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

Summary Evaluation Report

Evidence-Based Public Health| Centre for International Health Protection

Robert Koch Institute, October 2025

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Disclaimer

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

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List of Acronyms

ANC	Antenatal Care
AWIDHN	African Women in Digital Health Network
BMZ	Bundesministerin für Wirtschaftliche Zusammenarbeit und Entwicklung
BYOD	Bring-Your-Own-Device
CHIM	Centre for Health Information Management
CFIR	Consolidated Framework for Implementation Research
DAC	Development Assistance Committee
DAK	Digital Adaptation Kit
DIPC	Digital Innovation in Pandemic Control
DEA	Digital Ecosystem Assessment
DHMT	District Health Management Team
DPPA	Digital Pandemic Preparedness Assessment Tool
DPPI	Department for Policy, Planning and Information
GHS	Ghana Health Service
GEI	Gender Inclusion and Diversity
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
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
OECD	Organisation for Economic Co-operation and Development
PAHO	Panamerican Health Organization
PATH	Program for Appropriate Technology in Health
PHU	Peripheral Health Unit
PPME	Policy, Planning, Monitoring & Evaluation
SDGs	Sustainable Development Goals
SMART	Standards-based, machine-readable, adaptive, requirements-based, and testable

STEM	Science, Technology, Engineering, and Mathematics
SURD	Systems and Users Requirements Document
ToT	Training of Trainers
UHC	Universal Health Coverage
WIDHE	Women in Digital Health Event
WHO	World Health Organization

About This Report

This Summary Evaluation Report provides an integrated synthesis of findings from the comprehensive process evaluation of the Digital Innovation in Pandemic Control (DIPC) initiative conducted across Ghana, Malawi, and Sierra Leone. The report consolidates key achievements, critical challenges, cross-cutting themes, and strategic recommendations emerging from evaluation of five DIPC programme components.

This summary report is accompanied by five detailed topic-specific evaluation reports:

Report 1: Digital Ecosystem Assessments and Development of National Digital Health Roadmaps

Report 2: Piloting of WHO's SMART Guidelines Approach

Report 3: Digital Tool Roll-out

Report 4: Capacity Strengthening Activities for Digital Tool Use

Report 5: Gender Equity and Inclusion – Ghana's Women in Digital Health Event

The detailed reports provide comprehensive findings, extensive literature reviews, country-specific analyses, and component-specific recommendations. This summary report synthesises findings across components to identify common patterns, strategic priorities, and actionable insights for future digital health programming in LMICs. Readers seeking in-depth analysis of specific components should consult the respective detailed reports.

Executive Summary

Background and Purpose

Vaccine-preventable diseases claim approximately 1.5 million lives annually in Low- and Middle-Income Countries (LMICs), with 20.5 million children globally remaining unvaccinated or under-vaccinated. The COVID-19 pandemic exposed the fragility of immunisation systems, highlighting urgent needs for innovative approaches to strengthen vaccine delivery mechanisms. Digital health technologies offer substantial potential to enhance immunisation coverage through improved tracking, supply-chain management, and data accuracy, yet implementation at national scale faces persistent challenges: limited infrastructure, inadequate training, workforce capacity gaps, and the 'know-do gap' between research knowledge and real-world application.

The Digital Innovation in Pandemic Control (DIPC) initiative, launched by Germany's Federal Ministry for Economic Cooperation and Development (BMZ) through GIZ, aimed to strengthen digital vaccine delivery systems in five partner countries. The Robert Koch Institute (RKI) conducted an independent external process evaluation of DIPC implementation across Ghana, Malawi, and Sierra Leone, examining five key programme components: (1) Digital Ecosystem Assessments and National Digital Health Roadmap development, (2) piloting WHO's SMART Guidelines approach, (3) digital tool roll-out, (4) capacity strengthening for digital tool use, and (5) gender equity and inclusion with focus on Ghana's Women in Digital Health Event.

This evaluation assessed relevance to country contexts and target group needs, implementation processes including barriers and facilitators, and sustainability potential including integration into national systems and capacity for independent continuation. The evaluation employed qualitative methods comprising comprehensive document reviews and 72 semi-structured key informant interviews with stakeholders at international, national, regional, district, and facility levels, intentionally weighted towards frontline health workers to capture implementation experiences. Data were analysed thematically using predominantly deductive coding, with country-specific analyses followed by cross-country synthesis. The evaluation received ethical clearance from review boards in all three countries.

This summary report synthesises findings across all five components to share common patterns, cross-cutting themes, and strategic priorities for future digital health programming in LMICs. Detailed component-specific findings, country analyses, and technical specifications are available in five companion detailed topic reports.

Methodology

This 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 72 semi-structured key informant interviews with funders, implementation partners, government officials, district and regional public health officials, and facility-level healthcare providers across the three countries, complemented by global-level stakeholders. The sample was intentionally weighted towards health workers at facility and district/regional levels to capture frontline implementation experiences.

Interviews lasted on average 45-90 minutes and were conducted face-to-face or via secure videoconferencing. All interviews were audio-recorded, transcribed verbatim, and analysed thematically using predominantly deductive coding. Country-specific analyses were followed by cross-

country synthesis to identify common barriers and facilitators. The evaluation received ethical clearance from review boards in all participating countries.

Key Achievements

DIPC demonstrated consistent strengths across all five evaluation components, reflecting well-designed, contextually appropriate interventions with strong government ownership and methodological rigor.

All DIPC components achieved strong policy alignment with national priorities. Ghana's Digital Ecosystem Assessment operationalised the digital health strategy, Sierra Leone's National Digital Health Roadmap translated strategic commitments into costed actions, and digital tool implementations in all three countries responded to explicitly articulated government priorities. Adopting WHO's SMART Guidelines approach produced country-owned requirements documents through government-anchored multi-stakeholder workshops. Capacity strengthening interventions addressed operational needs identified by health system stakeholders and Ghana's Women in Digital Health Event aligned with the Affirmative Action Act 2024 and GHS Digital Health Strategy. This policy coherence reflects the principle that digital health system strengthening requires explicit alignment with national strategic frameworks to avoid fragmentation and support sustainable governance (Karuri et al., 2022; WHO, 2012).

Government ownership extended beyond policy alignment to operational stewardship. Ghana's GHS, and Sierra Leone and Malawi's MoH actively led implementation: directing assessments and roadmap development, stewarding SMART Guidelines localisation, assuming responsibility for digital tool rollout logistics, and leading cascade training delivery. This government leadership anchored legitimacy, accelerated decision-making, and positioned interventions for sustained impact beyond external project support.

DIPC achieved strong implementation fidelity within compressed timelines. Digital Ecosystem Assessments and roadmap development completed structured methodologies on schedule, producing validated planning instruments. SMART Guidelines localisation produced requirements documents translating clinical guidelines into digital specifications across all three countries. Digital tool rollouts achieved phased adaptive deployment across multiple pilot districts. Cascade training models reached impressive scale: Ghana trained approximately 1,400 staff from over 700 facilities, Malawi covered 1,200 health workers from 47-48 facilities, and Sierra Leone reached 44 peripheral health units. The Women in Digital Health Event achieved planned structure and attendance targets with over 200 registration requests within twelve hours.

DIPC interventions responded directly to documented needs and contextual realities. Assessments and roadmaps addressed system fragmentation and weak governance visibility. SMART Guidelines addressed requirements specification gaps. Digital tools replaced fragmented paper-based systems with platforms enabling granular, actionable data. Sierra Leone's hardware provision, solar panels, and digital literacy training explicitly addressed infrastructure deficits. Training employed contextually-relevant curricula addressing authentic workflows. The Women in Digital Health Event addressed documented perception barriers and absence of female role models in digital health careers.

Within three years, DIPC positioned countries with validated planning instruments providing institutional foundations, digital tools integrated within national platforms creating pathways for sustained use, district-level capacity enabling potential autonomous continuation, and demonstrated feasibility of gender-intentional workforce development. These achievements represent substantial

progress in demonstrating technical feasibility of multi-component digital health system strengthening in resource-constrained LMIC contexts.

Critical Challenges

Whilst DIPC demonstrated strong achievements, realising their full potential requires strengthening three interconnected areas to establish durable pathways from pilot success to sustained operation.

The policy-implementation gap constitutes the most fundamental challenge. Strong policy alignment, validated plans, and stakeholder endorsement proved insufficient without concrete implementation mechanisms to translate policy into practice. Ghana's DEA produced a comprehensive landscape overview of immunisation tools, replicates and gaps and validated interoperability specifications that reached requirements stage. However, designated custodianship and routine update cycles were not established to ensure continuity beyond project completion. DIPC supported development of Sierra Leone's NDHRM, producing comprehensive planning framework; realising the roadmap's implementation potential requires addressing financing gaps and staffing constraints that limited delivery to 45% of planned activities at the time of the evaluation. SMART Guidelines piloting successfully completed L2 requirements specification, with each country appropriately defining implementation pathways aligned to national priorities: Malawi embedded DAK-based data dictionaries within MAHIS EIR prioritising platform integration; Ghana incorporated DAK structures within enhanced eTracker as DHIS2 module; and Sierra Leone localised ANC DAK planning L3 hackathon development. The challenge lay not in achieving L3/L4 progression—which was not immediate priority for all countries—but in bridging the "missing middle" between L2 requirements and operational systems. Countries require sustained technical accompaniment for their diverse pathways, whether through immediate standards-based software development or integration within existing platforms, yet intermediate artefacts translating L2 specifications into developer-ready formats were not available, necessitating support extending beyond typical project cycles. The roll-out of the respective digital tools demonstrated partial uptake with persistent parallel paper-digital workflows. Capacity strengthening activities for digital tool use achieved activation-level competency but were reportedly not sufficient depth for independent operation among frontline health workers. The Women in Digital Health Event generated enthusiasm but did not provide follow-on structured mentorship, internship pathways, or outcome tracking systems.

This pattern reflects gaps between planning and implementation. Validated plans required accompanying structures to become operational: governance mechanisms coordinating action across institutions, predictable financing, accountability frameworks ensuring follow-through, designated custodians with dedicated time and resources, and systematic processes embedded in routine operations.

Infrastructure deficits emerged as the primary operational barrier across digital tool rollout and capacity strengthening. Device shortages, unreliable connectivity, inadequate power, and intermittent hosting resulted in partial uptake, inconsistent use, and disrupted reporting. Facilities rarely possessed sufficient devices, reliable power, or stable connectivity. Whilst initial procurement through donor funding facilitated adoption in Sierra Leone, replacement cycles, maintenance, and connectivity require recurrent financing that all three countries struggle to provide. Infrastructure constraints create self-reinforcing cycles: inadequate infrastructure prevents tools from demonstrating value, limiting political will for sustained investment; under-resourced systems cannot retire paper workflows, perpetuating dual burdens negating efficiency gains; trained health workers cannot practice competencies through routine use, leading to skill degradation; and peripheral facilities face

disproportionate disadvantage, risking that digital health advantages resource-privileged tiers absent equity-focused design.

The sustainability financing gap emerged across all components as the fundamental long-term challenge. DIPC's three-year cycle enabled upstream planning and initial deployment but was not sufficient for operational sustainability requiring documented 5-7 year transitions. A number of important dimensions remain incomplete:

- Recurrent financing for device lifecycles, connectivity, power, supervision, and technical support has not been secured through domestic budgets;
- Formal maintenance mechanisms for requirements documents, digital ecosystem registries, and application enhancements lack designated custodians, routine update cycles, and clear institutional responsibility;
- Continuous learning systems including refresher training, mentorship, and helpdesk support remain underdeveloped; and
- Progressive cost transfer from external to domestic budgets has not been institutionalised.

Countries demonstrate partial capacity for autonomous continuation, e.g., strong institutional frameworks, designated stewardship, technical competency, but countries' operational independence remains constrained by limited staffing, insufficient domestic budgets, and dependence on partner support for essential functions. This reflects well-known challenges where externally funded pilots struggle to achieve sustained domestic financing and scale within their project timelines and scope.

Strategic Priorities for Future Programming

Four strategic priorities emerge from cross-component synthesis to guide future digital health system strengthening in the DIPC partner countries.

1. **Integrate follow-through architecture into core digital health programming methodology.**

   The DIPC approach as a pilot initiative in the three partner countries focused on assessment and specification quality, treating implementation arrangements, custodianship, monitoring, and accountability as downstream concerns. Future initiatives should embed standardised follow-through components from design stage: designated custodians with protected time and budget allocation, routine update cycles with specified frequency, accountability mechanisms generating consequences for non-compliance, handover protocols ensuring continuity during personnel transitions, and monitoring frameworks enabling progress tracking. This applies across strategic planning (Digital Ecosystem Assessments, roadmaps), technical specification (SMART Guidelines), technology deployment, capacity development, and gender equity programming.

2. **Deploy integrated socio-technical approaches addressing technology, infrastructure, capacity, governance, financing, and equity concurrently rather than sequentially.**

   Infrastructure readiness assessments should precede training deployment, ensuring minimum device-to-staff ratios, reliable power, and connectivity with equity-focused distribution prioritising peripheral facilities. Phased paper retirement strategies should eliminate dual workflows through systematic triggers. Multi-tiered training should differentiate by role complexity with continuous learning systems and district-level technical support hubs. Gender equity initiatives should operationalise policy commitments through funded workplans, structured mentorship and internship programmes, and outcome monitoring systems.

3. **Establish realistic multi-year transition support acknowledging that durable digital health system transformation requires 5-7 year trajectories beyond typical 2-3 year project cycles.**

   Design progressive domestic financing integration with declining partner support, for example: Years 1-2 focusing capital investment and initial training, Years 3-4 transitioning supervision and basic support, Years 5-6 transitioning device replacement and connectivity, Years 7+ maintaining only advanced technical assistance. Develop standardised costing frameworks for complete implementation cycles including recurrent costs. Build government capacity for budget advocacy and domestic resource negotiation. Establish dedicated government budget lines for digital health operations, including recurrent costs.

4. **Implement equity-focused strategies ensuring digital health strengthens rather than exacerbates existing disparities.**

   For geographic equity, address spatial heterogeneity through peripheral-specific interventions including more intensive training, frequent supervision, prioritised offline resources and innovative training modalities, and infrastructure investments.

   Monitor digital tool adoption disaggregated by remoteness with transparent quarterly indicators and remediation protocols for underperforming facilities. For gender equity, operationalise commitments through concrete mechanisms that transform policy into practice. Make digital health career pathways transparent through clear qualification maps and defined entry routes. Establish structured programmes providing tangible opportunities: require participating organisations (public and private) to commit specific internship and mentorship places as condition of partnership; develop public-private partnership models enabling private sector contribution to workforce development; and create formal programmes pairing early-career women with experienced practitioners. Track progress systematically by monitoring educational pipeline, role transitions, and workforce composition, all disaggregated by gender, cadre, and location.

The evaluation demonstrates that whilst achieving system-level transformation requires coherent integration across strategic planning, technical specification, technology deployment, capacity development, sustainable financing, and gender equity, DIPC successfully laid critical foundations across all these dimensions. Countries are well-positioned for sustained success with validated plans, functioning platforms, trained workforces, and established governance. Building on these achievements, sustained political commitment, adequate resource mobilisation, continued partnership, and attention to follow-through mechanisms will enable countries to realize lasting digital health transformation serving diverse populations equitably and effectively.

Report Structure

This report is organised as follows. Section 1 provides background and evaluation objectives. Section 2 presents methodology overview. Section 3 presents key findings for each of the five DIPC components evaluated, with detailed analysis available in the companion topic reports. Section 4 synthesises cross-cutting findings and discussion themes emerging across components. Section 5 consolidates strategic recommendations organised by thematic priority area. Section 6 concludes with an overall assessment and proposed path forward.

1 Introduction and Background

1.1 Background and Purpose

Vaccine-preventable diseases claim approximately 1.5 million lives annually in Low- and Middle-Income Countries (LMICs) (Dimitrova et al., 2023), with 20.5 million children globally remaining unvaccinated or under-vaccinated in 2020 (WHO, 2020). The COVID-19 pandemic disrupted routine immunisation services across 170 countries, highlighting the fragility of immunisation systems in resource-constrained settings and the urgent need for innovative approaches to strengthen vaccine delivery mechanisms (Basu et al., 2023; Shet et al., 2022).

Digital health technologies offer substantial potential to enhance immunisation coverage through improved tracking, strengthened supply-chain management, and enhanced data accuracy (Zarekar et al., 2025). However, implementation at national scale faces substantial challenges: limited infrastructure, inadequate training, low digital literacy, and insufficient stakeholder engagement. Multiple factors impede adoption including unreliable electricity and connectivity, device shortages, workforce capacity gaps (World Bank, 2023a), and the persistent 'know-do gap' between research-based knowledge and real-world application (Skolarus & Williams, 2024).

1.2 The Digital Innovation in Pandemic Control (DIPC) 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.

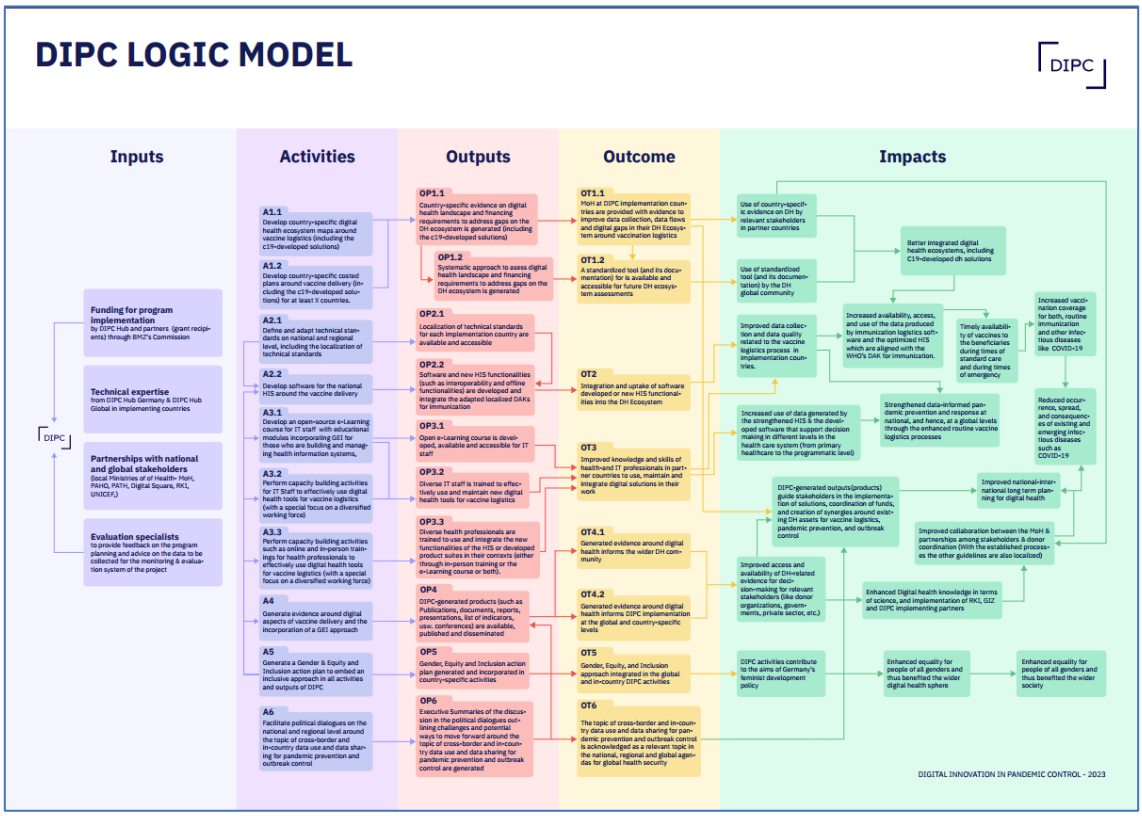

Figure 1. DIPC Logic Model

The initiative operated across several implementation components, which have been summarised in the DIPC Logic Model (Figure 1).

DIPC Partnerships

DIPC was implemented through partnerships coordinated by GIZ, working with international implementing organisations and country governments. Digital Square at PATH served as implementing partner in Ghana, Malawi, and Tanzania. UNICEF served as implementing partner in Sierra Leone. The Pan American Health Organization (PAHO) served as implementing partner in Peru. Country governments led implementation in each setting, ensuring alignment with national digital health strategies and sustainable integration within existing health systems.

This evaluation focused on three of the five DIPC partner countries: Ghana, Malawi, and Sierra Leone. Country governments led implementation through collaborative partnerships between national Expanded Programmes on Immunisation (EPI) and designated health system units. In Ghana, GHS Policy, Planning, Monitoring and Evaluation Division (PPME) and EPI jointly stewarded activities. In Malawi, the Ministry of Health Digital Health Division and EPI co-led implementation. In Sierra Leone, the Ministry of Health Directorate of Policy, Planning and Information (DPPI) and EPI directed activities jointly.

DIPC supported the development and rollout of digital immunisation tools tailored to each country's context: Ghana's enhanced DHIS2 eTracker (Child Health Module), Malawi's Healthcare Information System - Electronic Immunisation Registry (MaHIS EIR), and Sierra Leone's electronic Stock Management Tool (eSMT) extended to peripheral health units.

1.3 Evaluation Objectives and Approach

The Robert Koch Institute (RKI) conducted an independent external process evaluation of the DIPC initiative and examined DIPC's implementation across five key programme components across Ghana, Malawi and Sierra Leone, assessing relevance to country contexts, implementation processes (barriers and facilitators), and sustainability potential to generate actionable evidence for funders, implementers, national governments, and global health stakeholders.

The five DIPC programme components evaluated were:

1. Digital Ecosystem Assessments and Development of National Digital Health Roadmaps
2. Piloting of WHO's SMART Guidelines Approach
3. Digital Tool Roll-out
4. Capacity Strengthening Activities for Digital Tool Use
5. Gender Equity and Inclusion with focus on Ghana's Women in Digital Health Event

1.4 Purpose of This Report

This report presents an integrated synthesis of findings across the five evaluation components. It identifies common patterns, cross-cutting themes, and strategic priorities emerging from comprehensive evaluation of DIPC's multi-faceted approach to strengthening digital health systems. The report consolidates key achievements, critical challenges, and actionable recommendations to inform future digital health programming in the DIPC partner countries and LMICs more broadly. Detailed findings, discussions, and component-specific recommendations for each evaluation topic are available in five detailed companion topic reports:

Report 1: Digital Ecosystem Assessments & National Digital Health Roadmaps
Report 2: WHO SMART Guidelines Piloting
Report 3: Digital Tool Roll-out
Report 4: Capacity Strengthening for Digital Tool Use
Report 5: Gender Equity and Inclusion - Women in Digital Health Event

Readers seeking in-depth analysis of specific components, including country-specific details, comprehensive literature reviews, technical specifications, and detailed methodologies should consult the respective detailed reports.

1.5 Overview of Evaluation Components

The DIPC initiative encompassed multiple programmatic pathways designed to strengthen digital health systems across five partner countries. Figure 1 presents the DIPC logic model, illustrating the comprehensive scope of activities, outputs, and intended outcomes across the initiative's theory of change. For this evaluation, the five key programmatic components were strategically selected from the logic model pathways based on two primary criteria:

1. Implementation across multiple country contexts enabling cross-country comparative analysis, and
2. Relevance to different health system levels and stakeholder groups, facilitating comprehensive assessment of DIPC's multi-faceted approach to digital health system strengthening.

The selected components represent foundational planning processes (Digital Ecosystem Assessments and Roadmaps), technical specification methodologies (WHO SMART Guidelines), technology deployment (digital tool roll-out), and human resource development (capacity strengthening).

Additionally, Ghana's Women in Digital Health Event (WIDHE) was selected as a country-specific gender equity and inclusion activity, representing DIPC's main dedicated workforce GEI intervention and providing valuable insights for future gender-intentional programming despite implementation in a single country context. Whilst DIPC supported additional activities in individual countries, these five components provided coherent basis for systematic evaluation across Ghana, Malawi, and Sierra Leone. The following sections briefly describe each evaluation component to provide context for the findings presented in Sections 3-6.

Topic 1: Digital Ecosystem Assessments and National Digital Health Roadmaps

Digital Ecosystem Assessments (DEA) and National Digital Health Roadmaps (NDHRM) have emerged as critical planning instruments intended to address system fragmentation where 'vertical, partner-driven, programme-specific investments' operate independently, preventing effective data exchange and constraining governments' strategic oversight (Karuri et al., 2022). The WHO and International Telecommunication Union's National eHealth Strategy Toolkit (WHO & ITU, 2012) established that ecosystem assessments serve as foundational evidence for strategy development, requiring explicit connection to national health priorities and health system strengthening objectives. Within the DIPC framework, the evaluation examined Ghana's and Malawi's immunisation-specific DEA conducted in June-July 2023 and Sierra Leone's comprehensive NDHRM development process during 2022-2023. These planning instruments (Digital Square, 2023a; Digital Square, 2023b; Ministry of Health Sierra Leone, 2024) represent foundational components intended to inform subsequent implementation activities. The evaluation assessed how these processes aligned with country priorities and stakeholder

needs, examined implementation fidelity and constraining factors, and evaluated prospects for sustainable strengthening of digital health governance.

Topic 2: Piloting of WHO's SMART Guidelines Approach

WHO's SMART Guidelines provide a structured method for translating evidence-based standards into digital health interventions grounded in global data standards whilst adapted to national policies and local clinical guidelines. These **S**tandards-based, **M**achine-readable, **A**daptive, **R**equirements-based, and **T**estable guidelines represent an operationalisation of WHO's vision to facilitate rapid, effective, global implementation of guideline recommendations in the digital age (Mehl et al., 2021). Previously, translating health and data recommendations into digital systems has been largely unsystematic, slow, prone to error, and indifferent to technical standards, resulting in poor transparency and traceability. Moreover, many digital solutions are hard-coded, hindering ongoing alignment with evolving evidence and system interoperability needs. The SMART Guidelines framework comprises five progressive knowledge layers: from narrative guidelines (L1) through human-readable software-neutral documentation in Digital Adaptation Kits/L2, to machine-readable specifications (L3), reference software with interoperable components (L4), and precision health models (L5) (Figure 2).

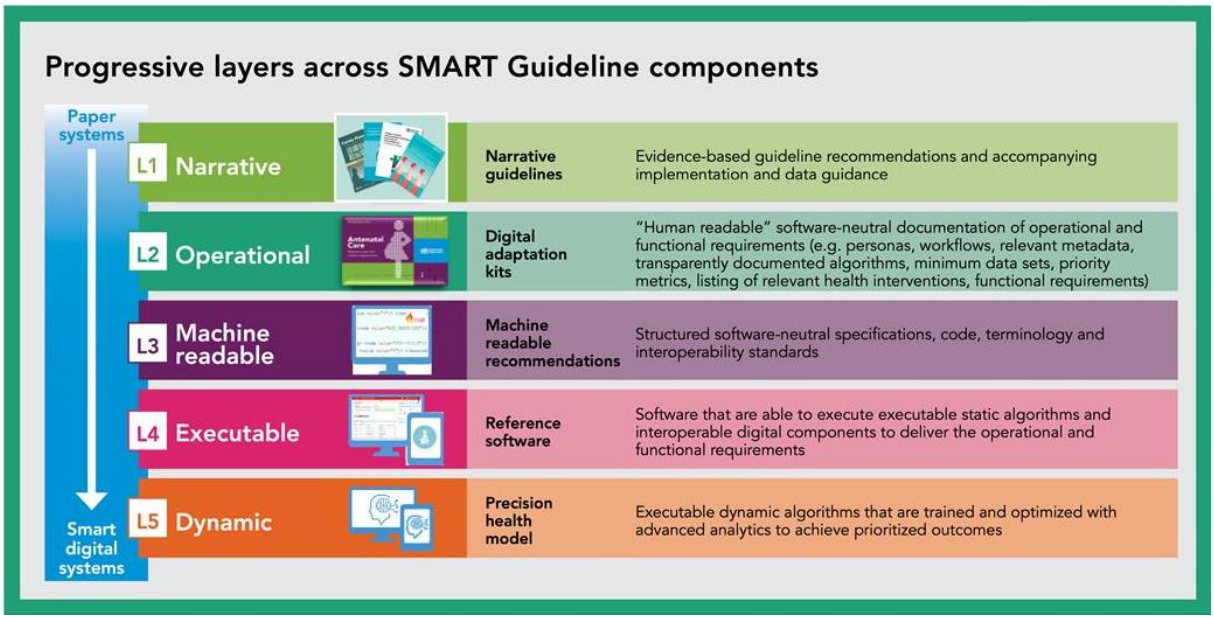

Figure 2. Progressive layers across SMART Guideline components (adopted from WHO, https://www.who.int/teams/digital-health-and-innovation/smart-guidelines/)

This systematic pathway aims to accelerate digital tool development, localisation, and implementation whilst promoting interoperability and long-term sustainability. DIPC represents one of the first initiatives to pilot the SMART Guidelines approach outside WHO technical assistance contexts, providing valuable opportunity to study framework application under "real-world" conditions in resource-constrained settings.

Topic 3: Digital Tool Roll-out

Digital Ecosystem Assessments (DEAs) conducted in Ghana and Malawi during DIPC Phase II identified critical gaps in digital immunisation infrastructure, informing subsequent programming through implementation partner Digital Square and country governments. In Ghana, Digital Square and Ghana Health Service (GHS) identified enhancement of the DHIS2 eTracker (Child Health Module) as the

priority solution to support end-to-end immunisation workflows for both COVID-19 and routine immunisation. The enhanced eTracker was rolled out in selected health facilities in Ghana's Ahafo and Volta regions through collaboration between GHS, GIZ, and Digital Square. In Malawi, Digital Square worked with the Ministry of Health to develop an EIR within the national MaHIS platform, addressing the need to digitalise existing paper-based immunisation registers and improve service delivery visibility. The EIR was implemented at all static immunisation sites in Mchinji District and three sites in Ntcheu District. In Sierra Leone, following the DIPC Phase I DEA and Phase II NDHRM development, UNICEF partnered with the MoH's DPPI and EPI to extend the existing electronic Stock Management Tool (eSMT) from district and national levels to Peripheral Health Units (PHUs) across four districts (Kailahun, Bonthe, Koinadugu, Karene), accompanied by hardware provision (laptops for District Health Management Teams (DHMTs) and focal points, solar panels at selected sites).

Topic 4: Capacity Strengthening for Digital Tool Use

Successful digital health implementation depends on workforce readiness and institutional capacity. The integration of digital technologies into LMIC health systems faces substantial human resource 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 (Long et al., 2018). Digital health literacy—encompassing information and data literacy, content creation, communication, problem-solving, and safety—has emerged as foundational competency, yet studies document that only 43.6-67.4% of healthcare professionals in some contexts possess adequate digital health literacy (Kasaye et al., 2024; Moges et al., 2024). DIPC's capacity strengthening interventions employed cascade Training of Trainers (ToT) models, wherein core groups receive intensive training and subsequently train others, representing a predominant approach for achieving scale with contained resource requirements. However, systematic reviews reveal highly variable training effectiveness in LMICs, with cascade models facing inherent depth-reach trade-offs and concerns regarding skill dilution and quality inconsistencies as training cascades to peripheral levels (Crisp & Raven, 2016). Evidence suggests sustainable capacity strengthening requires multi-component strategies combining initial training with continuous on-the-job support, regular supervision, and institutionalised learning mechanisms (Rowe et al., 2021). The evaluation examined DIPC's capacity strengthening interventions for digital tool use in terms of relevance, implementation processes, and sustainability.

Topic 5: Gender Equity and Inclusion – Ghana's Women in Digital Health Event

Women comprise 70% of the global health workforce yet face systematic underrepresentation in digital health leadership, technology development, and data science roles (Boniol et al., 2019). Digital health interventions designed without diverse perspectives risk reinforcing rather than addressing gender inequalities, potentially missing key populations or placing them at risk through failure to account for gendered social relations (George et al., 2018). In Ghana, stakeholders characterised the pre-DIPC digital health sector as male-dominated: women reportedly comprised fewer than 30% of informatics students and approximately 10% of GHS IT staff, concentrated in data entry roles whilst mostly absent from system design, data science, and leadership positions. The DIPC initiative integrated gender equity and inclusion (GEI) considerations throughout its programming as illustrated in the DIPC GEI-specific adaptation of its Logic Model (Figure 2).

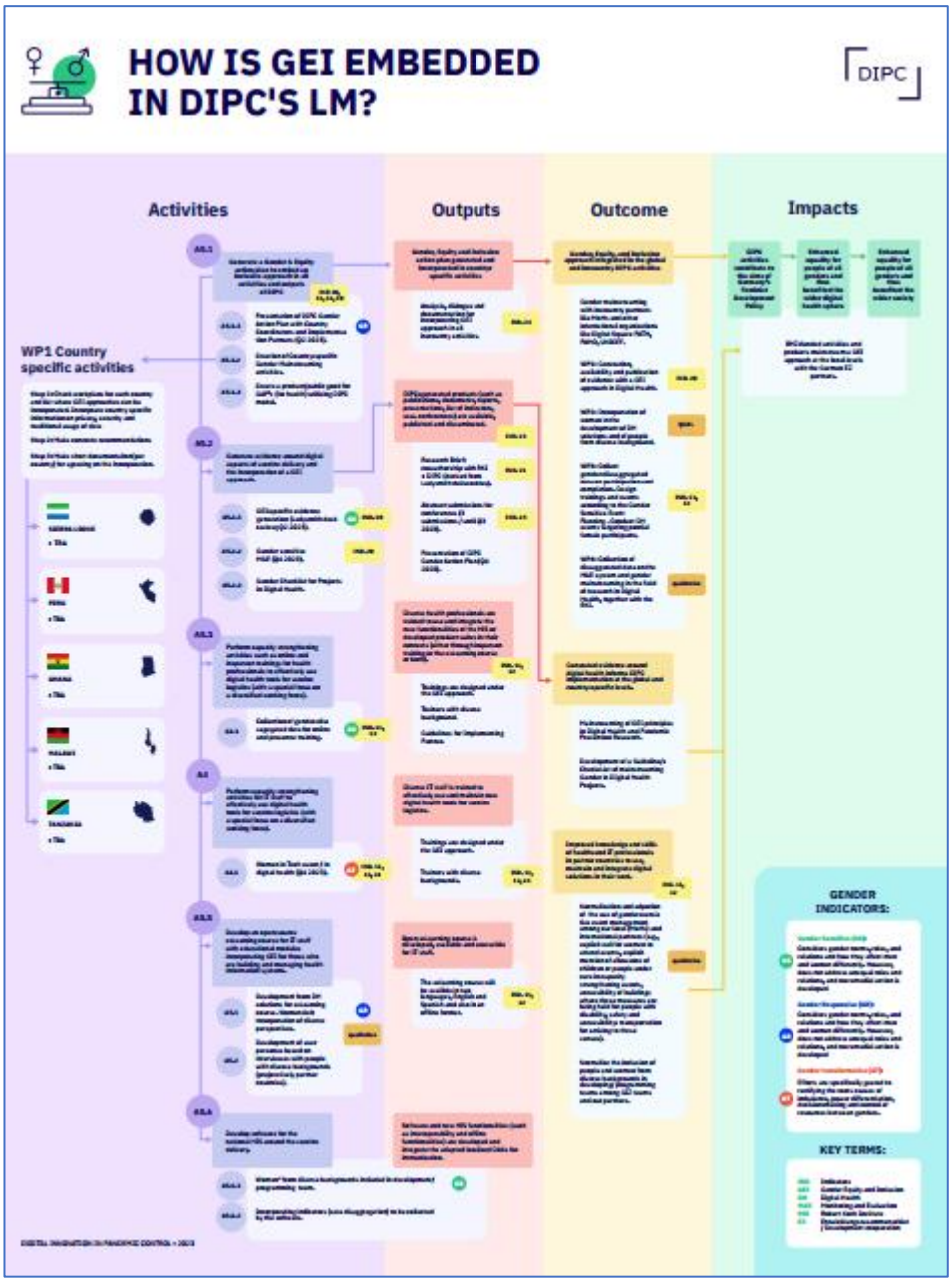

Figure 3. DIPC GEI Programming (Logic Model)

However, this evaluation focused systematic GEI analysis on the Women in Digital Health Event (WIDHE) in Ghana—a 1.5-day convening in Accra targeting female health staff and university students—for three reasons: it constituted a discrete intervention specifically designed to address gender disparities enabling coherent application of evaluation criteria; as a novel workforce development initiative distinct from tool implementation, it merited dedicated investigation; and comprehensive GEI evaluation across all components would require separate analytical frameworks beyond this process evaluation's scope. Whilst policy frameworks emphasising gender equity exist globally, including WHO's Gender Equal Health and Care Workforce Initiative (2021) and Ghana's Affirmative Action Act 2024, evidence on effective implementation of workforce development interventions remains limited. The WIDHE evaluation generates actionable evidence for strengthening future gender equity initiatives in contexts with supportive policies yet persistent gender segregation.

2 Methodology Overview

2.1 Study Design and Framework

This evaluation employed a qualitative process evaluation design grounded in the Consolidated Framework for Implementation Research (CFIR) and OECD Development Assistance Committee (DAC) criteria. The evaluation examined how DIPC activities aligned with national policies and priorities, responded to target group needs, and engaged key stakeholders (relevance); how implementation evolved relative to plans including barriers and facilitators (implementation processes); and potential for sustained results beyond the initiative (sustainability). Sustainability assessment included integration into national systems and capacity for independent continuation.

2.2 Study Settings and Participants

The evaluation was conducted in three of five DIPC partner countries: Ghana, Malawi, and Sierra Leone. Seventy-two semi-structured key informant interviews were conducted with stakeholders at international, national, regional/provincial, district, and health facility levels. The sample included four stakeholder groups: funders and implementing partners, government officials and health service administrators, regional and district public health officials, and healthcare providers and IT personnel at health facility level. The sample was intentionally weighted towards health workers at facility and district/regional levels (66% of respondents) to capture frontline implementation experiences.

Participants were purposively sampled to represent diverse perspectives on DIPC implementation. Inclusion criteria required participants to occupy professional roles relevant to digital health systems, DIPC implementation, or national immunisation programmes; serve as trainers, technical support staff, users, or beneficiaries of DIPC digital solutions; and have been employed continuously for at least six months in their current role. Sample size determination was based on the principle of data saturation (Guest et al., 2006; Hennink & Kaiser, 2022). Participants were identified through document reviews, stakeholder lists provided by GIZ and implementing partners, health system network knowledge, and snowball sampling.

2.3 Data Collection and Analysis

Data collection comprised comprehensive document reviews and semi-structured key informant interviews. Document review examined scientific literature, grey literature (programme documents, government policy papers), and project-specific materials (work plans, progress reports, stakeholder maps). Interviews lasted on average 45-90 minutes and were conducted face-to-face at locations convenient to participants or via secure videoconferencing. All interviews were audio-recorded, transcribed verbatim, and analysed thematically using predominantly deductive coding aligned to evaluation questions.

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 maintenance of reflexivity throughout the analysis process.

2.4 Ethical Considerations

The evaluation received ethical clearance from review boards in all participating countries: Ghana Health Service Ethics Review Committee (GHS-ERC-025/08/24), Sierra Leone Ethics and Scientific Review Committee (020/10/2024), and Kamuzu University of Health Sciences COMREC, Malawi (P.05/25-1585). Additional permissions were obtained from relevant health authorities. Informed consent was obtained from all participants, with confidentiality maintained through secure data storage, anonymisation of transcripts, and separation of identifying information from study data.

Detailed methodology for each evaluation component, including component-specific sampling strategies, and analytical frameworks, is available in the respective topic reports (Reports 1-5).

3 Findings by Topic

This section presents key findings for each of the five DIPC components evaluated. For each component, findings are organised according to the three evaluation criteria: relevance (alignment with national policies and target group needs), implementation processes (barriers and facilitators), and sustainability potential (integration into national systems and capacity for independent continuation).

Findings synthesised here draw from 72 key informant interviews across Ghana, Malawi, and Sierra Leone, complemented by comprehensive document reviews. Country-specific details, extensive literature reviews, technical specifications, and comprehensive component-specific recommendations are available in the respective detailed topic reports referenced at the end of each subsection.

This topic-by-topic presentation provides foundation for cross-cutting synthesis presented in Section 4, which identifies common patterns and themes across components, and consolidated recommendations in Section 5, which organise strategic priorities thematically rather than by individual component.

3.1 Topic 1 – Digital Ecosystem Assessments & National Digital Health Roadmap

Achievement and Relevance - DIPC support for the DEAs in Ghana and Malawi[1] and the NDHRM development in Sierra Leone delivered methodologically rigorous, stakeholder-endorsed planning instruments firmly anchored in national policy frameworks. Ghana's DEA (conducted June-July 2023) operationalised the digital health strategy by mapping systems, identifying tool duplications and interoperability gaps, and informing the decision to prioritise the eTracker enhancement. Sierra Leone's NDHRM translated the National Digital Health Strategy into a costed roadmap with over 50 prioritised actions, serving as a central governance instrument under DPPI to attract funding, reduce fragmentation and steer partner investments. Both processes demonstrated strong government ownership, achieved impressive implementation fidelity within compressed timelines, and generated tangible governance effects including tighter control over system proliferation and evidence-based partner alignment frameworks.

Critical Gaps and Challenges - Despite strong planning achievements, three critical gaps constrain translation into operational impact.

[1] Whilst DEAs were conducted in both Ghana and Malawi, implementation findings are limited to Ghanaian stakeholder perspectives only as Malawian interviewees did not discuss the assessment process.

1. **A significant follow-through gap exists between validated plans and execution**. Ghana's DEA produced validated interoperability specifications progressing to requirements stage, though designated custodianship and routine update cycles were not established to ensure continuity beyond the project period. DIPC supported development of Sierra Leone's NDHRM, providing comprehensive planning framework; subsequent implementation delivered fewer than 45% of roadmap activities at evaluation, constrained by financing gaps and staffing limitations, with progress occurring opportunistically through partner funding rather than sequenced government-led execution.
2. **Limited end-user integration during strategic planning creates the risk that system design may not fully address workflow realities**. Whilst institutional focus was appropriate for strategic planning instruments, frontline perspectives (e.g., technical software development teams, health workers) were integrated primarily during validation rather than throughout requirements definition.
3. **A "living registry" challenge** emerged, limiting governments' ability to coordinate digital health efforts and partner investments effectively. Ghana's DEA required updating 12-18 months post-completion as new systems came online and legacy systems were retired, yet no systematic update process had been established. Without designated government ownership and funded maintenance cycles, ecosystem registries become outdated, undermining their essential coordination function: enabling governments to direct partner organisations, prevent system duplication, and maintain strategic oversight of digital health investments.

Sustainability Prospects - Potential for sustainability was found to be credible but uneven and conditional. Sierra Leone demonstrates strong integration, with the NDHRM functioning as the governing blueprint and clear DPPI ownership, though operational execution lags due to financing and staffing constraints. Ghana's DEA demonstrates partial integration, with the SURD that emerged from the DEA having guided eTracker enhancement. However, it lacked designated custodianship, routine updates and system-wide institutionalisation. Both countries exhibit partial capacity for autonomous continuation with regards to the DEA and NDHRM: Sierra Leone demonstrates strong institutional capacity but remains constrained by lean staffing and insufficient domestic budgets; Ghana exhibits strengthening policy guardrails but lacks essentials for self-sustaining DEA stewardship. The evaluation identified three patterns shaping sustainability:

- the governance-to-execution gap (strong policy coherence insufficient without implementation mechanisms),
- context dependency (instrument utility varies by national readiness, with Ghana's high capacity enabling rapid decision-making whilst Sierra Leone's thinner capacity faces structural barriers), and
- follow-through architecture deficit (current methodologies treat implementation arrangements, custodianship and accountability as downstream concerns rather than core components).

Key Recommendations - Six recommendations address identified gaps:

(R1) Define clear handover processes from planning to implementation: Specify which government unit translates strategic plans into operational activities, establish concrete next steps with timelines, and convene initial planning workshops with district managers and facility staff to test feasibility and agree on actionable steps.

(R2) Tailor assessment depth to country capacity: Assess country readiness (governance strength, technical capacity, infrastructure, resources) and offer differentiated approaches—Foundation track for countries building basic governance structures, Consolidation track for integrating existing fragmented systems, Optimisation track for countries ready to operationalise established frameworks—with realistic scope and success criteria for each.

(R3) Establish accountability mechanisms before completing planning documents: Before finalising DEAs/NDHRMs, agree on and document who will steward implementation (specific government unit), when progress will be reviewed (quarterly/semi-annually through existing coordination forums), and what accountability measures exist, with brief technical partner participation in initial review meetings to support operationalisation.

(R4) Use existing coordination structures to drive implementation: Strengthen existing national digital health coordination forums rather than creating new structures, establishing standing agenda items to review priority integration tasks with responsible leads and deadlines, encouraging publication of simple quarterly progress updates, and aligning partner workplans to shared integration priorities.

(R5) Require designated ownership and maintenance schedules: Name specific institutional custodians (government office/unit and contact role) in final planning documents, establish realistic update schedules aligned with existing government cycles (e.g., annual sector reviews), provide simple maintenance protocols (what triggers updates, approval processes), and embed maintenance costs in routine budgets or multi-year partner agreements.

(R6) Keep digital health system registries current through simple update rules: Define clear triggers requiring registry updates (new system deployment, major system changes, system retirement), create standard submission templates and procedures routed through designated national digital health units, and include registry update obligations in partner agreements at grant inception and closure.

DIPC achieved what it set out to accomplish. Maximising impact requires methodological adjustments extending beyond planning to include implementation architecture, sustained accompaniment and financing covering maintenance alongside assessment.

[Detailed findings and country-specific analyses available in Report 1: Digital Ecosystem Assessments and National Digital Health Roadmaps]

3.2 Topic 2 – Piloting of WHO's SMART Guidelines Approach

Achievement and Relevance - DIPC successfully piloted WHO's SMART Guidelines approach across Ghana, Sierra Leone and Malawi, demonstrating that the L2 (requirements specification) methodology is replicable across diverse LMIC contexts. All three countries completed structured DAK/SURD localisation through multi-stakeholder workshops, producing validated, country-owned requirements documents translating clinical guidelines into digital specifications. Ghana's immunisation SURD guided eTracker enhancements and became EPI's first comprehensive design document. Sierra Leone localised the ANC DAK with planned integration into PresTrack, building foundational "standards literacy" across fragmented institutional structures. Malawi's immunisation SURD informed EIR development within MaHIS, ensuring standardised data formats and workflows. L2 specification value extended beyond immediate implementation to institutional knowledge preservation, with requirements documents serving as organisational memory capturing consensus on workflows, data elements and validation rules, surviving personnel turnover and supporting vendor accountability. The

initiative demonstrated strong methodological relevance for requirements specification, with structured, stakeholder-engaged processes aligning with implementation science principles emphasising content adaptation, stakeholder validation and documentation.

Critical Gaps and Challenges - Despite L2 success, three critical challenges emerged.

1. **The "missing middle" between specification and implementation:** developers characterised SURDs as "too theoretical" initially, requiring extensive facility-level consultation before software building. Requirements were often hard-coded rather than translated through formal L3 processes, bypassing the intended intermediate layer. Without developer-ready implementation guides (workflow diagrams, Fast Healthcare Interoperability Resource (FHIR) profiles, value sets, test cases), countries could not progress independently.
2. **No operational, standards-based data exchange was achieved during the project period**, despite all three countries articulating clear interoperability objectives during L2 specification. This gap between design intent and operational reality reflects systems developed from the same logical requirements using incompatible technical approaches.
3. **Context-dependent readiness variations substantially affected feasibility beyond L2**, with key bottlenecks including governance structures (institutional mandate fragmentation preventing coordinated action even where specifications articulated integration requirements), specialist capacities (FHIR expertise, architecture knowledge), infrastructure deficits (devices, connectivity, hosting) and financing gaps (support covered L2 but not fully L3 development, L4 implementation or operations). Late re-programming to pursue SMART Guidelines compressed government sensitisation timelines, limiting upfront readiness assessments. As one of the first programmes piloting SMART Guidelines at scale, DIPC navigated untested territory where financing L2 through L4 represents a multi-year process unrealistic within typical 2-3 year project cycles.

Sustainability Prospects - Sustainability is conditional and differentiated. L2 artefacts provide valuable institutional foundations persisting independent of operational system status, serving as organisational memory and enabling future development. However, no country achieved operational sustainability (domestically financed, interoperable implementations maintained through national capacity) at evaluation, aligning with literature documenting multi-year transitions (e.g., Vietnam's electronic immunisation registry required seven years from pilot to national scale, (Mvundura et al., 2023)).

Ghana’s GHS assigned stewardship to its PPME/Centre for Health Information Management (CHIM) with GHS technical teams possessing capacity to work with the SURD, but independent continuation depends on securing recurrent budgets and completing initial interoperability.

Sierra Leone established enabling conditions (policy alignment, requirements documentation, Hackathon planned for L3, national PresTrack integration plans, coordination forums) but technical capacity remained limited and financing for essential infrastructure unsecured.

Malawi demonstrated institutional commitment, but government developer positions remained scarce, hosting relied on partner support, and no functional MaHIS-DHIS2 data exchange existed. Critical sustainability gaps include absent formal DAK/SURD maintenance mechanisms (without designated stewards, review cycles and change management processes, requirements risk obsolescence as guidelines evolve), unfunded recurrent operational costs (devices, connectivity, support systems), capital-versus-recurrent financing disparities, and external dependencies for

technical L3/L4 competencies. Financial sustainability emerged as the primary determinant of system durability, with transition from donor to domestic budget integration remaining incomplete.

Key Recommendations - Seven recommendations address identified gaps:

(R1) Develop intermediate technical artefacts bridging the "missing middle" through "layer 2.5" templates translating L2 into developer-ready specifications, open-source reference implementations and conformance testing frameworks;

(R2) Establish differentiated SMART Guidelines implementation pathways based on country readiness, defining three tracks (Full Implementation, Capacity Building, Foundation) with tailored scope and success criteria;

(R3) Strengthen early technical team engagement from DEA through L2 validation, establishing regional L3 specialist rosters for extended engagements providing hands-on assistance;

(R4) Strengthen governance mechanisms for cross-system coordination through explicit mandates, policy directives requiring standards-based implementation and procurement criteria requiring standards compliance;

(R5) Address infrastructure and financing prerequisites through standardised costing frameworks for complete implementation cycles, infrastructure readiness assessments before L2 initiation and progressive domestic co-financing expectations;

(R6) Establish realistic multi-year transition support (5-7 years) with declining partner financing and clear operational milestones enabling progressive transition;

(R7) Establish formal stewardship and governance processes for DAK/SURD maintenance through designated institutional stewards, regular review cycles and standardised change management protocols.

DIPC successfully demonstrated that SMART Guidelines L2 requirements specification is achievable across diverse LMIC contexts, with all three countries completing DAK/SURD localisation and integrating standards-based frameworks into national platforms. As one of the first initiatives piloting this methodology beyond WHO technical assistance, DIPC generated critical implementation insights contributing to ongoing global methodology refinement. Countries now possess validated, standards-based requirements providing strong foundations for digital health development. Whilst progression to operational systems requires sustained technical accompaniment and multi-year support extending beyond typical project cycles, DIPC positioned countries well with governance structures, technical foundations, and demonstrated commitment enabling continued advancement along their chosen implementation pathways.

[Detailed findings including technical specifications and FHIR implementation guidance available in Report 2: Piloting of WHO's SMART Guidelines Approach]

3.3 Topic 3 – Digital Tool Roll-out

Achievement and Relevance - DIPC digital tool implementation (Ghana's enhanced DHIS2 eTracker, Sierra Leone's eSMT, Malawi's MAHIS EIR) demonstrates evidence-informed digital health investment through strong policy alignment, direct response to operational needs, and government-led multi-stakeholder engagement. Tools demonstrated high relevance across contexts, reportedly replacing fragmented paper-based systems with platforms enabling timelier, more granular and actionable

immunisation data. Ghana's enhanced eTracker operationalised the digital health strategy by creating a transactional layer within established DHIS2 infrastructure under GHS/PPME stewardship. Sierra Leone's eSMT implementation was informed by comprehensive pre-roll-out landscape assessment identifying infrastructure and capacity gaps, with design choices (hardware provision, solar panels, digital literacy training, DHIS2 integration planning) directly addressing documented operational constraints. Malawi's MaHIS EIR demonstrated strong relevance to national priorities for digital health system consolidation and sovereignty, with the government directive that partners must "join ours" directly addressing donor dependency and system fragmentation, whilst design choices (reverse-billing, role-based access, offline-first architecture) responded to operational realities. DIPC's integration strategy, building within existing platforms rather than creating standalone systems, avoided fragmentation documented across hundreds of isolated digital health tools, combined with WHO DAK-based standards adoption creating technical foundations for future interoperability. Within three years, DIPC achieved phased adaptive deployment across multiple districts, capacity built amongst hundreds of health workers, governance structures established with clear government stewardship, and operational value demonstrated through improved defaulter tracking, stock visibility and reporting efficiency.

Critical Gaps and Challenges - Despite strong design achievements, four main critical gaps emerged.

1. **Infrastructure deficits as primary barrier:** device shortages, unreliable connectivity, inadequate power and intermittent hosting resulted in partial uptake, inconsistent use and disrupted reporting, frequently forcing reversion to paper-based systems. Facilities rarely possessed sufficient devices, reliable power or stable connectivity. Sierra Leone's hardware provision alongside software and phased training addressed multiple dimensions of existing deficits, whilst Malawi and Ghana relied on existing equipment with reports of non-functioning devices and severe equipment shortages. Whilst initial procurement through donor funding facilitated adoption (Sierra Leone), replacement cycles, maintenance and connectivity require recurrent financing that countries struggle to provide, representing the capital versus operational financing gap.
2. **Dual paper-digital workflows undermined operational relevance:** persistent parallel workflows created workload burdens, back-entry requirements and data quality challenges. Dual systems often persisted because digital tools lacked sufficient reliability to justify paper retirement, creating vicious cycles where under-resourced systems could not demonstrate value sufficient to secure investment enabling paper retirement.
3. **Legacy system dependencies and data migration challenges slowed implementation:** Ghana's need to maintain the operational legacy eTracker system across 14 regions during transition constrained scale-up of the enhanced version. Critical data migration processes required careful sequencing to ensure data continuity, slowing rollout timelines. This highlighted tensions between maintaining functioning systems during transitions and advancing new implementations, particularly when resources could not support parallel operations indefinitely whilst ensuring uninterrupted service delivery.
4. **Design-infrastructure mismatches limited consistent use:** Online-only system designs, particularly Sierra Leone's eSMT, posed significant challenges in contexts with weak internet infrastructure and intermittent electricity. Single-device-per-facility allocations created bottlenecks, frequently relegating data entry to retrospective "back-entry" by facility in-charges rather than point-of-service recording. Teams frequently reverted to paper-based recording during outreach activities where connectivity was absent, requiring subsequent manual data transfer and creating delays.

Sustainability Prospects - Integration within national platforms positions tools for sustained use. Ghana's enhanced eTracker operates within DHIS2 under GHS/PPME stewardship, Malawi's EIR functions within MaHIS under MoH governance, and Sierra Leone's eSMT exists within the national system under MoH EPI stewardship. This government-led platform integration supports sustainable institutional ownership and long-term system maintenance. However, DIPC's three-year implementation cycle proved insufficient for operational maturity and national scale-up.

Ghana demonstrates institutional integration with established monitoring loops, routine data use at district and national levels, and WhatsApp-based problem-solving channels providing accessible technical support. However, the enhanced eTracker remains at pilot status whilst the legacy system continues across 14 regions. Migration faces incomplete interoperability specifications, device shortages, connectivity limitations and dual paper-digital burdens. Sustainability requires predictable financing for device procurement, data bundles, power solutions, institutionalized refresher training cycles to address staff turnover, and progressive paper phase-out supported by reliability improvements.

Malawi established clear institutional foundations through the "MaHIS-first" policy directive, defined stewardship, national hosting and reverse-billing innovation demonstrating local ownership principles. However, recurrent operating cost challenges persist: device maintenance and replacement, transport and supervision funding, intermittent connectivity and limited in-house developer capacity. This reflects constraints from low domestic health spending and high aid dependency documented in country financial data.

Sierra Leone demonstrates operational integration with eSMT established as a national stock management tool prior to DIPC, which extended use to PHU level across four pilot districts. Under MoH EPI stewardship, emerging governance routines and staff uptake indicate receptivity to sustained use. However, full adoption remains contingent on continued infrastructure and capacity support (digital literacy, hardware, electricity, connectivity). Architectural integration remains incomplete: eSMT-DHIS2 interoperability under development but not operational, help-desk functions external to the tool, and coverage limited to pilot districts. Sustainability requires transition from donor to domestic financing for recurrent costs, more equitable digital skills distribution across facility staff, and completion of DHIS2 interoperability to eliminate dual entry burdens.

Three critical dimensions remain incomplete across all contexts:

1. Recurrent financing for device lifecycles, connectivity, power, supervision and technical support not secured through domestic budgets;
2. Three-year timeline insufficient for full institutional adaptation, comprehensive geographic coverage, workforce normalisation, and institutionalisation of continuous learning systems (refresher training, peer networks, help-desk functions); and
3. Systematic capacity for budget advocacy, domestic resource negotiation, and in-house technical capacity development (software developers, data analysts) underdeveloped, limiting countries' ability to secure sustained domestic financing and autonomous system management.

Key Recommendations - Nine recommendations address structural challenges:

(R1) Conduct infrastructure readiness assessments and deploy innovative solutions (Bring-Your-Own-Device (BYOD), reverse-billing, device-as-a-service, asset management with vendor service agreements);

(R2) Design phased paper retirement strategies with clear triggers (e.g., >95% uptime, >80% confidence, >90% concordance, >70% adoption) eliminating dual workflows;

(R3) Institutionalise continuous user feedback mechanisms (multi-tiered channels, systematic capture, transparent roadmaps, dedicated maintenance resources);

(R4) Implement in phases with clear readiness criteria (minimum devices, power, connectivity, trained staff) before expanding to new sites; document lessons from each phase; adjust timelines based on progress; maintain paper systems until digital systems prove reliable;

(R5) Enable data use at all levels: facility staff receive performance dashboards, district managers identify struggling sites, national programmes inform decisions; address both technical needs (devices, connectivity, hosting) and support needs (training, supervision, mentorship) concurrently; build capacity progressively through initial training, refreshers, and ongoing coaching;

(R6) Build local technical capacity through strategic vendor partnerships (knowledge transfer obligations, in-country ecosystems, formal training, sustainable financing);

(R7) Plan 5-7 year transitions from donor to domestic financing: governments progressively assume costs (starting with supervision and support, then devices and connectivity, finally full operations) whilst partner support declines; build government budget advocacy capacity;

(R8) Establish dedicated government budget lines for recurrent costs (devices, connectivity, power, supervision, support, comprehensive costing, cost-sharing, innovative financing);

(R9) Complete technical interoperability and eliminate fragmentation (pending specifications, system retirement strategies, consolidated support functions, governance frameworks).

Within three years, DIPC demonstrated feasibility of government-led, standards-based digital immunisation systems in resource-constrained contexts. However, progression from pilot to sustained national systems requires addressing structural challenges beyond single project cycles: recurrent financing for infrastructure lifecycles, institutionalised capacity development, systematic paper retirement, and completed interoperability. These transitions require 5-7 year trajectories—timescales reflecting digital health system transformation realities rather than individual intervention limitations.

[Detailed findings including facility-level implementation experiences and technical specifications available in Report 3: Digital Tool Roll-out]

3.4 Topic 4 – Capacity Strengthening for Digital Tool Use

Achievement and Relevance - DIPC capacity strengthening across Ghana, Malawi and Sierra Leone demonstrates substantial achievements in digital health workforce development.

Cascade ToT models achieved substantial geographic reach: 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, demonstrating cascade training's capacity for large-scale workforce development with contained resource requirements. The country interventions successfully employed contextually relevant curricula reportedly addressing authentic operational workflows through hands-on, workflow-oriented didactics using authentic facility registers, live demonstrations and practical drills, effectively building health worker confidence and initial competency. Sierra Leone's evidence-informed sequencing (foundational digital literacy

preceding technical tool training) exemplified appropriate baseline needs assessment addressing documented minimal digital maturity.

Strong government ownership anchored legitimacy: Ghana's GHS units led delivery logistics, Sierra Leone's MoH DPPI and EPI provided stewardship, Malawi's MoH Digital Health Division and EPI directed the cascade, facilitated by the DIPC implementation partners Digital Square and Unicef respectively. Training reportedly directly addressed operational needs: accelerated client processing, reduced transcription errors, improved defaulter tracing, enhanced stock visibility and faster reporting cycles, with stakeholder reports confirming immediate applicability to daily tasks. District-level adoption was substantive across settings with documented operational improvements, providing proof-of-concept in multiple pilot settings that trained health workers can effectively integrate digital tools when enabling conditions exist. Creation of district-level training capacity represents particularly important accomplishment, with Malawi demonstrating autonomous training expansion beyond initial implementation plans, illustrating successful capacity transfer and emerging local ownership.

Critical Gaps and Challenges - Despite strong training achievements, three critical gaps emerged.

1. **Training depth vs. reach trade-offs:** 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 reportedly particularly pronounced for peripheral health workers with fewer post-training practice opportunities due to infrastructure/equipment constraints. Skills degraded without regular practice and reinforcement mechanisms. Training reached only two to three staff per facility, typically facility in-charges, whilst excluding lower cadres, creating vulnerability during staff absences or turnover. Respondents highlighted several notable gaps in the training curricula. Foundational capabilities—typing speed, basic IT navigation, troubleshooting—required strengthening. Content focused on technical operation (how to use the system) without adequately developing data quality verification or analytical interpretation skills. Reportedly, training did not sufficiently differentiate instruction by baseline digital literacy, leaving some participants with surface-level learning whilst under-challenging those with stronger foundational skills. Post-training support architecture remained underdeveloped, with structured refresher schedules, competency tracking and mentorship systems not systematically embedded within district supervision routines.
2. **Infrastructure as binding constraint:** inadequate device-to-staff ratios, unreliable connectivity, intermittent power and occasional hosting downtime forced temporary reversion to paper workflows regardless of competency levels. Single-device arrangements restricted practice opportunities, staff reverted to paper-first workflows digitising retrospectively, and hybrid paper-digital workflows persisted, creating self-reinforcing cycles wherein infrastructure deficits perpetuate skill gaps. Health workers in remote, poorly equipped facilities receive equivalent initial training yet have substantially fewer opportunities to apply competencies through routine use, highlighting two concurrent requirements: infrastructure investment and potentially more intensive training for staff in resource-constrained peripheral settings.
3. **Governance and sustainability constraints:** supervision and refresher provision remained substantially dependent on external partner presence and funding rather than institutionalised government mechanisms. Unclear user permissions limited tool functionality in some instances, limited help-desk capacity constrained troubleshooting access, incomplete interoperability perpetuated data duplication, and training remained episodic and partner-

funded rather than continuous and government-financed. Stakeholder feedback suggests that peripheral facilities in some instances adopted digital tools less consistently than district facilities. As such, without intentional support prioritising remote areas, digital health risks widening gaps between well-resourced and under-resourced facilities.

Sustainability Prospects – According to stakeholder reports, the cascade training approach demonstrated viability across several dimensions.

Governments have the capacity to deliver training independently through existing structures. Training multiple staff types at each facility created redundancy when individuals leave and peer support networks function informally at district level. Training content can integrate into routine pre-service and in-service programmes. Countries demonstrated strong local capacity: district trainers deliver independently, Malawi's district trainers independently trained additional facilities beyond the original project plan, operational improvements motivate continued use, and governments manage training delivery, logistics, and troubleshooting. Malawi's MoH stewardship model with reverse-billing innovation and district-managed onboarding exemplifies promising governance approaches demonstrating local ownership principles.

However, tool adoption remained incomplete and spatially uneven: some regions had not commenced implementation receiving only training without tool rollout, persistent parallel paper-based workflows continued, device and data availability gaps constrained consistent use, staff turnover eroded facility-level competency, and skills strengthened inconsistently across sites.

Facilities reporting routine use also described presence of system enablers (Ministry stewardship, reverse-billing arrangements, functional ToT cascade, accessible peer support through WhatsApp networks), whilst uneven uptake was frequently reported in settings with connectivity limitations, data bundle unavailability, insufficient devices, thin post-training supervision and staff turnover.

Digital Square's subsequent development of training videos for enhanced eTracker and MaHIS EIR represents commendable effort addressing sustainability gap by providing lasting resources acknowledging that in-person refresher trainings are highly resource-intensive and often financially unsustainable for national governments.

However, moderate-to-credible sustainability potential reflects realistic acknowledgment that consolidating initial achievements requires transitioning from episodic partner-supported implementation to institutionalised government-owned systems, a well-documented challenge where externally-funded pilot programmes frequently struggle to achieve sustained domestic financing and scale. Durability depends on routine operational mechanisms: calendared refresher cycles aligned with deployment timelines, structured onboarding for new staff, designated peer trainers with protected time, regular supervision incorporating digital health monitoring, basic "facility package" (functional tablets, assured data connectivity, stable application performance, single-entry workflows replacing parallel paper systems), and progressive cost transfer of core operational expenses (device replacement, data bundles, technical support) into routine government budgets.

Key Recommendations - Seven recommendations address identified gaps, converging on continuous learning, proximal support, comprehensive coverage and adequate resourcing:

(R1) Implement multi-tiered training duration based on role complexity (e.g., 5-7 days for district super-users/facility champions, 3-4 days for frontline staff with mandatory follow-up, extended training for peripheral facility staff, pre-training digital literacy assessments);

(R2) Establish institutionalised continuous learning systems with multi-modal delivery (mandatory quarterly refresher cycles with government ownership, multi-modal resources including instructional videos/job aids/WhatsApp micro-learning/offline-accessible materials, curriculum expansion to data quality/dashboard interpretation/statistical literacy);

(R3) Deploy infrastructure before conducting training: ensure facilities meet minimum requirements—e.g., at least one device per three staff, reliable power, stable connectivity—before training begins; prioritise peripheral facilities with appropriate solutions (solar panels for power, durable devices, offline capability); establish clear maintenance protocols for device repair and replacement;

(R4) Establish district-level digital health support: designate district staff with protected time (e.g., at least 25% of workload) to provide technical assistance; create peer coaching systems with monthly facility visits, virtual check-ins, and responsive troubleshooting; use district dashboards to identify facilities with low adoption or technical problems requiring support;

(R5) Institutionalise government-led governance and sustainable financing frameworks (Memoranda of Understanding with Ministries assuming recurrent training costs/infrastructure maintenance/connectivity/supervision whilst partners support capital investment/technical assistance, embedding digital health training in pre-service curricula and routine in-service structures, dedicated government budget lines);

(R6) Deploy scalable digital learning resources and institutionalise quality assurance (comprehensive digital resource libraries in local languages, standardised trainer competency assessments/post-training participant assessments/six-month follow-up evaluations, national training registries documenting coverage gaps/refresher needs/quality variations);

(R7) Implement equity-focused strategies ensuring inclusive reach (equity-explicit planning prioritising remote facilities with transparent quarterly indicators and remediation protocols, peripheral-specific interventions with more intensive training/ frequent supervision/ prioritised offline resources, gender-balanced cohorts/ local language materials/ visual pedagogy/ adoption monitoring disaggregated by remoteness/ gender/ cadre).

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. DIPC demonstrates this integration is both feasible (documented successes show well-designed interventions can function effectively in challenging contexts) and essential (isolated capacity building without complementary system investments yields incomplete and potentially inequitable outcomes).

[Detailed findings including training curricula, competency assessments, and facility-level adoption patterns available in Report 4: Capacity Strengthening for Digital Tool Use]

3.5 Topic 5 – Gender Equity and Inclusion: Ghana's Women in Digital Health Event

Achievement and Relevance – The WIDHE implemented by Digital Square at PATH with GIZ and GHS in October 2024, represents gender-intentional workforce development through strong policy alignment and direct response to documented barriers. In Ghana, stakeholders characterised the pre-DIPC digital health sector as male-dominated: reportedly women represented fewer than 30% of

informatics students and approximately 10% of GHS IT staff, concentrated in data entry roles whilst largely absent from system design, data science, and leadership positions.

The WIDHE demonstrated high relevance across evaluation dimensions. The event aligned with Ghana's Affirmative Action Act 2024 and GHS Digital Health Strategy, appropriately targeted female health staff and university students as priority workforce cadres, and addressed identified needs through practical event design. The structure showcased diverse digital health career pathways including business analysis, UX design, data science, quality assurance, project management, and software development; featured female practitioners in keynote and panel roles; and facilitated cross-sectoral networking amongst participants and potential employers from government, academic, and private sectors.

Strong demand validated the event's relevance. Over 200 registration requests were received within twelve hours. Between 95-100 participants attended from multiple regions. Qualitative feedback included repeated descriptions of a "whole world opening up," with sustained post-event networking through self-organised WhatsApp groups. The event employed evidence-informed design strategies: featuring female practitioners in visible roles, combining lifecycle simulation with role-based sessions, and engaging cross-sectoral partnerships. Within its defined scope as a pilot awareness-raising intervention, WIDHE achieved strong implementation fidelity.

Critical Gaps and Challenges - Despite strong awareness-raising achievements, three critical gaps emerged constraining translation of initial engagement into sustained career outcomes.

1. **Absence of follow-through mechanisms:** registration demand exceeded capacity, some content proved too advanced for beginners, no consolidated resource guide mapping training opportunities to roles was provided, and neither public nor private sector partners translated participation into concrete offerings. Private sector engagement contributed visibility but did not convert into mentorship programmes, internship placements, or recruitment pipelines.
2. **No systematic outcome tracking:** without monitoring systems documenting whether initial interest translated into training enrolments, role transitions or workforce composition changes, demonstrating impact or identifying effective elements becomes difficult.
3. **Policy-implementation gap:** whilst Ghana's Affirmative Action Act 2024 and GHS Digital Health Strategy provide strong normative frameworks, legal and strategic commitments have not been translated into funded operational workplans with targets, timelines, budgets and accountability. Structured implementation mechanisms remain absent—formalised mentoring cohorts with designated mentors and clear progression pathways, internship programmes with defined selection processes and partner commitments, transparent qualification maps showing educational routes to employment, and standardised GHS entry routes. Institutional ownership depends on individual champions rather than embedded organisational structures, creating vulnerability to personnel changes.

Sustainability Prospects - The WIDHE generated meaningful initial results: participants exposed to career pathways, WhatsApp community created, isolated follow-on activities including conference bursaries and training enrolments, and anecdotal reports of an increase in women applying to digital programmes with documented staff reassignments. Ghana's supportive policy environment and improving infrastructure provide enabling conditions.

However, sustaining momentum requires addressing identified gaps. Without dedicated funding for mentorship and internship programmes, employer connections remain informal. No system exists to track outcomes over time, limiting ability to demonstrate impact and secure continued investment.

Most critically, translating policy commitments into operational systems with measurable targets, standardised pathways, and accountability mechanisms remains incomplete—the fundamental challenge for sustained workforce transformation.

Key Recommendations - Seven recommendations address identified opportunities:

(R1) Hold regular events tailored to different career stages with annual/biannual cycles, audience-specific tracks and rotating regional locations;

(R2) Develop career pathway resources consolidating training opportunities mapped to roles with prerequisites, costs and employment linkages;

(R3) Require partner commitments for structured mentorship and internship programmes as condition of participation, establishing mentorship cohorts with defined criteria, transparent internship programmes, formalised agreements and accountability mechanisms;

(R4) Implement lightweight outcome monitoring systems tracking educational pipeline, role transitions and workforce composition through existing systems with participant follow-up surveys;

(R5) Operationalise gender equity policy commitments by translating policies into funded operational workplans with targets, timelines, budgets, accountability mechanisms, and integration into HR planning processes;

(R6) Embed digital health content in pre-service and in-service training by integrating modules within health professions curricula and GHS training cycles;

(R7) Deepen institutional ownership and multi-sectoral coordination by assigning responsibility to specific GHS unit, establishing steering committee, and integrating initiatives into routine planning and budgets.

The WIDHE successfully demonstrated that gender-intentional design effectively catalyses initial interest. Translating awareness into sustained workforce transformation requires extending beyond awareness-raising to establish concrete career pathway mechanisms, operationalise policy commitments through funded workplans, and embed initiatives within institutional structures. Ghana's enabling policy environment and demonstrated demand create strong foundations for developing a model with relevance for similar contexts across sub-Saharan Africa.

[Detailed findings including participant experiences, gender analysis across digital health roles, and regional benchmarking available in Report 5: Gender Equity and Inclusion – Women in Digital Health Event]

4 Cross-Cutting Findings and Discussion

This section synthesises findings across the five evaluation components, identifying common patterns, cross-cutting themes, and strategic insights emerging from DIPC's multi-faceted approach to strengthening digital health systems.

Common Achievements: Strong Relevance and Implementation Fidelity

DIPC demonstrated consistent strengths across all five components, reflecting well-designed, contextually-appropriate interventions with strong government ownership.

Strong Policy Alignment and Country Ownership - All DIPC components demonstrated high relevance to country contexts through alignment with national policies and priorities. Ghana's DEA operationalised the digital health strategy, Sierra Leone's NDHRM translated strategic commitments into costed actions, and all three countries' digital tool implementations responded to explicitly articulated government priorities. WHO's SMART Guidelines localisation processes were government-anchored, with multi-stakeholder workshops producing country-owned requirements documents. Capacity strengthening interventions addressed operational needs identified by health system stakeholders. The WIDHE aligned with Ghana's Affirmative Action Act 2024 and GHS Digital Health Strategy. This policy coherence distinguishes DIPC from partner-driven vertical programmes that operate independently of national frameworks.

Government ownership extended beyond policy alignment to operational stewardship through effective partnership arrangements. GIZ coordinated DIPC implementation working with Digital Square at PATH in Ghana and Malawi, and UNICEF in Sierra Leone. These partners provided technical expertise, facilitation, procurement support, and capacity-building whilst governments were the decision-makers and implementation leaders. Ghana's GHS, Sierra Leone's and Malawi's MoH actively led: directing DEAs and roadmap development, stewarding SMART Guidelines localisation, managing digital tool rollout logistics, leading cascade training delivery, and championing gender equity initiatives. This partnership model—where international organisations enabled rather than directed—anchored legitimacy, accelerated decision-making, and positioned interventions for sustained impact beyond external project support.

Methodological Rigor and Implementation Fidelity - DIPC achieved strong implementation fidelity across components. DEAs and roadmap development followed structured, time-bound methodologies completing planned landscape mapping, synthesis, and validation within schedules. SMART Guidelines piloting completed DAK/SURD development through systematic multi-stakeholder workshops producing validated requirements documents. Digital tool rollouts achieved phased adaptive deployment across multiple districts. Cascade training models achieved impressive geographic reach (Ghana: 1,400 staff from 700+ facilities; Malawi: 1,200 health workers from 47-48 facilities; Sierra Leone: 44 peripheral health units). The Women in Digital Health Event achieved planned structure and attendance targets.

This process fidelity demonstrates DIPC's capacity to deliver technically sound, stakeholder-engaged interventions within compressed timelines characteristic of donor-funded projects. However, as analysis reveals, process fidelity constitutes a necessary but insufficient condition for sustained operational impact. *[Component-specific implementation details available in Reports 1-5]*

Responsive Design Addressing Documented Needs - DIPC interventions responded directly to documented needs and contextual realities. DEA and roadmap addressed system fragmentation and weak governance visibility. SMART Guidelines addressed requirements specification gaps. Digital tools replaced fragmented paper-based systems with platforms enabling granular, actionable data. Sierra Leone's hardware provision, solar panels, and digital literacy training explicitly addressed infrastructure deficits and digital maturity constraints. Training employed contextually-relevant curricula addressing authentic workflows. The Women in Digital Health Event addressed documented perception barriers and absence of role models. This responsiveness reflects evidence-informed design grounded in stakeholder consultation.

Common Critical Gaps: The Follow-Through Architecture Deficit

Despite strong design and implementation fidelity, three interconnected gaps constrain translation of initial achievements into sustained operational impact.

The Policy-Implementation Gap - The most fundamental pattern across components is the gap between validated plans and operational execution. Ghana's DEA produced validated interoperability specifications progressing to requirements stage, though designated custodianship and routine update cycles were not established to ensure continuity beyond the project period. DIPC supported development of Sierra Leone's NDHRM as a comprehensive planning instrument; however, subsequent implementation delivered fewer than 45% of roadmap activities at evaluation, constrained by financing gaps and staffing limitations. The DAK/SURD localisation process produced valuable L2 requirements documents. However, progression from requirements specification (L2) to operational systems (L3/L4) and standards-based data exchange was not achieved within the three-year project cycle—a timeline insufficient for transitions requiring sustained technical accompaniment, substantial development resources, and multi-year implementation trajectories. Digital tools demonstrated partial uptake with persistent parallel paper-digital workflows. Capacity strengthening achieved activation-level competency but insufficient depth for independent operation. The WIDHE generated enthusiasm without structured mentorship, internship pathways, or outcome tracking.

Stakeholders consistently identified a gap between planning and implementation. Strong plans and policies exist, but practical systems to execute them are missing. Plans require supporting structures to become reality: clear coordination processes, predictable funding, accountability for delivery, designated staff with protected time, and regular progress review built into institutional routines. *[Detailed analysis of policy-implementation gaps by component available in Reports 1-5]*

Infrastructure as Binding Constraint - Infrastructure deficits emerged as the primary barrier constraining operational impact across digital tool rollout and capacity strengthening. Device shortages, unreliable connectivity, inadequate power, and intermittent hosting resulted in partial uptake, inconsistent use, and disrupted reporting. Facilities rarely possessed sufficient devices, reliable power, or stable connectivity. Whilst initial procurement through donor funding enabled adoption, replacement cycles, maintenance, and connectivity require recurrent financing that countries struggle to provide.

Infrastructure constraints create self-reinforcing cycles: inadequate infrastructure prevents tools from demonstrating value, limiting political will for sustained investment; under-resourced systems cannot retire paper workflows, perpetuating dual burdens that negate efficiency gains; trained health workers cannot practice competencies through routine use, leading to skill degradation; and peripheral facilities face disproportionate disadvantage, risking that digital health advantages resource-privileged tiers absent equity-focused design. *[Infrastructure assessment details and facility-level experiences available in Reports 3 and 4]*

Ongoing Costs - The main sustainability challenge is funding ongoing operational costs. DIPC supported initial investments—planning, technology, first training—but digital systems require continuous funding: replacing broken devices, paying for internet, maintaining power, conducting supervision, providing technical support. A three-year funding cycle proved not enough to establish the gradual transitions needed for governments to start to absorb these costs.

Key gaps remain: Governments have not secured budget lines for recurring costs (devices, connectivity, power, supervision, support); no systems exist to maintain and update planning documents, registries, and applications; continuous training and support systems are underdeveloped; and no clear process exists for progressively shifting costs from donor to government budgets.

Countries demonstrate partial capacity for autonomous continuation including strong institutional frameworks, designated stewardship, technical competency. However operational independence remains constrained by limited staffing, insufficient domestic budgets, and dependence on partner support for essential functions. *[Country-specific sustainability analyses and financing models available in Reports 1-5]*

Cross-Cutting Themes

Context-Dependent Readiness and Differentiated Support Needs - DIPC employed largely standardised methodologies across countries with varying digital health maturity. Ghana's high readiness (established infrastructure, technical capacity, governance structures) enabled rapid translation of assessments into decisions, though coordination gaps and budgetary constraints prevented complete follow-through. Sierra Leone and Malawi faced thinner capacity, unfunded infrastructure, and fragmented governance requiring more intensive, longer-term support extending beyond typical project cycles.

This variation suggests that maximising relevance and sustainability requires explicit readiness assessment informing differentiated support: varying intervention scope by ecosystem maturity, adjusting technical depth by governance capacity, scaling support intensity to match readiness, and establishing realistic timelines aligned with country prerequisites. Foundation-level countries may require extended capacity building before undertaking complex initiatives like SMART Guidelines L3/L4 implementation, whilst mature contexts can progress more rapidly with lighter facilitation. *[Country readiness assessments and context-specific adaptation strategies available in Reports 1-3]*

The "Missing Middle" Between Specification and Implementation - A critical "missing middle" emerged between L2 requirements specification and operational implementation. Countries strategically defined pathways aligned with national priorities and technical capacity: Malawi prioritised a functional EIR within MAHIS using DAK data dictionaries for potential future L3/L4 work, Ghana incorporated DAK structures within enhanced eTracker as DHIS2 module, and Sierra Leone localised ANC DAK planning L3 development through hackathon for PresTrack integration.

The challenge centred on the "missing middle" between L2 specification and operational implementation—not L3/L4 progression itself, which was not immediate priority for all countries, but rather the gap in intermediate artefacts and sustained technical support needed to translate L2 requirements into functioning systems along countries' chosen pathways. Developers characterised SURDs as "too theoretical," requiring extensive facility-level consultation before software building. Without developer-ready implementation guides (workflow diagrams, FHIR profiles, value sets, test cases) and sustained technical accompaniment, independent progression remained challenging.

Notably, the L2 development generated valuable outcomes. In Malawi, extensive facility consultations enabled developers to understand workflow logic deeply, built local technical capacity, and led to application adaptations based on frontline observations—ultimately improving software alignment with facility realities and strengthening local development capacity. This "missing middle" reflects broader patterns where validated planning outputs require intermediate translation artefacts and sustained accompaniment to enable operational implementation. *[Technical analysis available in Report 2]*

Equity Implications of Digital Health Implementation **-** Findings reveal spatial heterogeneity in adoption, with peripheral facilities showing markedly more limited uptake in terms of digital tool use than districts. According to some stakeholder accounts, health workers in remote, poorly equipped facilities receive equivalent initial training yet have substantially fewer opportunities to apply competencies through routine digital tool use. Too few functioning devices per facility restrict practice opportunities, forcing paper-first workflows with retrospective digitisation.

These patterns highlight potential risks that digital health may benefit better-resourced facilities and perpetuate gender segregation without intentional equity design. Equity requires: prioritising peripheral facilities with infrastructure investments, providing extended training and support to remote areas, ensuring gender-balanced participation in planning and leadership, monitoring adoption disaggregated by location, gender, and staff type, and establishing clear action protocols to address identified disparities. *[Equity analysis and disaggregated adoption patterns available in Reports 3, 4, and 5]*

Synthesis: The Multi-Year, Multi-Dimensional Nature of Digital Health System Transformation

The evaluation provides evidence that durable digital health system transformation extends substantially beyond what individual specification exercises or typical 2-3 year project cycles can achieve. DIPC successfully demonstrated technical feasibility: structured methodologies work, stakeholder engagement is achievable, country ownership is attainable, initial deployment is feasible. However, transition from pilot to operational sustainability requires multi-year trajectories (5-7 years documented in literature) with progressive domestic financing integration, continuous capacity strengthening, infrastructure investment, governance institutionalisation, and sustained accompaniment.

Three overarching lessons emerge.

- First, process fidelity does not guarantee operational impact—the critical question is not whether planning can be done well, but whether planning instruments generate sustained operational change.
- Second, successful implementation requires integrated socio-technical approaches addressing technology alongside infrastructure, capacity, governance, financing, and equity.
- Third, achieving sustainability demands follow-through architecture embedded in core methodology: designated custodianship, funded maintenance cycles, accountability mechanisms, continuous learning systems, and realistic multi-year transition support.

The evaluation contributes important empirical evidence that whilst individual components may appear successful in isolation, achieving system-level transformation requires coherent integration across strategic planning, technical implementation, capacity development, sustainable financing, and gender equity. The findings suggest that DIPC-support positioned countries well for long-term success. Realising this potential requires sustained political commitment, adequate resource mobilisation, and continued partnership acknowledging that durable systems require sustained investment beyond single project cycles.

5 Consolidated Recommendations

Based on evaluation findings across all five components, recommendations are organized into six strategic priority areas. These recommendations apply across DIPC components and contexts, though

specific implementation approaches should be tailored to country readiness and contextual factors. *[Component-specific recommendations available in Reports 1-5]*

Strategic Planning and Governance

Build Follow-Through Architecture into Core Methodology - Current planning methodologies focus on assessment and specification quality, treating implementation arrangements, custodianship, monitoring, and accountability as downstream concerns. Future initiatives should integrate standardised follow-through components agreed before sign-off: designated custodian with protected time and budget allocation, routine update cycles with specified frequency, accountability mechanisms generating consequences for non-compliance, handover protocols ensuring continuity during personnel transitions, and monitoring frameworks enabling progress tracking. For DEAs and roadmaps, this includes naming owner units in final documents, establishing update cadences (annual reviews minimum), and integrating registry updates into existing coordination processes. For SMART Guidelines, this includes formal stewardship for DAK/SURD maintenance with regular review cycles and standardised change management protocols. *[Additional findings on planning follow-through challenges and country examples available in Reports 1 and 2]*

Clarify Pathways from Strategic to Operational Planning - Strategic planning processes (DEAs, roadmaps, SMART Guidelines L2) should explicitly specify when and how sub-national managers and frontline users engage in subsequent operational design phases. Establish clear handoff points between planning and implementation phases with defined deliverables, responsibilities, and timelines. Support practical coordination for cross-institutional delivery through existing digital health coordination forums with explicit mandates, policy directives requiring standards-based implementation, and procurement criteria requiring standards compliance. *[Further analysis of planning-to-implementation transitions and country experiences available in Reports 1 and 2]*

Differentiate Support Pathways by Country Readiness - Conduct explicit readiness assessments before major initiatives, evaluating governance structures, specialist capacities, infrastructure status, and financing prospects. Offer differentiated support tracks aligned to the digital ecosystem maturity, e.g.: Foundation Track (1-2 years capacity building before technical implementation, focus on governance strengthening and infrastructure investment, intensive accompaniment); Consolidation Track (standard timelines with enhanced technical assistance, concurrent capacity and infrastructure development, structured peer learning); Optimisation Track (accelerated timelines with lighter facilitation, focus on interoperability and standards adoption, autonomous progression with advisory support). Avoid one-size-fits-all approaches that under-support foundation countries or over-engineer support for mature contexts. *[Detailed findings on country readiness variations and implementation experiences available in Reports 1 and 2]*

Technical Implementation and Interoperability

Bridge the "Missing Middle" with Intermediate Technical Artefacts - Develop "layer 2.5" templates translating L2 DAK/SURDs into developer-ready specifications including workflow diagrams, FHIR profiles, standardised value sets, API specifications, and conformance test cases. Create open-source reference implementations demonstrating L3 specifications in executable code, reducing barrier for countries with limited technical capacity. Establish regional L3 specialist rosters providing extended hands-on assistance beyond initial L2 workshops. Strengthen early technical team engagement from DEAs through L2 validation ensuring developers participate in requirements definition rather than

interpreting specifications retrospectively. *[Analysis of specification-to-implementation challenges available in Report 2]*

Complete Technical Interoperability and Eliminate Fragmentation - Prioritise completion of pending interoperability specifications (eTracker/DHIS2-GLHIMS, MAHIS-DHIS2, PresTrack-DHIS2 integrations). Develop system retirement strategies for legacy platforms once modern replacements achieve stability, eliminating dual workflows. Consolidate support functions across platforms reducing maintenance burden. Strengthen governance frameworks mandating standards-based development and blocking proliferation of non-compliant systems. *[Detailed findings on interoperability challenges and country-specific integration experiences available in Reports 2 and 3]*

Infrastructure and Sustainable Financing

Deploy Integrated Socio-Technical Investment - Conduct infrastructure readiness assessments before training deployment, ensuring minimum device-to-staff ratios (1:3), reliable power solutions, and assured connectivity. Implement equity-focused distribution prioritising peripheral facilities with solar solutions, ruggedised devices, and offline-capable systems. Deploy innovative solutions including Bring BYOD with data reimbursement, reverse-billing arrangements, device-as-a-service models, and vendor service agreements with asset management. Establish predictable maintenance, repair, and replacement protocols preventing equipment degradation. *[Infrastructure assessment findings and country-specific deployment experiences available in Reports 3 and 4]*

Design Phased Paper Retirement Strategies - Eliminate dual paper-digital workflows through systematic retirement triggered by documented readiness: system uptime exceeding 95%, user confidence above 80%, data concordance exceeding 90%, and facility adoption above 70%. Phase paper retirement progressively across facility tiers as infrastructure stabilises. Establish data continuity protocols ensuring no patient records lost during transitions. Monitor workflow burden ensuring digital systems reduce rather than add to health worker tasks. *[Analysis of dual workflow challenges and country experiences available in Report 3]*

Establish Multi-Year Financing Transition Plans - Design realistic 5-7 year transition support with declining partner financing and progressive domestic budget assumption. Develop standardised costing frameworks for complete implementation cycles including recurrent costs (devices, connectivity, power, supervision, technical support, training, maintenance). Build government capacity for budget advocacy and domestic resource negotiation. Establish dedicated government budget lines for digital health operations rather than dependence on project-specific allocations. *[Financing challenges and sustainability findings across components available in Reports 1-4]*

Capacity Development and Continuous Learning

Implement Multi-Tiered, Continuous Learning Systems - Differentiate training duration by role complexity: 5-7 days for district super-users and facility champions, 3-4 days for frontline staff with mandatory follow-up, extended training for peripheral facility staff facing infrastructure constraints. Establish mandatory quarterly refresher cycles with government ownership. Deploy multi-modal delivery including instructional videos, job aids, WhatsApp micro-learning, and offline-accessible materials enabling self-paced learning without resource-intensive in-person sessions. Expand curriculum beyond technical operation to data quality verification, dashboard interpretation, and basic statistical literacy. *[Detailed training implementation findings and country examples available in Report 4]*

Establish District-Level Technical Support Hubs - Create district digital health technical support roles with minimum 25% workload allocation (or full-time in large districts). Formalise super-user networks providing peer coaching through scheduled monthly visits, virtual check-ins, and responsive technical assistance. Deploy district dashboards monitoring facility adoption, identifying declining usage patterns, and flagging technical issues for proactive intervention. Integrate digital health monitoring into routine supervision rather than parallel reporting. *[Analysis of supervision and technical support approaches and challenges available in Report 4]*

Institutionalise Quality Assurance and Equity Monitoring - Develop comprehensive digital resource libraries in local languages accessible offline. Implement standardised trainer competency assessments, post-training participant assessments, and six-month follow-up evaluations. Maintain national training registries documenting coverage gaps, refresher needs, and quality variations. Monitor adoption disaggregated by remoteness, gender, and cadre with transparent quarterly indicators. Establish remediation protocols for facilities showing low adoption, prioritising equity-explicit interventions for peripheral sites. *[Training quality findings and equity considerations available in Report 4]*

Gender Equity and Inclusion

Operationalise Gender Equity Policy Commitments - Translate legal and strategic commitments (Affirmative Action Acts, gender strategies) into funded operational workplans with specific targets, timelines, budget allocations, and responsible units. Integrate gender equity targets into HR planning processes, explicitly prioritising recruitment and reassignment of women into digital health roles. Establish accountability through quarterly reporting to senior leadership, incorporation into manager performance reviews, and public progress reporting. *[Detailed findings on policy-implementation gaps and Ghana WIDHE experience available in Report 5]*

Establish Structured Career Pathway Mechanisms - Move beyond awareness-raising to concrete support structures. Require organisations participating in gender equity events to commit specific opportunities (internship slots, mentorship places, advertised positions) as condition of partnership through formalised agreements specifying deliverables and timelines. Establish structured mentorship cohorts (6-12 months) pairing early-career women with experienced practitioners with defined selection criteria and engagement expectations. Develop transparent career pathway resources consolidating training opportunities mapped to specific roles, distinguishing coding versus non-coding entry points with prerequisites and costs. Embed digital health content in pre-service curricula and in-service training cycles, normalising digital competencies as core professional skills for all cadres. *[Analysis of WIDHE implementation available in Report 5]*

Implement Outcome Monitoring and Institutional Ownership - Track gender equity progress through three core indicators: educational pipeline (training enrolments and completions by gender), role transitions (new hires and reassignments to digital health functions by gender), and workforce composition (women in digital health roles disaggregated by level and location). Assign institutional responsibility for gender equity coordination to specific unit with dedicated staff time and budget. Establish multi-sectoral steering committees with representation from government, academia, private sector, and civil society to oversee progress and address barriers. Integrate gender equity initiatives into routine planning and budget cycles rather than dependence on external project funding. *[Gender equity monitoring challenges and institutional ownership findings available in Report 5]*

Cross-Cutting Enablers

The recommendations above share common enabling conditions: Political Commitment and Leadership: Sustained senior leadership championing digital health and gender equity as strategic priorities, reflected in resource allocation decisions and accountability enforcement.

- Adequate and Predictable Financing: Transition from project-specific donor funding to domestically-financed operational systems with predictable multi-year budgets.
- Institutional Capacity: Sufficient staffing with appropriate skills, protected time for digital health functions, and career progression opportunities retaining talent.
- Coordination Mechanisms: Functional digital health coordination platforms enabling cross-institutional collaboration, partner alignment, and accountability.
- Learning Systems: Routine monitoring generating data for iterative improvement, systematic documentation of lessons learned, and knowledge sharing across contexts.

Successful implementation of these recommendations requires integrated approaches addressing multiple dimensions concurrently rather than sequential, siloed interventions.

6 Limitations

This evaluation has several limitations that should be considered when interpreting findings.

Scope and coverage: The evaluation examined three of DIPC's five partner countries (Ghana, Malawi, Sierra Leone), excluding Tanzania and Peru. Findings reflect implementation experiences in these three African contexts and may not represent the full range of DIPC implementation approaches or outcomes across all partner countries.

Timing and sustainability assessment: Data collection occurred shortly after implementation completion (October 2024-May 2025), limiting ability to definitively assess long-term sustainability outcomes. Whilst evaluation findings identify sustainability prospects and critical gaps, actual sustainability can only be confirmed through longitudinal observation beyond the evaluation period. The three-year implementation timeframe meant operational maturity and sustained adoption patterns were still emerging at evaluation.

Methodological constraints: The evaluation relied primarily on stakeholder interviews and document review. Whilst this approach enabled comprehensive perspectives from national, district, and facility levels, it carries potential limitations including social desirability bias (stakeholders may emphasise positive aspects), recall limitations for earlier implementation phases, and reliance on stakeholder perceptions rather than independent observations for some findings. Facility visits were conducted in selected sites rather than comprehensive coverage of all implementation locations.

Outcome measurement: As a process evaluation, this assessment examined relevance, implementation processes, and sustainability prospects rather than measuring health outcomes or immunisation coverage impacts. The evaluation cannot attribute changes in immunisation indicators, data quality improvements, or health outcomes directly to DIPC interventions. Impact assessment would require different methodological approaches including comparison groups and longer timeframes.

Data availability: The evaluation relied on available documentation and stakeholder recall for some implementation details, particularly for earlier project phases. Some technical specifications, monitoring data, and implementation records were incomplete or unavailable, potentially limiting depth of analysis for certain components.

Generalisability: Findings reflect implementation in specific country contexts with particular governance structures, technical capacity levels, infrastructure constraints, and partner configurations. Whilst insights may inform similar initiatives, direct generalisability to other contexts should be undertaken cautiously, considering contextual differences.

Despite these limitations, the evaluation provides robust evidence on DIPC implementation processes, achievements, and challenges through triangulation across multiple data sources (stakeholder interviews, document review, site observations) and perspectives (national, district, facility levels; government, partners, implementers). The evaluation's process focus and multi-country comparative approach enable identification of cross-cutting patterns and context-specific adaptations valuable for informing future digital health system strengthening initiatives.

7 Conclusion

Within three years, DIPC accomplished substantial digital health system strengthening across three diverse contexts. The initiative pioneered WHO's SMART Guidelines implementation in real-world LMIC settings, established government-led implementation models distinguishing it from typical partner-driven programmes, and generated valuable insights on realistic timelines, infrastructure-training sequencing, and mechanisms translating policy commitments into operational systems. These lessons extend beyond DIPC, informing digital health programming globally.

Evaluation findings demonstrate that countries now possess critical foundations often absent in LMIC health systems: validated strategic plans positioning governments to coordinate partner investments and prevent system fragmentation, digital tools integrated within national platforms under government stewardship, thousands of trained health workers with demonstrated delivery capacity, and established governance structures anchoring institutional ownership. These achievements represent substantive infrastructure for sustained digital health advancement.

Realising the full potential of these investments requires four strategic priorities: strengthening follow-through mechanisms connecting plans to implementation, deploying infrastructure before training with deliberate peripheral facility prioritisation, establishing realistic 5-7 year transitions enabling progressive domestic budget absorption, and implementing equity-focused approaches ensuring digital health reduces rather than widens existing disparities.

DIPC successfully demonstrated that comprehensive digital health system strengthening—integrating strategic planning, technical standards, technology deployment, capacity development, and gender equity—is achievable in resource-constrained LMIC contexts when governments lead implementation and partners provide enabling support. The foundations are established, the pathways are documented, and the building blocks for scale are identified. With continued partnership, adequate resourcing, and systematic attention to the implementation mechanisms highlighted through this evaluation, Ghana, Malawi, and Sierra Leone are well-positioned to translate DIPC's achievements into durable digital health systems delivering sustained improvements in immunisation coverage and data quality for all populations.

Detailed component-specific findings, country analyses, and implementation guidance are available in the five topic reports accompanying this summary.

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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%)*