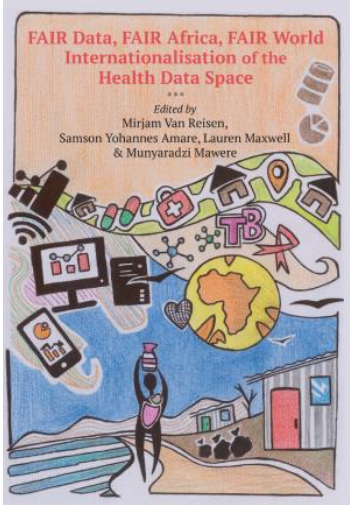
GO Change: Adoption of FAIR-OLR Architectures to Support Insights from Patient Health Data Records in Africa

Putu Hadi Purnama Jati, Samson Yohannes Amare, Abdullahi Abubakar Kawu, William Nandwa, Getu Tadele Taye & Mirjam van Reisen

Chapter in:
Fair Data Fair Africa Fair World:
Internationalisation of the Health Data Space



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Chapter 7

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Abstract

This study investigates the impact of contextual factors on the adoption of a patient information system that is Findable, Accessible (under well-defined conditions), Interoperable and Reusable (FAIR), and with clear Ownership in Locale under Regulatory Compliance (OLR). An intervention with the deployment of a minimal viable product (MVP) was carried out in 2021–2022. The architecture included federated data repositories handled in health facilities in multiple countries. Stakeholders associated with the implementation were approached in five selected African countries, before and after the intervention, to research the variables for adoption. The Unified Theory of Acceptance and Use of Technology (UTAUT) model was used to analyse the adoption by comparing factors emerging at the country level. The research found considerable convergence towards the principles of FAIR-OLR across all five countries, leading to legislative changes in some. We found that the introduction of dashboards in health facilities was critical to demonstrate that the analysis of digital patient data is relevant to patient care. The study confirmed federated data handling, which was important for health facilities in conflict zones. Variations across countries were significant, showing the need to adapt architectures to different conditions.

Keywords: FAIR-OLR, EMR, digital patient records, Africa, innovation adoption

Introduction

Data architectures grounded in the principles of Findable, Accessible (under well-defined conditions), Interoperable, and Reusable (FAIR) data have yet to undergo rigorous, systematic investigation in regions outside the Western hemisphere and in real life settings (Lin et al., 2022; Van Reisen, Stokmans, Basajja et al., 2020; Van Reisen, Stokmans, Mawere et al., 2020). The influence of social context, encompassing cultural, political, and other contextual factors, on stakeholders' expectations of system performance remains underexplored (Van Reisen, Stokmans, Basajja et al., 2020; Van Reisen, Stokmans, Mawere et al., 2020).

Addressing this gap, Amare et al. (2024) discuss the applicability of FAIR-based data architecture in low-connectivity settings. Amare et al. (2024) show the relevance of the ability to federate a data system in the context of war and the focus of investigators operating in a war situation to respond to situations of being disconnected from the Internet and disconnected from backbone structures. In addition, Taye et al. (2024) demonstrate how prevailing data integration systems become inoperable during conflict, precisely when health information is essential for coordinating effective humanitarian interventions.

The studies conducted by Gebrselassie et al. (2024) and Kahsay (2024) illustrate the challenges of obtaining information during the digital blackout and siege in Tigray, Ethiopia, emphasising its critical role in humanitarian response. Stocker and Medhanyie (2024) emphasise how such information in the health domain is lacking and crucial for determining the resilience of affected regions. Gebreslassie et al. (2024) and Amare et al. (2024) propose the adoption of federated digital infrastructure to reduce reliance on centralised systems, bolstering digital resilience in future crisis scenarios.

The unavailability of direct access to patient data during conflict and war represents one of many motivations for data federation. Nalugala and Van Reisen (2024) emphasise the importance of data 'ownership' in driving digital health innovation across Africa, which has led to an expansion of the FAIR principles to include three additional facets:

Ownership, Localization, and Regulatory Compliance (OLR) (Amare et al., 2023; Van Reisen, et al., 2023).

The global uptake of FAIR principles has shown substantial variation, with regional contexts emerging as a decisive factor in adoption pathways (Lin et al., 2022). Moreover, adoption in Africa has been relatively limited. Van Reisen, Stokmans, Mawere et al. (2020) identify three key pathways for transitioning to FAIR infrastructure: 'GO BUILD', which focuses on creating and testing architectures to showcase their value; 'GO TRAIN', which emphasises training data handlers to support the innovation process; and 'GO CHANGE', which involves adapting implementation to the specific context of each location. Taking a continental approach, Van Reisen, Stokmans, Mawere et al. (2020) do not distinguish among subregions within the African continent. Van Reisen, Stokmans, Basajja et al. (2020) recognise the significance of the interdisciplinary uptake of FAIR implementation.

This research responds to the need for a granular approach to understanding contextual factors relevant to adopting FAIR-OLR in the healthcare sector in Africa. We explored the adoption and implementation of FAIR-OLR-based digital health systems in five African countries- Kenya, Uganda, Nigeria, Ethiopia, and Somalia- as part of the Value-driven Ownership of Data and Accessibility Network (VODAN) initiative.

This study addresses the question of how unique contextual factors within Africa influence the GO CHANGE component in the implementation of FAIR infrastructures, the challenges health facilities face when adopting FAIR-OLR digital architectures, and the role of key stakeholders. We illustrate a broad array of contextual scenarios that bear directly on effective FAIR implementation and adoption strategies in varied African settings.

Unified Theory of Acceptance and Use of Technology

The Unified Theory of Acceptance and Use of Technology (UTAUT) is a comprehensive theoretical model extensively employed to explain technology acceptance and use predictors. Venkatesh et al. (2003) developed the UTAUT framework to integrate eight existing models of technology adoption that explained the predictors of users' intention and actual use of technology. We selected UTAUT as the theoretical framework for our research because of its versatility and wide use for analysing technology adoption in different contexts.

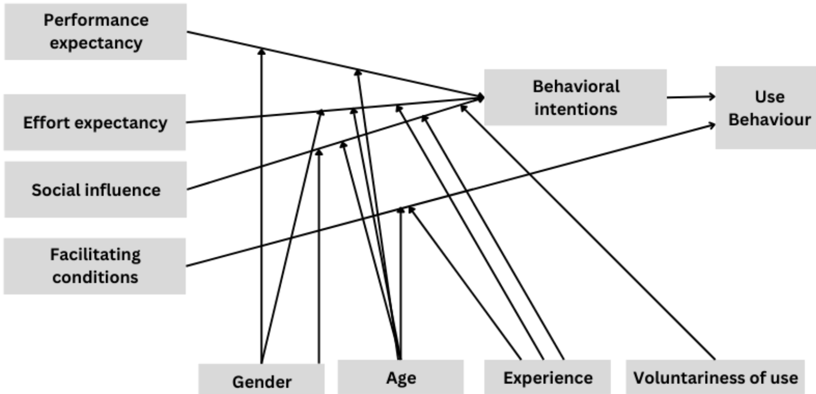

Figure 1. UTAUT model

Source: Venkatesh et al., 2003

In UTAUT, four primary constructs are identified as directly affecting behavioural intention and further use of technology: performance expectancy, effort expectancy, social influence and facilitating conditions.

Performance expectancy

Performance expectancy refers to the extent to which an individual perceives that using a specific technology will improve their job performance or facilitate attaining desired results. It derives from concepts such as perceived usefulness in the Technology Acceptance Model (TAM) and relative advantage in Diffusion of Innovation Theory. Performance expectancy includes attitudes and beliefs, which Ajzen (1991) identified as important predictors of behaviour in his Theory of Planned Behaviour.

Effort expectancy

Effort expectancy denotes the usability associated with the technology. It is based on notions such as perceived ease of use in the Technology Acceptance Model and complexity in alternative frameworks. The framework highlights the significance of intuitive interfaces and reduced learning curves in promoting acceptance.

Social influence

Social influence identifies the extent to which an individual perceives that others who hold social significance to the person (e.g., peers, supervisors, or community leaders) advocate for adopting a specific technology. This factor encompasses subjective norms (Ajzen, 1991), social influences, and image constructs. Social influence is important in all social situations where community norms, cultural expectations, or organisational hierarchies substantially affect technology adoption. Endorsement by influential figures or alignment with cultural values can improve adoption rates.

Facilitating conditions

Facilitating conditions represent how an individual perceives that adequate resources, infrastructure, and support are available to use the technology effectively. This construct aligns with perceived behavioural control (Ajzen, 1991) and facilitating conditions in earlier theories.

As shown in Figure 1, UTAUT considers how four moderators, gender, age, experience, and voluntariness of use, shape the relationships between the four primary constructs and the main outcomes, behavioural intentions and use behaviour.

UTAUT recognises that (at least) four variables moderate the connections between these fundamental constructs and technology adoption:

- Gender: Men and women may show variations in their technological advantages and usability assessments, which can influence their adoption behaviours.
- Age: Younger users generally show a higher tendency for technology adoption, whereas older users may necessitate targeted interventions to overcome challenges.
- Experience: Familiarity with technology may reduce effort expectancy over time and improve facilitating conditions.
- Voluntariness of use: the extent to which technology adoption is perceived as mandatory rather than voluntary, which influences acceptance behaviours.

We considered these variables in the analysis of the findings.

Research design

We conducted an implementation study of a minimum viable product (MVP) to test the adoption potential of a FAIR-OLR architecture for improved patient data interoperability in selected African countries. Because this was exploratory research, we included a wide range of health facilities with varying conditions. This diversity allowed for a richer understanding of how adoption and cross-border data visiting flows varied by healthcare infrastructures and regulatory landscape.

Conducting the study in real-life settings allowed us to capture the social dynamics that shape technology uptake. The study gathered insights about (i) the expectations that different stakeholders had for a new digital health system and (ii) the system's actual performance once it was in use. We conducted two rounds of data collection:

1. Pre-implementation survey (expectations-focused)

Before the intervention, we surveyed various stakeholders, including facility directors, health information technicians (HITs), nurses, and clinicians. The goal was to investigate their expectations about how the system could help them individually and benefit the facility overall. The survey was grounded in the UTAUT concepts of performance expectancy, effort expectancy, and facilitating conditions, and it explored participants' priorities and social influence. The analysis of survey results informed the technical setup and training.

2. Post-implementation interviews (performance-focused)

Once the MVP was installed and used for daily record-keeping, we conducted semi-structured interviews to assess whether or not and how the system met stakeholder expectations captured in the pre-implementation survey. These interviews focused on the system's practical performance variables in keeping with UTAUT, focusing on the real-life impacts of the digital technology. We re-interviewed the country coordinators to capture their perspective on how stakeholder feedback from the initial phase had been addressed. These coordinators had overseen the system rollout, trained facility staff, and coordinated with ministries and administrators, giving them a unique point of view on both technical and social feasibility. In the interviews, we focused on effort expectancy, social influence, and facilitating conditions.

The analysis was carried out at the health facility and country levels to measure variations in attitudes between the pre- and post-implementations.

Selection of deployment sites and establishment of country teams

The country teams were selected as a convenience sample with the following preconditions:

- Expression of interest
- Availability of interested research staff
- Demonstration of leadership by weekly participation in research meetings
- Interest and a signed memorandum of understanding (MoU) from the research-lead university in the country
- Interest in training technical staff
- Availability of funding for instalment (computer, data for connectivity, electricity)
- Demonstrated interest in participation by health facilities
- Demonstration of trust in the innovation potential

The initial selection of deployment sites included Zimbabwe, Tunisia, Liberia, and Tanzania, which was subsequently extended to include four more countries. Study country teams were established and participated in the weekly meetings. However, the preparation for deployment was not finalised due to different constraints, such as time constraints of technical staff, delays in approving MoUs with participating health facilities, lack of approval from the research ethical committee, lack of health facility interest in participation, and lack of trust in the innovation potential of the intervention. In some instances, the study country coordinators could not raise the necessary funding for the installation, despite their interest in participation.

The MVP deployment sites differed extensively. In Ethiopia, the deployment sites were concentrated in Tigray, a region suffering from conflict and siege during the intervention, and in the capital, Addis Ababa. In Kenya, deployment sites were selected from the urban

Nairobi metropolitan area. In Uganda, the sites were a mix of urban and rural hospitals. In Nigeria, the sites included hospitals and facilities in different regions of the country, and two country coordinators managed the research. In Somalia, one country coordinator was active, and the deployment was carried out in the Northern region, where conflict erupted shortly after the deployment.

Research timeline

As shown in Figure 2, the research was divided into the following phases.

1. Participant selection (September 2021–December 2021)
   - Selection of countries
   - Trust-building and establishment of networks in countries
   - Selection of candidate health facilities for further outreach
   - Fundraising for deployment
2. Preparation (January 2022–August 2022)
   - Preparation of health facilities
   - Signing of MoUs with health facilities for deployment
3. Deployment (May 2022–December 2022)
   - Training of trainers for deployment
   - Purchase and preparation of material
   - Deployment in health facilities

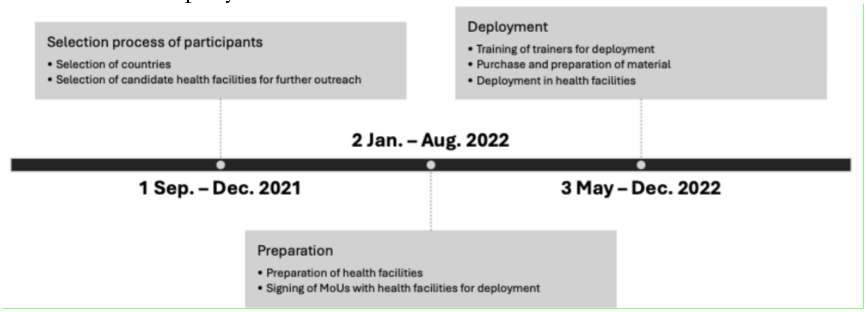

Figure 2. The timeline for the first and second interviews

The timeframes for preparation and installation in six study sites in five countries were staged, with deployment initiated in the following order:

- Tigray – Ethiopia
- Nigeria
- Uganda
- Kenya
- Addis Ababa, Ethiopia
- Somalia

The survey and interviews were carried out before and after each intervention. The survey and interview schedules are presented in Figure 3.

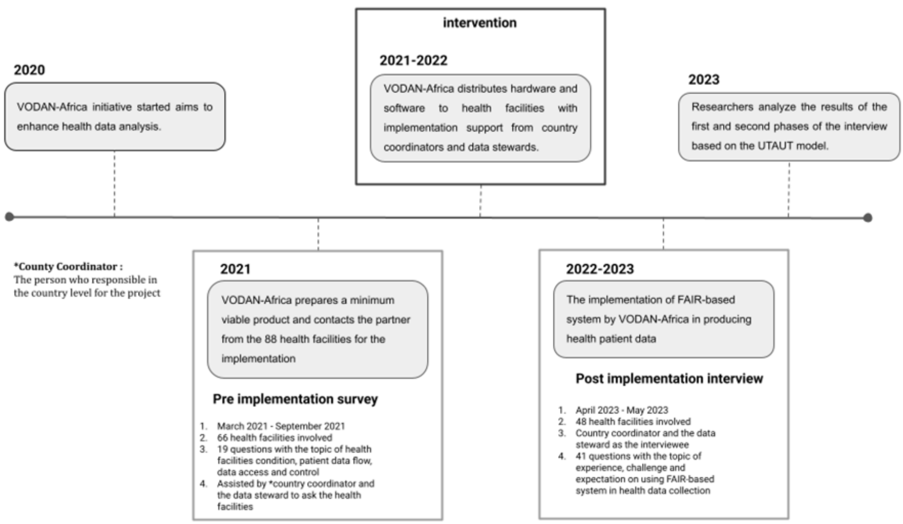

Figure 3. The survey and interview timelines

In the 2020 study, country coordinators were identified in each country. The country coordinators met weekly and introduced technical staff. Meetings were conducted to familiarise MoHs and health facility administrators with the study objectives and rationale. In this selection phase, we focused on gauging interest in participation in each country.

The preparatory phase was conducted from March 2021 until September 2021. Between 2021 and 2022, VODAN distributed the hardware and software to health facilities for installation. The study country coordinators and data stewards provided coordination support, and the health facilities began implementing the FAIR-OLR-based system.

Study preparation

Eighty-eight health facilities agreed to participate in the preparatory phase. The interest was higher than the initially planned number of 30 health facilities. The study sites also differed from the initial research plan to deploy in Uganda, Ethiopia, and Zimbabwe. Kenya was added because the Nairobi metropolitan area was very interested in participating in the study. Similarly, in Nigeria, a very active team supported by the executive research director expressed a high level of interest and was able to secure funding for participation. Somalia was added in 2022 because the study country coordinator engaged the MoH in supporting training and installation, carried out with the coordinating support of the regional bureau. In Ethiopia, the study was supported by the MoH and the Regional Bureau of Health. Given the high level of interest and engagement, the research team extended the target number of facilities from the original target of 30 to 88.

The planning process was carried out in three steps:

1. MoH approves the intervention.
2. Health facility participates in preparatory training and signs an MoU.
3. The relevant health facility staff participated in the first round of interviews conducted for the implementation study.

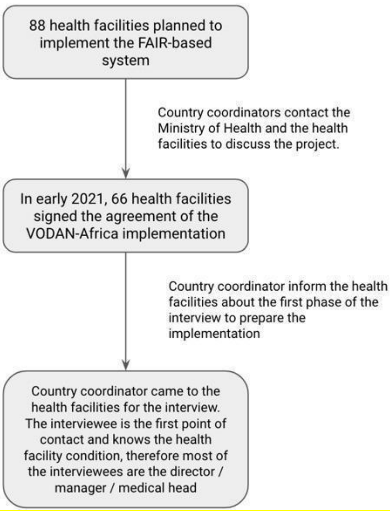

Figure 4. Health facilities selection process

Following the preparatory phase, 66 health facilities fulfilled the preparatory conditions for continuation into the implementation phase of the study.

Table 1. Health facilities numbers by country

Country	Health facilities total
Ethiopia	20
Kenya	3
Nigeria	21
Somalia	19
Uganda	3
TOTAL	66

As shown in Table 1, the division of health facilities was as follows: 3 health facilities in Uganda, three health facilities in Kenya, 19 health facilities in Somalia, 20 health facilities in Ethiopia, and 21 health facilities in Somalia. The 20 health facilities in Ethiopia were divided over two sites: the metropolitan Addis Ababa region and the northern province of Tigray. The deployment was divided across the North Central and Southwest regions in Nigeria. The implementation phase in the 66 health facilities consisted of training for installation, training for using the data, installation of the hardware and software, data production, and, finally, the post-intervention interview.

Selection of health facilities

The study country coordinators in Ethiopia, Nigeria, and Somalia showed interest in implementing the study widely.

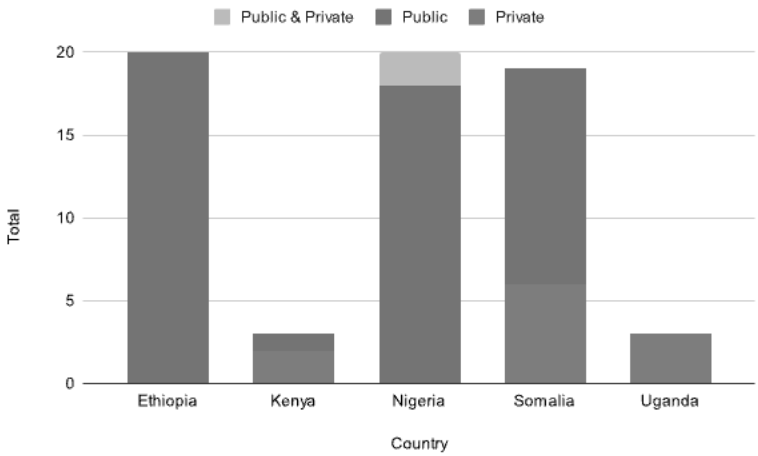

Figure 5. Number of VODAN-Africa health facilities by country and facility type

Figure 5 summarises the number of selected health facilities by country and facility type (public, private, or both public and private). Most or all facilities were public in Somalia, Nigeria, and Ethiopia. In contrast, Uganda and Kenya had higher levels of private ownership. Most participating sites were public health facilities directly overseen by the MoH or regional health bureaus.

Data collection

The survey was conducted in the pre-intervention phase with the assistance of the country coordinators. All 66 health facilities participated.

<u>Pre-implementation survey: Investigation of the conditions in the health facilities</u>

A 19-question paper survey was provided to the health facilities for completion by the people in charge of health facility data production, the director, manager, or medical head of the facility, and selected staff, nurses, and HITs. As shown in Table 2, in most cases, the health facility director, manager, or medical head completed the survey.

Table 2. Pre-implementation survey respondents by country and role

Country	Director/manager / medical head	Staff/doctor/nurse
Ethiopia	20	0
Kenya	1	2
Nigeria	14	7
Somalia	6	13
Uganda	1	1
Total	42	23

Survey questions focused on the facility's conditions for patient data handling and information flow, the availability of data clerks and information communication technology (ICT) staff, whether a computer was available, and electricity and data connectivity.

The survey was administered to the respondents in the health facilities with the support of the country coordinators. The 19 questions were administered during three rounds that focused on a particular topic. Before initiating each data collection round, the research team discussed how the survey questions should be formulated and how the survey should be administered with the country coordinator.

Communication with survey respondents was systematically initiated through a collaborative effort involving the research country coordinator and the director of the respective health facility. The primary researcher reviewed and interpreted the survey results. The country coordinators managed and processed the survey data during the pre-implementation phase. To ensure accurate data collection, the coordination team facilitated a physical visit by a research assistant to the facilities, during which the survey questions were administered. When responses required further clarification, the country coordinator arranged follow-up visits by the research assistants to verify and refine the interpretations of the original answers. The country coordinator managed the setup and oversight of the survey process for their country.

Post-implementation interviews

The post-implementation interviews were conducted via teleconference after MVP installation. The country coordinators and data stewards participated in the post-implementation interviews. Seventeen respondents were selected based on their active involvement in the implementation. The respondents were selected from 48 health facilities and did not include Somalia. No interviews could be conducted with the country coordinator and data stewards in Somalia because war had broken out in the region following the deployment, and it was difficult to reach the participants, who were engaged in urgent humanitarian efforts. Table 3 shows the country-level distributions and participant roles for the post-implementation interviews.

The semi-structured interview included 41 questions related to (i) experiences, (ii) challenges during contracting, set-up, or implementation, and (iii) expectations. Following the semi-structured approach, participants could answer questions in the format and order that followed the natural flow of the conversation. The interviewer then had to ensure all topics had been adequately covered.

Table 3. Post-implementation interview respondents by country and role

Country	Country coordinator	Data stewards	Health facilities monitored
Ethiopia	2	2	20
Kenya	1	3	3
Nigeria	2	7	21
Somalia	N/A	N/A	0
Uganda	1	0	4

Country	Country coordinator	Data stewards	Health facilities monitored
TOTAL	5	12	48

Five country coordinators in Ethiopia, Kenya, Nigeria, Uganda and Somalia and twelve data stewards in Ethiopia, Kenya, Nigeria, and Uganda) were interviewed. Forty health facilities managed by five country coordinators and 12 data stewards were included in the post-implementation interviews. Because of the ongoing conflict, health facilities in Somalia could not be included in the post-implementation survey.

The health facility, rather than the individual participant, was the primary unit of analysis. During the pre-implementation phase, data were collected via a survey from facility directors, managers, and leaders to establish baseline conditions and organisational readiness. In contrast, the post-implementation phase involved interviews with country coordinators and data stewards who oversaw or supported the same facilities. Although these respondent groups were distinct, their insights collectively provide a multifaceted view of the health facility's engagement with the FAIR-OLR-based system over time. We aimed to collect different perspectives to ensure a comprehensive understanding of system adoption and implementation.

We aggregated facility-level findings within each country to compare findings across countries. Specifically, we combined individual responses from pre- and post-implementation phases and identified common themes, challenges, and facilitators across facilities. By centring the analysis at the facility level, we could maintain a coherent comparison of facility-level adoption and implementation outcomes despite variations in respondent roles. This methodological design ensured that the key focus remained on how each country's set of health facilities experienced the intervention rather than on the experiences of individual respondents.

Analysis of the pre-implementation survey and post-implementation interviews

We used a quantitative approach to analyse results from the pre-implementation survey. We characterised frequencies by (i) type of health facility, (ii) technical infrastructure, and (iii) data production.

We employed theory-informed grounded theory thematic analysis for the qualitative analysis of pre-implementation survey and post-implementation interviews data, maintaining consistency across facilities and countries. This modified grounded theory approach included three stages: (1) open coding, (2) axial coding, and (3) selective coding.

- *Open coding* consisted of an in-depth analysis of individual responses to identify repeating themes, important ideas, and viewpoints stated by respondents throughout pre- and post-implementation phases. Codes were inductively generated from the data to capture stakeholder perspectives accurately.
- *Axial coding* involved organising open codes into general concepts that summarised common experiences within each institution. Based on the study's theoretical framework, these themes corresponded with the four UTAUT variables: performance expectancy, effort expectancy, social influence, and facilitating conditions. This phase provided a systematic comparison of pre- and post-implementation results within each facility, allowing for the identification of changes in perception, adoption obstacles, and primary enablers.
- *Selective coding* was subsequently used to consolidate information from several facilities within each nation, explaining the variations in adoption patterns, difficulties, and facilitating factors at the national level. Comparative analysis of country-level findings revealed overall adoption patterns and regional differences, highlighting factors that affected successful implementation in various national contexts.

The approach combined inductive (open) and deductive (axial) coding to provide depth to the findings. Coding first focused on facility-level insights before considering the aggregation of codes and themes at the country level to account for the participation of different respondent groups in each phase.

We ensured inter-coder agreement through weekly small group meetings of the two team members who led the coding process. We held discussions with the larger team on an as-needed basis to review the code book and discuss emergent themes at the facility and country level. We analysed the interviews as they became available and modified the interview guide during the interview process to capture emerging themes. We defined saturation as when no new themes emerged at the facility or country level. Coding was conducted in Excel.

The final analysis provided intra-country comparisons, monitoring temporal changes within each nation, and cross-country comparisons, highlighting common and divergent adoption trends and factors across health systems.

By organising the qualitative analysis in this format, the study maintained a coherent and systematic approach to capturing adoption patterns across all levels while preserving the diversity of participant responses.

Ethical considerations and regulatory compliance

Ethical approval for conducting the research was obtained before initiating participant recruitment from Tilburg and Kampala International Universities, which coordinated the study. The ministries and bureaus of health were informed about the study. Written informed consent was obtained from each participant.

Data management

Responses from paper-based surveys were collected, digitised, and securely uploaded to a password-protected repository. The scanned data was transcribed and anonymised. The roles of the respondents, including the director, manager, or HIT, were maintained.

Post-implementation interviews were transcribed, and participant names and other identifying information were removed. The respondents' roles were maintained for analytical purposes when analysing pre-implementation phase data.

Result and findings

The MVP architecture deployed at each facility followed the requirements and specifications established by the research team in January 2021 and incorporated findings from the pre-implementation survey. The research team compared two different architectural approaches: the Data Stewardship Wizard (DSW) and the University of Stanford-based Center for Expanded Data Annotation and Retrieval (CEDAR) metadata annotation system. The following requirements were considered:

R1: Flexible data production (based on VODAN controlled vocabulary)

R2: Localisation of the metadata system

R3: Bulk input of data in the data production platform

R4: Usability and demonstration of value

The tools were compared according to the following specifications:

S1: Open source

S2: Programmability and adaptability

S3: Own maintenance

S4: Availability for training

S5: Convergence with other FAIR developers to increase efficiency

Following the analysis of tool requirements and specifications in keeping with the aforementioned schema, the CEDAR metadata annotation system was selected over the DSW (VODAN, 2021).

The VODAN Board decided on the specifications for the MVP's initial functionality. These initial functions of the Healthcare Data System are expandable based on the facility's needs. The Board of VODAN Africa considered and approved the following requirements for the MVP:

R1: Flexible data production (based on VODAN controlled vocabulary)

R2: Localization of the CEDAR metadata system (Figure 6) to achieve:

- Convergence between CEDAR localised formats
- Localised availability of CEDAR templates for premise installation
- CEDAR templates based on the District Health Information System (DHIS) forms in use in the hospitals and with a VODAN-agreed vocabulary

R3: Bulk upload of data into the CEDAR platform

- Data storage in the hospital with metadata pointing to the data in residence (own data repositories for hospitals are required)
- Programming a tool for the transfer of the data included in the CEDAR templates into the DHIS forms that hospitals can upload as per ministry regulations (hospitals do not need to input data twice)
- Ability to run queries within hospitals, across hospitals within countries, and between countries

R4: Training for template development with controlled vocabularies

R5: Usability and demonstration of value

- African data stewards to deploy these solutions across each of the implementation countries and partner hospitals in the other countries for visualisation in dashboard format
- Creation of synergy across FAIR leading projects

Figure 6 shows the original design flow specifications, which use CEDAR to organise data input templates linked to FAIR semantically annotated data with output in the Resource Description Framework (RDF).

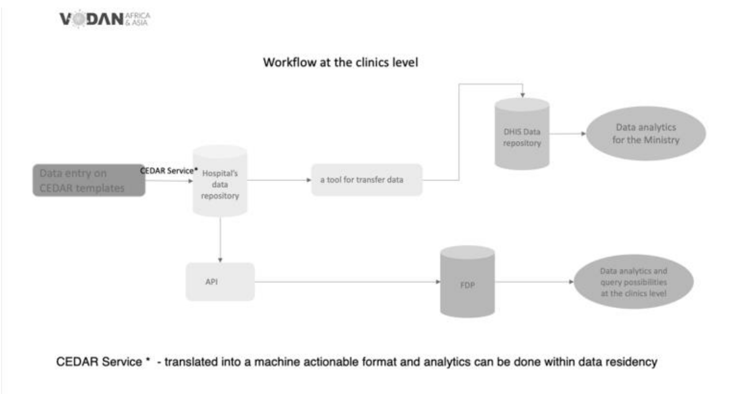

Figure 6. Original design flow of CEDAR-based data entry form

In this architecture, represented in Figure 7, a double functionality was assumed in which the DHIS2 data templates formed the basis for the analytics. The data input was required only once and resulted in output to DHIS and to the Fair Data Point (FDP), with data insights available at the clinic level. Data insights were enabled via a health facility-specific data dashboard.

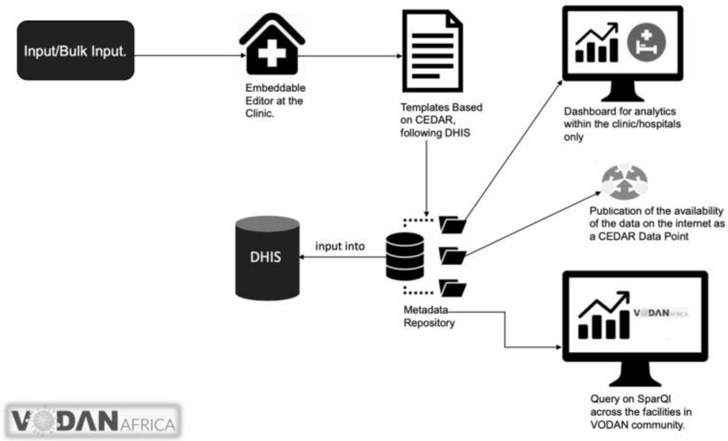

Figure 7. VODAN-Africa general architecture

Source: Van Reisen et al., 2023

Insights obtained across health facilities are also visualised collectively via a community dashboard. Publishing the metadata via an FDP enables re-use of the data for additional workflows or insights.

Quantitative results

The quantitative results from the pre-implementation survey are structured around the three main themes that emerged from our thematic analysis: type of health facility, technical infrastructure, and data production.

<u>Digital infrastructure available in health facilities</u>

As shown in Figure 8, computer availability in health facilities in the participating sites varied across Uganda, Kenya, Somalia, Nigeria, and Ethiopia.

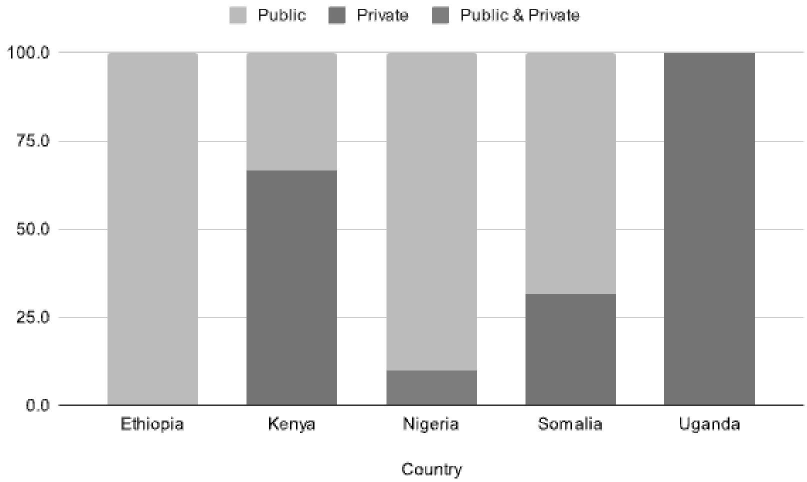

Figure 8. Computer availability in health facilities by country

All participating health facilities in Uganda and Kenya had computer equipment. In contrast, in Nigeria and Ethiopia, the majority of facilities lacked computers. The type of computer is an important determinant of how the system can be adopted. Along with hardware, the availability of the Internet is important for the FAIR-OLR-based implementation because the system is more complete if it connects to the Internet. Figure 9 shows internet access among the participating facilities in the five countries.

Internet connectivity in health facilities differed substantially across participating countries. For example, while health facilities in Uganda, Somalia, and Ethiopia had internet access, the assessment in Kenya focused on Nairobi—an urban centre with a high level of accessibility to computers and the Internet. In contrast, most health facilities in Nigeria lacked the connectivity required for daily operations. In Ethiopia, despite facilities like Ayder Hospital in Tigray being among the best equipped in the country before the war, the conflict resulted in a complete loss of internet access due to the siege.

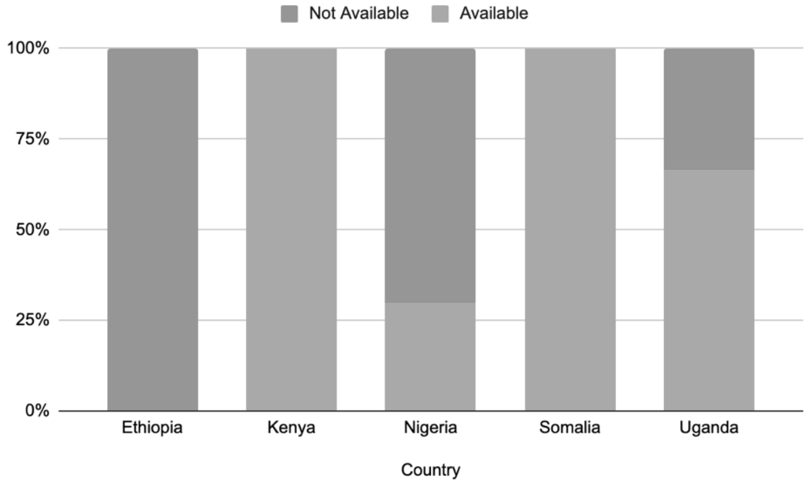

Figure 9. Internet availability in the participating health facilities by country

We did not collect data on the reliability or speed of the Internet in each country, which is a critical factor in the successful implementation of new healthcare systems.

Patient data processing

Figure 10 illustrates the utilisation of electronic systems, paper-based registries, or a combination of both methods by each facility. Understanding their current condition according to the categories enabled us to establish a baseline prior to the beginning of the FAIR-OLR intervention. A clinic that had primarily utilised paper records may require additional time and help to transition to digital systems, in contrast to one that has been managing patient data electronically for years. Facilities using a combination of paper and digital systems have some electronic experience; thus, their transition to a fully interoperable digital framework may be faster.

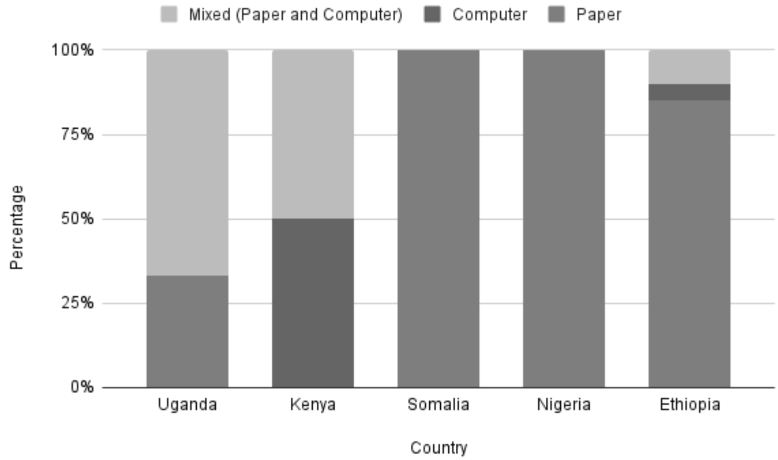

Figure 10. Percentage of patient data collection method

All health facilities in Somalia and Nigeria collected patient data using paper-based methods. Most health facilities in Ethiopia collect patient data using paper-based methods, with only a few employing fully computerised systems or a combination of both paper- and computer-based approaches. Most health facilities in Uganda used paper-based and computer-based systems, while others relied only on paper-based methods. One healthcare facility in Kenya implemented a fully computerised method for patient data collection.

<u>Roles assigned for data control</u>

The pre-implementation survey identified the data controllership roles related to patient data handling. A data controller is an individual or legal entity determining how and why personal data is processed. They are charged with the establishment and management of the data filing system.

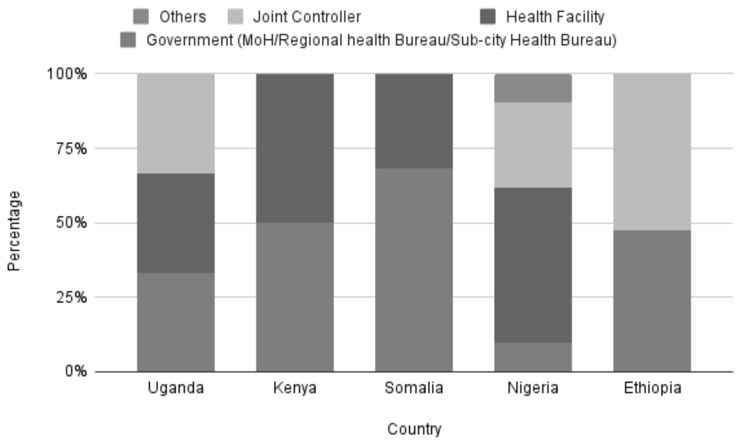

Figure 11. Percentage of data controller type by country

Figure 11 illustrates that the government, specifically the Ministry of Health or health bureau, rather than the health facility, was regularly identified as the data controller in most countries. Health facilities and authorities jointly determined the role of the data controller in Uganda, Nigeria, and Ethiopia, a process known as joint controllership. Two health facilities in Nigeria identified different organisations as their data controllers: the World Health Organization (WHO) and the Organization of Islamic Cooperation. The perception of what 'data-control' entails in patient data handling may vary widely and may not be understood in the same precise or legal terms in different countries.

Qualitative results: Perspective of change

The qualitative results of this research are obtained both from the analysis of the survey data (pre-implementation) and the interview results (post-implementation). We classify the results according to the UTAUT themes: performance expectancy, effort expectancy, social influence, and facilitating conditions.

<u>Performance expectancy</u>

Performance expectancy measures the degree to which an individual believes that using the system will help him or her improve job performance. Table 4 compares respondents' perspectives on performance expectations before and after the MVP implementation by country.

Table 4. Performance expectations before and after MVP implementation

Country	Pre-implementation phase	Post-implementation phase
Ethiopia	The patient data collection using a paper-based system results in a lack of detailed information during the patient referral process (lack of interoperability). Participants feared data loss due to the absence of backup practices in the health facilities.	The MVP dashboard was considered very informative and helpful. There were complaints about the slowness of the data entry process.
Kenya	Data management systems in health facilities align with high-performance expectations. Digital patient data management is perceived to enhance operational effectiveness in health facilities and improve health workers job performance.	The MVP is perceived as promising in digital data handling and interoperability. Patient data analysis based on the FAIR data principles is a potential improvement that can help decision-making in health facilities.
Nigeria	Participants were afraid of data loss due to the absence of digital data in the health facilities. The current processes for patient data handling are perceived to be inadequate.	FAIR implementation is seen as providing an opportunity to make data interoperable, which is perceived to enhance the data insights. The MVP dashboard is seen as very helpful in describing the current situation for patients.
Somalia	Paper-based systems lack efficiency in fast-paced healthcare environments. There is no specific data storage method available across all health facilities.	N/A

Country	Pre-implementation phase	Post-implementation phase
Uganda	Paper-based recording of patient data and computers are only used for the other operational objectives such as financial calculations and reporting of DHIS2 aggregate patient information to the Ministry of Health. The current process needs improvements to motivate healthcare professionals to continuously accept and use the system.	The MVP system is useful, as the previous method was paper-based. The MVP system makes the data accessible to the medical staff.

In the Tigray-based hospitals, patient data handling did not include electronic patient records. Before the war, digital tools were available for health information systems and other health tools, but these stopped during the war. The collection of data using paper-based methods frequently led to complications. The patient referral process, which had broken down with the transition from electronic to paper records during the conflict, was a challenge that respondents thought needed to be addressed. After the deployment of the MVP, most respondents reported being concerned about data loss, which they attributed to the lack of backup procedures in health facilities. Respondents were particularly satisfied with the MVP's data dashboard but were concerned about the slowness of the MVP when they needed to start or reboot the machine.

Respondents in Kenya reported that the digital patient data management system aligned with high-performance expectations. Respondents in Kenya were enthusiastic about the MVP. They reported that the MVP innovation had the potential to enhance operational effectiveness and improve job performance. The pre-implementation perception of stakeholders at Kenyan health facilities was that the innovation would enhance their efficiency. The post-implementation results indicated that the MVP had been successfully implemented, and that adoption was high. The health facilities perceived the MVP as promising for improving digital data handling and interoperability. The health facilities mentioned that the MVP dashboard helped them with clinical decision-making.

In Nigeria, the pre-implementation survey found that respondents were concerned about the absence of electronic patient records in health facilities. After MVP deployment, they felt they could access electronic patient data, and, like Kenya's respondents, the MVP dashboard was perceived as very helpful and generated excitement.

In Somalia, using a paper-based system for patient data collection resulted in a deficiency of detailed information during patient referrals. Somalia lacked a specific data storage method for patient data. Due to the outbreak of war, there was no data following the deployment of the installation.

Before implementing the MVP, most respondents in Uganda reported that they frequently used their computers for financial calculations instead of processing patient data. They believed the process needed improvement to encourage healthcare professionals to accept and continuously use the system for patient data insights. Post-implementation results in Uganda showed that the health facilities were satisfied with the MVP, which they saw as improving services and enabling data accessibility for the medical staff. The dashboard was also appreciated in the health facilities.

With regard to performance expectancy, the dashboard stood out as the key element that increased performance expectancy after MVP deployment. Interestingly, the dashboard was not mentioned before installation, and the result that this made a big impact on performance expectancy was not predicted from the elements mentioned on performance expectancy prior to the implementation of the MVP.

Effort expectancy

Effort expectancy is defined as the degree of ease associated with using the system. Table 5 shows expectations of effort across countries before and after MVP deployment.

Table 5. Expectation of effort before and after MVP implementation

Country	Pre-implementation phase summary	Post-implementation phase summary
Ethiopia	The current procedure for patient health records cannot provide digital patient data. Paper-based data causes problems. Data reporting is not done regularly.	A user-centred approach is needed to demonstrate the value of the system. There were complaints about the double effort required to complete the patient register and the MVP simultaneously.
Kenya	Issues reported include data loss and erroneous data input. Users believe that the system requires significant work.	The MVP needs to be more user-friendly to avoid confusion. One of the health facilities reported slowness in using the MVP system, which clashes with their current system.
Nigeria	There are insufficient shelves for paper-based patient files. The process for accessing patient data is slow. Natural disasters pose a risk for data storage.	The MVP improves the current patient data flow. The current record production of the MVP is cumbersome and needs to be more user-friendly. The focus should be on making the system appealing, not just achieving results.
Somalia	The paper-based method is time-consuming. Errors occur in counting diseases. No storage system exists; full paper registers can be lost anytime.	N/A
Uganda	Patient volume and system capacity affect the perceived effort to use the data management system. Effort expectation varies across health facilities. Facilities with fewer patients report no challenges.	The adoption of the MVP takes time. Data input is time-consuming.

In Ethiopia, the pre-implementation phase was characterised by a heavy reliance on paper-based records, significantly delaying data management—challenges worsened by the ongoing conflict. In the post-implementation phase, interviewees observed that although the MVP enabled digital data production, it unintentionally created a data entry duplication scenario, requiring staff to enter patient data into both the conventional system and the new MVP. Furthermore, the participants highlighted the need for a more user-cantered design that minimises redundant data entry.

In Kenya, the participants were in a situation where an electronic health system was already available. However, they still perceived misinput and data loss as significant issues before implementing the MVP, and they expected that the MVP would improve this. After the deployment, persons reporting from the health facilities in Kenya believed that further improvements are necessary for the current system. The participants from the health facilities expressed the need for the MVP to be enhanced with greater user-friendliness. The participants also reported system slowness and conflicts of error messages.

The health facilities in Nigeria reported that the management of the patient records flow was progressing very slowly. They also expressed concerns about the insufficient storage of paper-based patient data files. Participants reported that the potential risk of destruction of patient records due to natural disasters was perceived as high. Implementing the FAIR-based system improved the flow of patient data processing; however, they believed that improving the user interface would simplify data input and enhance the system's appeal to data stewards.

In Somalia, it was reported that the paper-based method of patient records was time-consuming. They also mentioned the problem of errors occurring in the recording of diseases. The participants from Somalia mentioned that the storage system in place was inadequate and that paper registers that had been filled out could be lost at any time. Due to the war, the participants in Somalia could not be interviewed after the MVP was installed.

A variety of perceptions were reported from Uganda. Respondents from health facilities with a high patient volume perceived that the data management system of patient records required significant effort. Participants from health facilities with a smaller patient load did not report this as a problem. After MVP installation, the participants from health facilities reported that they needed time to adapt to the new system. Moreover, the health facilities stated that the data input was time-consuming.

Overall, the effort expectancy was high before the deployment of the MVP. After deployment, the MVP was assessed as needing to be more user-friendly and that the data input was cumbersome. In some instances, the data input was reported as duplicating with the DHIS2 reporting, which increased the workload.

Social influence

Social influence refers to the extent to which individuals believed others were supportive of the adoption of the innovation and whether users should adhere to a particular system. As reported in Table 6, social influences for adoption play a critical role in societal transformation, as people adopt new behaviours when they observe influential figures, peers, or social norms promoting these changes.

In Ethiopia, the influence of a series of initiatives to introduce HITs provided a fertile basis for adopting digital health innovation. Participants reported that the Ministry of Health in Ethiopia was very active in encouraging the introduction of digital tools for improved health data management in health facilities. The introduction of the MVP and the related training broadened stakeholder perspectives by demonstrating that using a digital data system was not only relevant for conducting research but also for improving the quality of care and services for patients visiting the hospital.

In Kenya, the Ministry of Health was a crucial stakeholder that had the potential to influence the utilisation of a system and the perception of its value. Given the high uptake of EHRs in Kenya, normative pressure drove health facilities to use the system. This pressure was compounded by the perceived need to address the needs of COVID-19 patients between 2021 and 2022. The health facilities reported that their director's and the VODAN team's support were important for implementing the system effectively. Participants reported that, after the MVP introduction, issues of data ownership and how it could be promoted by a different curation of data in health facilities were discussed, leading to new models for health data sovereignty.

Health facilities in Nigeria reported that health workers and the Ministry of Health were the primary users of current and future systems. They felt that implementing the FAIR-OLR system improved data stewards' knowledge. The data steward was central for data input and had an important impact on the health facility's perception of the system's usefulness. Respondents underscored the importance of future training to enhance data stewards' understanding of the new system.

In Somalia, doctors are the primary data collectors and were central to MVP implementation, while the Ministry of Health provided overall direction.

In Uganda, the Ministry of Health was also perceived as a significant data management stakeholder whose buy-in was critical for updating data flows at both public and private health facilities. In addition, respondents emphasised the importance of facility managers for ensuring the project's continuation.

Table 6. Social influence

Country	Pre-implementation phase summary	Post-implementation phase summary
Ethiopia	The role of HIT is crucial in system implementation. The Ministry of Health influences the application of the system for data management.	It is important to shift the perspective that the system can be used not only for research but also for improving the quality of care. Training helps show the medical staff the bigger picture.
Kenya	The Ministry of Health's usage and senior officials' support impact the	The country coordinator interviewed shared that the management's concern is data ownership and curation.

Country	Pre-implementation phase summary	Post-implementation phase summary
	perception of the system's value and effectiveness. Organisations like KEMRI prioritise normative pressure to use the system for tracking vital data (e.g., COVID-19).	VODAN support is useful The Director of KEMRI supports the study
Nigeria	Health workers and the Ministry of Health can access patient data in the current system. Both stakeholders will influence future system use.	FAIR implementation has added knowledge for data stewards and changed their perspective on data. Future training is needed to enhance understanding of the system. The Ministry of Health is monitoring the system's implementation.
Somalia	Doctors influence future system use as the first point of patient data collection. It is beneficial for the future system to be endorsed by the Ministry of Health.	-
Uganda	The Ministry of Health influences the application of the system for data management. The Ministry of Health requires data collection and analysis.	The Ministry of Health is essential in terms of giving approval and being involved in the process of introducing the MVP. There is a lack of support from health facility management to keep the project going.

Respondents in most countries saw the Ministry of Health as having a high influence over adopting the MVP. Respondents reported that the MVP showed potential for improved data use for better patient care. Participants also highlighted the importance of training to demonstrate the broader value of data to the health care services. In Uganda, support by health facility management was reported as critical for the sustainability of the MVP.

Facilitating conditions

Facilitating conditions, reported in Table 7, refer to the perception of the resources, infrastructure, and support available to help individuals adopt and use a system or technology effectively.

In Ethiopia, nine out of twenty health facilities lacked computers. The health facilities that owned computers used them for DHIS2 reporting and other tasks. The use of computers for the MVP was more difficult due to the unreliable electricity and Internet connection due to the war and Internet blockade in Tigray.

In Kenya, the survey before the deployment of the MVP showed that health facilities felt that the hardware and software were in place and functional. Users did not report any technical obstacles to the MVP. After the installation of the MVP, unstable Internet and electricity were reported as problems when using the system. However, the health facilities arranged generators to tackle the electricity issues. The health facilities felt that training was needed not only for the data stewards but also for all staff members who had good technical skills.

Infrastructure availability varied in Nigeria; most health facilities owned computers, but seven did not. Moreover, the available computers were not used for health data capture. Most facilities lacked an Internet connection; where it was available, it was not stable. The FAIR-based implementation revealed that the Internet and electricity were two major implementation obstacles. The health facilities suggested that a standalone system would have improved the implementation effectiveness.

In Somalia, computers were available in the health facilities; however, they were not used for patient data management, and the medical staff did not use computers for daily work. Due to the outbreak of war, the facilitating conditions perceived following the deployment could not be studied.

The participants in the health facilities in Uganda reported that hardware and software were in place and functional. Following the introduction of the MVP, the health facilities expressed a need for additional personnel and computers to manage the data produced effectively. Unreliable electricity and limited Internet access weakened MVP adoption. This was overcome by health facilities putting additional support, such as generators, in place.

Table 7. Facilitating conditions

Country	**Pre-implementation phase summary**	**Post-implementation phase summary**
Ethiopia	Nine out of twenty health facilities did not have computers. Computers are used in facilities for DHIS2 reporting and other tasks.	Unreliable electricity and Internet connection remain issues when running the system.
Kenya	The necessary hardware and software for the current system are in place and functional. Users perceived no technical obstacles. Indicates high enabling conditions.	Unstable Internet and electricity are problems when using the system. Health facilities prepare generators for unstable electricity. Training is needed not only for the data stewards but also for staff with good technical skills.
Nigeria	Infrastructure conditions at health facilities vary. Most facilities have computers, but seven do not. Available computers are not used for medical recording. Most facilities lack an Internet connection, and where it is available, it is not stable.	Unreliable electricity and Internet connection remain issues when running the system. The interviewees feel that the system should be standalone.
Somalia	Infrastructure, like computers, is available in health facilities.	N/A

Country	Pre-implementation phase summary	Post-implementation phase summary
	Computers are not used for patient data management. Medical staff do not use computers for daily work.	
Uganda	The necessary hardware and software for the current system are in place and functional. No technical obstacles were reported, suggesting high enabling conditions. Not all computers are used for data collection.	Health facilities need more personnel and computers to handle the data.

Discussion

This chapter emphasises the vulnerability of centrally located data infrastructure in conflict-affected areas and the urgent need for federated and sustainable digital health systems. This corresponds with findings of case studies illustrating how humanitarian efforts are obstructed when data systems malfunction during digital blackouts and sieges, particularly when timely health information is essential (Amare et al., 2024; Taye et al., 2024; Kahsay, 2024, Gebreslassie et al., 2024; Stocker & Medhanyie, 2024).

This study shows that the FAIR-OLR data principles offer potential for improving the reliability and utility of global information systems (Van Reisen et al., 2023). However, it also points to the importance of exploring the significance of contextual factors in Africa for adopting FAIR-based infrastructure, particularly in low-connectivity environments and war situations. The inconsistency in adopting FAIR-OLR principles throughout the continent highlights the necessity for adaptable strategies (Amare et al., 2023).

The UTAUT framework is used to examine the contextual factors that affect adopting a FAIR-based health system in health facilities within the VODAN-Africa project.

Performance expectancy

The findings indicate gaps in expectations and outcomes regarding performance expectancy across the analysed regions. Participants from health facilities in Kenya, Nigeria, and Uganda were reported to have high expectations of the MVP's potential to improve data accessibility, operational efficiency, and decision-making processes. The high expectations point to problems in available data recording systems.

The dashboard for visualisation of the data, deployed in the health facility, had significant appeal. The situation in Ethiopia indicated that investment and training were insufficient, but that data handling must be decentralised to the health facility level. In Ethiopia, the deployment was successful despite the conditions of war and the Internet black-out, speaking to the heightened relevance of data during war and generating increased awareness of the importance of digital data autonomy in health. More generally, in Ethiopia, the introduction of the MVP showed participants in the study the relevance of digital patient data for care services, debunking the idea that digital data only served research. In Somalia, which was also struck by war, the situation led to a collapse, and no interviews could be conducted as a result. In Kenya, the deployment of the MVP generated awareness of the relevance of data availability for health services at the clinic level.

The study shows that the MVP holds potential for improving information use and data workflows in healthcare facilities. The enhanced data utilisation capabilities are particularly relevant, as well as the capability to integrate and operate across different digital systems.

Effort expectancy

Effort expectancy and perceived ease of system usage varied across countries. The pre-implementation survey found that many health facilities reported difficulties with current information management systems, including paper-based procedures and obstacles to utilising digital tools. The lack of adequate information processing raised their expectations for the proposed tools.

The installation of the MVP showed mixed results. The ability to produce patient data within the facility and for insights available to health workers was highly rated. That said, participants reported challenges with the MVP, including time-consuming data entry processes in Uganda and system-user conflicts. There were also problems with error messages, system slowness and cumbersome data input related to software issues generated by the CEDAR central platform, which did not respond well to the federated CEDAR micro-services.

Post-intervention interviews highlighted the importance of the following:

- Maintaining the clinical patient data in the health facility
- Having a dashboard for visualisation and querying the data for generic and abstract uses, as well as for personalised care
- Moving from paper-based to digital electronic medical records and, based on the FAIR-OLR capability, and the ability to use and query this data in the health facility
- Data handling in the health facility, excited stakeholders who felt that the MVP increased insights, accountability, and improved care.
- The entire spectrum of stakeholders was engaged, from data clerks, stewards, medical personnel, and administrators
- Policy changes reflect the need for local ownership of patient data in the jurisdiction where data is collected so data processing and reuse results in better care.

Overall, we found that improved user-centric design, intuitive interfaces and seamless integration with current workflows should be incorporated into future iterations of the MVP. Offering training and technical assistance may help reduce perceptions of significant effort, especially in resource-limited environments.

Social influence

Implementing the MVP generated discussions among stakeholders in all jurisdictions regarding patient data ownership and patient data curation and handling. The implementation study itself impacted social influence. Ministries of Health emerged as key actors facilitating system acceptance, using their authority to advocate for the FAIR-based system. The involvement of Ministries in endorsing and monitoring the system enhanced its legitimacy and facilitated adoption among healthcare professionals (Nalugala & Van Reisen, 2024).

Training programmes facilitated a transformation in perceptions, as data stewards and medical personnel acknowledged the comprehensive value of the system in enhancing healthcare outcomes. In Kenya, the regulatory framework was changed in 2023, requiring patient data to be reposited within the country's jurisdiction and the development of a national system for patient electronic medical records (EMR), called Afya.ke. In Uganda, a national policy was developed in January 2025 requiring all public hospitals to introduce an EMR system for patient records (Ministry of Health, Uganda, 2023). These developments have sped up the possibility of integrating FAIR-OLR elements as a foundational layer in EMRs, which is being investigated by Lasroha (2025) and Lin (2025).

The localisation of data handling and supporting infrastructure was perceived as critical in Ethiopia. This corresponds with findings that attacks on health facilities during violent conflicts combined with sieges were triggers for innovation in which the ownership and localisation of data handling became extremely important. Participants in Nigeria were particularly interested in data ownership, particularly patient data sovereignty as a basis for patient data interoperability, with a focus on remote patient populations (Kawu et al., 2023; Kievit, 2024).

Facilitating conditions

The availability of proper infrastructure proved to be an important factor in the successful implementation of the MVP. The reliability of electricity and Internet access in all participating health facilities was a significant problem, directly affecting the maintenance of digital health record systems. The absence of reliable power sources and network infrastructure presented significant challenges to the continuous functioning of systems, resulting in operational inefficiencies and interruptions in data access and storage.

In response to these issues, healthcare facilities in Kenya and Uganda adopted localised solutions, including deploying generators to help with power outages. Although these initiatives showed resilience, they underscored the need for sustainable financial support for digital health data infrastructure to facilitate long-term adoption. In Nigeria and Ethiopia, Internet connectivity and power instability were recognised as serious barriers. Unless such fundamental challenges are resolved, the potential advantages of the MVP—such as enhanced interoperability and data-informed decision-making—will likely remain limited.

Moderating variables

Although the UTAUT framework emphasises the moderating impact of factors like age, gender, experience, and voluntariness, these aspects are not specifically relevant to this research. The pre-implementation phase of the study involved gathering data from facility directors, managers, and leaders; the post-implementation phase involved gathering data from country coordinators and data stewards. Rather than their demographic variety, these responders were chosen specifically for their monitoring and leadership responsibilities. In this case, their views on technology adoption focused mainly on their professional knowledge and organisational duties, rather than their characteristics. As a result, this study was unable to evaluate the influence of demographic factors on the adoption of technology. To further capture and explore these possible moderating effects, future studies should try to include a larger sample of end users.

Evaluation of MVP implementation

The evaluation presents a detailed picture of the MVP's performance, as perceived by the participating healthcare facilities. First, the MVP's key features were effectively implemented. For example, several respondents strongly recommended the data visualisation dashboard for facilitating access to patient data and decision-making. This element turned out to be a crucial enabler of digital interoperability.

However, the assessment also points out instances where the MVP failed to meet participants' expectations. The system's slowness, which restricted effective data processing, was an ongoing issue. Additionally, the need for dual data entry—in which employees had to enter data into the MVP and the traditional paper-based system—introduced additional workload and exposed a weakness in the user-centred design methodology. This could be overcome by scanning the paper-based records and potentially keeping both paper-based and digital archives without duplicating. This would speed up digital data integration, in which the stages, proposed by the WHO for SMART transformation, should be no longer regarded as successive stages (Kumar et al., 2021).

In some cases, the user interface did not properly match the facilities' operational requirements, limiting acceptance of the new system. While the MVP effectively met fundamental needs related to interoperability and data visualisation, it failed to fulfil important requirements for usability and operational effectiveness. Future versions should focus on improving system responsiveness, simplifying data entry procedures, and improving the user interface to better suit the operational reality of healthcare facilities in keeping with stakeholder inputs.

Convergence of approach with adaptation to regional variation

The convergence shown in expectations on basic principles of patient information systems align with recommendations from the WHO SMART model and Observational Health Data Sciences and Informatics (OHDSI) communities (Sung et al., n.d.), and with emerging legislation (Van Reisen, 2024; Wang, 2025).

The results of this study confirm the convergence in social influence, while highlighting the regional variability of the contextual factors relevant to adoption. The different regional responses demonstrate the relevance of GO CHANGE, to ensure that GO BUILD and GO TRAIN tracks in GO FAIR are combined with adaptations to make innovation relevant to a particular context. The implementation study demonstrated the capacity of the MVP to remain interoperable while being adapted to priorities in different places.

Demographic factors

Although the UTAUT framework emphasises the moderating impact of factors like age, gender, experience, and voluntariness, these aspects are not specifically relevant to this research. The pre-implementation phase of the study involved gathering data from facility directors, managers, and leaders; the post-implementation phase involved gathering data from country coordinators and data stewards. Respondents were explicitly chosen for their monitoring and leadership responsibilities rather than based on demographic factors. In this case, their views on technology adoption focused mainly on their professional knowledge and organisational duties, rather than their characteristics. As a result, this study could not evaluate the influence of demographic factors on the adoption of technology. To further capture and explore these possible moderating effects, future studies should try to include a larger sample of end users.

Conclusion

This study examines how unique contextual factors in Africa shape the GO CHANGE component within the FAIR infrastructure. While not comprehensive, it highlights a diverse range of scenarios that directly impact the effective implementation and adoption of FAIR principles across different African contexts. The study found that the FAIR infrastructure and tools are highly adaptable to different circumstances and conditions.

The research employed a mixed-methods approach, combining a pre-implementation survey (n=66 health facilities) and qualitative post-implementation interviews (n=46 health facilities). The UTAUT framework guided the analysis, focusing on four key dimensions: performance expectancy, effort expectancy, social influence, and facilitating conditions.

By comparing pre- and post-implementation data across countries, this study identified patterns of digital health adoption, highlighting infrastructure barriers, data sovereignty concerns, and regulatory influences that shape implementation outcomes. This study's findings point to the significant influence of contextual factors on the adoption and implementation of FAIR-based systems in the VODAN-Africa project. The results demonstrate differences in infrastructure preparedness, stakeholder involvement, and social dynamics across included African countries. These variations will influence strategies for successful adoption and future iterations of the MVP.

Data ownership and local data governance are perceived as crucially important for FAIR infrastructure adoption. Health ministries and other significant stakeholders play a crucial role in legitimising and advocating for the FAIR-OLR-based system, underscoring the importance given to ensuring the alignment of governance frameworks with findings that emerged from the implementation study. Training programs and capacity-building initiatives were crucial in altering user perceptions and cultivating ownership among healthcare professionals and data stewards.

The assessment provided important insights into the complexity of the MVP implementation. The data visualisation dashboard and other key features were effectively implemented, improving data interoperability and the potential to use data for clinical decision-making and maternal and child health-related surveillance. Obstacles, including system slowness, the need for dual data entry, and an inadequate user interface suggested the need for additional modifications to enhance usability and operational efficiency, especially in resource-constrained environments.

Research participants highlighted the importance of technical inefficiencies, disparities in infrastructure accessibility, and issues regarding data ownership and security as challenges for MVP implementation. Results suggested that the FAIR-OLR patient data system was a viable option for areas with inconsistent electricity and Internet access but that additional refinements would be needed to address these added challenges.

The implementation of the MVP following FAIR-OLR guidelines has led to policy changes, mandating electronic medical records, localised data handling, and the prioritisation of patient data sovereignty, including ownership within jurisdictions. There is growing interest in leveraging linked interoperable data systems under strict access controls (I-Beat, 2025). Further research on the ongoing impact of FAIR-OLR on healthcare data quality is essential for continued product development, particularly in integrating FAIR-OLR into EMR systems across African health facilities to build cross health facility interoperability. Future research should focus on subregional differences to enhance the effectiveness of continental implementation strategies in support of the African Health Data Space.

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Authors' Contributions

Putu Hadi Purnama Jati: Conceptualization, methodology, validation, formal analysis, writing, including original draft, and visualization; **Samson Yohannes Amare:** investigation, technical lead; **Abdullahi Abubakar Kawu:** investigation, project administration; **William Nandwa:** investigation, data steward; **Getu Tadele Taye:** investigation, technical support; **Mirjam van Reisen:** supervision, validation.

Ethical Considerations

Tilburg University, Research Ethics and Data Management Committee of Tilburg School of Humanities and Digital Sciences REDC#2020/013, June 1, 2020-May 31, 2024, on Social Dynamics of Digital Innovation in remote non-western communities. Uganda National Council for Science and Technology, Reference IS18ES, July 23, 2019-July 23, 2023.

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