired skills into routine practice:

Infrastructure Deficits: Intermittent connectivity and electricity interruptions disrupted system access and data synchronisation. Occasional hosting service downtime prevented log-ins. These infrastructure failures forced temporary reversion to paper workflows regardless of staff competency levels.

Resource Inequities: Programme-owned device availability remained insufficient relative to trained staff numbers. Some health workers relied on personal mobile phones, incurring data bundle costs as unfunded operational expenses. Resource constraints limited practice opportunities and contributed to uneven adoption.

Governance Ambiguities: Uncertainties persisted regarding account creation rights, user permission structures, data privacy protocols, hosting responsibilities, and device stewardship procedures. These ambiguities complicated system administration and accountability.

Workflow Integration Barriers: Mandatory dual paper-digital entry requirements and high competing workload demands reduced time available for digital system engagement. Parallel workflows slowed competency consolidation and negated potential efficiency gains.

Supervision Inconsistencies: Digital health monitoring integration within routine supervision proved variable. Local troubleshooting capacity at facility and district levels remained thin and unevenly distributed.

4.3.5 Sustainability

Evidence of Adoption

Adoption patterns demonstrated spatial variability. Certain facilities, notably in Salima district, reported routine MAHIS engagement including regular system log-ins, accelerated client retrieval, improved defaulter tracing, and faster reporting. Users attributed these improvements to practical workflow value.

Adoption proved strongest where enabling conditions coalesced: Ministry of Health stewardship, reverse-billing arrangements containing costs, functional Training of Trainers cascade, and accessible peer support through WhatsApp networks. These system-level enablers translated training into sustained practice.

However, uptake remained uneven. Connectivity limitations, data bundle unavailability, and insufficient devices constrained system access and synchronisation. Reduced practice opportunities perpetuated parallel paper-MAHIS workflows. Residual challenges including password management, interface navigation, and perceived increased workload indicated needs for targeted coaching rather than comprehensive retraining.

Post-training supervision proved thin in some locations. Staff turnover created competency gaps as new recruits missed initial training. Districts reported satisfactory participation metrics but limited visibility regarding actual utilisation frequency and data completeness, constraining targeted support interventions.

Evidence indicates skills consolidate where enabling infrastructure, governance, and support conditions exist. Absent these prerequisites, adoption remains partial, spatially uneven, and vulnerable to reverting toward paper-based workflows.

Potential for Sustainability

Implementation established a locally anchored delivery model. National Training of Trainers created district super-users who subsequently delivered practical facility-based sessions across multiple cadres. Content focused on operational tasks including account management, client enrolment, and data entry, achieving basic competency thresholds for most participants.

Onboarding capacity now resides predominantly at district level. Districts report independently inducting new staff, with first-line technical support channelled through EPI structures and peer WhatsApp networks. Evidence of autonomous expansion emerged: district trainers delivered sessions at additional facilities without implementer presence, demonstrating capacity transfer beyond initial programme support.

However, sustainability remains conditional. Initial training achieved system activation but not comprehensive mastery across all users. Three requirements underpin long-term viability: regular refresher cycles incorporating quality verification, predictable recurrent funding accommodating service expansion and site scale-up, and dependable infrastructure enablers including devices, connectivity, and hosting supporting daily usage.

Capability resides proximal to use points and demonstrates credible durability potential. Consolidation depends on institutionalising periodic refreshers and modest ongoing support maintaining quality and enabling continued scale rather than relying on episodic external intervention.

Stakeholder Recommendations

Stakeholders articulated a coherent vision for evolving capacity strengthening from project-based interventions into institutionalised health system functions. Recommendations emphasise continuous learning, proximal support, comprehensive coverage, and adequate resourcing.

Transition to Continuous Learning: Replace episodic training with scheduled refresher cycles and rapid skill reinforcement mechanisms preventing competency degradation. Differentiate delivery by user experience: provide longer structured induction for new staff whilst keeping refresher sessions brief and targeted for existing users.

Establish Proximal Support Systems: Formalise district super-user roles providing accessible first-line technical assistance. Embed peer coaching within routine supervision incorporating regular facility follow-ups addressing practical challenges as they emerge rather than requiring escalation.

Ensure Comprehensive Facility Coverage: Train all relevant cadres rather than concentrating skills among limited individuals. Distribute competencies across facility teams so that services continue during staff absences or rotation. Maintain deliberately gender-inclusive participation preventing digital divides reinforcing existing inequities.

Deepen Curriculum Content: Expand beyond basic data entry to encompass data quality verification procedures, basic statistical concepts, and simple analytical interpretation enabling facility-level decision-making rather than solely data capture.

Guarantee Operational Enablers: Provide sufficient devices per facility with reliable charging infrastructure. Ensure data connectivity through assured bundles or alternative arrangements. Integrate MAHIS training modules within routine health workforce development programmes rather than maintaining as separate vertical activities. Align facility staffing levels ensuring adequate capacity for applying acquired competencies within daily workflows.

Stakeholder recommendations collectively describe a district-anchored, continuous learning model adequately resourced to translate initial capacity into sustained routine digital health system functionality.

4.4 CROSS-COUNTRY SYNTHESIS

Across Ghana, Sierra Leone, and Malawi, DIPC capacity strengthening demonstrated consistent patterns. Training achieved relevance through workflow-aligned practical content and cascade delivery achieving substantial reach. All three contexts exhibited similar implementation constraints: infrastructure inadequacy (devices, power, connectivity), non-institutionalised refresher mechanisms, supervision limitations, skill concentration among limited facility staff, and partner-funding dependency. Adoption proved substantive at district levels but spatially uneven at peripheral facilities.

Context-specific variations reflected baseline conditions: Ghana's partial digital readiness versus Sierra Leone's minimal maturity necessitating foundational digital literacy; Malawi's MoH governance model with reverse-billing demonstrating infrastructure financing innovation. Despite design quality, training as standalone intervention proved insufficient. Competency translation into sustained practice required concurrent system enablers frequently absent or unreliable.

Sustainability across contexts remains conditional, requiring transitions from episodic partner-supported training to government-institutionalised continuous learning systems. Common stakeholder recommendations converged: scheduled refreshers, embedded district-level coaching, comprehensive facility coverage, curriculum expansion beyond data entry, infrastructure assurance, systematic usage monitoring, and clarity in governance financing roles.

The evaluation evidence illuminates digital health capacity strengthening principles: training effectiveness is context-mediated; infrastructure, supervision, equitable skill distribution, and systematic monitoring constitute interdependent success determinants; and sustainable adoption requires integrated implementation packages rather than isolated training interventions. These findings align with established digital health implementation science emphasising socio-technical systems perspectives where human capacity, technological functionality, and organisational systems must be concurrently addressed for durable outcomes.

5 Discussion

This evaluation of DIPC capacity strengthening interventions across Ghana, Malawi, and Sierra Leone demonstrates substantial achievements in digital health workforce development within resource-constrained settings. The interventions successfully employed cascade training models that achieved impressive geographic reach, developed contextually-relevant curricula addressing authentic operational needs, and catalysed initial digital health system adoption across facility, district, and national levels. These accomplishments provide important empirical evidence that well-designed capacity strengthening can facilitate digital health integration in low- and middle-income countries (LMICs), while simultaneously illuminating opportunities for enhancing intervention sustainability and equity. The evaluation's organization around intervention relevance, implementation processes, and sustainability prospects enables systematic assessment aligned with established implementation science frameworks (Labrique et al., 2018; Long et al., 2018).

5.1 Relevance

The evaluation documented high intervention relevance across all three contexts, with training content effectively addressing documented workforce development needs. Cascade Training of Trainers models successfully achieved rapid geographic coverage: Ghana trained approximately 1,400 staff from over 700 facilities within five weeks; Malawi covered 47-48 facilities with 1,200 health workers; Sierra Leone reached 44 peripheral health units across four districts. This efficiency demonstrates cascade training's capacity for large-scale workforce development with contained resource requirements, consistent with evidence from other LMIC settings where hierarchical trainer networks have enabled successful scale-up (Crisp & Raven, 2016; Muhammad et al., 2024; Mason et al., 2022). The achievement of such extensive coverage within compressed timeframes represents a significant accomplishment for resource-constrained health systems.

Curriculum design demonstrated strong alignment with operational requirements. The emphasis on hands-on, workflow-oriented pedagogy using authentic facility registers, live demonstrations, and practical drills effectively built health worker confidence and initial competency. Stakeholder reports of immediate applicability to daily tasks confirm that training content successfully addressed real workflow challenges rather than theoretical abstractions. This practical, task-centred approach aligns with evidence that training effectiveness increases substantially when incorporating clinical practice opportunities and work-site delivery (Rowe et al., 2021; Botha et al., 2025). Sierra Leone's evidence-informed sequencing—foundational digital literacy preceding technical tool training—exemplifies appropriate baseline needs assessment and context-responsive design, addressing documented minimal digital maturity through targeted foundational instruction (Kasaye et al., 2024; Moges et al., 2024).

However, the evaluation findings regarding depth-reach trade-offs reveal shortcomings of the training design that require attention in future implementations. Stakeholder reports consistently indicated that two to three-day training durations achieved only activation-level competency, often leaving health workers unable to perform tasks independently without ongoing support. This was particularly pronounced for peripheral health workers who received equivalent initial training but had substantially fewer opportunities for post-training practice due to infrastructure constraints, creating a self-reinforcing cycle of skill gaps.

As such, whilst the cascade model successfully achieved geographic reach, it appears to have come at the cost of insufficient skill consolidation. This represents a fundamental design shortcoming rather

than an implementation variation, as the abbreviated duration proved insufficient for the complexity of competencies required, a finding consistent with training effectiveness literature demonstrating that brief courses without systematic follow-up yield limited sustained impact (Karvande et al., 2024; Abdel-All et al., 2017). Given well-established evidence that LMIC health workforce strengthening requires continuous professional development mechanisms rather than one-off training events (Upadhyay et al., 2023; Rowe et al., 2021), the identified need for consolidation support should have been anticipated and integrated into initial design, even if in form of concrete training follow-up methods.

Importantly, in the late phase of the DIPC programme, the implementation partner Digital Square developed instructional videos guiding health workers through MAHIS EIR and enhanced eTracker operations in Malawi and Ghana. This initiative represents an innovative, resource-conscious response to the recognised gap, acknowledging that in-person refresher trainings are highly resource-intensive and often financially unsustainable for national governments in LMIC contexts. Whilst the effectiveness of these videos in consolidating skills remains to be evaluated, the approach demonstrates appropriate recognition of the financial and human resource constraints that LMICs face in providing ongoing staff training and skills development.

5.2 Implementation Processes

Evaluation findings on the implementation processes of the DIPC-supported capacity strengthening activities in the three partner countries highlighted both significant achievements, but also valuable lessons for optimisation. The cascade ToT model was received as functional across the diverse contexts with differing challenges: Ghana's partial digital readiness in terms of equipment and connectivity, Sierra Leone's digital maturity that spanned across infrastructure and digital skills, and Malawi's fragmented systems, demonstrates that the TOT model’s adaptability and also implementer accomplishment in contextual tailoring. The creation of district-level training capacity represents a particularly important accomplishment, establishing local technical expertise positioned for ongoing workforce support. Malawi's evidence of autonomous training expansion, wherein district trainers independently onboarded additional facilities beyond initial implementation plans, illustrates successful capacity transfer and emerging local ownership (Witter et al., 2022). This achievement aligns with learning health systems literature emphasising development of embedded local capacity rather than external dependency (Witter et al., 2022).

Digital tool adoption patterns, which can be seen as a proxy measure for training success, demonstrate encouraging progress alongside opportunities for enhancement. Adoption at the district level was shown to be substantive across the settings, with e.g., routine eSMT and enhanced eTracker utilisation generating faster reporting cycles and earlier stock alerts in Sierra Leone and Ghana pilot sites respectively. These are tangible reported and perceived operational improvements that support programme management. This district-level success can be viewed as providing proof-of-concept that trained health workers can effectively integrate digital tools into routine workflows when enabling conditions exist.

The findings also reveal significant spatial heterogeneity in tool adoption, with peripheral facilities showing markedly more limited uptake than district-level counterparts. This pattern reflects well-documented dynamics wherein infrastructure availability mediates technology adoption (Ouma & Maina, 2024; Azzopardi-Muscat & Sorensen, 2023). However, the infrastructure-adoption relationship creates a compounding disadvantage for peripheral health workers: inadequate equipment not only directly limits digital tool utilization but also restricts opportunities for hands-on practice and skill

consolidation. Consequently, health workers in remote, poorly equipped facilities receive equivalent initial training to their more urban counterparts yet have substantially fewer opportunities to apply and reinforce newly acquired competencies through routine use. This creates a self-reinforcing cycle wherein infrastructure deficits perpetuate skill gaps, which in turn limit adoption even when equipment becomes available. The pattern therefore highlights two concurrent requirements for strengthening future implementation: infrastructure investment to enable tool utilisation, and potentially more intensive or extended training specifically for staff in resource-constrained peripheral settings to compensate for limited post-training practice opportunities.

The evaluation's identification of infrastructure constraints as primary implementation barriers provides essential evidence for integrated intervention design. Findings that unreliable devices, intermittent power, and limited connectivity necessitated hybrid paper-digital workflows align with systematic evidence documenting infrastructure as a fundamental prerequisite for digital health effectiveness in LMICs (Yew et al., 2025; Qureshi et al., 2013; Adeloye et al., 2016). Importantly, these findings do not diminish training achievements but rather underscore that capacity strengthening requires complementary system investments. The documented district-level success under more favourable infrastructure conditions demonstrates training's potential effectiveness; peripheral constraints highlight infrastructure as the limiting factor requiring attention. This evidence strengthens the case for integrated socio-technical approaches wherein training, infrastructure, supervision, and governance receive concurrent investment (Labrique et al., 2018; Alotaibi et al., 2025).

Stakeholder-articulated recommendations converge on actionable improvements: scheduled refreshers, district-anchored peer coaching, comprehensive facility coverage, curriculum expansion to encompass data quality and analytics, and infrastructure assurance. The specificity and consistency of these recommendations across contexts provide valuable guidance for intervention enhancement. Notably, stakeholders advocate strengthening rather than redesigning the cascade model, suggesting core approach validity with opportunities for optimisation. Recommendations for continuous learning systems align closely with supervision enhancement literature demonstrating that regular follow-up and supportive supervision substantially improve health worker performance sustainability (Udeh et al., 2022). The stakeholder-driven emphasis on district-level super-users corresponds to effective supervision models positioning districts as accessible technical resources, reducing perceived effort and increasing technology acceptance (Longhini et al., 2022; Borges do Nascimento et al., 2023).

5.3 Sustainability Prospects

Sustainability assessments reveal promising foundations alongside clear requirements for consolidation. The evaluation identified several positive sustainability indicators: functioning cascade training mechanisms, established district-level technical capacity, evidence of local ownership and autonomous expansion (e.g., in Malawi), and documented operational improvements motivating continued use. These elements represent important sustainability building blocks. Malawi's MoH stewardship model with reverse-billing innovation and district-managed onboarding exemplifies promising governance approaches demonstrating local ownership principles. Ghana's GHS digital health leadership structures and Sierra Leone's MoH hands-on engagement similarly indicate government commitment, which are essential prerequisites for sustained implementation (Labrique et al., 2018).

The DIPC-supported training's success in achieving initial activation for many front-line workers over a short period of time (e.g., Ghana: 1,400 staff from over 700 facilities; Malawi: 1,200 staff from 47-48 facilities), should be weighed against its insufficient depth to ensure independent operational

competency within the initial implementation phase. However, Digital Square's subsequent development of training videos represents a commendable effort to address the sustainability gap by providing lasting resources that address remaining knowledge gaps and mitigate skill degradation beyond the project duration.

The overall moderate-to-credible sustainability potential assessed across contexts reflects realistic acknowledgment that consolidating initial achievements requires transitioning from episodic partner-supported implementation to institutionalised government-owned systems. This transition challenge is well-documented in LMIC digital health literature, where externally-funded pilot programs frequently struggle to achieve sustained domestic financing and scale (Campbell et al., 2025; Verhey et al., 2020). The evaluation's documentation of this challenge provides important evidence for funders and policymakers regarding investment requirements beyond initial implementation. As such, findings indicate that successful initial capacity building now requires complementary governance, financing institutionalisation and innovative solutions for capacity strengthening scale up and refreshers in order to consolidate gains. This represents a natural implementation phase transition documented in scaling frameworks (Barker et al., 2016).

Stakeholder recommendations regarding governance and financing clarity provide actionable pathways for sustainability enhancement. The convergence across contexts on government assumption of core operational costs while partners support acceleration and infrastructure investment reflects established public-private collaboration frameworks for LMIC digital health sustainability (Aisyah & Kozlakidis, 2025). Ghana's recommendation for diversified financing with Ghana Health Service assuming core costs, Malawi's emphasis on embedding training within routine structures, and Sierra Leone's call for Ministry of Health-led training cycles all articulate similar governance principles: institutional ownership, predictable financing, and clear accountability mechanisms. These recommendations align closely with WHO Digital Health Strategy guidance emphasising government leadership, policy alignment, and sustainable financing as essential for digital health maturation (World Health Organization, 2021).

5.4 Cross-Cutting Insights

Cross-country analysis reveals both universal implementation principles and valuable context-specific adaptations. The identification of common constraints, namely infrastructure inadequacy, non-institutionalised refresher mechanisms, supervision resource limitations, alongside common facilitators, including practical curricula, cascade training functionality, district capacity development, and strong stakeholder engagement, provides important evidence regarding generalisable implementation principles. At the same time, documented context-specific adaptations demonstrate that the implementation partners Digital Square and UNICEF were able to appropriately tailor the training activities, exemplified by Sierra Leone's foundational digital literacy strand addressing minimal baseline competency as identified through structured pre-intervention assessments. This pattern aligns with implementation science emphasising fidelity-adaptation balance wherein core intervention components maintain consistency while surface features adapt to local contexts (Nilsen & Bernhardsson, 2019).

The useful convergence of stakeholder recommendations despite contextual variations provides strong evidence that identified priorities, i.e., continuous learning systems, district-anchored support, comprehensive coverage, infrastructure assurance, governance clarity, represent fundamental rather than context-specific requirements. This suggests these principles may be generalisable across diverse LMIC settings while acknowledging that implementation modalities require local adaptation (Omar et

al., 2009). For funders and implementers, this finding indicates that investments addressing these fundamental elements will likely yield benefits across diverse contexts, providing confidence for broader application beyond the three evaluation countries.

The evaluation's documentation around equity considerations, particularly Sierra Leone stakeholders' explicit emphasis on deliberate inclusion of remote chiefdoms and gender-inclusive participation, raises important attention to ensuring digital health interventions reduce rather than exacerbate existing inequities. Findings of spatial adoption heterogeneity, with peripheral facilities showing more limited uptake than districts, highlight risks that digital health may inadvertently advantage resource-privileged tiers absent intentional equity-focused design (Tudor Car et al., 2019; Strasser & Strasser, 2020). Stakeholder articulation of equity imperatives demonstrates awareness of these risks and provides valuable guidance for ensuring future implementations explicitly address inclusive reach.

5.5 Implications for Policy and Practice

The evaluation generates several actionable insights for strengthening digital health capacity building in LMICs. First, the documented success of cascade training in achieving rapid reach while identifying depth-consolidation needs suggests that cascade models should be complemented with scheduled refreshers, district-based continuous learning mechanisms and the introduction of innovative learning methods. This represents an enhancement opportunity building on demonstrated strengths. Second, the strong evidence that infrastructure availability mediates training effectiveness underscores the importance of integrated investment strategies wherein capacity building and infrastructure development receive concurrent funding rather than sequential attention. Third, the identification of district-level adoption success alongside peripheral challenges suggests that strengthening district technical support capacity and ensuring equitable infrastructure distribution represent high-value investments for maximizing training returns.

Fourth, stakeholder articulation of governance and financing transition requirements provides clear guidance that funders should anticipate and plan for institutionalisation support extending beyond initial implementation periods. The sustainability challenge does not reflect implementation failure but rather natural phase transition requiring explicit attention and investment. Fifth, the documented context-specific adaptations demonstrate that successful implementation requires combining evidence-based core principles with locally-informed surface adaptations, which suggests that implementation partnerships should ensure adequate space for local tailoring while maintaining evidence-based design elements. These insights align closely with established digital health implementation best practices while providing context-specific empirical support from three diverse African settings (Labrique et al., 2018; World Health Organization, 2021).

This evaluation contributes important empirical evidence to LMIC digital health implementation science. The multi-country, multi-level stakeholder engagement approach provides robust qualitative evidence regarding implementation experiences, barriers, facilitators, and stakeholder-driven improvement priorities. The consistency of findings across three diverse contexts strengthens confidence in generalisability. The explicit organisation around relevance, implementation processes, and sustainability enables systematic assessment aligned with implementation science frameworks. The documentation of both achievements and optimisation opportunities provides balanced evidence useful for funders, implementers, and policymakers.

5.6 Limitations

Several limitations warrant acknowledgment. The evaluation relied primarily on stakeholder interviews without systematic observation of training delivery or quantitative competency assessment, limiting definitive effectiveness measurement. Usage data limitations precluded rigorous adoption quantification, necessitating reliance on stakeholder perceptions. The evaluation occurred during relatively early implementation; longer-term follow-up would strengthen sustainability evidence. Cost-effectiveness analysis was not conducted, limiting resource allocation guidance. Training quality variations across cascade levels were not systematically assessed. Despite these limitations, the evaluation's qualitative depth, cross-country scope, and stakeholder engagement breadth provide valuable implementation insights. The convergence of findings with published literature strengthens confidence in principal conclusions and recommendations.

The DIPC capacity strengthening evaluation demonstrates that well-designed cascade training can successfully achieve substantial geographic reach, develop contextually-relevant workforce competencies, and catalyse initial digital health system adoption in resource-constrained LMIC settings. These achievements provide important proof-of-concept for digital health workforce development feasibility. Simultaneously, the evaluation illuminates that consolidating these achievements and achieving sustained independent utilisation requires integrated approaches addressing training alongside infrastructure investment, supervision strengthening, governance institutionalization, and sustainable financing. Stakeholder-articulated recommendations provide clear, actionable pathways for intervention enhancement: continuous learning systems with scheduled refreshers, district-anchored technical support, comprehensive facility coverage, curriculum expansion beyond basic data entry, infrastructure assurance, and governance-financing clarity. These recommendations align closely with established digital health implementation best practices while providing context-specific empirical support. For funders and implementers, the evaluation demonstrates both the value of initial DIPC investments and the specific requirements for consolidating gains and achieving long-term sustainability. The findings contribute important empirical evidence to digital health implementation science in LMICs while providing practical guidance for strengthening capacity development interventions across diverse resource-constrained settings.

6 Recommendations

6.1 Relevance

R1: Implement Multi-Tiered Training Duration Based on Role Complexity and Infrastructure Context

Rationale: The evaluation revealed that two to three-day training durations achieved only activation-level competency, leaving health workers unable to perform tasks independently, a fundamental design shortcoming given the complexity of required competencies. This inadequacy is compounded for peripheral health workers who receive equivalent initial training but have substantially fewer opportunities for post-training practice due to infrastructure constraints, creating a self-reinforcing cycle of skill gaps (Karvande et al., 2024; Abdel-All et al., 2017; Upadhyay et al., 2023).

Priority Actions:

- Differentiate training duration by role: 5-7 days for district super-users and facility champions; 3-4 days for frontline staff with mandatory follow-up within 2-4 weeks

- Design extended training for peripheral facility staff to compensate for limited practice opportunities, incorporating additional simulation and structured district-trainer mentorship
- Conduct pre-training digital literacy assessments to identify workers requiring foundational skills training before technical instruction

R2: Establish Institutionalised Continuous Learning Systems with Multi-Modal Delivery

Rationale: Stakeholders across all three countries emphasised that single-occasion training is inadequate and skill degradation occurs without reinforcement. Digital Square's post-evaluation development of instructional videos represents an innovative, resource-conscious response acknowledging that in-person refreshers are financially unsustainable for national governments. Multi-component strategies combining initial training with ongoing support yield superior outcomes (Rowe et al., 2021; Udeh et al., 2022).

Priority Actions:

- Institutionalise mandatory quarterly refresher cycles with government ownership, incorporating progressive curriculum from basic data entry to quality assurance and analytics
- Deploy multi-modal resources: instructional videos, visual job aids, WhatsApp/SMS micro-learning, offline-accessible digital materials
- Expand curriculum to include data quality principles, dashboard interpretation, and statistical literacy for facility-level decision-making

6.2 Implementation Processes

R3: Adopt Integrated Socio-Technical Investment with Concurrent Infrastructure and Training Deployment

Rationale: Infrastructure constraints—unreliable devices, intermittent power, limited connectivity—emerged as primary implementation barriers. District-level success under favourable infrastructure demonstrated training effectiveness, while peripheral constraints highlighted infrastructure as the limiting factor. These findings underscore that capacity strengthening requires concurrent rather than sequential investment in training, infrastructure, supervision, and governance (Yew et al., 2025; Labrique et al., 2018).

Priority Actions:

- Mandate infrastructure readiness before training: functional devices (minimum 1:3 staff ratio), reliable power with backup, connectivity or demonstrated offline functionality
- Implement equity-focused distribution prioritising peripheral facilities: solar solutions, ruggedised devices, robust offline systems
- Establish predictable maintenance, repair, and replacement protocols with government ownership and service level agreements

R4: Establish District-Level Technical Support Hubs with Formalised Super-User Networks

Rationale: District-level capacity development proved particularly successful, with Malawi demonstrating autonomous training expansion beyond initial plans. Stakeholders consistently emphasised DHMTs as optimal first-line support. This aligns with evidence that accessible, district-

based technical resources reduce perceived effort and increase adoption whilst providing ongoing supervision critical for performance sustainability (Witter et al., 2022; Udeh et al., 2022; Longhini et al., 2022).

Priority Actions:

- Formalise district digital health technical support roles with clear terms of reference, dedicated time allocation (minimum 25% workload), and performance management integration
- Establish peer coaching systems: scheduled monthly site visits, virtual check-ins, responsive technical assistance with documentation of common challenges
- Develop district dashboards to monitor facility adoption, identify declining usage, and track technical issues for escalation or curriculum modification

6.3 Sustainability

R5: Institutionalise Government-Led Governance and Sustainable Financing Frameworks

Rationale: Moderate sustainability potential reflects the need to transition from partner-supported pilots to government-owned systems—a well-documented challenge where externally-funded programmes struggle to achieve sustained domestic financing (Campbell et al., 2025; Verhey et al., 2020). Stakeholder recommendations converged on government assumption of core operational costs whilst partners support acceleration, aligning with WHO guidance emphasising government leadership and sustainable financing (World Health Organisation, 2021).

Priority Actions:

- Formalise ownership through Memoranda of Understanding: Ministries assume recurrent training costs, infrastructure maintenance, connectivity, and supervision integration; partners support capital investment, technical assistance, and M&E strengthening
- Embed digital health training in pre-service curricula and routine in-service structures rather than parallel vertical programmes
- Establish dedicated government budget lines with transparent allocation processes and accountability mechanisms

R6: Deploy Scalable Digital Learning Resources and Institutionalise Quality Assurance

Rationale: Cascade models achieved impressive reach but faced trade-offs in terms training depths and unassessed quality variations across cascade levels. Digital Square's instructional videos demonstrate commendable and appropriate recognition of resource constraints, though effectiveness requires evaluation. Systematic quality assurance is essential to ensure cascade fidelity whilst multi-modal resources can provide cost-effective continuous support.

Priority Actions:

- Develop comprehensive digital resource libraries: step-by-step videos in local languages, visual job aids for low-literacy contexts, FAQ databases, self-assessment quizzes—all offline-accessible

- Implement quality assurance: standardised trainer competency assessments, structured observation using validated rubrics, post-training participant assessments, six-month follow-up evaluations
- Establish national training registries documenting who, when, by whom, competency level—enabling identification of coverage gaps, refresher needs, and quality variations

R7: Implement Equity-Focused Strategies Ensuring Inclusive Reach

Rationale: Spatial adoption heterogeneity with peripheral facilities showing limited uptake raises concerns that digital health may exacerbate geographic disparities. Sierra Leone stakeholders emphasised deliberate inclusion of remote areas and gender equity, recognising that infrastructure deficits create compounding disadvantages. Equity requires explicit policy attention rather than assuming uniform approaches yield equitable outcomes (Tudor Car et al., 2019; Strasser & Strasser, 2020).

Priority Actions:

- Adopt equity-explicit planning: geographic targeting prioritising remote facilities, transparent quarterly equity indicators (device functionality, trained staff, adoption rates), remediation protocols when gaps exceed thresholds
- Design peripheral-specific interventions: more intensive initial training (5-7 vs. 3-4 days), more frequent supervision (monthly vs. quarterly), prioritised offline-accessible learning resources
- Ensure inclusive participation: gender-balanced cohorts, local language materials, visual-heavy pedagogy accommodating literacy variations, adoption monitoring disaggregated by remoteness, gender, and cadre

7 Conclusion

This evaluation of DIPC capacity strengthening interventions across Ghana, Malawi, and Sierra Leone demonstrates that well-designed cascade training can successfully achieve substantial geographic reach and catalyse initial digital tool adoption in resource-constrained LMIC settings. The interventions accomplished significant milestones: training approximately 3,600 health workers across more than 800 facilities within compressed timeframes, developing contextually-relevant curricula addressing authentic operational workflows, establishing district-level technical capacity, and generating documented operational improvements including faster reporting cycles and earlier stock alerts. These achievements provide important proof-of-concept that strategic workforce development can facilitate digital health integration when appropriately designed and implemented.

The evaluation's organisation around intervention relevance, implementation processes, and sustainability prospects enabled systematic identification of both strengths and opportunities for enhancement. Whilst training content demonstrated high relevance and practical applicability, the abbreviated duration proved insufficient for independent skill consolidation without ongoing support mechanisms. Implementation processes revealed that training effectiveness is fundamentally mediated by infrastructure availability, with district-level adoption success under favourable conditions contrasting sharply with peripheral facility constraints. Sustainability assessments identified promising foundations, functioning cascade mechanisms, established district capacity, emerging local

ownership, alongside clear requirements for transitioning from partner-supported pilots to government-institutionalised systems.

The remarkable convergence of stakeholder recommendations across three diverse contexts, continuous learning systems, district-anchored technical support, concurrent infrastructure investment, comprehensive facility coverage, and governance-financing clarity, provides strong evidence that these represent fundamental rather than context-specific requirements for digital health workforce development in LMICs. The consistency of findings with published implementation science literature strengthens confidence in the generalisability of evaluation insights beyond the three countries assessed.

The seven recommendations emerging from this evaluation provide actionable pathways for strengthening future digital health capacity building initiatives. These recommendations are grounded in empirical evidence from multi-country, multi-level stakeholder engagement and aligned with established best practices whilst providing context-specific guidance for LMIC settings. For funders and implementers, the evaluation demonstrates both the substantial value of initial DIPC investments in achieving rapid workforce mobilisation and the specific requirements for consolidating these gains into sustained, equitable digital health system maturation.

Ultimately, this evaluation contributes important empirical evidence that digital health workforce development in resource-constrained settings requires integrated approaches addressing training alongside infrastructure investment, supervision strengthening, governance institutionalisation, and sustainable financing. The DIPC experience demonstrates that achieving this integration is both feasible and essential. Feasible because documented successes showed that well-designed interventions can function effectively even in challenging contexts; essential because isolated capacity building without complementary system investments yields incomplete and potentially inequitable outcomes. By documenting both achievements and enhancement opportunities with granular specificity, this evaluation provides practical guidance for advancing digital health implementation science whilst strengthening capacity development interventions across diverse LMIC settings.

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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%)*