ICAP at Columbia University

Electronic ART Registration in South Sudan

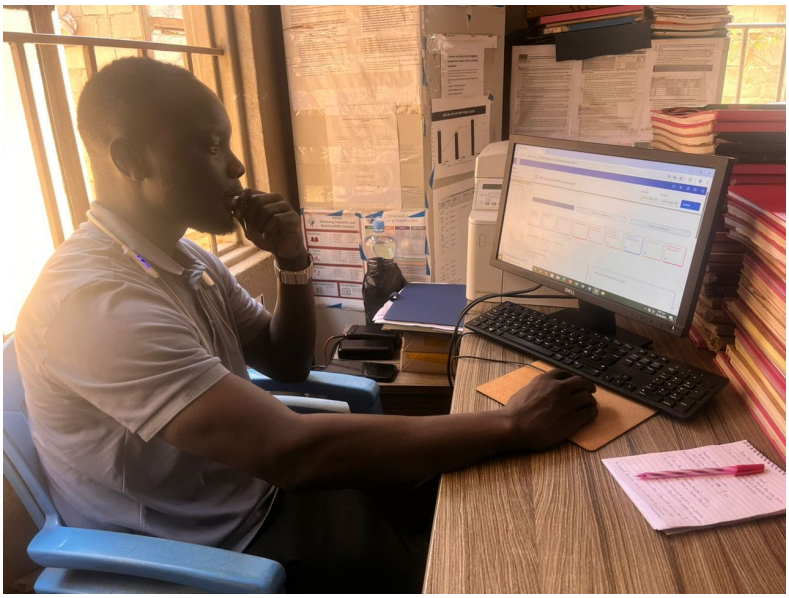
Pioneering a Case-Based Electronic System for Data-Driven HIV Care

A Success Story from ICAP's Health Information Systems Strengthening Work

Evidence through January 2026

Strategic Information / Health Information Systems

October 2022 – March 2026



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March 2026

Acknowledgments and Disclaimer

ICAP acknowledges the South Sudan Ministry of Health (MOH), including the Directorate of Policy, Planning, Budgeting, Research, and M&E, especially the HIS and HMIS divisions, for their leadership and partnership throughout the project. The U.S. Centers for Disease Control and Prevention (CDC) provided essential funding through the U.S. President's Emergency Plan for AIDS Relief (PEPFAR) and ongoing technical guidance. IntelliSOFT Consulting served as the ART E-register development partner. Implementing partners, including CMMB and IHI, supported data quality activities and hosted E-register sites.

Most importantly, ICAP recognizes the dedication of the health workers, data entry clerks, and facility and unit heads at E-register sites who carry this work forward under extraordinarily challenging conditions.

PEPFAR supported this publication through CDC. The contents are the responsibility of ICAP and do not necessarily reflect the views of the United States Government.

Table of Contents

Contents

Acronyms

AIDS: Acquired immunodeficiency syndrome
AIDS 2026: International AIDS Conference (2026)
ART: Antiretroviral therapy
CDC: U.S. Centers for Disease Control and Prevention
DHIS2: District Health Information Software 2
EAC: Enhanced adherence counseling
EMR: Electronic medical record
HIS: Health information system(s)
IIT: Interruption in treatment
MER: Monitoring, Evaluation, and Reporting (PEPFAR)
MOH: Ministry of Health
OpenMRS: Open Medical Record System (open-source EMR platform)
PEPFAR: U.S. President's Emergency Plan for AIDS Relief
PHCC: Primary Health Care Centre
RTT: Return to treatment
SI: Strategic information
SOP: Standard operating procedure(s)
SRS: System Requirement Specification
UAN: Unique ART number
VL: Viral load
VLC: Viral load coverage

Executive Summary

Between October 2022 and March 2026, ICAP at Columbia University supported the South Sudan Ministry of Health (MOH) to design, test, and deploy the country's first case-based, open-source electronic antiretroviral therapy (ART) register ("ART E-register"). This work was implemented as part of a broader health information systems (HIS) strengthening project funded by the U.S. President's Emergency Plan for AIDS Relief (PEPFAR) through the U.S. Centers for Disease Control and Prevention (CDC).

South Sudan's HIV response operates in one of the world's most challenging environments. With nearly 140,000 people estimated to be living with HIV in 2023, including more than 8,100 new infections and 5,600 AIDS-related deaths that year, and approximately 70,416 individuals receiving ART as of mid-2024, the ability to track, retain, and manage patients in care is a matter of direct consequence for survival. The ART E-register was designed as an intervention to address this challenge.

Built on the OpenMRS 3.x platform, the ART E-register was deployed across five health facilities in three states. These sites were selected for their programmatic importance and together account for approximately 17% of PEPFAR-supported ART treatment volumes and 15% of national ART treatment volumes.

ICAP and partners followed a phased implementation approach: field testing began at Munuki Primary Health Care Centre (PHCC) in July 2024 and expanded to four additional facilities by August 2024. Across the five facilities, 75 end users were trained, and more than 12,700 legacy patient records were digitized. Routine program monitoring data from the Monthly PEPFAR Dashboard show improvements in several operational indicators across the five implementation sites. Between May 2025 and February 2026, the proportion of missed appointments declined by 81% (from 58% to 11%), and the number of clients recorded as interruption in treatment (IIT) declined by 44% (from 159 to 89). Routine paper-to-electronic data verification showed high concordance, reaching up to 98%, and cumulatively through February 2026, 80% of eligible clients (7,373 of 9,221) across the five facilities had viral load (VL) samples collected. A separate synthetic-control evaluation submitted to AIDS 2026 found a more complex early rollout pattern at two high-volume facilities: recorded IIT initially increased relative to comparison sites, a pattern consistent with improved case identification, data maturation, and reporting stabilization during transition, while return-to-treatment (RTT) moved in a favorable direction under the primary analysis and several alternative specifications.

Beyond digitizing paper forms, the ART E-register was designed as a clinical decision-support tool. It generates line lists, identifies clients who miss appointments, and supports follow-up actions that can prevent clients from being lost to care. Sustainability-oriented actions—such as a five-day hackathon to migrate the codebase, a structured artifacts transition package from the development partner, and a defined handover model for ongoing operations—position the system for continued use beyond the project period.

1. Context and Problem Statement

South Sudan: The Operating Environment

South Sudan faces profound challenges that make health service delivery extraordinarily difficult. Recurrent humanitarian crises, population displacement, and infrastructure limitations affect the availability and continuity of health services. According to the United Nations Office for the Coordination of Humanitarian Affairs (OCHA)'s South Sudan Humanitarian Needs Overview 2023, South Sudan faced a severe humanitarian crisis, with 9.4 million people projected to need assistance in 2023, including 1.9 million internally displaced people, 1.4 million returnees, and 337,000 refugees, alongside widespread food insecurity.[1]

HIV remains a major public health concern in South Sudan. The United Nations reporting estimated approximately 140,000 people living with HIV in 2023, including about 8,100 new HIV infections that year.[2] CDC reporting further indicates that PEPFAR-supported services provided antiretroviral therapy (ART) to 44,631 people living with HIV in FY2024, representing 62% of all people living with HIV receiving ART nationally.[3].

Historically, the HIV program has relied on manual, paper-based patient records and reporting systems. In this context, health workers and program managers face recurring barriers to managing client information, including record duplication, difficulty retrieving and storing files, limited ability to generate patient line lists for follow-up, and persistent data quality concerns.

ICAP's Strategic Information (SI) project was designed to strengthen South Sudan's health information systems through several complementary workstreams, including national HIV program monitoring and evaluation, routine reporting and data quality improvement, DHIS2 optimization, digital health initiatives, and HIV surveillance. Within this broader effort, the ART E-register was developed as one component to address two persistent program challenges: high interruption in treatment (IIT) and suboptimal viral load coverage (VLC). Specifically, it was intended to help clinical teams identify clients who missed appointments, generate follow-up lists, and strengthen treatment continuity and viral load monitoring.

A Prior EMR Attempt and Lessons Applied

The need for electronic health information systems in South Sudan was recognized prior to ICAP's SI project. In 2019, a previous PEPFAR-supported EMR initiative developed and deployed an EMR system based on the Bahmni platform at Juba Teaching Hospital and Nimule Hospital. ICAP's subsequent ART E-register was built on a different platform, OpenMRS.

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[1] United Nations Office for the Coordination of Humanitarian Affairs. South Sudan Humanitarian Needs Overview 2023. November 25, 2022.
[2] United Nations in South Sudan. "South Sudan's Urgent Call to Action on HIV Prevention." November 12, 2024.
[3] Centers for Disease Control and Prevention (CDC). "HIV and TB Overview: South Sudan." June 30, 2025.

Although the system was developed and deployed at Juba Teaching Hospital, specific implementation constraints limited routine clinical use and scale-up. Power availability and internet connectivity were unreliable; internet access was reported to be available only after 6:00 PM, the Early ART Clinic had no network connection, and no data entry clerks had been employed at the sites. In addition, the EMR was not integrated with the national DHIS2 reporting platform at the production level. The system delivered its contracted technical deliverables but did not achieve the scale, sustainability, or routine clinical use needed to transform patient management nationally.

In addition to these operational constraints, the earlier rollout highlighted two other important lessons. First, the system's clinic workflow design and System Requirements Specification (SRS) did not fully align with national HMIS requirements and standards, including alignment with South Sudan's routine HIV clinical documentation and reporting tools. As a result, the system was not accepted for wider use.. This reflected the limited involvement of clinical and health informatics expertise during design, review, and testing. Second, end-to-end stakeholder engagement before development and deployment was insufficient, including consistent engagement of facility leadership and clinical teams needed to support adoption and sustained use. ICAP applied these lessons in the ART E-register initiative at the five Phase 1 sites by strengthening stakeholder engagement across all stages, ensuring clinical and informatics review throughout development and testing, and aligning system workflows and outputs with national reporting MOH clinical workflows and national reporting requirements.

2. Designing the ART E-Register

The ART E-register was designed as a patient-centered, case-based system intended to strengthen both clinical management and program monitoring. Rather than functioning only as a data digitization tool, the system supports clinical decision-making and proactive follow-up. It helps health workers identify service needs, such as ARV refills and viral load sample collection, and flags priority clinical issues, including TB screening and advanced HIV disease (AHD). The tool generates line lists and follow-up views for key client categories, including clients who missed appointments, are due for drug pick-up, are eligible for viral load testing, or require targeted clinical review. By enabling timely tracking and tracing, the system helps teams reduce missed appointments and treatment interruptions (IIT) and improve viral load testing coverage.

ICAP led the design and development using OpenMRS 3.x, a globally recognized open-source electronic medical record platform. OpenMRS is implemented in countries including Rwanda, Kenya, Uganda, and South Africa, supporting peer learning and access to a large developer community and documentation. ICAP also drew on lessons from peer country implementations, including implementation experience shared during the Lesotho learning visit, which reinforced the value of phased deployment, dedicated data-entry staffing, and structured feedback loops between clinical teams and system developers in comparable low-resource settings.

Following comprehensive stakeholder engagement with the MOH, CDC, PEPFAR agencies, implementing partners, ART clinicians, and facility data management teams, ICAP initiated requirements-gathering and system-design activities in October 2023. These activities included customizing a System Requirement Specification (SRS), documenting reporting requirements for PEPFAR Monitoring, Evaluation, and Reporting (MER) and MOH reports, and revising line list templates to support continuity-of-care activities.

By December 2023, ICAP had signed a service agreement, confirmed OpenMRS 3.x as the platform, and procured key equipment and supplies to support deployment and maintain uptime, including servers, backup power generators, computers with uninterruptible power supply (UPS) units, and local area network (LAN) components.

The system was customized to align with South Sudan’s official MOH ART and HIV Care Card and ART Register, ensuring that electronic data elements mirrored existing paper-based clinical workflows. This design choice reduced the burden of workflow change at the facility level and supported adoption by clinical teams.

To guide implementation, ICAP followed a phased process that moved from stakeholder engagement and requirements gathering to system customization, review, field testing, and deployment. Figure 1 summarizes this progression from October 2023 to August 2024, showing how the ART E-register was developed iteratively through technical review, partner feedback, and staged rollout.

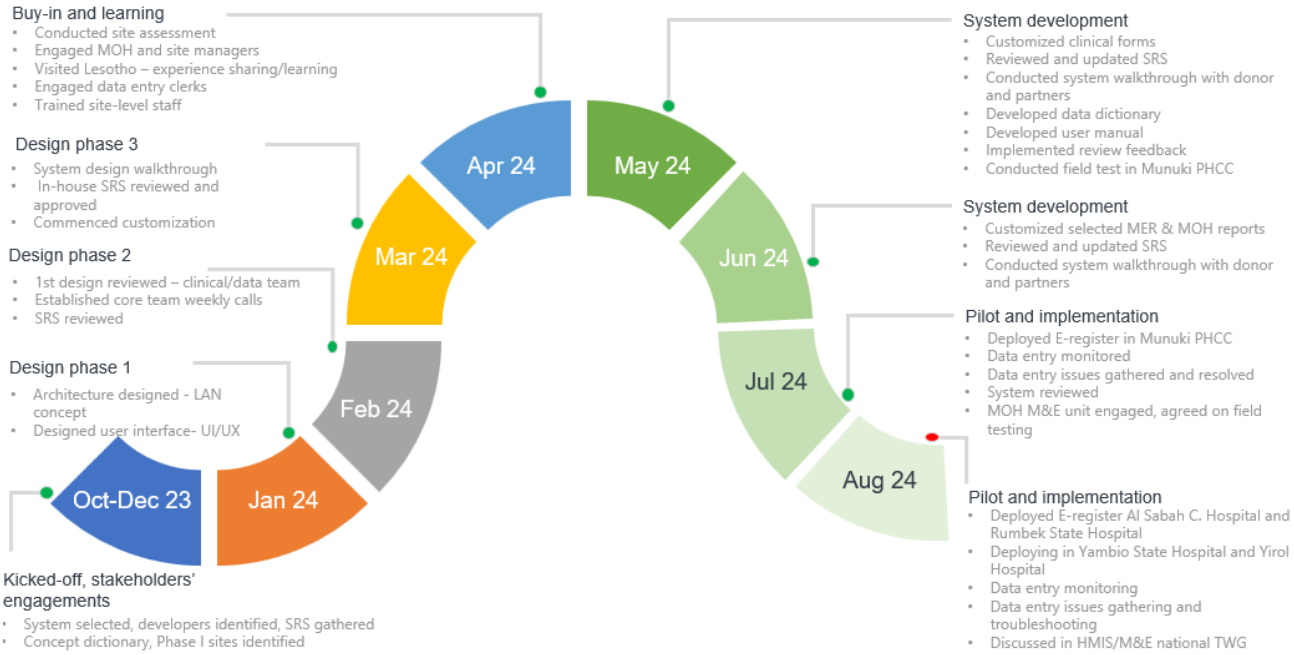

Figure 1. ART E-register implementation timeline, showing the phased progression from stakeholder engagement and system design to field testing at Munuki PHCC and deployment to five Phase 1 facilities, October 2023 to August 2024..

As shown in Figure 1, the ART E-register was not introduced through a single-step deployment. Instead, it was refined through successive design and development phases, followed by field testing at Munuki PHCC and phased expansion to four additional facilities. This staged approach allowed ICAP to incorporate feedback, address implementation issues early, and prepare sites for routine use.

3. Implementation: From Field Testing to Five-Facility Deployment

Before field testing and phased deployment, ICAP reviewed facility-level operational conditions that could affect the implementation of ART E-register, including leadership support, power availability, connectivity, and staff preparedness. These findings helped inform site preparation, equipment planning, and the phased implementation approach. Figure 2 shows an extract from the facility review used to inform ART E-register implementation, showing selected findings on leadership readiness and power availability at three assessed facilities.

2.1. Leadership Readiness

- Facility leadership at all seven locations expressed their readiness to adopt the digital system and support the piloting and implementation of the ART E-register. However, some of the staff members require basic IT training to handle system-related tasks.

2.2. Power Availability

Facility	Power Source	Efficiency	Remarks
Munuki PHCC	Solar panels	High	No outages reported in the past month.
Al Sabah C. Hospital	Solar and JEDCO	Medium	Solar is inefficient and has experienced interruptions in the past month. JEDCO is costly, with the facility paying 75,000 SSP per day
Rumbek State Hospital	Solar panels	Low	The available solar panel is non-functional due to a lack of batteries. No other additional power sources

Figure 2. Extract from the facility readiness assessment report, showing selected findings on leadership readiness and power availability at assessed facilities.

Field Testing at Munuki PHCC

In July 2024, ICAP launched field testing of the ART E-register at Munuki Primary Health Care Centre (PHCC), marking the first live use of the system in a routine service delivery setting. This phase focused on entering legacy patient records from paper forms into the electronic system, assessing the server and workstation setup, and observing how facility staff interacted with the platform during actual clinic operations. Early testing also allowed the team to document user feedback, identify workflow and usability issues, and troubleshoot infrastructure and system performance challenges in real time. As shown in Figure 3, field testing at Munuki involved both technical setup and hands-on user engagement, helping ICAP refine the system and address practical implementation issues before expanding rollout to four additional facilities.

Figure 3. Field testing at Munuki PHCC: server and workstation setup (left) and a facility staff member using the ART E-register during early implementation (right).

Phased Deployment to Five Facilities

Following field testing, deployment expanded to four additional facilities by August 2024. Phase 1 included five facilities across three states: Munuki PHCC, Al Sabah Children's Hospital, Rumbek State Hospital, Yirol Hospital, and Yambio State Hospital. This phased expansion allowed ICAP to test implementation across facilities with different service volumes and operating contexts while maintaining a manageable rollout scope

Table 1: Deployment timeline for field testing, data migration, and rollout across five facilities. Source: ICAP SI project monitoring records (2024–2025).

Health Facility	Date Deployed	Data Entry Completed	Date System Use Started
1. Munuki PHCC	3 July 2024	30 September 2024	15 December 2024
2. Al Sabah Children's Hospital	30 July 2024	30 September 2024	15 December 2024
3. Rumbek State Hospital	5 August 2024	30 March 2025	15 May 2025
4. Yirol Hospital	19 August 2024	30 March 2025	15 May 2025
5. Yambio State Hospital	19 August 2024	30 April 2025	15 June 2025

The facilities were selected for both feasibility (space, power, access, and leadership acceptance) and potential impact. Together, they account for approximately 17% of PEPFAR-supported ART treatment volumes and 15% of national ART treatment volumes, enabling meaningful learning at scale while maintaining a manageable implementation scope.

By November 2024, the ART module registration page had been finalized, and the clinical forms completed. Legacy data entry was finalized at Al Sabah and Munuki, with ongoing entry at other sites during FY25. Legacy data migration began during field testing in July 2024 and was implemented through a dedicated data-entry team, with records entered in three categories: historical (legacy) records, newly enrolled patients, and daily visit records. At sites with large historical caseloads, additional clerks were engaged, and key clinical events were prioritized to accelerate backlog reduction. By the end of FY25, more than 12,700 legacy patient records had been digitized across the five Phase 1 sites. Figure 4 shows the geographic distribution of the five Phase 1 ART E-register sites across South Sudan, illustrating that the initial rollout was implemented across multiple states.

The site distribution reflects a deliberate, phased approach that tested implementation across facilities with varying patient volumes and operating contexts.

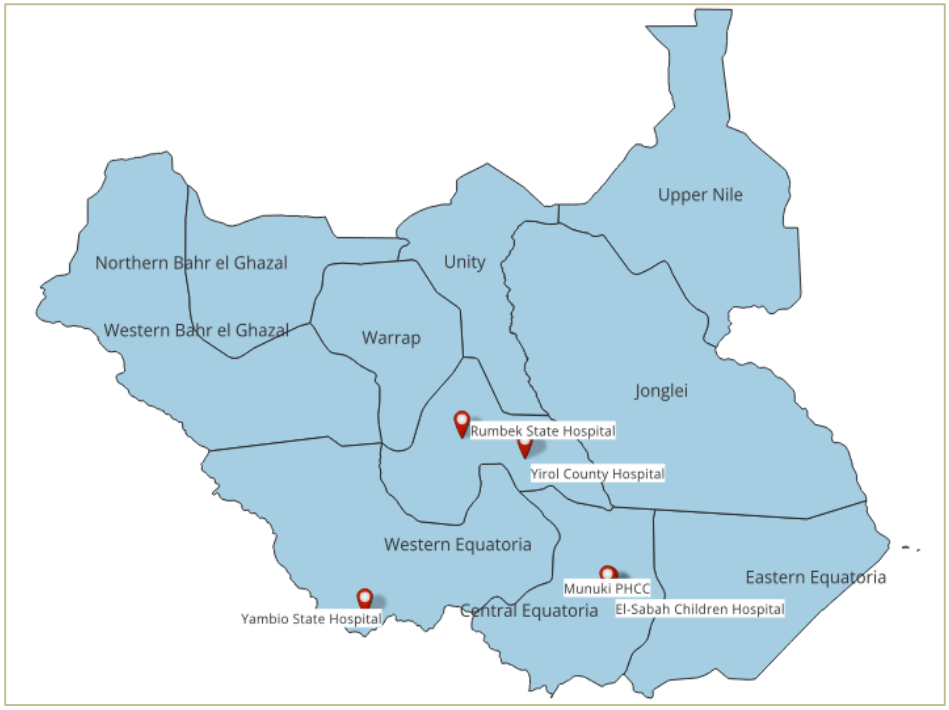

Figure 4. Map of South Sudan showing the five Phase 1 ART E-register implementation sites.

Implementation Approach

Implementation was structured to address several requirements simultaneously:

- **Dedicated data entry team and end user capacity:** A dedicated team of data entry clerks was recruited and trained, together with facility-based clinical and M&E staff. By FY25, 75 end users had been trained across the five facilities.

- **Legacy data migration:** Records were entered in three categories: historical (legacy) data, newly enrolled patients, and daily visit records. At sites with large historical caseloads, additional clerks were engaged and key clinical events were prioritized to accelerate backlog reduction.
- **System infrastructure and continuity:** A local data backup approach was established, and a system administrator was trained. Equipment investments (servers, power backup, LAN components) supported uptime in settings with unstable power and connectivity.
- **Monitoring and learning:** Implementation included daily follow-up on data entry progress and quality checks, routine system reviews with facility clinical teams, iterative updates to data management SOPs, and regular technical reviews with the development team. ICAP also developed a weekly dashboard to track selected process indicators related to retention and viral load testing coverage across the E-register sites.
- **Clinic workflow:** Each E-register site has a unique patient flow. At several sites, gaps in communication between service points contributed to missed opportunities for service delivery. ICAP collaborated with facilities to design “optimized clinic workflows,” detailing the unit, service provider, services provided, service documentation, and referral pathway to the next service unit. Key service points along the clinic workflow were equipped with an E-register workstation with role-based access control (RBAC).

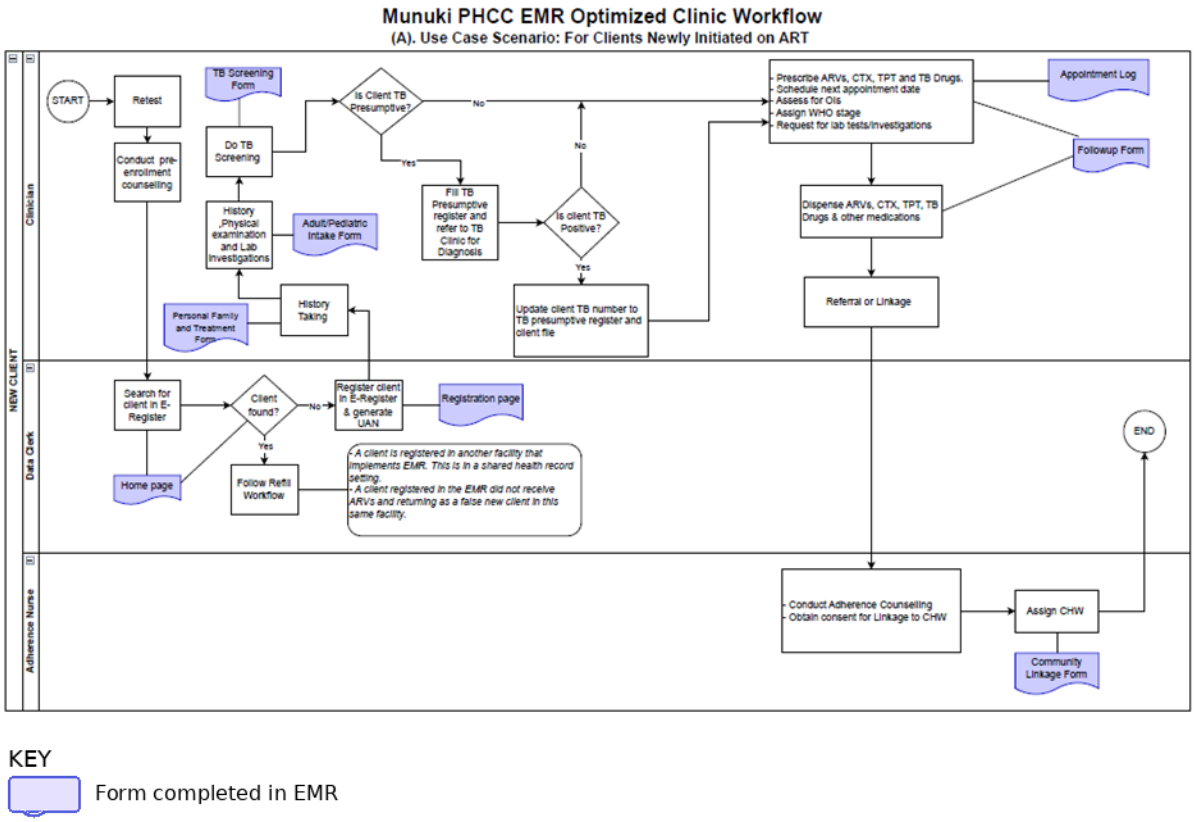

Figure. 5: Extract from the optimized clinic workflow at Munuki PHCC for clients newly initiated on ART. The diagram shows how the ART E-register was embedded in routine service delivery, highlighting where key services were delivered and documented, including TB screening, history-taking, ART initiation, appointment logging, follow-up actions, and referral or linkage to adherence counseling and community health worker (CHW) support. This extract shows forms completed in the EMR; no edited forms are shown in this workflow extract.

- **Above-site users training:** ICAP trained 15 HIV clinical mentors who support the five sites and created role-based user login credentials. This group accesses dashboards and reviews facility-level performance. An HIV Clinical Mentor at Rumbek State Hospital and one of the 15 above-site users trained by ICAP, described how the dashboard supports weekly performance review:
  "Every Friday, we conduct a review meeting where we monitor trends in the appointment cascade and viral load cascade, including high viral load management and EAC sessions. Using these insights, I work closely with the clinical team to identify gaps and implement targeted interventions."
  — An HIV Clinical Mentor, Rumbek State Hospital (Field testimony, March 2026)
- **Data Quality Assurance:** Three data management SOPs were developed to support and guide data entry, data quality checks, and concordance review with the existing paper-based system. The ICAP team worked with partner M&E officers and facility staff to conduct weekly, monthly, and quarterly data reviews, resolving identified gaps as they arose. ICAP included E-register data verification as part of the quarterly PEPFAR DQA activity. Additional results and examples from E-register data quality reviews are summarized in Section 4 (Data Quality Improvements).
- **On-site mentoring and training:** ICAP supported a dedicated staff "EMR champion" at each site during implementation to provide real-time on-site mentorship for service providers on correct E-register use for clinical documentation and program performance review and reporting. The champion also trained newly recruited or reassigned staff. Basic ICT skills were provided to help facility teams operate computers effectively.

Stakeholder Engagement and Governance

Stakeholder engagement was integrated throughout the implementation process. Ahead of ART E-register field testing and deployment, in April 2024, ICAP led a multidisciplinary team of seven HIV program and health informatics experts on a south-to-south learning visit in Lesotho. The team included senior representatives from the Ministry of Health HIV program, CDC, implementing partners, DHIS2 technical leadership (HISP South Sudan), and ICAP's project team. During this visit, the South Sudan team gained practical insight into EMR implementation in a comparable setting and reinforced the importance of stakeholder engagement, clear leadership, and well-defined steering and technical structures in advancing EMR implementation.

In October 2024, ICAP supported the establishment of the HIS sub-Technical Working Group (sub-TWG) and the national HMIS/M&E Technical Working Group, both chaired by MOH, to spearhead digital health strategies, including the E-register and DHIS2. The pre-deployment site readiness assessment questionnaire included a question on facility leadership's readiness to adopt and support the implementation of the E-register. ICAP met with hospital directors at all facilities to present the rationale for the E-register and how it would support patient management and routine reporting. PEPFAR and CDC site visits provided additional opportunities to review progress, reinforce national ownership, and identify sustainability considerations, including data protection and national capacity building. Figure 6 shows the PEPFAR Chair's visit to Munuki PHCC in August 2024, one of several site visits that provided opportunities to review progress and reinforce national ownership.

Figure 6. PEPFAR Chair visit to Munuki PHCC (16 August 2024).

4. What Changed at the Facility Level

The ART E-register was designed not as a standalone data-entry tool but as a clinical decision-support system integrated into facility workflows. By May 2025, Phase 1 sites had progressed beyond initial implementation stages. Rumbek, Yirol, and Yambio were using client profiles and clinical flags to support data verification, while Munuki PHCC and Al Sabah Children's Hospital had advanced to routine clinical use. An ART Clinic In-Charge at Yambio State Hospital described the practical difference the E-register made in daily clinic operations:

"We can locate a client using the UAN or name, which saves time during clinic days. It also allows us to quickly retrieve a patient's treatment history even when a client arrives without their treatment card, ensuring continuity of care and reducing delays in service delivery."

— *The ART Clinic In-Charge, Yambio State Hospital (Field testimony, March 2026)*

Clinical Workflow Support

The E-register supports several core clinical and programmatic functions:

- Managing appointments: recording next appointment dates and generating lists of clients who miss appointments for follow-up and tracing.
- Service line listings: client-level lists for due services, including appointments, viral load, enhanced adherence counseling (EAC), and repeat viral load.
- Clinical decision flags: alerts for due refill, viral load, TB screening, advanced HIV disease, and index testing.
- Routine verification: paper records compared to E-register data for selected indicators (including TX_NEW, TX_CURR, TX_ML, and TX_PVLS) as part of ongoing data quality checks.

At Al Sabah Children's Hospital, an ART Clinician described how the E-register transformed tracking for the pediatric and adolescent caseload:

> *"With the E-register, the system automatically generates line lists for adolescents and young people aged 10–24, enabling us to easily track individual clients and monitor key services, including ARV refill dates, viral load sample collection, and schedules for child-friendly OTZ activities. As a result, more children and adolescents are attending the weekend clinics for these specialized services."*

— *An ART Clinician, Al Sabah Children's Hospital (Field testimony, March 2026)*

At the time of reporting, the facility's OTZ cohort included 148 enrolled clients, of whom 139 were on active treatment, with no missed appointments and documented viral suppression.

At Yirol Hospital, an ART Clinician highlighted how clinical alerts support guideline adherence during consultations:

> *"The system clearly indicates when TB screening is due or when a patient meets the criteria for advanced HIV disease assessment, helping us adhere to national treatment guidelines and provide comprehensive care."*

— *An ART Clinician, Yirol Hospital (Field testimony, March 2026)*

The E-register also helps clinicians identify priority clients for additional clinical review based on configured clinical criteria and documented follow-up needs.

Box 2. ART E-register workflow support: appointments, line lists, and paper-to-E-register verification.

- **Managing appointments for people living with HIV appointments**
  - Appointment reminders, tracking, and tracing of misses and IITs
- **Service line listing**
- **Clinical decision flags**
  - Due for refill, due for viral load testing, prioritize linkage, TB screening, advanced HIV disease, index testing
- **Data verification**
  - Paper records compared with E-register data (average 98% concordance)
  - Monthly data verification for new ART enrollments, current ART patients, interruptions in treatment, and viral load suppression

Data Quality Improvements

The E-register introduced several immediate improvements in data quality. Built-in validation rules and required fields help prevent common data entry errors. Routine paper-to-electronic comparison helped identify issues, including duplicate unique ART numbers and gaps in documentation. Daily file audits, improved filing systems, and report triangulation strengthened confidence in the completeness and accuracy of the data.

Routine verification activities reported up to 98% concordance between paper and electronic records. Box 2 summarizes the core workflow support functions of the ART E-register

5. Evidence of Results and Early Outcomes

Continuity in Treatment

Early program monitoring data from the Monthly PEPFAR Dashboard indicate improvement in continuity-in-treatment indicators across the five E-register sites between May 2025 and February 2026, although trends varied by facility and month. As summarized in Table 2, the aggregate proportion of missed appointments declined from 58% to 11%, while the number of clients recorded as interruptions in treatment (IIT) declined from 159 to 89. A routine comparison of manually generated and E-register-generated TX_CURR data also showed improved concordance, increasing from 72% in May 2025 to 98% in February 2026.

Indicator	Baseline (May 2025)	Endline (Feb 2026)	Change (+/-)
Missed appointment proportion	58%	11%	−81%
Clients who became IIT (n)	159	89	−44%
Paper–E-register data concordance (Reference indicator: TX_CURR)	72%	98%	+26%

Table 2. Key continuity-in-treatment indicators (May 2025 – February 2026). Source: Monthly PEPFAR Dashboard (reported through SI project monitoring).

Paper–E-register data concordance (Reference indicator: TX_CURR):

To monitor data quality during early implementation, the team conducted routine comparisons between manually generated TX_CURR counts and E-register-generated counts. By February 2026, concordance had improved from 72% to 98%, reducing the variance between the two systems to 2%. This improvement reflected repeated data reviews, correction of indicator calculation gaps, resolution of data entry errors, the introduction of mandatory fields in the system, and ongoing mentorship of data entry teams. As shown in Table 3, the largest early discrepancies were observed at Yambio State Hospital, Rumbek State Hospital, and Yirol Hospital, with substantial narrowing by February 2026.

The improvement in data concordance was supported by several actions:

- Identifying and correcting indicator calculation gaps with the developers
- Identifying and resolving data-entry gaps
  Introducing mandatory data-entry fields in the system

- Providing ongoing mentorship to data-entry teams on common entry errors

Facility	TX_CURR in May 2025 (Baseline at real-time use): Manually generated	TX_CURR in May 2025 (Baseline at real-time use): E-register generated	TX_CURR in Feb 2026: Manually generated	TX_CURR in Feb 2026: E-register generated
Al Sabah Children's Hospital	563	500	697	691
Munuki PHCC	1487	1456	1680	1671
Yambio State Hospital	3141	1848	3163	3041
Rumbek State Hospital	3132	2117	2713	2704
Yirol Hospital	2234	1715	2293	2276
Total	10557	7636	10546	10383

Table 3. Comparison of manually generated and E-register-generated TX_CURR counts by facility at baseline (May 2025) and follow-up (February 2027).

Missed Appointment Trends

Site-level monitoring also showed an improvement in missed-appointment performance across all five E-register sites (Table 4). The largest reductions in missed appointment proportion were observed at Yambio State Hospital (74% to 13%), Yirol Hospital (62% to 8%), Munuki PHCC (59% to 9%), and Rumbek State Hospital (51% to 7%), while Al Sabah Children's Hospital improved from 54% to 23%. These site-level differences suggest that implementation conditions, patient volumes, and follow-up performance were not uniform across the five facilities.

	May 2025 (Baseline)			Feb 2026 (Endline)		
Facility	**Appointed for ARV refill**	**Missed appointment**	**% missed appointment**	**Appointed for ARV refill**	**Missed appointment**	**% missed appointment**
Al Sabah Children's Hospital	110	59	54%	88	20	23%
Munuki PHCC	78	46	59%	139	13	9%
Yambio State Hospital	211	156	74%	418	56	13%
Rumbek State Hospital	567	288	51%	311	21	7%
Yirol Hospital	154	95	62%	213	16	8%
Total	**1120**	**644**	**58%**	**1169**	**126**	**11%**

Table 4. Baseline-to-endline comparison of missed appointments by site (May 2025 – February 2026).

Figure 8 shows that the aggregate monthly trend in missed appointments declined overall, but not in a straight line. The proportion of missed appointments fell from 33% in June 2025 to 11% in October 2025, then increased again to 20% in November and 28% in December, before declining to 18% in January and 11% in February 2026. Following the introduction of E-register-

generated line lists, providers were better able to identify clients due for appointments and implement reminder strategies, including direct phone calls and coordination with community teams for client tracing and notification for ARV refills and viral load sample collection.

The temporary increase in missed appointment rates in November and December 2025 should be interpreted in context. Likely contributing factors included seasonal mobility during the festive period and funding uncertainties in December 2025 and January 2026, which affected appointment-clerk staffing at three sites. These contextual factors also help explain the short-term fluctuations seen in IIT and viral load trends.

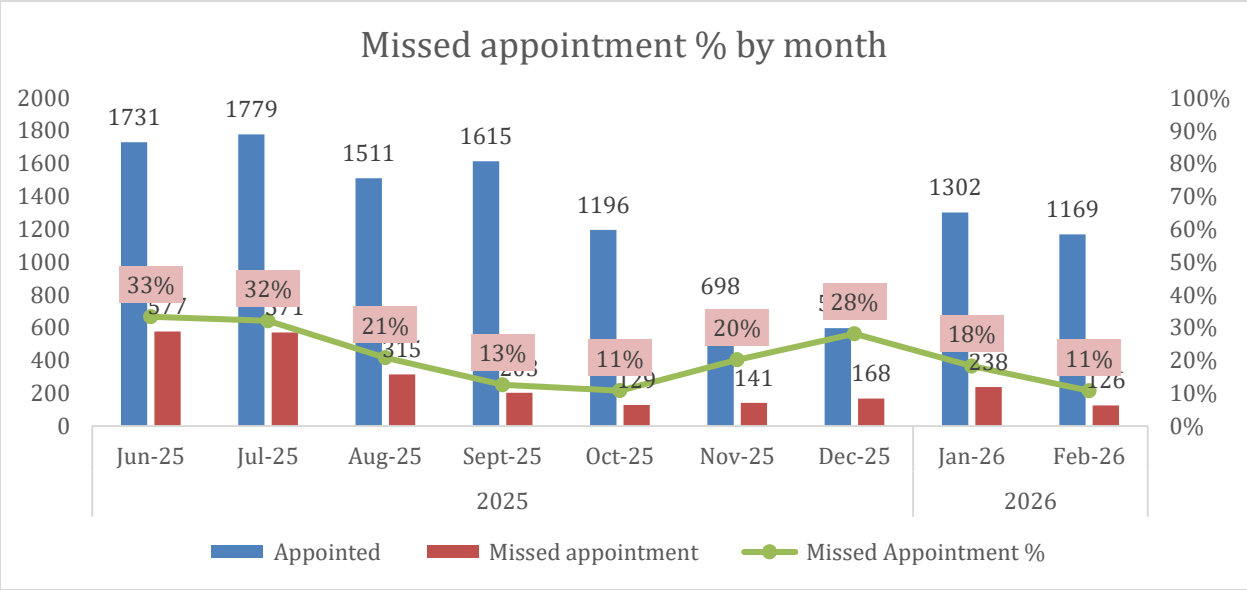

Figure 8. Missed appointment trends by month (June 2025 – February 2026).

Interruption in Treatment (IIT) and Return to Treatment (RTT)

Figure 9 and Table 5 provide additional context on interruption in treatment (IIT) and return to treatment (RTT). From June 2025 to February 2026, the five facilities recorded a total of 927 clients who became IIT and 1,046 RTT events. Munuki PHCC and Yambio State Hospital recorded the highest numbers of clients who became IIT (291 and 288, respectively). Yirol Hospital recorded the highest RTT total (251), followed by Yambio State Hospital (233) and Munuki PHCC (231).

Monthly IIT and RTT trends were also uneven over time. IIT counts fell from 141 in June 2025 to 37 in October 2025, rose again in November through January, and ended at 89 in February 2026, while RTT fluctuated across the same period. Taken together, these findings suggest that the E-register improved visibility of continuity-in-treatment challenges while also supporting more systematic follow-up and re-engagement of clients.

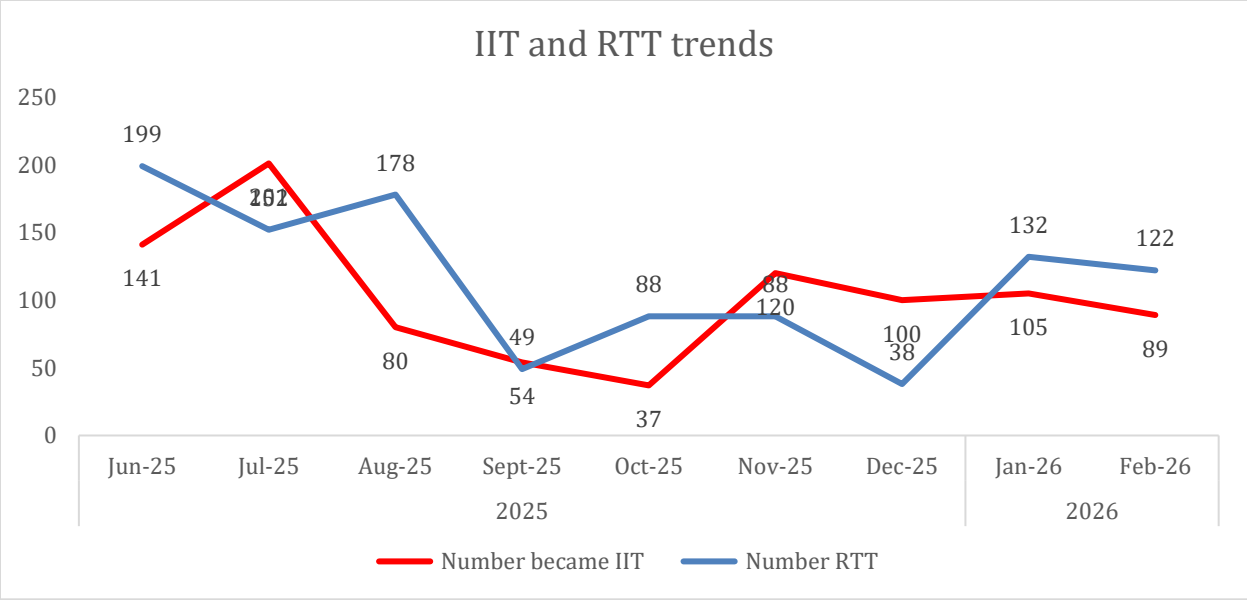

Figure 9. Monthly Interruption in Treatment (IIT) and Return to Treatment (RTT) trends across the five E-register sites (June 2025 – February 2026).

Row Labels	Number became IIT	Number RTT
Al Sabah Children's Hospital	160	191
Munuki PHCC	291	231
Rumbek State Hospital	87	140
Yambio State Hospital	288	233
Yirol Hospital	101	251
Grand Total	**927**	**1046**

Table 5. Summary of interruption in treatment (IIT) and return to treatment (RTT) across the five E-register sites (June 2025–February 2026)

Viral Load Monitoring

Before the ART E-register was introduced, facilities generally identified viral load (VL)-eligible clients when they presented for routine ARV refills. As a result, clients who missed scheduled appointments were less likely to be assessed for VL eligibility, creating missed opportunities for timely VL testing and monitoring. This gap was identified as an important contributor to suboptimal VL sample collection.

	June 2025 (Baseline)			Feb 2026 (Endline)			
	VL eligible	VL collected	% VL samples collected	VL eligible	VL collected	% VL samples collected	Change in proportion collected (percentage points)
Al Sabah Children's Hospital	214	44	21%	124	98	79%	+58
Munuki PHCC	210	120	57%	117	98	84%	+27

Yambio State Hospital	289	249	86%	189	162	86%	0
Rumbek State Hospital	329	306	93%	211	178	84%	-9
Yirol Hospital	266	95	36%	199	163	82%	+46
Total	**1308**	**814**	**62%**	**840**	**699**	**83%**	**+21**

Table 6. Baseline-to-endline comparison of viral load sample collection among eligible clients by site (June 2025–February 2026).

Since June 2025, VL sample collection among eligible clients has improved across the five E-register sites, supported by automated identification of VL-eligible clients before and on the due date and by the generation of line lists for follow-up. As shown in Table 6, the proportion of eligible clients with a VL sample collected increased from 62% (814/1,308) in June 2025 to 83% (699/840) in February 2026. Baseline-to-endline improvement was greatest at Al Sabah Children's Hospital (21% to 79%) and Yirol Hospital (36% to 82%), followed by Munuki PHCC (57% to 84%). Yambio State Hospital remained consistently high (86% to 86%), while Rumbek State Hospital declined modestly from 93% to 84% but still maintained high cumulative performance over the full monitoring period.

Row Labels	Viral load eligible	Viral load collected	Viral load not collected	Viral load samples collected %
Rumbek State Hospital	2911	2654	257	91%
Yambio State Hospital	2378	2129	249	90%
Yirol Hospital	1561	1191	370	76%
Munuki PHCC	1335	868	467	65%
Al Sabah Children's Hospital	1036	531	505	51%
Grand Total	**9221**	**7373**	**1848**	**80%**

Table 7. Viral load-eligible, Viral load-collected, gaps, and proportions by site (June 2025 – Feb 2026). Source: ICAP SI project monitoring (FY26 Q1 reporting).

Table 7 provides the cumulative site-level picture for June 2025 to February 2026. Across the five E-register sites, 9,221 clients were identified as VL-eligible, and 7,373 (80%) had VL samples collected. Cumulative performance was highest at Rumbek State Hospital (91%) and Yambio State Hospital (90%), followed by Yirol Hospital (76%), Munuki PHCC (65%), and Al Sabah Children's Hospital (51%). These differences suggest that although overall performance improved, the pace and consistency of implementation varied across sites.

At Munuki PHCC, the Senior Data Clerk described how line lists and community health worker collaboration improved viral load sample collection:

"With a single click, we can generate lists of clients who are due for viral load testing or ARV refills. We are now able to collaborate more effectively with community health workers to provide appointment reminders one to two weeks in advance. From December last year to February this year, we collected viral load samples from 85% of clients who were due. We used to collect around 50%–65% only."

— Senior Data Clerk, Munuki PHCC *(Field testimony, March 2026)*

Figure 10 shows that monthly VL sample collection performance improved substantially after implementation, but not in a straight line. The proportion of eligible clients with samples collected increased from 62% in June 2025 to 93% in October 2025, remained high at 92% in November, then declined to 84% in December and 79% in January 2026, before increasing again to 83% in February 2026. The overall upward trend is consistent with improved identification of VL-eligible clients and stronger follow-up through E-register-generated line lists.

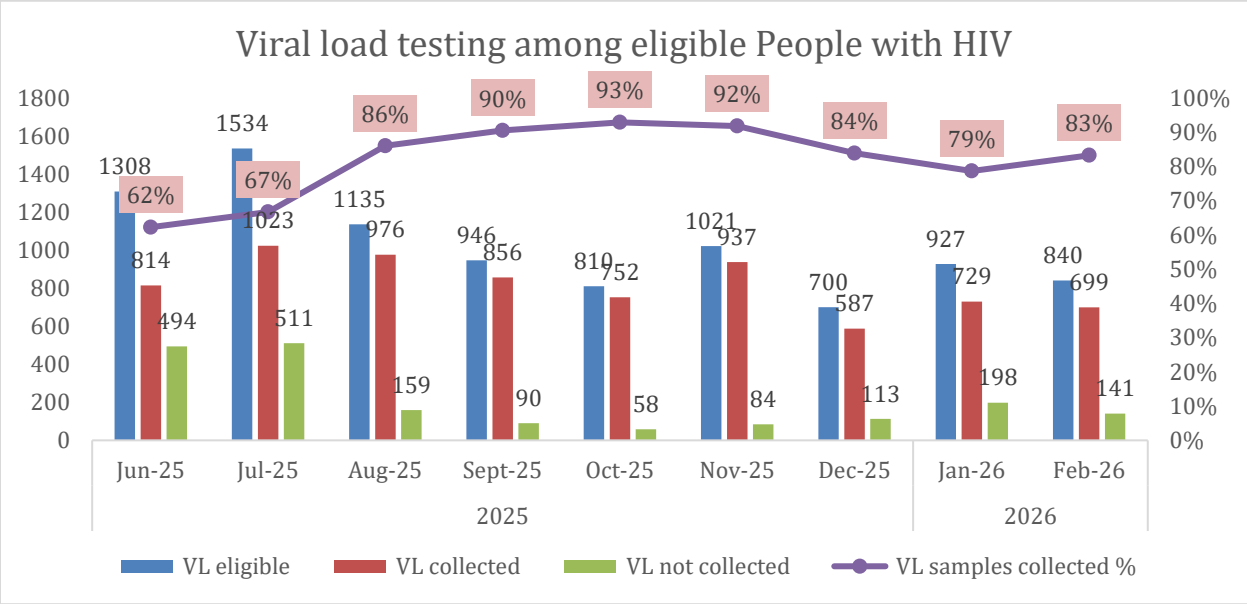

Figure 10. Viral load sample collection performance across E-register sites (June 2025–February 2026). Source: ICAP SI project monitoring (FY26 Q1 reporting).

The temporary decline in December 2025 and January 2026 should be interpreted in context. Likely contributing factors included seasonal mobility during the festive period and funding uncertainty that affected staffing at several sites. The partial recovery in February 2026 is consistent with the resumption of support during the bridge period.

Scientific Evaluation: AIDS 2026 Abstract Submission

To strengthen the evidence base for digital health implementation in fragile settings, ICAP applied a quasi-experimental evaluation approach using the synthetic control method. The analysis focused on two high-volume E-register facilities, Rumbek State Hospital and Yirol Hospital, and compared each with a weighted combination of similar non-E-register sites matched on pre-intervention trends.

Importantly, these findings should be interpreted in the context of broader implementation. The E-register rollout did not occur in a vacuum: it coincided with legacy data entry, workflow adjustment, staff learning, and reporting stabilization. In the primary analysis, recorded interruption in treatment (IIT) initially increased relative to the synthetic controls, a pattern consistent with improved case identification, data maturation, and more complete recording during transition rather than sustained worsening of performance. At the same time, return-to-

treatment (RTT) moved in a favorable direction under the primary and several alternative specifications, suggesting improved follow-up and re-engagement as implementation matured.

This work was submitted for presentation at the International AIDS Conference (AIDS 2026) as Abstract #9708. Taken together with the routine monitoring data presented earlier, the abstract underscores that early post-deployment trends should be interpreted cautiously: some indicators may temporarily worsen as surveillance improves, even as patient follow-up and data quality strengthen.

6. Sustainability and Transition

Building Local Technical Capacity

ICAP implemented deliberate actions to reduce dependence on external developers. A five-day hackathon held in Juba on 16 August 2025, with senior OpenMRS developers guiding the ICAP HIS team, established a prototype hosting environment and repositories (Maven, GitHub, server, and domain), transferred the code base, and supported system and component testing, hypercare, and monitoring. As shown in Figure 11, this process involved hands-on technical collaboration in Juba between ICAP's HIS team and senior developers, helping translate formal training into practical system administration and maintenance skills.

Figure 11. Hackathon and knowledge transfer session in Juba (16 August 2025), supporting code transfer, system testing, and local technical capacity for ART E-register maintenance.

At the facility level, ICAP established a network of EMR champions, site-based staff who provided day-to-day mentorship, supported data-entry quality, and helped troubleshoot system and workflow issues during routine use. These champions served as the primary link between clinical teams and the central HIS team, helping sustain adoption and build confidence in the system across the five implementation sites, helping sustain adoption and build confidence in the system across the five E-register sites. As shown in Figure 12, the EMR champions played a visible and active role in supporting the transition to electronic record-keeping at each facility.

Figure 12. Facility-based EMR champions providing day-to-day mentorship and supporting adoption across the five E-register sites.

What Made ICAP's Approach Successful?

Several factors contributed to the success of the ART E-register initiative and helped position it for continuity beyond the project period:

- **Strong SI and HIV program grounding (tools and workflows):** The implementation team combined health information systems expertise with practical HIV program knowledge—helping ensure the E-register aligned with core workflows and supported service delivery and performance monitoring needs (not only data entry).
- **Consultative approach with early stakeholder engagement:** ICAP engaged MOH leadership and partners during field testing and rollout, including walkthroughs, structured feedback, and joint review discussions to align expectations, usability, and sustainability considerations.
- **Leveraging cross-country experience and peer learning:** The approach drew on OpenMRS implementation experience and lessons shared during the Lesotho

learning visit; planning materials also referenced a learning visit to Lesotho as a mechanism to accelerate peer learning.

- **Frequent follow-up and rapid problem-solving:** The implementation approach used structured feedback loops—weekly touchpoints with developers, routine system reviews, and real-time troubleshooting during early field testing—to surface challenges quickly and resolve them iteratively.
- **Strong teamwork across institutions:** Implementation depended on coordinated roles across ICAP South Sudan, ICAP HQ/informatics support, MOH counterparts, technical development partners, and implementing partners involved in service delivery and quality improvement follow-up.

These "success factors" also served as sustainability enablers by strengthening local ownership, building internal technical capacity, and embedding continuous-improvement routines rather than relying on one-time deployment support.

Artifacts Transition Package

To support long-term maintenance, a comprehensive artifacts transition package was finalized in September 2025 and delivered from the development partner to ICAP. Box 3 summarizes the main documents and technical resources included in the handover.

Box 3. Key documents and resources included in the ART E-register transition package

- Finalized System Requirements Specification (SRS)
- Final data dictionary
- System architecture / technical design documentation
- Feedback tracker / issue log
- Source code and code repositories
- Deployment guide
- Server configuration guide
- Issue resolution / troubleshooting guide
- Training materials
- User reference materials

Transition to Care and Treatment Partners

The transition plan outlines three domains of responsibility for ongoing operations: (1) system use for clinical services, including data entry, clinical decision support, client profiles and line lists, and dashboards/reports; (2) standards, training, and mentorship to support continued use; and (3) system management, maintenance, and IT support for both hardware and software.

In practice, the transition model places primary responsibility for day-to-day system use at facility level, with additional technical, supervisory, and mentorship support provided by above-site teams. Facility-based service delivery teams are expected to perform routine data capture, data quality checks, system monitoring, and data backups as part of regular service delivery. Juba-based care and treatment teams provide strategic oversight, standard operating procedures (SOPs), and data-informed guidance to support consistent use of the system. County and state teams provide advanced case review, onsite mentorship, and supportive follow-up as needed. Together, these roles are intended to support continued system use while gradually reducing dependence on central project staff.

7. Lessons Learned and Recommendations

Lessons Learned

Implementation of the ART E-register across five facilities generated lessons that may be relevant for digital health efforts in other fragile and resource-constrained settings:

- **Design for clinical action, not only reporting.** Automated line lists and clinical flags can help health workers address missed appointments and overdue services, shifting facility practice from reactive record-keeping to proactive patient management.
- **Phased implementation supports learning and risk management.** Field testing and staged rollout allowed issues to be addressed before broader deployment, reducing risk and generating learning that improved subsequent site implementations.
- **Dedicated data entry capacity is essential during transition.** Recruiting and training dedicated clerks helped accelerate digitization and support data quality—a lesson underscored by the prior EMR attempt, in which the absence of dedicated data-entry personnel at one site contributed to limited system uptake.
- **Routine verification builds confidence.** Paper-to-electronic concordance checks, daily file audits, and report triangulation helped identify errors early and reinforce accountability.
- **Technology selection has long-term implications.** Choosing an open-source platform with a broader community of practice can strengthen sustainability and peer learning. OpenMRS 3.x connected South Sudan to regional implementations in Kenya, Rwanda, and other countries, while lessons shared during the Lesotho learning visit provided additional implementation insights.
- **Evaluation must account for transition effects.** Early post-deployment trends may reflect improved case detection and documentation rather than true deterioration in performance. The AIDS 2026 analysis demonstrated that transition effects must be accounted for in evaluation design. That return-to-treatment (RTT) may be a more informative retention signal than raw IIT counts in early implementation.
- **Integrated approaches outperform siloed interventions.** The E-register was embedded within a broader ecosystem of routine reporting management, data quality assurance, and surveillance governance. Facilities had functioning reporting routines and quality-conscious data practices before the E-register was introduced. This integrated approach created mutually reinforcing systems and avoided the limitations of deploying a digital tool in isolation.
- **Government and other stakeholders' engagement from Day 1 builds sustainability.** The MOH was engaged as a full partner at every stage through the HMIS/M&E Technical Working Group, the HIS sub-TWG, and joint site visits. This investment in national ownership from the earliest design stages ensured alignment with existing clinical workflows and built the institutional commitment essential for long-term sustainability.

Recommendations

Based on implementation experience and transition planning, the following actions are recommended to sustain gains and support future scale-up:

- Formalize a phased handover plan with MOH and care and treatment partners that clarifies responsibilities for clinical use, data quality monitoring, and technical maintenance.
- Protect system uptime and data continuity through reliable power backup and routine local data backup, especially at sites with limited connectivity.
- Maintain routine data verification practices (paper-to-electronic concordance, daily file audits, indicator verification) as standard operating procedures.
- Address legacy data backlogs through time-limited surge support and clear prioritization rules at facilities with large historical caseloads.
- Before scale-up beyond 5 sites, conduct a facility-readiness assessment covering staffing, power, local network infrastructure, and mentorship capacity.

	Deployment		Data entry and quality checks							Real-time use and monitoring										
Indicator	Jul-24	Aug-24	Sep-24	Oct-24	Nov-24	Dec-24	Jan-25	Feb-25	Mar-25	Apr-25	May-25	Jun-25	Jul-25	Aug-25	Sep-25	Oct-25	Nov-25	Dec-25	Jan-26	Feb-26
System uptime (%)	80%	98%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Average system downtime (hours/week)	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Number of facilities with functional EMR hardware	2	2	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5

Backup Frequency

Green = Fully met

Yellow = Partially met

Red = Gap

About ICAP

A major global health organization that has been improving public health in countries around the world for more than two decades, ICAP works to transform the health of populations through innovation, science, and global collaboration. Based at Columbia University Mailman School of Public Health, ICAP has projects in more than 40 countries, working side-by-side with ministries of health and local governmental, non-governmental, academic, and community partners to confront some of the world's greatest health challenges. Through evidence-informed programs, meaningful research, tailored technical assistance, effective training and education programs, and rigorous surveillance to measure and evaluate the impact of public health interventions, ICAP aims to realize a global vision of healthy people, empowered communities, and thriving societies.

Online at icap.columbia.edu

Annex A. ART E-Register Timeline

Table A1. ART E-register implementation timeline (selected milestones).

Date	Milestone
Oct 2023	SRS customization; reporting requirements gathered; site infrastructure assessment
Dec 2023	Rapid assessment of earlier EMR at JTH; service agreement with IntelliSOFT; OpenMRS 3.0 selected; equipment procured
Dec 2023	Phase 1 SRS finalized; data entry forms completed and under testing; reports progressing.
3 July 2024	Munuki PHCC deployed; 75 files entered in first week.
30 Jul 2024	Al Sabah Children's Hospital deployed
5 August 2024	Rumbek State Hospital deployed
16 August 2024	PEPFAR Chair's visit to Munuki PHCC
19 August 2024	Yirol Hospital and Yambio State Hospital deployed
12 September 2024	PEPFAR/CDC team visit to Al Sabah; sustainability discussion
Nov 2024	All 5 sites deployed; legacy data complete at Al Sabah and Munuki
15 December 2024	System use begins at Munuki PHCC and Al Sabah
15 May 2025	System use begins at Rumbek and Yirol
15 June 2025	System use begins at Yambio.
16 August 2025	Five-day Hackathon: hosting environment, code transfer, testing
Sep 2025	Artifacts transition from IntelliSOFT to ICAP finalized
May 2025–Feb 2026	81% reduction in missed appointment proportion (58% to 11%); 44% reduction in IIT (159 to 89)
Jun–Feb 2026	Continued performance tracking: missed appointments, IIT/RTT, and VL trends across five sites; VL sample collection reached 80% (7,373/9,221 eligible)
Dec 2025–Feb 2026	Paper–E-register data concordance improved from 72% to 98% (reference indicator: TX_CURR)
FY26 (Bridge)	Maintain 5 sites; focus on uptime, data quality, clinical use; no expansion.